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A TWO-LEVEL APPROACH FOR HUMAN RESOURCE PLANNING TOWARDS ORGANIZATIONAL EFFICIENCY OF A POSTAL DISTRIBUTION SYSTEM

Abstract: *Optimal human resources management, optimization of the required number of workers in specific technological operation phases, represents one of the most important management tasks in postal systems worldwide. Actuality of the problem has been especially distinct during recent years, when postal administrations have been going through the process of restructuring, facing the ever growing competition and making a huge step away from the status of a public service towards that of a corporation. Modern approach in this kind of problem solving includes sophisticated managerial techniques, supported by a powerful operational research tools. This paper introduces a two-level model for optimal human resources management in delivery post offices, which operates in conditions of unpredictable service requests. The presented model, combining regression analysis and DEA method, was tested in an example of optimization of the number of employees in postal network delivery units on the territory of the city of Belgrade.*

Keywords: *Human resource allocation, Post distributive system, Organizational efficiency, Data envelopment analysis*

JEL Classification: C2, C8, L3

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1. Introduction

Postal distribution system represents (in most of the cases) the largest logistic infrastructure at a national level. In addition to classic postal services, these logistic flows also include a set of other services, such as: payment services, transport of goods, trade, and state administration support (support during issuance of documents). Postal logistic infrastructure finally represents a "public good", and subsequently and increasingly needs to be managed in an optimal way. One of the most important aspects of managing such a complex system is an optimal and feasible human resources planning strategy.

In this sense, this paper shall try to make certain contribution, within the technological segment of postal item delivery (last mile problems). The reason for choosing this technological phase of postal item transmission is the fact that relevant statistical data easily point out that delivery generates 60-70% of all fixed costs in the process of postal item transmission and that all possible improvements in this segment result in the biggest benefits for the entire system.

On the other hand, the challenge is also the very process of service volume forecast within the delivery segment, since the number of point of calls is manyfold higher than that of collection points used by users and is actually more or less identical with the number of recorded households on the territory of the Republic of Serbia.

The structure of this paper is the following. After the introduction and problem description, an overview of literature dealing with human resources management is given, followed by brief description of regression analysis and DEA method (Data Envelopment Analysis), to be further examined in the following section. In the next section, the two-level model for human resources management in postal distributive systems using regression analysis and DEA method is presented. In the final discussion, results of the applied model are systemized, specific activities for dealing with managerial problems are offered and some guidelines for the system solutions thereof are given.

2. Problem description

Postal industry represents an economic activity with certain specific features issuing from its role in the modern society. Specifically, modern approach to this problem balances between the public and commercial role of national postal operators. On one hand, Posts, as complex and universal systems, are required to be at service to the state with its logistics, and on the other hand, there is a need for business commercialization, support to the development of other economy branches, and especially to business activities of small and medium enterprises. Specific features of the postal industry can be described in the following manner:

- **Space–oriented system** – Covering the entire national territory. Offering services of postal item collection at *n* points, while performing delivery of

these items at k points, where $k>>n$, and represents virtually all addressed points in the country. Territory of the Republic of Serbia covers 88.361 km², whereas delivery of postal items is performed to 2.485.343 addresses[2].

- **High labour costs share** – Despite continuous technology development, still large number of production operations within the posts cannot be automated in an adequate manner. Optimization of these costs represents one of the biggest management challenges in the postal sector.
- **Specific management in view of the double Post's role in the society** – Part of the postal system is oriented towards satisfaction of the widest spectrum of customers' needs (universal service segment), whereas the other part is commercially oriented (post express, courier and logistics services). This specific feature conditions relatively different management strategies.

In modern business operations conditions, an adequate system of decision making can have an extremely large impact on postal system business efficiency. In order to establish an efficient and effective decision making system in the big business environment such as postal distributive systems, composed of relatively large number of business units, especially in the domain of human resources management, it is necessary to identify problems, find suitable and satisfactory solutions and finally, choose an optimal solution for the system as a whole.

Taking into account the above mentioned, it becomes fairly clear that the purpose of this paper's authors is to explore and research the efficiency of production related labour management in the segment of delivery. In this sense, a two-level model of human resources management was developed, to be subsequently tested in an example of postal item delivery on the territory of the city of Belgrade.

During the first phase of the model, based on the past data (27 months in the period 2007 - 2009), using the regression analysis, forecast on volume of postal items for 2010 is made, followed by optimization of employee management in the sense of efficiency regarding the forecasted number of services at the delivery, by means of DEA method, in the second part of the model.

3. Brief review of the relevant literature

Both strategic and dynamic human resources management are the subjects of the researches of many papers during the last few decades. The main reason for this prolonged interest in human resource management is its relevance and influence achieving the company's long-term objectives and goals. Human resource

[2] Post of Serbia – Business Report for 2008, internal document, Belgrade 2009

allocation, HRA, is one part of the human resource management, but not less important. HRA means defining the certain number of employees with properly skills requested for the tasks.
Labroukos, Lioukas and Chambers (1995) emphasized the close relation between planning and performance in the context of the State-Owned Enterprises. They used regression equations among output effectiveness and planning variables to determine planning-performance relationships. By review of some relevant international papers (Becker and Gerhart, 1996; Rogers and Wright, 1998), authors concluded that human resource decisions influence organizational performance. Human resources do not have a contribution only in improvement the efficiency and growing the revenue, but also in the implementation of the operating and strategic objectives of firms. Truss (2001) in his paper observed the link between HRM and organizational outcomes. He analyzed in detail one firm's human resource policies and practices in order to describe the relation between these two entities. Stavrou-Costea (2005) investigated the effect of HRM on organizational performance in Southern Europe. The electronic industries in Taiwan are the research object of the paper of Tseng, Lee, and Ishii (2005). The authors integrated AHP and DEA with the aim to define the optimal human resource practices allocation, including the ranking of variables with multiple inputs, human resource practice, and multiple outputs, organization performance. Trappey and Chiang (2008) developed a DEA benchmarking methodology for optimizing new product development (NPD) activities based on profit center business model. With a view to successfully manage a set of NPD activities on time and in accordance with the budget, decision makers should have accurate perception of the relations of resources allocation, profits, costs and times for each NPD activity.

4. Methodology

Twenty post offices in Belgrade are considered in this paper. For each of them the data (table 1) are collected for the period from February 2007 to April 2009, and they are used as an input of the system.

Table 1. Inputs of the system

X1	No. of delivery post offices
X2	No. of mailmen
X3	No. of workers in preparation
X4	No. of delivery workers
X5	Work time of mailmen
X6	Work time of workers in preparation
X7	Work time of delivery workers
X8	Covered area
X9	No. of households
X10	GDP
X11	Internet users

The next table presents the four outputs of the system.

Table 2. Outputs of the system

Y1	Letter mails (LM)
Y2	Registered letters (RL)
Y3	Insured letters (IL)
Y4	Parcels and Post Express (PPE)

Implementation of the proposed model for human resources management (planning) is to be realized through the following phases (figure 1):

- Definition and selection of postal distributive system units where human resources planning is required.
- Selection of input and output values that is relevant and suitable to be used in the regression analysis.
- Application of the regression analysis for the selected values forecast.
- Selection of input and output values that is relevant and suitable for the evaluation of relative efficiency of the selected postal distributive system units.
- Selection of adequate DEA models.
- DEA model solving.
- Analysis and interpretation of results.

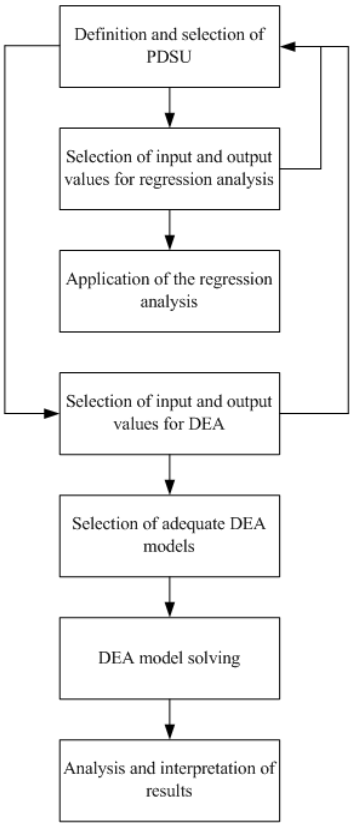

Fig. 1 Steps of the developed model

First of all, all needed data for considered 20 post offices in Belgrade are collected. The data are from the period of 27 months from 2007 to 2010. The target year is 2010. The regression analysis is used for the output variables forecasting. All 11 inputs and four outputs are the part of the regression analysis. Actually, we developed for each output the independent system for regression analysis, separately. Based on the regression equations, it is possible to estimate the new output values. Before this step, we have to estimate values for all considered inputs. The first named input is constant during the whole considered period. For the next six inputs, the increasing of 3% is assumed, based on the existing post managers' plans. The covered area of each post office is the same value as the previously year, which is the same assumption for the next input, the number of family. In accordance with the national economy plans, the growth of GDP is 1.5% [12] and the use of Internet is increased by 15% (according to the national sources). After this estimation for the 2010 year, using the regression equations, the new output value for each considered post office is calculated. DEA considers total number of employees and their work time as inputs, considered outputs are: letter mails, registered letters, mails and packages and post express.

Based on this, DEA defined the efficiency of the post office. Much more, using the sensitive analysis it is possible to suggest certain actions for the post office manager.

4.1. Forecasting – regression analysis

There are many known methods for data prediction, such as: rolling forecast, extrapolation, trend estimation, regression analysis, Delphi method, artificial neural networks, simulation, etc.

Regression analysis is a method which purpose is to determine an equation that best predicts the Y variable as a linear function of X variable. When the system has two or more independent and one dependent variable than the multiple regression analysis should be used.

Regression analysis is the old known method but its application is still in expansion. Spathis and Ananiadis (2004) used a multivariate regression analysis for accounting data concerning a 12-year period, with the aim to optimize the resource allocation. Neal, West and Patterson (2005) examined the relationship between human resource management and productivity using the regression analysis. Bogner and Bansal (2007) confirmed a relation between firm's growth rate and its ability to generate rare and valuable knowledge by the ordinary least squares regression analysis.

We chose the multiple regression analysis because of the nature of the considered data, the huge number of items in data set, its simplicity and ability to develop regression model in MS Excel.

4.2. DEA

In each company's business activities, the efficiency is one of the most important goals managers seek to attain, comprising realization of as big as possible economic effects (outputs), with as little as possible economic investment (inputs). For the assessment of relative efficiency of related units with multiple common inputs and outputs, in most of the cases, Data Envelopment Analysis is used. DEA was developed by Charnes et al. (1978) in the aim of measuring the efficiency of organizational units, especially of those that do not generate profit. Organizational unit the efficiency of which is to be evaluated using analysis of several various inputs and outputs was named Decision Making Unit - DMU.

The basic CCR DEA model, developed by Charnes, Cooper and Rhodes, based on the data on used inputs and output for each of n DMU the efficency of which needs to be estimated, is solvable by an optimization equation (1) where weight coefficient values u_r and v_i need to be determined, so that its efficiency is maximum. If x_{ij} represents the observed input value of i class for DMU_j ($x_{ij}>0$, i = l,2,…,m, j = l,2,…,n), and y_{rj} – represents the observed output value of r class for DMUj ($y_{rj}>0$, r = l,2,…,s, j = l,2,…,n)

$$h_k = \max\left(\sum_{r=1}^{s} u_r y_{rk}\right) / \left(\sum_{i=1}^{m} v_i x_{ik}\right) \tag{1}$$

with restrictions:

$$\sum_{r=1}^{s} u_r y_{rj} / \sum_{i=1}^{m} v_i x_{ij} \le 1, \quad j=1,2,\ldots,n$$

$$u_r \ge 0, \quad r = 1,2,\ldots,s$$

$$v_i \ge 0, \quad i = 1,2,\ldots,m$$

CCR DEA model calculates total technical efficiency, including net technical efficiency and various business volume related efficiency. Constant volume increase is presumed, i.e. increase in value of used inputs should result in proportionate increase in realized output levels.

During more than 30 years since the establishment of DEA method, a whole set of different models has been developed (Cook and Seiford, 2009), which all found multiple application in practice. DEA method is very frequently used for school (Thanassoulis (1996), Beasley (1990) and (1995), Kirjavainen and Loikkanent (1998)), production performance (Aldea and Vidican (2007)), bank branch-office (Berger and Humphrey (1997), Lim and Randhawa, (2005)), and health institution performance and efficiency. In the transport domain, DEA method was used in the assessment of bus industry in the United Kingdom (Cowie and Asenova (1999)),

airport in Spain (Martin and Roman (2001)), and the European Transport System (Savoloinen (2007)).

Measurement of postal unit efficiency by means of DEA model was implemented for the first time by Deprins, Simar and Tulkens (1984), when efficiency of 792 post offices in Belgium was assessed, based on the data for one input and six outputs.

4.3. Efficiency assessment of postal distributive system units

In order to implement DEA method for the efficiency assessment of postal distributive system units (PDSU), it is necessary to select the group of the unit whose relative efficiency is to be determined. During this procedure, homogeneity of the group according to Gollany and Roll (1989) should be respected, meaning that all PDSU should perform the same tasks and have the same objectives, operate under the same market conditions and have the same characteristic input-output factors, differing by intensity from unit to unit.

The most important phase in PDSU efficiency analysis is the selection of relevant inputs and outputs, based on which the assessment is to be made. During the selection of input and output data, also consultations with employees in the units which are to be assessed are necessary, in order to identify the most important inputs and outputs. All resources using PDSU should be included as inputs in the analysis, and all realized product and service values should be included as outputs. The initial list of factors for the examination of the selected units' performance should be as long as possible, i.e. it should enable inclusion in the analysis of all factors possibly influencing the observed unit's efficiency. Next step in the process of determination of input and output factors is reduction of factors from the initial list to the one containing only the most important factors. This is done because relatively big number of inputs and outputs compared to that of the assessed units reduces the discriminative power of the method. In other words, this makes possible to identify the relevant input and output subsets for the considered PDSU and to determine the appropriate weight so that it becomes efficient during the evaluation. This can result in relatively high number of efficient units.

For efficiency evaluation of PDSU, variables presented in table 3 were used as an input values.

Table 3. DEA inputs

Z1	Total No. of employees (Z1=X2+X3+X4)
Z2	Total Work time of employees (Z2=X5+X6+X7)

DEA outputs are the same as four system's outputs: Y1, Y2, Y3 and Y4 (table 2).

Regarding hiring of work force, it is common practice to consider and include in the input, beside the number of workers, also the number of working hours of all

employees or employees at certain working positions. Reduction of input number in the DEA model, compared to the number of inputs used in regression analysis, to a total number of workers and total number of working hours is performed for two reasons. First, as mentioned before, a great number of input-output factors reduce discriminative power of the method. Second, in postal distributive systems, it is possible for almost all employees to work at all posts (workplaces). Indicated input-output values (table 4) for PDSU efficiency assessment are chosen because in the practice of the Public Enterprise of PTT Communications „Serbia“ regarding both units and company as a whole, these factors are used.

Table 4. Values of the considered DEA inputs and outputs

DMU	No. of employees	Work time	LM	RL	IL	PPE
PDSU 1	147	14005	507271,17	69181,43	6545,68	18263,30
PDSU 2	51	6390	172687,25	18406,92	1555,51	2141,77
PDSU 3	97	11444	388680,33	31583,59	3658,54	3431,50
PDSU 4	55	6338	183017,08	13973,57	1469,00	3686,62
PDSU 5	38	5086	122572,27	17952,62	1316,42	1717,89
PDSU 6	43	5029	162161,96	22869,40	1234,88	4617,81
PDSU 7	48	5360	183172,85	9875,13	1486,85	450,49
PDSU 8	18	2075	67468,23	1768,97	554,12	159,94
PDSU 9	112	10772	388912,83	59694,01	4520,94	17990,06
PDSU 10	39	4915	133480,03	17290,18	929,58	3515,80
PDSU 11	74	8802	301038,39	29614,25	2367,89	5901,90
PDSU 12	41	4874	141509,59	14322,55	662,04	5544,11
PDSU 13	29	3912	94502,15	16068,63	796,50	2688,48
PDSU 14	32	3867	126243,05	20646,24	512,20	5903,89
PDSU 15	36	4122	145861,77	11973,18	944,93	2326,38
PDSU 16	13	1595	55609,76	3408,91	279,25	1126,93
PDSU 17	22	3347	96549,15	5277,57	303,49	1468,33
PDSU 18	16	1690	41641,66	2375,00	75,19	2211,68
PDSU 19	28	3878	123249,29	3968,02	608,13	40,30
PDSU 20	21	2693	83718,03	10347,96	305,40	3296,07

For PDSU efficiency assessment an input oriented CCR model was chosen. The reason for such a choice was that managers in PDSUs, as well as in the company itself, can influence the decrease in inputs, while on the other hand, they do not have much influence, if any at all, on output values, since we are talking about the delivery of postal items and not the collection of new items. The primary CCR model for each of the 20 considered PDSUs includes six variables and 27 restrictions.

5. Results and Discussion

Application of DEA method revealed relative efficiency of 26 postal distributive system units operating on the territory of the city of Belgrade. For the DEA method solving, the EMS (Efficiency Measurement System) software was used, where solutions to both primary and dual DEA model are available. Results of the

efficiency assessment of the observed units are shown in Table 5, where relative efficiency indexes for each PDSU are given, as well as model (exemplary) units list for non-efficient units.

Table 5. Final results – Indexes of PDSU relative efficiency

DMU	Effectiveness %	Benchmarks
PDSU 1	100	4
PDSU 2	86,56	1 (0,08) 3 (0,01) 11 (0,44)
PDSU 3	100	4
PDSU 4	83,12	1 (0,06) 3 (0,11) 11 (0,12) 16 (1,27)
PDSU 5	90,49	9 (0,26) 11 (0,06) 14 (0,05)
PDSU 6	98,92	9 (0,13) 11 (0,16) 14 (0,49)
PDSU 7	97,03	1 (0,12) 3 (0,05) 16 (1,86)
PDSU 8	93,70	1 (0,02) 3 (0,07) 16 (0,50)
PDSU 9	100	6
PDSU 10	87,00	9 (0,05) 11 (0,22) 14 (0,39)
PDSU 11	100	5
PDSU 12	86,58	9 (0,03) 14 (0,70) 16 (0,72)
PDSU 13	94,67	9 (0,13) 14 (0,40)
PDSU 14	100	7
PDSU 15	100	0
PDSU 16	100	4
PDSU 17	100	1
PDSU 18	81,42	9 (0,07) 14 (0,16)
PDSU 19	100	0
PDSU 20	98,66	14 (0,51) 17 (0,20)

The obtained results in this example show that nine out of 20 considered PDSUs are relatively efficient and can be regarded as model (exemplary) units. Model units represent a good example of work practice for inefficient units, having positive values for dual weights in optimal solution of dual DEA model for the observed inefficient unit. Model units are efficient with optimal weights selected as inputs and outputs in the primary DEA model by the considered inefficient units. This means that, with the same input-output orientation as in inefficient units, the efficient units achieve greater efficiency, thus presenting a good operational practice to the inefficient units, guiding them in how to become efficient. In this way, inefficient unit management can improve its business activities.

For the majority of inefficient units, a good example of how to eliminate inefficiency is PDSU 14, which appears seven times as a model (exemplary) unit, as well as PDSU 9, appearing six times as an exemplary unit. On the other hand, certain PDSUs (i.e. 15 and 19), in spite of being assessed as relatively efficient, do not figure in the model unit list, which leads to the conclusion that their input-output structure does not correspond as a model to any of the inefficient units. Certain authors suggest that the frequency of relatively efficient unit incidence in

model groups can be used as a criterion for relatively efficient units rating. This paper's authors, however, think that this criterion is insufficiently good, since the incidence frequency in model groups merely shows the volume of inefficient units with the similar importance (structure) of certain inputs and outputs as those of a relevant efficient unit.

As an example of inefficient PDSUs, we shall analyze PDSU 10, assessed by efficiency of 87.00%. Its referent groups are PDSU 9, PDSU 11 and PDSU 14, whereas the dominant model group is PDSU 14 (dual weight is 0.39). Dominant model group PDSU 14 with smaller inputs compared to those of the inefficient PDSU 10 has a higher forecasted realization of two out of four outputs, whereas realization of one output is approximately the same for the both PDSUs. For that reason, PDSU 14 should be regarded as PDSU 10's comparison model, in the sense of channeling and management, so it could become more efficient and successful in its operation, with the very same volume of services.

In addition to the fact that for every PDSU one needs to establish whether it is relatively efficient or not, it is also possible to obtain, via DEA method, a whole set of other information important for operations management of further acitvities, related both to efficient and inefficient PDSUs. One of the important details is defining the conditions under which inefficient PDSUs would become efficient. In Table 6, input and output target values that would turn the inefficient PDSUs into the efficient ones are shown.

Table 6. Final results – Input and output target values for inefficient PDSUs

DMU	Effectiveness %	No. of employees	Work time	LM	RL	IL	PPE
PDSU 1	100						
PDSU 2	86,56	0	544,34	0	0	0	1847,96
PDSU 3	100						
PDSU 4	83,12	0	0	0	1876,82	0	0
PDSU 5	90,49	0	1163,86	0	0	0	3509,43
PDSU 6	98,92	0	226,92	0	0	0	1635,95
PDSU 7	97,03	0	0	0	6363,63	0	4032,47
PDSU 8	93,70	0	0	0	3798,84	0	1065,29
PDSU 9	100						
PDSU 10	87,00	0	331,94	0	0	0	899,28
PDSU 11	100						
PDSU 12	86,58	0	0	0	4578,57	43,83	0
PDSU 13	94,67	0	747,35	6879,82	0	0	2026,86
PDSU 14	100						
PDSU 15	100						
PDSU 16	100						
PDSU 17	100						
PDSU 18	81,42	0	0	5954,48	5128,41	329,14	0
PDSU 19	100						
PDSU 20	98,66	0	13,32	0	1207,59	16,33	0

In order to become efficient, the observed PDSU 10 should decrease the input value related to the total work time. In addition to that, the value above 0 is allocated only to one out of four inputs, so the increase of the correspondent ouput is necessary.
The obtained results in this example show that for all the inefficient units to become efficient, the proposed action is to decrease the total work time, while preserving the existing number of employees. In other words, taking into account the total work time of all employees in PDSU, the conclusion is that inefficient units could turn into efficient ones by means of a better defining of work time length at certain posts (workplaces).
The given model, with slight modifications, can be used in other technological phases too, as well as in administration, in the aim of realizing an optimal human resources management within the whole system.

6. Conclusions

Two-level model described in this paper is one of the first attempts to solve priority managerial tasks (such as optimal human resources management in postal distributive system) using combined sophisticated operational research methods.
Regression analysis, which is usually also called the „average method“, evaluates average values of dependent variables based on independent variables, thus leading to obtaining of the basis for the efficiency calculation. As a result of the linear model of multiple regression, a regression hyperplane occurs, where parameters are estimated and optimization for mystic average unit is made. In the process, specific functional form interconnecting dependent and independent variables is defined. As a supplement to the regression analysis, which performs optimization through all considered units, application of DEA analysis for each single unit the problem of linear programming is solved, i.e. it is being focused on individual characteristics. In other words, regression analysis is used to define general features, average behavior of all PDSUs, whereas using DEA analysis, the best units representing examples of the best practice for all the rest are selected, for the purpose of the latter to improve their business operations.
In the aim of application of the model to other system segments, additional adjustments conditioned by heterogeneous HR structure both profession and education-level related need to be done. These adjustments, however, do not influence the fundamental idea and character of the research.
The two-level model implementation in other postal system segments produces an integral human resources management system, which is of great operational importance to various-level managers.

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