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Measuring the performance of local e-government in the Republic of Croatia using data envelopment analysis

Abstract

Information and communication technology impacts all spheres of life and thus brings innovations in the public sector management. This paper examines the effeciency of e-business in the local administration and provides a way of grading the effectiveness through the usage of nonparametric approach. Data envelopment analysis is a non-parametric method that allows the use of multiple inputs and outputs and provides the possibility of using qualitative and quantitative data simultaneously. It also allows the use of data regardless of their measurement units so according to its characteristics it greatly fits for analysis of city e-governments. With the help of the data envelopment analysis, 41 city administrations were analyzed across 8 selected inputs and 3 outputs. Each city government's e-business was considered with 5 primary aspects, in the respected order: information and communication technologies (ICT), human potentials, information security, information and documentation base and availability of e-services. The obtained results make it possible for managers to compare inefficiently rated city administration units with those of their reference group and improve their effeciency throught the usage of efficiency limit projections. The analysis has shown that city government's e-business has just begun to develop and, depending on the individual city government, is currently situated in the first two phases of development (administration centric and customer aware). From the Croatian e-government development strategy, it's clearly evident that there is hurrying with the harmonization of the legislative for the development of e-government only in those areas which are crucial for the joining with the EU, while the development of e-services is only being mentioned as a mean for satisfying the form.

Keywords: relative efficiency, data envelopment analysis (DEA), local government, e-government.
JEL Classification: C14, C44, C61, C67, I28.

Introduction

E-business, being one of the economic and social development generators, represents an important factor for the functionality of the modern society and is integral part of the globalization process. In such an environment, information represents a key resource for successful business, and its rapid exchange between all actors in the business process is of crucial importance. Digitalization process is being included into all layers of life, from business all the way to the private life, changing the ways of interaction between people, their life environment and habits, and imposing a question on how do these changes reflect on surrounding institutions and their business. Modern e-government puts citizens in the center of their business processes, offering them a maximum accessibility of their services, 24 hours a day, 365 days a year, while taking care of high reliability and data security at the same time. On the other hand, high technology brings a long list of dangers and misusage capabilities, which represent a huge threat to e-business (Alabau, 2004; Heichlinger, 2004).

Given the complexity of the process of building e-government, management of the city becomes aware that learning through the experiences of others they can learn much more than facing the challenge of digitization themselves and as a result, project benchlearning e-government has been launched (Local e-government Bench-learning Survey, 2009).

Benchlearning is an educational method of acquiring a better understanding and knowledge of our own operations which are observed in comparison with other subjects in order to achieve better performance. There have been many authors in the recent years who have written on the subject of benchlearning in e-government (Cattaneo, 2007; Wauters; Lorincz, 2008; Xue-Lian, 2008; Seoul et al., 2008; Jin, 2011). Some cities, through benchlearning, have created an idea of the need for mutual comparisons in order to improve their own e-government. Data envelopment analysis (DEA) as a non-parametric method that examines the relative efficiency of analyzed units, fits perfectly in the testing of e-business efficiency, because it doesn't determine the type of variables or measurement units that are included in the analysis, and allows at the same time to compare the relative efficiency of homogenous decision-making units and with the help of projections suggests potential business improvement of relatively inefficient units. It also suggests potential business improvement of relatively inefficient units.

Data envelopment analysis (DEA) represents a relatively new methodology with the tendency of rapid expansion that links operations research, economics and mathematics and is used for the efficiency evaluation of congeneric units allowing the comparison of their relative efficiency. In just thirty years since its inception (Charnes, Cooper and Rhodes, 1978), this method has become a central technique in a series of productivity and efficiency analyzes used to compare companies, regions and countries. More than 4,000 scientific paper were written in which the DEA was applied as a tool for efficiency evaluation in various areas of management, several models were developed that differ in the type of return assumed in the range of activities (constant or variable return to scale), focusing on the model inputs or outputs, ranking of efficiently graded units with the help of super efficiency (Andersen and Petersen, 1993), etc.

Recently, DEA is increasingly used for evaluation of IT in public institutions and companies which resulted with several papers evaluating the relative efficiency of e-business in banking sector (Cook, Seiford and Zhu, 2004), efficiency of IT projects (Asosheh, Nalchigar and Jamporazmey, 2010), efficiency of public institutions web portals (Luna et al., 2012), while there is very little research on the effeciency of the local e-government.

The efficiency of e-business is difficult to measure, because it is not easy to identify factors which are to be taken in to analysis, as well as series of factors involved in improving its functioning. Development of the DEA is motivated by the need to precisely assess the efficiency of nonprofit organizations such as public hospitals and public schools (Neralić, Bahovec, 2001; Nunamaker, 2006). It was found, due to the fact that the city government units are nonprofit organizations which operations are affected by a number of indicators that are of a qualitative nature, that the DEA is suitable for solving the problems of assessment of city government's e-business efficiency.

1. Research methodology

DEA is a methodology based on mathematical programming. It evaluates the efficiency of individual decision making unit (DMU) within a set of comparable decision making units, that is, those that convert multiple inputs into multiple outputs equivalent to those of the observed DMU.

Since the efficiency of a specific DMU is compared to other DMUs, it is about a relative efficiency which value is between 0 and 1, where deviations from 1 are attributed to excess of the input or lack of the output. DEA determines the empirical efficiency margin (production possibilities margin) bordering the inputs from bellow and outputs from above. Considering that it is being determined by the set of (best) existing DMUs, efficiency margin represents the achievable goal to which inefficient DMUs should strive. Thus, unlike the typical statistical approaches that are based on average values, DEA is based on extreme observations by comparing each of the DMU only with the best. Input and output weights are determined in a way where each DMU is joined with the set of most beneficial weights. The term "most beneficial" means that the resulting ratio of the outputs and inputs for each DMU is maximized regarding all other DMUs when those weights are associated with corresponding inputs and outputs for each DMU. It is necessary to classify the relative efficiency for each of the *n* observed *DMUj* (*j* = 1, ..., *n*) which uses *m* input and generates *s* output. The basic models in the data envelopment analysis which are commonly used are Charnes-Cooper-Rhodes (CCR) model and Banker-Charnes-Cooper (BCC) model.

1.1. CCR model. CCR model is one of the basic models in the DEA, created in 1978 and named for the initial letters of their founders surnames Charnes, Cooper and Rhodes. CCR model is based on the assumption of constant returns to scale. The marginal efficiency is graphically shown in the figure below.

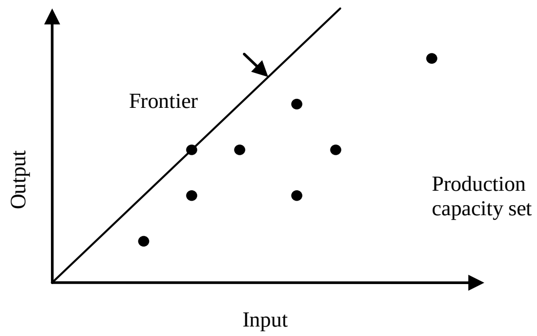

Fig. 1. Efficiency frontier in the CRR model

Source: Cooper, W., Seiford, L., Tone K. (2006). *Introduction to Data Envelopment Analysis and its Uses*, Springer.

The model's basic idea is to form virtual output and input for every DMU by using the outputs weight (u_r) (r = 1, ..., s) and inputs weight (v_i) (i = 1, ..., m). The goal is to determine the weights which maximize their ratio.

The problem is formed in the following way (Cooper, Seiford and Tone, 2006, p. 23):

$$(RP_o)\max_{u,v} \theta = \frac{u_1 y_{1o} + u_2 y_{2o} + ... + u_s y_{so}}{v_1 x_{1o} + v_2 x_{2o} + ... + v_m x_{mo}}$$

with constraints $\frac{u_1 y_{1j} + u_2 y_{2j} + ... + u_s y_{sj}}{v_1 x_{1j} + v_2 x_{2j} + ... + v_m x_{mj}} \leq 1$

$$j = 1,...,n,$$

$$u_1, u_2, ..., u_s \geq 0,$$

$$v_1, v_2, ..., v_m \geq 0.$$

Constraints make it sure that the ratio of "virtual output" against "virtual input" doesn't exceed 1 for each

DMU. The goal is to gain value for weights (v_i) and (u_r) which maximize the ratio of DMU_o, decision making unit that has been assessed. With the help of set constraints, the optimal value that can be obtained for θ^* is at most 1.

Presented fractional programming problem is equivalent to the linear program given below.

$$(LP_o)\ \max_{\mu,\nu} \theta = \mu_1 y_{1o} + \mu_2 y_{2o} + ... + \mu_s y_{so}$$

with constraints $\nu_1 x_{1o} + \nu_2 x_{2o} + ... + \nu_m x_{mo} = 1,$

$$\mu_1 y_{1j} + \mu_2 y_{2j} + ... + \mu_s y_{sj} \le \nu_1 x_{1j} + \nu_2 x_{2j} + ... + \nu_m x_{mj}$$

$$j = 1,...,n,$$

$$\mu_1, \mu_2,..., \mu_s \ge 0,$$

$$\nu_1, \nu_2,..., \nu_m \ge 0.$$

The optimal problem solution (LP_o) is given with (θ^*, v^*, u^*) and can be identified using the CCR-efficiency definition below.

Definition (CCR- efficiency):

1. DMU_o is CCR efficient if $\theta^* = 1$ and if there is at least one optimal solution (v^*, u^*) for which following applies: $v^* > 0$, $u^* > 0$.
2. In contrary, DMU_o CCR is inefficient.

   Subset E_o of set $E_o' = \left\{ j : \sum_{r=1}^{s} u_r^* y_{rj} = \sum_{i=1}^{m} v_i^* x_{ij} \right\}$

   which consists of CCR efficient solutions of DMU is called a reference set or peer group. The set obtained by merging elements from E_o is called the efficiency frontier.

1.2. BCC model. In the previous subsection the basic settings of the CCR model were discussed, which is based on the assumption of constant returns. At the very beginning of using the DEA, a variety of different models including the most representative BCC (Banker-Charnes-Cooper) model were proposed. BCC model has a frontier of productivity that is stretched along the convex hull formed from the existing DMU. Frontiers have piecewise linear and concave features, as shown in Figure 2, which leads to the concept of yields (variable yields) characterized with:

- increasing yields in the first segment of the curve;
- decreasing returns in the second segment;
- constant yields at the point of transition between from the first into the second segment.

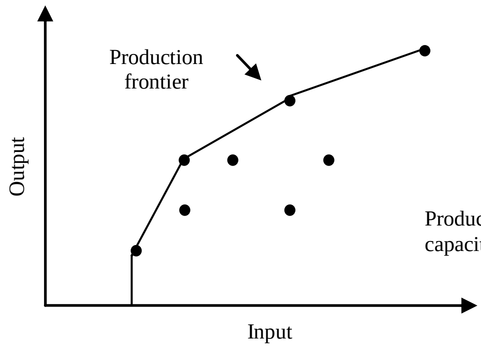

Fig. 2. Efficiency frontier in BCC model

Source: Cooper, W., Seiford, L., Tone K. (2006). *Introduction to Dana Envelopment Analysis and its Uses*, Springer.

CCR and BCC models differ only in that BCC also includes the convexity constraints:

$$\sum_{j=1}^{n} \lambda_j = 1,\ \ \lambda_j \ge 0, \forall j$$

within the constraints, while CCR doesn't. The definition of BCC-efficiency is the following (Cooper, Seiford, Tone, 2006): If the optimal solution $(\theta_B^*, \lambda^*, s^{-*}, s^{+*})$ of the BCC model satisfies $\theta_B^* = 1$ and there are no additional variables $(s^{-*} = 0, s^{+*} = 0)$, then DMU is considered to be BCC efficient, otherwise it is considered to be BCC inefficient.

2. Efficiency analysis of e-business for cities in Croatia

Croatia has 127 cities. In this paper the efficiency of e-business in 41 municipalities were analyzed, taking into consideration the limited amount of data that were collected with the questionnaire. It is important to emphasize that all major cities in Croatia are included in the analysis (Zagreb, Rijeka, Split, Osijek, Zadar, Dubrovnik).

2.1. Selection of inputs and outputs. IT systems are very complex and dispose of a large number of data, so the question is how to turn them into information that could be used in order to increase the efficiency of an entities e-business. The first step in developing model used for the evaluation of e-business is to identify major resources (inputs) that are being used and those operating results (outputs) that reflect the desired goals. Among them it is necessary to identify those that represent the assessed process best and show the truest picture of the total e-business. Selection of models, inputs and outputs of the process which effeciency is being researched should be the only elements of subjectivity entering into the DEA. This very moment of subjectivity is a basic constraint in its application as a tool for decision making that analysts, researchers and decision makers must be aware of. Selection of relevant inputs and outputs is, therefore, one of the most important and most difficult steps in the analysis.

It is, therefore, important to constantly bear in mind that this choice must reflect the interests of analysts and managers, that is justify the analysis's goal of conducting. Additionally, one should also take into account the ratio of number of input and output variables and the number of analyzed units so that the results of the analysis would be as most credible as possible. Although there is no defined policy, the number of units should be at least three times greater than the sum of the chosen inputs and outputs. For the purpose of this research, a total of 11 indicators were selected. For each of the city administration unit, 8 inputs and 3 outputs were included in the analysis, whereby the following applies $j = 1, ..., 41$.

Table 1. Inputs and outputs

Selected inputs	Selected outputs
1. x_{1j} – ICT infrastructure grade (I_1). 2. x_{2j} – Level of investment in human potentials (I_2). 3. x_{3j} – Information security (I_3). 4. x_{4j} – Number of servers (I_4). 5. x_{5j} – Number of employees (I_5). 6. x_{6j} – Access speed (I_6). 7. x_{7j} – Number of computers (I_7). 8. x_{8j} – Application and documentation coverage (I_8).	1. y_{1j} – Classification given the reliability of the systems (O_1). 2. y_{2j} – Degree of maturity of the management system (graded according to the COBIT model) (O_2). 3. y_{3j} – Degree of development of web services (O_3).

During their selection, the professional judgment of a competent person in this area was taken into account. It is also necessary to emphasize that a large number of data was difficult to display in a numerical form, so they were aggregated into one in order to express them numerically. The reasons for selecting these indicators were the following.

The first input relates to the *ICT infrastructure* that represents a very important element in assessing the effectiveness of city government's e-business, since the whole business is conducted with its help and it represents one of the e-commerce foundations. This input are obtained in a manner where computing and communication infrastructures are evaluated considering whether there is procedure of making document copies on a daily basis, whether the city government possesses the virtualization technology, whether the network segmentation exists, etc.

The second input is the *level of investment in human potentials* which is also a very important aspect of e-business, because a bare implementation of high technology in organization, without educating its personnel on how to use it, wouldn't result with the expected effects. This input is obtained by rating where each point was given the fact whether there is an IT Helpdesk service, whether the care of educating the city governments employees is taken (given the use of IT, that is if they attend courses), whether there is a concern on educating the citizens who will use e-government services, etc.

Security, as a third selected input, is also difficult to measure and is very important in business, because neglecting it may result in stopping the whole business. It was also obtained through the fact-rating whether a certain city government possesses e-business security related certificates, whether there are precisely determined user roles and rights in interaction with the information system, whether smart cards are being used (a card that allows its user to access, that is log in, onto specific workstation), whether system for filtering the web content exists, etc.

City administration number of employees and computers are also two significant values in testing the efficiency of e-business, because their number reflects the size of city administration and in addition determines the complexity of the system, which is consequently harder to maintain, at the same time.

These values are also interconnected, because they should indicate whether each employee possesses his own computer or shares it with others in a case where shift work is present.

Number of servers is selected as a value which also reflects the degree of development of e-business, that is information infrastructure for the individual city administration.

Broadband network access speed (bandwidth) is also an important input. It reflects of how quickly one can access the needed content on the Internet which also affects the efficiency of work within the city administration.

Application and documentation coverage is a data which is obtained from a survey in a way where the existence and number of tightly specialized applications are identified (accounting, payment operations), as well as the documentation coverage which refers to the specific budgetary funds, procedures and documents related to e-development while affecting the efficiency of the business as well.

The three selected outputs are of a qualitative nature. One of them is the *management maturity level* which is assessed using the COBIT methodology (IT Governance Institute, COBIT 4.1 Excerpt, 2007) according to which there are five stages of maturity of IT systems. In the respected order, stages are the following; first stage according to which the system is chaotic, the second in which the management's degree of maturity is initial (reactive), the third according to which the system is proactive, the fourth stage according to which the IT system is defined and the fifth according to which it is assessed as a controlled and measured system. Person responsible for filling the questionnaire from each of the respected city administrations assessed the degree of maturity of information system management according to this model. It is necessary to comment that there isn't a single city administration which score the highest degree.

Classification according to the number of failures is the second output that assesses the *reliability* of the system given the number of failures and their complexity considering its structure (number of servers).

The third output is the *degree of development of web services*, assessed through the usage of the 1-5 scale depending on the degree of development (Lane and Lee, 2001).

2.2. E-government's empirical data. Data used in the further analysis, regarding the chosen inputs and outputs, for each city administration is only for year 2011, were obtained from the conducted questionnaire. Table 2 shows the basic statistical characteristics of selected variables for 41 city administration.

Table 2. Statistics of variables involved in the DEA analysis

	Inputs								Outputs		
	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	O_1	O_2	O_3
Max	161	48	10	131	3005	20	2460	16	524	4	4
Min	4	1	1	1	12	0	2	3	3	1	1
Average	22,56	5,29	5,4878	8,658537	150,488	9,46	131,39	8,56	38,98	1,9756	2,61
SD	25,93	8,71	2,5578	21,45058	463,075	4,43	382,13	3,04	89,79	0,8407	0,62

Source: Made by the author.

2.2.1 Selecting the model. At the beginning of the analysis, both the CCR and BCC models were used to analyze the selected data. Number of the assessed efficient units using the CCR model is 18 (see Table 3.), while there are 24 when using the BCC model. Because of the difference in 6 efficiently assessed units in favor of the BCC model, which represents a significant difference (more than 30%), this author recommends to use BCC model. This difference occurred as a result of the effect of scale, which is logical taking into account because changes in inputs caused a linear increase in output when handling the problem of e-business.

Summary results of the efficiency obtained by the DEA according to the CCR and BCC models are shown in Table 3. The table shows that the DMU's average CCR efficiency equals 0.834569, which means that average DMU, if one wants to do business on the efficiency frontier, must decrease it's resource consumption by 19.8%, given the achieved output level.

According to the BCC model, average efficiency equals 0.924523, which means that average DMU, if one wants to do business on the efficiency frontier, must decrease it's resource consumption by 8.22%, given the achieved output level. There is 44% of relatively efficient units according to the CCR, and 58.5% according to the BCC model. It's also evident that the mean efficiency values are very high and equal 83% for CCR, that is 92% for the BCC model, while the lowest relative efficiency level ranges from 0,49787 (according to the CCR model) and 0.502475 (according to the BCC model).

Table 3. Summary results of the CCR and BCC input-oriented model

	CCR	BCC
Number of DMU which entered the analysis	41	41
Number of relatively efficient DMUs	18	24
Relatively efficient DMUs in percent	44%	58.5%
Average relative efficiency	0,834569	0,924523
Maximum value	1	1
Minimum value	0,49787	0,502475
Number of DMUs that have relative efficiency below average	16	12

Source: Made by the author.

In a case where efficiency is separated by the units, their direct comparison becomes possible. Comparing the results obtained by the CCR and BCC models, it can be seen that values for 4 of the DMUs are around an average relative efficiency level, while keeping the significant number below that limit.

Almost every big Croatian city can be found in the efficient group of cities, which confirms the assumption of existence how necessary qualitative digitalization in business is, and that the existing business has started restructuring and adapting itself to e-governments requirements based on the available documents and standards related to e-government. Such an attitude is also reflected in the assessment of the relative efficiency of city administrations that have been highly graded using both the CCR and BCC models.

Ranking according to the BCC model (see Table 4) isn't as expressed as in previous case, because a large number of entities (as many as six more than in the CCR model), becomes efficient when using this model.

Table 4. Ranked units according to the relative efficiency considering the BCC model

Rank	DMU	Result
1	g40, g35, g2, g34, g4, g5, g6, g33, g8, g9, g10, g11, g12, g13, g14, g32, g30, g17, g18, g19, g20, g27, g23, g25	1
26	g31	0,997151
27	g16	0,966788
28	g21	0,960532
29	g1	0,859597
30	g36	0,852627
31	g26	0,847959
32	g28	0,836971
33	g22	0,828066
34	g37	0,823231
35	g24	0,786363
36	g39	0,781961
37	g38	0,759159
38	g15	0,756916
39	g41	0,75678
40	g3	0,588884
41	g7	0,502475

Source: Made by the author.

Apart from the fact that this fundamental analysis enables classification of DMUs as efficient and inefficient, it also allows one to gain an insight in just how many times a specific efficient unit found itself in the reference group. The reference group is represented by efficient units which make a peer group. The intensity of its relative efficiency also proves just how many times a specific unit has found itself in the reference group. Namely, since all efficient units are rated with the maximum value of 1, their occurrence frequency in reference group can tell one just how "strong" that evaluation really is, that is whether they are assessed as relatively efficient only according to the input-output data or whether they possess an additional role as an example of imitation for the inefficient city administration units, which are found in its reference group. The frequency can show just how good the observed efficient unit in its business activity is, thus providing all other inefficient units from the same reference group with the guidelines and a goal which they should aspire to. In Table 5 every efficient city administration unit was given an occurrence frequency in the reference groups for inefficient city administrations.

Table 5 shows that city g27 has the highest frequency. The obtained result isn't surprising, given the fact this is a city administration of a mid-sized Croatian city which is located near a larger city and which, because of the lower input level (number of employees, computers, etc.), achieves a high output level. The regional location holds a key role in the analysis, therefore many small cities, which are located near larger ones, have also proven efficient, as well as touristic cities which have shown high output levels in assessment of their web services and design and quality of their web sites where a variety of qualitative and useful services are offered.

Table 5. Frequency occurrence in the reference group according to the BCC model

DMU	Occurence frequency in reference group	DMU	Occurrence frequency in reference group
g2	3	g19	1
g4	6	g20	13
g5	1	g23	0
g6	2	g25	13
g8	1	g27	15
g10	0	g29	0
g11	0	g30	5
g12	2	g32	5
g13	2	g33	3
g14	0	g34	1
g17	0	g35	1
g18	1	g40	3

Source: Made by the author.

Table 6. Members of the reference group for the relatively inefficient DMUs according to the BCC model

No	DMU	Grade	Rank	Reference group						
1	g7	0,502475	41	g2	g20	g25	g27	g32		
2	g3	0,588884	40	g2	g25	g27	g32	g40		
3	g41	0,75678	39	g25	g27	g32	g33	g34		
4	g15	0,756916	38	g4	g20	g25	g27			
5	g38	0,759159	37	g2	g5	g20	g27			
6	g39	0,781961	36	g4	g6	g20	g25	g27		
7	g24	0,786363	35	g20	g25	g27	g30	g33	g40	
8	g37	0,823231	34	g8	g20	g25	g27	g35		
9	g22	0,828066	33	g20	g25	g27	g30	g33		
10	g28	0,836971	32	g4	g13	g18	g20	g25	g27	g30
11	g26	0,847959	31	g4	g20	g25	g27			
12	g36	0,852627	30	g4	g6	g20	g25	g27		

Table 6 (cont.). Members of the reference group for the relatively inefficient DMUs according to the BCC model

No	DMU	Grade	Rank	Reference group						
13	g1	0,859597	29	g20	g27	g32				
14	g21	0,960532	28	g20	g25	g27	g30	g40		
15	g16	0,966788	27	g12	g20	g25	g27	g30		
16	g31	0,997151	26	g4	g12	g13				
17	g9	1	1	g19	g32					

Source: Made by the author.

Based on the obtained data it can be seen which units could achieve efficiency and which city administrations could serve them as a role model. Namely, if one takes unit g37 as an example, it can be seen that this unit could improve its efficiency according to units g8, g20, g25, g27 and g35. In order to declare a "role model" for the corresponding relatively inefficient city administration unit among the members of the reference group, this "role model" must have a maximum value of λ. Therefore, among the five members of the reference group, the one with the highest value of λ is chosen as a role model for the corresponding relatively inefficient city administration units. Particular attention should be paid to unit g9, which is colored in grey in Table 6, because its relative efficiency value is assessed with maximum value, that could adduce someone into declaring it relatively efficient, never mind the fact it is located in the same reference group as units g19 and g32. This fact could be interpreted in a manner that unit g9 is perceived as a *weak efficient* unit and as such could be placed in the inefficient city administration reference group, since its supplementary variables differ from zero. Namely, unit g9 achieves surpluses toward supplementary variables in six inputs which definitely is classified as an inefficient unit.

DEA can be used to obtain information on potential improvements that a relatively inefficient unit could accomplish. It is about the projections on the efficiency frontier that can be obtained using this method for every relatively inefficient city administration. Table 7 shows projection values of unit g37. The first column in Table 7 shows input names which are taken into analysis, the second column displays real input values for unit g37 that is assessed as relatively inefficient, while the third column displays values which this unit should achieve in order to become relatively efficient. Data in the fourth column represent difference between real and projected values that are shown in previous two columns, while the same difference is shown in percent in the last column.

Taking into consideration DMU g37 and projections calculated with the help of DEA-Solver Pro5.0 software package (see Table 6), it can be seen that this unit would achieve efficiency when it would decrease its number of employees by 13, that is for 21,7% (from 61 to 48 employees), number of computers by 17,68% (from 55 to 45), and number of servers by 39,28%, coverage with specialized applications should decrease by 2-3 programs (17.68%) and investment in human potential should decrease by 38.22%.

Table 7. Possible improvements for the city administration unit g37

Input/output	Information	Projection	Difference	%
g37	0,823231			
ICT Infrastructure grade	13	10,70201	-2,29799	-17,68%
Investments in human potentials	5	3,088929	-1,91107	-38,22%
Information security	6	4,269444	-1,73056	-28,84%
Number of servers	8	4,857899	-3,1421	-39,28%
Number of employees	61	47,75959	-13,2404	-21,71%
Access speed	10	8,232314	-1,76769	-17,68%
Number of computers	55	45,27773	-9,72227	-17,68%
Application coverage	9	7,409082	-1,59092	-17,68%

Source: Made by the author.

Figure 3 shows the two most inefficient DMUs (g7 and g3), that are in a mid-size city category, but given the fact they have unexpectedly low output levels in relation with the input levels, their position as a relatively inefficient unit is entirely justified. Such a poor result can only be justified with poor management staff that shows no interest in advanced technology. In such a case it is appropriate to hire an external company that would take care of implementation and maintenance of ICT systems.

In a case when using the output-oriented BCC model for DEA where obtained results are compared with the results obtained when using the input-oriented BCC model, one can notice that the result of city administrations efficiency remains the same, which is in accordance with the feature saying that efficiency doesn't depend on the type of orientation of the BCC model.

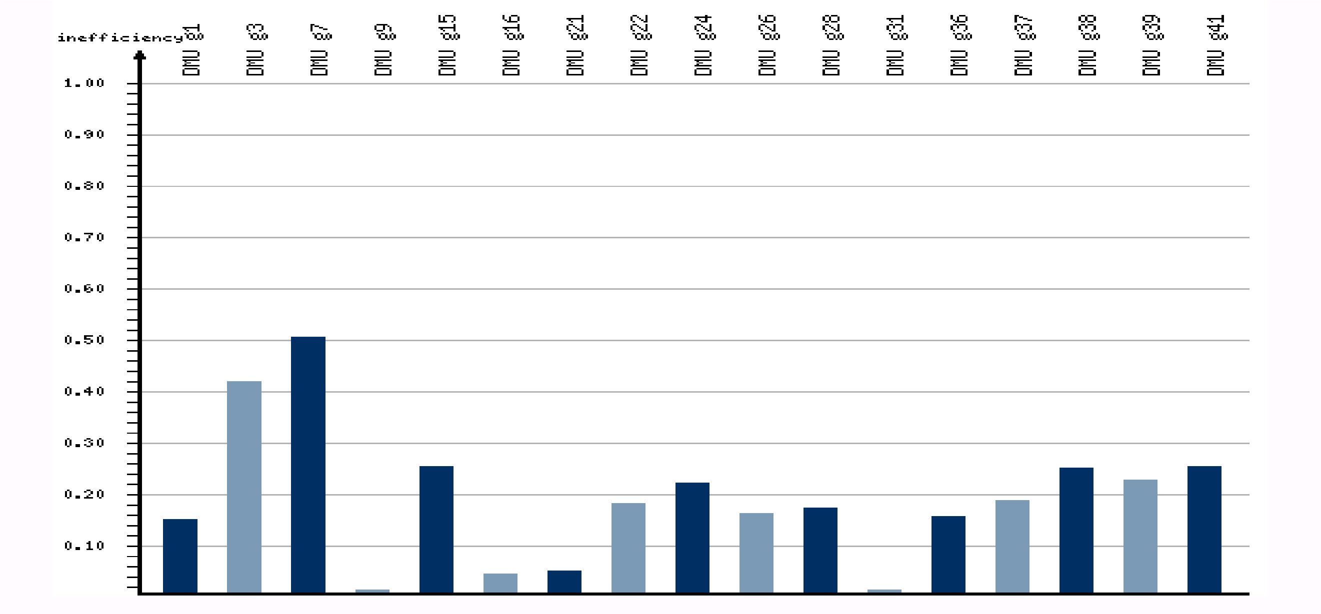

Fig. 3. Graphical representation of relatively inefficient units

Source: Made by the author.

The differences in these two models are perceived in the values of additional variables and optimal weights, which withdraws a change in the value of projections as a result. Which of these two models will be taken into account depends solely on the interest of analyst. If one wants to maintain the same (or higher) output level and to thereby determine a minimum value of the input, one will use the input-oriented model, otherwise it will use the output-oriented model. When having a problem of analyzing the efficiency of business operations of city administrations, it is more meaningful to analyze it using the input-oriented models.

3. Recomandations for the improvement of e-business in city governments

The performed analysis of e-business in city governments indicates the need of creating the e-government development strategy on the local level, and coordinate it with the development of e-business on the state level. Establishment of task forces and associations which would comprise of representatives from both state and local level would ensure exchange of experience in the implementation of certain e-government technological solutions, ease choosing the most qualitative solutions while lowering the costs of implementation at the same time, coordinate with interoperability standards of state administration and EU, and result in the creation of strategy which would unite the needs of every city, never mind their size. Participation in an association which would contain representatives of every city would greatly assist in the development of those cities that don't have permanent staff employed in the ICT sector. Education and information in e-government would at least somewhat equalize digital services offered to the citizens by the local administration. Fundamental role in ensuring the minimum technological requirements in the implementation of e-government at the local level should be ensured by the state which should define rules and laws that prescribe the technological framework and standards for the use and manipulation (input, processing and storage) of data. Looking back at the coverage of city governments with software applications, it's necessary to unite and standardize all the data inside a joint database, primarily to ensure efficiency in their use. This would also ensure the accomplishment of fundamental requirement of interoperability in information exchange with other institutions. From the aspect of information security it's necessary to ensure monitoring of legislation in this field, appoint a person responsible for the enforcement of those, and basically enlighten the management about the risks that city government's business is being exposed to if they don't show a required attention in the mentioned field.

One of the possible solutions is the implementation of e-business through "cloud" services which should be initiated and ensured by the state. Such a solution would ensure the same service quality and development of all cities regardless of their financial and geographical development. It would also ensure that all Croatian citizens, regardless of their place of residence, have the same service quality in interaction with the local and state administration. Although this is financially acceptable solution, a necessary requirement in achieving the "cloud" service lies in enabling broadband Internet access to every Croatian citizen.

EU development strategies put development of digital society in the center, as one of the factors of economic and social development. Also it should be noted that e-government represents a barycenter, as a mean that removes administrative barriers, while ensuring high degree of privacy, reliability and safety in offering their services at the same time, and as such it represents one of the EU priorities and its future state members.

Conclusion

The contribution of this paper is primarily reflected in the definition of practical measures in the form of projections (obtained by the DEA) that the management of the inefficient city administration unit should carry out in order to become efficient, and a series of suggested proposals based on studied literature, which could provide improved e-business for city administration. However, it is necessary to bear in mind that it (DEA) doesn't provide guidelines for achieving an absolute efficiency. Basic DEA models do not provide one with the difference in scores between the efficient units. However they should be in the future analyzed using the model of super efficiency in order to allow ranking of the efficiently assessed units. The mathematical tool used in this paper provides one with relative efficiency of city administration's e-business that is mostly at a similar stage of development, however, all city governments are far from the absolute efficiency that is essential for setting the foundation of a functional e-government that is currently present in the EU cities. This analysis is useful because the efficiency frontier was formed by the Croatian cities with best performance making it possible for other cities to use their experiences in order to achieve maximum efficiency with a minimum of invested resources.

Further researches should focus on other possibilities provided by the DEA, namely the possibility to use categorical variables (Segota, 2008) according to which the city administration could be divided into three categories considering to their size. Furthermore, there is a possibility of using the restrictions for certain input (output) weights that are less important in assessing the efficiency of e-government (e.g., the number of employees).

Placing the constraints on the weights would prevent a greater impact of less important factors in DEA and would thus induce more realistic results. Further more, future research could be directed into an attempt to obtain data on EU cities that conduct best e-government implementation practices in order to drive current efficiently assessed city administration units to absolute efficiency as close as possible. In theoretical terms it is possible to try combining the DEA and analytical hierarchy process in a way to determine local criteria and alternatives weights for the analytical hierarchy process with the help of professionals, and then generate global weights for each criterion, which (weights) would be used as an input or output in DEA in order to set weight constraints, resulting in a new dimension when combining these 2 methods. It should be also emphasized that it's possible to use the window analysis in further researches for a longer period of time, which would allow formatting a trend of the relative efficiency of e-business for each city government.

The approach described in this paper can provide a very strong support for the city government's management during the decision-making process in order to increase the relative efficiency, and also serve as a model for testing the efficiency of e-business in institutions such as banks, for which the efficiency of e-business is of a great importance, because every minor interruption in e-business or negligence in the safety of their system can cause a large scale damage in both financial and operational sense.

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