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DESIGN OF DELIVERY AREAS OF PUBLIC POSTAL OPERATOR BY APPLYING AHP MODEL

ABSTRACT

The design of delivery districts is a continuous task of postal technology because migration of population, construction of buildings and traffic routes etc. change the quantity and structure of postal items thus significantly influencing the delivery effect. In solving the problem of designing the delivery areas of public postal operator the key values are the quantity of postal items, length of delivery route and load (effect) of the carrier. Delivery district borders have to be adequately determined and they should be relatively uniform in order to achieve rationalization and to balance the load on the carrier. To gather the data about the postal centre area, a model of AHP method application has been set, in which the optimal solution of organizing delivery areas is selected by means of the multi-criteria analysis of alternative solutions.

KEY WORDS

public postal operator, postal delivery, efficiency, AHP method

1. INTRODUCTION

The distribution of postal items represents the key technological phase and the basic activity of every postal operator. This is a complex technological and organizational task since it refers to the physically distributed system with significant variations in the postal item quantities. The delivery is organized on the territorial principle so that postal centres (as a rule) cover the areas of counties, and consist of certain number of delivery postal offices from which the delivery is performed to the surrounding places. The development of society changes the cultural habits of the population, changes the customs, places of income and consumption. The data on the arrived postal item to individual addresses change every day. In order to rationalize the technology and operation of the public operator HP – Hrvatska pošta d. d. (Croatian Post) the delivered postal items were counted in the month of October 2004 [8]. This count showed various illogical character-

istics in the organization of delivery – individual letter carriers have too much and others too little work.

The task of the traffic technologist is to optimise the delivery by levelling the work of the letter carrier. By applying the AHP method the standardized model of designing and reorganizing the delivery area is elaborated, with the consistent comparison of alternative solutions. The comparison of several benefit-cost types for certain delivery organization variants yields the optimal variant.

The practical actuality of solving the problem of the delivery area design follows from the new regulations about the general conditions for performing postal services which results in new challenges for the Croatian Post. The regulations (among other things) regulate the conditions of receiving and delivering postal items so that the work that awaits the technologists of the Croatian Post will be a hard one: new design of delivery areas within the framework of new regulations, and using the data obtained by postal item count.

2. DELIVERY OF POSTAL ITEMS

The delivery of postal items is done by the post office employees with organized delivery i. e. delivery area. The delivery area of a certain post office consists of one or several delivery district, and this depends on the size of the delivery district and the structure of postal items. The design of delivery districts is a continuous task of postal technology since the migration of population, construction of buildings and roads, etc. change the quantity and structure of postal items thus significantly influencing the effect of delivery. According to relevant literature [1] reorganization should be done in an interval between two and five years.

According to types and categories of postal items [1] the delivery district can be divided into:

- letter delivery districts,
- package delivery districts,

- money delivery districts,
- newspaper delivery districts,
- delivery districts for urgent postal items and delivery districts for various combined postal items.

The design of the delivery district assumes that every residential or business object is included in one of the districts. Therefore, all relevant elements need to be elaborated, which includes:

- map of the settlements with the city and municipality borders,
- geographical and topographical characteristics,
- start and end district points,
- method of transporting workers to the district and within the district,
- total covered distance.

The following data need to be added:

- data on the quantities of postal items per types and categories,
- data on the structure of receivers,
- data on the number of deliveries,
- data on possible lengths of itineraries with productive and non-productive time, and
- assessment of habits and preferences of the receivers.

The once determined itinerary of the delivery is defined by the Carrier Route Scheme (Putni list poštunoše), and the letter carrier has to go from building to building as defined in this route scheme. The purpose of making the Carrier Route Scheme is to create the habit by the customer to expect the letter carrier always at the same time. Carrier Route Scheme is an official form [7] made by the Postal Centre, and it contains the following data:

- name of the Postal Centre and the post office,
- date when it started to be implemented,
- code of the district (name and number),
- manner in which the delivery is performed (on foot, by motorcycle, bicycle, car),
- sequence of the itinerary of the letter carrier,
- number of deliveries per week or days when the delivery is done,
- time at which the letter carrier starts the delivery,
- time of return of the letter carrier from delivery,
- code of the postal box emptied by the letter carrier,
- map of the district for the wider, widest and combined delivery district,
- covered distance in the total length of the delivery district.

There is a rule for the letter carrier making the delivery on foot not to be loaded by more than 15 kg of postal items so that district depots are to be set at such districts to which the postal items may be delivered by vehicles.

The delivery district boundaries have to be correctly determined and balanced in order to provide a relatively equal working load on the letter carriers. In order to achieve this it is necessary to develop a model that will describe the effects of delivery. A minimum number of relevant values in developing the delivery model is [1]:

- initial quantity of postal items for the delivery (Q_p) and
- length of the route to the last delivery point (s_z).

$$Q_p = f(s) \tag{1}$$

represents the falling function in the domain $[0, s_z]$, with the properties:

$$f(0) = Q_p, \\ f(s_z) = 0,$$

For several workers the effect of the k-th worker is set by the expression:

$$R^{(k)} = \int f(s) ds. \tag{2}$$

The mean value of the effect for m worker amounts to:

$$R_{sr} = 1/m \sum_{k=1}^m R^{(k)}. \tag{3}$$

The simplest model can be presented as linear function so that the following is valid:

$$f(s) = As + B \\ f(0) = Q_p \rightarrow Q_p = B \\ f(s_z) = 0 \rightarrow A = -Q_p/s_z, \\ \text{thus } f(s) = Q_p(-s/s_z + 1) \tag{4}$$

whereas the delivery effect is determined by the expression:

$$R = \int_0^{s_z} Q_p(-s/s_z + 1) ds = Q_p s_z / 2. \tag{5}$$

Table 1 - Minute norms

Type of activity	Norm
Regular letter items brought for delivery	0.5 minutes
Registered postal items and remittance letters – delivered	1.7 minutes
Postal items with return receipt	1.5 minutes
Leaving report on postal item arrival	2.7 minutes
Postal orders paid out at home	4.4 minutes
Kilometre of covered distance on foot	15.0 minutes
Kilometre of covered distance by bike – narrow area delivery	7.5 minutes
Kilometre of covered distance by bike – wider area delivery	6.0 minutes
Kilometre of covered distance by moped – narrow area delivery	4.5 minutes
Kilometre of covered distance by moped – wider area delivery	3.0 minutes

Table 2 - Delivered postal items in the area of Postal Centre Koprivnica in October 2004. The offices have been sorted according to the number of carriers.

Ordinal number	Postal office	Number of citizens per delivery area	Number of citizens per letter carrier	Number of households in the delivery area	Number of households per letter carrier	Number of letter carriers	Number of delivered registered postal items	Number of delivered registered postal items per citizen	Number of delivered registered postal items per household	Number of delivered registered items per carrier	Number of delivered regular letters	Number of delivered letters per citizen	Number of delivered letters per citizen / average	Number of delivered letters per households	Number of delivered letters per letter carrier	Average daily covered kilometres per district
1	48000	31247	2083	10575	705	15	10046	0.32	0.95	670	142377	4.56	1.17	13.46	9,492	7.05
2	48260	18824	1882	5850	585	10	6292	0.33	1.08	629	100505	5.34	1.37	17.18	10,051	8.15
3	48350	9620	1924	3080	616	5	2131	0.22	0.69	426	44950	4.67	1.20	14.59	8,990	5.98
4	48267	3538	1179	1134	378	3	746	0.21	0.66	249	12127	3.43	0.88	10.69	4,042	9.84
5	48326	4203	1401	1347	449	3	1143	0.27	0.85	381	13364	3.18	0.82	9.92	4,454	6.66
6	48214	3745	1873	1090	545	2	797	0.21	0.73	399	16539	4.42	1.13	15.17	8,270	12.99
7	48264	2560	1280	820	410	2	730	0.29	0.89	365	11199	4.37	1.12	13.66	5,600	11.39
8	48265	2078	1039	888	444	2	441	0.21	0.50	221	9850	4.74	1.22	11.09	4,925	10.00
9	48268	2545	1273	976	488	2	362	0.14	0.37	181	12158	4.78	1.23	12.46	6,079	7.00
10	48306	3488	1744	1040	520	2	823	0.24	0.79	412	10742	3.08	0.79	10.33	5,371	12.89
11	48312	3335	1668	1000	500	2	532	0.16	0.53	266	9819	2.94	0.76	9.82	4,910	12.45
12	48325	2924	1462	958	479	2	810	0.28	0.85	405	15117	5.17	1.33	15.78	7,559	6.64
13	48362	4632	2316	1484	742	2	1279	0.28	0.86	640	16195	3.50	0.90	10.91	8,098	9.23
14	48213	1736	1736	538	538	1	385	0.22	0.72	385	8311	4.79	1.23	15.45	8,311	11.03
15	48269	1930	1930	619	619	1	576	0.30	0.93	576	6552	3.39	0.87	10.58	6,552	10.00
16	48311	2228	2228	794	794	1	331	0.15	0.42	331	7012	3.15	0.81	8.83	7,012	7.71
17	48316	2122	2122	678	678	1	252	0.12	0.37	252	7113	3.35	0.86	10.49	7,113	6.79
18	48317	2578	2578	915	915	1	464	0.18	0.51	464	6502	2.52	0.65	7.11	6,502	13.65
19	48321	2792	2792	896	896	1	552	0.20	0.62	552	7603	2.72	0.70	8.49	7,603	7.4
20	48322	2181	2181	681	681	1	419	0.19	0.62	419	6898	3.16	0.81	10.13	6,898	14.35
21	48322	1598	1598	560	560	1	305	0.19	0.54	305	5391	3.37	0.87	9.63	5,391	8.00
22	48324	2878	2878	931	931	1	427	0.15	0.46	427	8346	2.90	0.74	8.96	8,346	10.35
23	48327	1863	1863	633	633	1	420	0.23	0.66	420	8548	4.59	1.18	13.5	8,548	6.42
24	48331	2051	2051	632	632	1	359	0.18	0.57	359	9435	4.60	1.18	14.93	9,435	9.60
25	48356	2002	2002	641	641	1	482	0.24	0.75	482	13884	6.94	1.78	21.66	13,884	10.98
26	48361	1753	1753	561	561	1	530	0.30	0.94	530	6849	3.91	1.00	12.21	6,849	8.09
27	48363	1915	1915	663	663	1	292	0.15	0.44	292	7531	3.93	1.01	11.36	7,531	12.90
28	48314	1474	2948	402	804	0.5	334	0.23	0.83	334	4782	3.24	0.83	11.90	4,782	5.66
29	48332	1261	2522	401	802	0.5	180	0.14	0.45	180	3430	2.72	0.70	8.55	3,430	6.60
30	48355	1414	2828	411	822	0.5	121	0.09	0.29	121	4833	3.42	0.88	11.76	4,833	9.30
	Σ	126515	1968	41198	634	68	32497	0.21	0.66	409	537962	3.89	1.00	12.01	7,461	9.35

Table 3 - Delivered postal items to PU 48326 Virje

Ordinal number	street, town	hpe	R individual	R collective	AR individual	AR collective	VP	redemption	regular - collective	regular individual	printed material addressed indiv.	printed mat. addressed collect.	printed mat. non-addressed	postal orders	pension money orders	FINA money orders
1	A. Hebranga, Virje	0	9	0	11	5	0	1	153	47	44	0	20	1	1	1
2	A.Cesarca, Virje	0	1	0	1	0	0	0	83	2	26	2	5	5	0	4
3	A.Starčevića, Virje	2	23	6	28	0	0	0	217	109	65	22	66	0	4	3
4	B.Radića, Virje	0	5	0	3	0	0	2	92	6	19	0	13	0	3	1
5	Brestova, Virje	0	3	0	7	0	0	0	70	13	18	0	10	0	6	2
6	Ciglenska, Virje	0	0	0	2	0	0	0	81	8	22	0	13	0	1	2
7	D.Zdjelice	0	5	0	8	0	0	1	243	0	43	0	150	0	20	8
8	Đ.Sudete, Virje	2	7	0	8	2	0	2	98	86	44	12	25	1	0	3
9	F.V.Šignjara, Virje	0	5	0	18	1	0	0	156	11	25	3	30	0	6	1
10	Fanićeva, Virje	0	4	0	8	0	0	1	95	12	12	2	10	2	0	2
11	Gajeva, Virje	0	23	0	71	3	2	6	772	168	180	23	196	0	33	25
12	Gorička, Virje	0	9	0	63	4	0	4	609	97	146	11	71	1	23	13
13	Gradišće, Virje	0	15	2	30	0	0	2	201	87	38	8	23	0	10	7
14	Gundulićeva, Virje	0	4	1	10	0	0	2	165	26	51	4	35	0	0	0
15	Hrv.Domobrana, Virje	0	1	0	7	0	0	0	124	9	12	0	17	0	1	1
16	Istarska, Virje	0	1	0	2	0	0	0	55	11	19	3	14	0	0	2
17	J.Kucela, Virje	0	5	0	9	0	0	0	91	21	36	5	18	0	2	2
18	Kolodvorska, Virje	0	16	0	45	0	0	4	350	52	100	2	77	1	7	12
19	Kvaternikova, Virje	0	1	0	5	0	0	0	56	10	12	0	5	1	0	2
20	Lugarićeva, Virje	0	20	0	36	0	0	2	264	101	87	20	57	0	12	6
21	M.Gupca, Virje	0	1	0	7	2	0	1	82	3	14	0	8	0	2	0
22	M.P.Miškine, Virje	0	8	0	26	0	0	2	168	20	55	7	53	0	5	7
23	Miholjanec	0	9	0	47	0	0	6	935	0	131	0	250	0	54	28
24	Miholjanska, Virje	0	16	0	31	2	2	3	368	53	191	4	60	2	16	14
25	Mitrovica, Virje	0	16	0	83	0	2	3	997	147	300	25	150	49	0	25
26	Nazorova, Virje	0	0	0	6	0	0	0	86	6	24	0	10	0	2	1
27	Novigradska, Virje	0	8	0	56	0	0	7	540	112	120	14	45	1	12	11
28	Paromlinska, Virje	0	0	0	0	0	0	0	63	2	9	1	37	0	1	0
29	Preradovićeva, Virje	0	2	0	2	0	0	1	101	20	27	2	15	3	0	3
30	Rusanova, Virje	1	6	0	17	0	1	0	146	31	57	2	20	1	3	0
31	Šemovečka, Virje	0	9	0	15	0	0	0	270	42	63	2	10	4	0	4
32	Šenoina, Virje	0	1	0	4	0	0	1	105	19	23	2	17	0	4	5
33	Tomislavova, Virje	0	3	0	2	0	0	0	86	9	19	1	21	0	5	0
34	Trg B.Jelačića, Virje	4	8	0	26	1	0	0	262	92	69	0	45	2	0	3
35	Trg Prodavić, Virje	2	10	0	21	1	0	0	202	50	51	10	35	1	3	4
36	Trg.S.Radića, Virje	0	17	0	18	25	1	0	168	40	45	2	41	0	5	5
37	Trnovec, Virje	0	20	4	35	2	1	7	461	98	152	43	81	1	18	17
38	Vinogradska, Virje	0	3	0	12	1	0	0	53	1	3	1	5	1	2	1
39	Vrbas, Virje	0	1	0	6	0	0	0	71	7	12	0	17	1	4	1
	Total	11	295	13	786	49	9	58	9139	1628	2364	233	1775	78	265	226

with average effect:

$$R = 1/m \sum_{k=1}^m Q_p^{(k)} S_z^{(k)} \quad (6)$$

Since the effect is determined by the product of the quantity and the covered distance it is necessary to determine the relative influence of individual values. The instructions for collection and processing of statistical data have determined the time required to perform a certain service as well as the time to cover a distance. The most important tasks have been given in Table 1.

Since the mentioned instructions are not valid any more (others have not been adopted), and the delivery districts are more complex than the linear model, the technologists are facing hard work. In order to assess the efficiency of individual workers involved in the delivery, during October 2004 an extensive job of counting the postal items was carried out. The deliveries were counted every day per types, streets and settlements. The data obtained by counting of postal items in the Postal Centre Koprivnica are presented in Table 2. The data for other centres (counties) are not yet available, but it may be assumed that they are similar.

Ordinal number, POSTAL OFFICE, Number of citizens per delivery area, Number of citizens per letter carrier, Number of households in the delivery area, Number of households per letter carrier, Number of letter carriers, Number of delivered registered postal items, Number of delivered registered postal items per citizen, Number of delivered registered postal items per household, Number of delivered registered items per carrier, Number of delivered regular letter, Number of delivered letters per citizen, Number of delivered letters per citizen / average, Number of delivered letters per households, Number of delivered letters per letter carrier, average daily covered kilometres per district

Table 2 shows that the biggest number of postal items was delivered in the urban areas of the postal offices 48000 Koprivnica, 48260 Križevci and 48350 Đurđevac. Since financial indicators for these offices

are positive, new district design should be carried out in other postal offices. In the last three postal offices ((48314 Koprivnički Ivanec, 48322 Ždala and 48355 Novo Virje) one employee works part-time at the counter, and part-time delivering mail, and therefore these offices do not need to be redesigned. The offices with three carriers (48267 Orehovac and 48326 Virje) have a relatively small number of delivered letters per carrier and there is justification in the assumption that here also nothing needs to be done. Since the daily covered distance by the carrier in Virje is much smaller than of those from Orehovac, the delivery reorganization should start from Virje. The delivery area of the postal office 48326 Virje includes the following settlements:

- Donje Zdjelice with 100 inhabitants,
- Miholjanec with 400 inhabitants, and
- Virje with 3703 inhabitants.

The first and simplest proposal is to reduce the number of letter carriers by one. The second option is for the employee to work part-time at the counter and part-time as letter carrier. Next possibility is for one carrier to be shared by two offices, that is – Virje and the neighbouring Đurđevac, Novigrad Podravski or Molve. Since each of these variants has both advantages and drawbacks, a method should be found that will help in bringing the correct decision. Table 3 presents the data on the delivered postal items in the postal office Virje according to types and streets.

Ordinal number, street, town, hpe, R individual, R collective, AR individual, AR collective, VP, redemption, regular - collective, regular individual, printed material addressed indiv., printed mat. addressed collect., printed mat. non-addressed, postal orders, pension money order, FINA money order

3. AHP MODEL

Analytic hierarchical process is a very applicable method of solving complex problems where there are several alternatives and the decision-making criteria

Table 4 - Saaty scale of importance

Intensity of importance	Definition	Explanation
1	Equal importance	Both elements bring equal contribution towards achieving the objective
3	Moderate preference	Moderate preference of one element compared to another based on experience and evaluation
5	Strict preference	Strict preference of one element compared to another based on experience and evaluation
7	Very strict preference	Domination of one element compared to another, proven in practice
9	Extreme preference	Greatest possible preference of one element compared to another
2, 4, 6, 8	Intermediary values	Values of compromise between adjacent values

[2]. The multi-criteria decision-making is based on the optimisation of function of objective on a set of possible solutions. The process allows the decision-makers to set the priorities and to make decisions for the case when it is necessary to take into consideration both quantitative and qualitative characteristics. The complex decision-making process is reduced to a sequence of individual comparisons between the set objectives and the criteria allowing full insight into the decision-making process in order to select the best scenario. The Saaty scale of importance given in Table 4 is used for intercomparison.

In the decision-making process it is necessary to know the value of consistence. There are two extremes that have to be taken into consideration; the first for which it is true that the decisions that have low consistency seem as if they were randomly chosen, and the other that it is difficult to achieve perfect consistency in practise. As long as the consistency is such that it insures coherence among elements there is no need to achieve perfect consistency. New ideas that often appear in practise result in different assumption values, which may sometimes lead to reduced consistency compared to the previous solutions. Therefore, all the acquired knowledge that needs to be involved in the decision-making process has to be within the range of values between the least acceptable value and the perfect value of consistency. The acceptable values of the consistency ratio depend on the value of intercomparison matrix. For the matrix 3x3 the consistency ratio should not be greater than 5%, for matrix 4x4 - 9%, and for bigger matrices it should not be greater than 10%.

4. MODELLING THE DELIVERY AREA BY MEANS OF AHP - MODEL

The modelling procedure of delivery areas begins with the proposal of variants. The analysis of data in Tables 3 and 4 defines four alternatives:

- alternative 1 – number of letter carriers in (Postal Office) PU 48326 is reduced by one, and the number of clerks working at the counter remains two,
- alternative 2 – number of letter carriers in PU 48326 is reduced by one, and one clerk at the counter works part-time as a carrier,
- alternative 3 – number of carriers in PU 48326 is reduced by one, and one letter carrier from PU 48325 works part-time in PU 48326,
- alternative 4 – number of carries remains one, and one carrier from PU 48326 works part-time in 48350.

Each alternative has different costs of income, etc. as well as the purchase needs of new operation means. Each alternative has also a difference in effect so that the optimal choice is the one where the benefit-cost

ratio is most favourable. Table 5 presents costs per alternatives:

- cost 1 is cost of employees in PU 48326 expressed through number of points,
- cost 2 is cost of employees in PU 48325 expressed through number of points,
- cost 3 is cost of employees in PU 48350 expressed through number of points,
- cost 4 is total cost of purchase of vehicles and equipment expressed piece-wise.

Table 5 - Costs

	cost 1	cost 2	cost 3	cost 4
alternative 1	2400	1680	5220	2
alternative 2	2355	1680	5220	2
alternative 3	2640	1410	5220	1
alternative 4	2640	1680	5460	1
Σ	10035	6450	21120	6

In order to make the comparison it is necessary to normalize the costs, which is presented in Table 6.

Table 6 – Normalized costs

	cost 1	cost 2	cost 3	cost 4
alternative 1	0.239	0.260	0.247	0.333
alternative 2	0.235	0.260	0.247	0.333
alternative 3	0.263	0.219	0.247	0.167
alternative 4	0.263	0.260	0.259	0.167
Σ	1.000	1.000	1.000	1.000

Since there are four points of costs the intercomparison matrix 4x4 presented in Table 7 needs to be taken. Experience shows that the costs of employees of "small" postal offices are of approximately equal weight and in this case more significant than the same cost in a "big" postal office. At the same time these costs are much higher than the costs of new equipment.

Table 7 – Matrix of inter-comparisons

Criteria	A1	A2	A3	A4
A1	1	1	2	5
A2	1	1	2	5
A3	0.5	0.5	1	5
A4	0.2	0.2	0.2	1
Σ	2.7	2.7	5.2	16

The intercomparison matrix needs to be normalized, row sums determined and priority values calculated, which is presented in Table 8.

Table 8 – Calculation of priority values

Criteria	A1	A2	A3	A4	Σ	priority value
A1	0.370	0.370	0.385	0.313	1.438	0.359
A2	0.370	0.370	0.385	0.313	1.438	0.359
A3	0.185	0.185	0.192	0.313	0.875	0.219
A4	0.074	0.074	0.038	0.063	0.249	0.062
Σ	1.000	1.000	1.000	1.000	4.000	1.000

By multiplying each intercomparison matrix column with the priority values, the values presented in Table 9 are obtained.

Table 9 – Calculation of row sum

Criteria	A1	A2	A3	A4	Σ
A1	0.359	0.359	0.438	0.311	1.468
A2	0.359	0.359	0.438	0.311	1.468
A3	0.180	0.180	0.219	0.311	0.890
A4	0.072	0.072	0.044	0.062	0.250
Σ	0.971	0.971	1.138	0.996	4.075

Dividing the sum of rows with the priority values yields the characteristic value λ_1 .

$\lambda_1 = (4,084 + 4,084 + 4,066 + 4,011) / 4 = 4,061$ and consistency index CI and the consistency ratio CR:

$$CI = \frac{\lambda_1 - n}{n - 1} = \frac{4.061 - 4}{4 - 1} = 0.020$$

$$CR = \frac{CI}{RC} = 0.022 = 2.2\%$$

which is within the allowed limits, where RC is the average value of consistency.

Table 10 – RC - values

Size of matrix	1	2	3	4	5	6	7	8	9	10
RC	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Final values are obtained by product of the priority values and the column of normalized alternative matrix, presented in Table 11.

Table 11 – Weights of individual alternatives

Criteria	A1	A2	A3	A4	Σ
alternative 1	0.086	0.094	0.054	0.021	0.254
alternative 2	0.084	0.094	0.054	0.021	0.253
alternative 3	0.095	0.079	0.054	0.010	0.238
alternative 4	0.095	0.094	0.057	0.010	0.255
Σ	0.359	0.359	0.219	0.062	1.000

It is obvious from Table 11 that regarding costs the most favourable is the alternative 3 with the result $w_3 = 0,238$.

Once the costs are determined, the calculation of benefits follows, where:

- benefit 1 is the assumed income in PU 48326,
- benefit 2 is assumed income in PU 48325,
- benefit 3 is the assumed income in PU 48350,
- benefit 4 is the assessment of customer’s satisfaction,
- benefit 5 is the evaluation of employee’s satisfaction.

Table 12 - Benefits

	benefit 1	benefit 2	benefit 3	benefit 4	benefit 5
alternative 1	100	105	100	4	3
alternative 2	80	105	100	3	4
alternative 3	100	100	100	4	3
alternative 4	100	105	105	4	5
Σ	380	415	405	15	15

Table 13 – Normalized values of benefit

	benefit 1	benefit 2	benefit 3	benefit 4	benefit 5
alternative 1	0.263	0.253	0.247	0.267	0.200
alternative 2	0.211	0.253	0.247	0.200	0.267
alternative 3	0.263	0.241	0.247	0.267	0.200
alternative 4	0.263	0.253	0.259	0.267	0.333
Σ	1.000	1.000	1.000	1.000	1.000

Since there are five “types” of benefits, it is necessary to take the intercomparison matrix 5x5 presented in Table 14. The direct financial benefits have the same weight in all the post offices, and may be inter-compared by the overall volume, whereas benefits resulting from the customers’ satisfaction and the satisfaction of the employees have lower weight since they come to the fore after a certain period of time.

Table 14 – Matrix of benefit intercomparisons

Criteria	A1	A2	A3	A4	A5
A1	1	0.5	0.2	3	5
A2	2	1	0.5	3	5
A3	5	2	1	3	5
A4	0.333	0.333	0.333	1	3
A5	0.200	0.200	0.200	0.333	1
Σ	8.533	4.033	2.233	10.333	19

The application of the calculation as in case of costs yields the results presented in Tables 15 and 16.

Table 15 – Calculation of benefit priority values

Criteria	A1	A2	A3	A4	A5	Σ	priority value
A1	0.117	0.124	0.090	0.290	0.263	0.884	0.177
A2	0.234	0.248	0.224	0.290	0.263	1.260	0.252
A3	0.586	0.496	0.448	0.290	0.263	2.083	0.417
A4	0.039	0.083	0.149	0.097	0.158	0.526	0.105
A5	0.023	0.050	0.090	0.032	0.053	0.247	0.049
Σ	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table 16 – Calculation of benefit rows sum

Criteria	A1	A2	A3	A4	A5	Σ
A1	0.177	0.126	0.083	0.315	0.247	0.949
A2	0.354	0.252	0.208	0.315	0.247	1.377
A3	0.884	0.504	0.417	0.315	0.247	2.368
A4	0.059	0.084	0.139	0.105	0.148	0.535
A5	0.035	0.050	0.083	0.035	0.049	0.254
Σ	1.509	1.016	0.930	1.086	0.940	5.482

$$\lambda_1 = (5,366 + 5,465 + 5,683 + 5,093 + 5,124) / 5 = 5,346$$

$$CI = \frac{\lambda_1 - n}{n - 1} = \frac{5,346 - 5}{5 - 1} = 0.087$$

$$CR = \frac{CI}{RC} = 0.078 = 7.8\%$$

Final values are obtained by multiplying the priority values and the columns of normalized variants matrix, presented in Table 17.

Table 17 – Weights of individual benefit variants

Criteria	A1	A2	A3	A4	A5	Σ
alternative 1	0.047	0.064	0.103	0.028	0.010	0.251
alternative 2	0.037	0.064	0.103	0.021	0.013	0.238
alternative 3	0.047	0.061	0.103	0.028	0.010	0.248
alternative 4	0.047	0.064	0.108	0.028	0.016	0.263
Σ	0.177	0.252	0.417	0.105	0.049	1.000

The greatest benefit is obtained by applying alternative 4 with the result $w_4 = 0.263$. In order to determine the optimal alternative it is necessary to divide the costs and the benefits.

0.251	0.254	0.987	
0.238	0.253	0.942	
0.248	0.238	1.044	
0.263	0.255	1.030	

By comparing the alternatives, the one with the highest benefit / cost ratio is selected.

$$\text{Max} \left(\frac{\text{benefits}}{\text{costs}} \right) = 1.044$$

which in this case is alternative 3.

5. CONCLUSION

The process of making decisions among different alternative variants can be divided into several steps. After having determined the final, not too large set of comparative alternatives, the necessary data about possible benefits and possible costs have to be gathered for each of them. Here, not only financial aspect needs to be taken into consideration, but also some non-measurable values such as user – customer satisfaction.

The value of applying the AHP method to the organization of delivery at the public postal operator consists of the objective evaluation which allows comparison of the difficult-to-compare values. Further research may include special criteria and specific requirements of individual delivery areas into the analysis.

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SAŽETAK

DIZAJN DOSTAVNIH PODRUČJA JAVNOG POŠTANSKOG OPERATORA PRIMJENOM AHP MODELA

Oblikovanje dostavnih rajona kontinuirana je zadaća poštanske tehnologije obzirom da se migracijom stanovništva, izgradnjom zgrada i prometnica i dr. mijenja količina i struktura pošiljaka što bitno utječe na učinak dostave. U rješavanju problema dizajniranja dostavnih područja javnog poštanskog operatora ključne veličine su količina pošiljaka, dužina dostavnog puta i opterećenje (učinak) dostavljača. Dostavni rajoni trebaju biti odgovarajuće razgraničeni i približno ujednačeni kako bi se postigla racionalizacija i izjednačilo opterećenje dostavljača. Za prikupljene podatke na području poštanskog središta postavljen je predložak primjene AHP metode gdje se višekriterijskom analizom alternativnih rješenja izabire najpovoljnije rješenje organizacije dostavnih područja.

KLJUČNE RIJEČI

javni poštanski operator, dostava pošiljaka, učinkovitost, AHP metoda

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