Methods for determination weights in multi-criteria model of cities certification

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Abstract

The aim of this study is comparing of two approaches - mathematical and statistical for determination weights in the multi-criteria model of certification cities and municipalities in Serbia. Mathematical approach involves the use of DEA methods for determining the weights based on the effectiveness of those criteria in terms of the amount of investment in the given city, while the statistical approach uses F parameters of classical ANOVA to determine the significance of each of the criteria through mutual comparison.

Key words: Certification of Cities, ANOVA, DEA, Criteria Weights, Investments

1. Introduction

All activities in the certification of cities are focused on the implementation of specific objectives arising from the mission, which consists of three basic components: (1) investment promotion, and support the existing economy, (2) legal reform with active participation of corporate sector in terms of proposals for improvement of existing, inadequate legal solutions and (3) strengthening the capacity of municipalities and increase their competitiveness in terms of attracting direct investments.

Using data from the local governments that have been reached in the process of certification, the authors draw attention to the possibility of applying higher level of scientific approach in this procedure. Namely, the criteria that are considered relevant to certification, as well as their importance, have been established based on previous experiences. Without denying the importance and validity of empirical methods, the authors propose forming multi-criteria model for certification cities to review the business environment in the municipalities based on the same, already determined criteria. The difference in approach lies in the application of mathematical and statistical methods in determining the importance of these criteria. Also, the scientific approach involves the introduction of some new reference parameters, such as the amount of investment in the territory of the given city or the municipality.

2. Certification of cities and municipalities in Serbia

Friendly business environment standards are introduced in Serbia in 2007 by National Alliance for Local Economic Development (*NALED*) in cooperation with the U.S. Agency for International Development (*USAID*). Currently, the certification program includes 48 cities and municipalities in Serbia.

2.1. Business friendly certification process

After getting acquainted with the program steps and conditions, the municipality makes a decision about their participation and signed the agreement. Certification process consists of the following steps [1]: (1) presentation of certification program to municipal leadership, (2) signing of the agreement between the municipality and *NALED*, (3) training and establishment of municipal team for certification, (4) preparation of documentation, (5) visit of evaluators and analysis of the municipality, (6) report on the recommendations, (7) fulfilment the required levels of all relevant criteria, (8) visit of verification commission, (9) granting business friendly certificates, (10) continuous promotion of the city or municipality and recertification.

Certification Programme includes 12 criteria and over 80 sub-criteria by which is assessed whether and to what extent a municipality meets the standards of a friendly business environment [1]:

C1: Strategic planning of local economic development in partnership with businesses
C2: Special department in charge of *LED*, *FDI* promotion and business support - *LED* Office
C3: Business council for economic issues – advisory body to the mayor and local governments
C4: Efficient and transparent system for acquiring construction permits
C5: Economic data and information relevant for starting and developing a business
C6: Multilingual marketing materials and website
C7: Balanced structure of budget revenues / debt management
C8: Investing into the development of local workforce
C9: Cooperation and joint projects with local business on fostering *LED*
C10: Adequate infrastructure and reliable communal services
C11: Transparent policies on local taxes and incentives for doing business
C12: Electronic communication and on-line services

2.2. Certification results

A friendly business environment certificate is given to those municipalities that meet the level of at least 75% of the above criteria. According to latest *NALED* reports, in the procedure to issue certificates are 31 municipalities in Serbia, while a total of 17 municipalities have already earned a certificate of a friendly business environment. The official certificate is issued by *NALED* and Ministry of Economy and Regional Development, as a sort of guarantee to investors that the city or municipality offers all the necessary conditions for a successful start and development of business.

Evaluation process is conducted in two stages: assessment of compliance with sub-criteria, in the first resort, and then assessment compliance with the criteria. The second level of evaluation is the average rating of all sub-criteria, which are defined criteria. Also, using the two-level evaluation is defined and the importance of each criterion. At the level of sub-criteria are defined by three levels of importance as follows: elimination - score two relevance, very influential - from a significant and important - relevance score 0.5.

The importance of the criteria w_j is defined as the average score of the previous level of evaluation and as such can be called the relative importance of observed criteria C_j. Data about significance evaluation of all relevant certification criteria in the model, according to the methodology applied by the municipality and *NALED*, are given in Table 1. Since, multi-criteria analysis models include the application of weights such that , where weight ratio that expresses the relative importance of criteria C_j, $j = 1,2, ..., n$, this the results generated by methodology of local governments will be adapted by using the appropriate type of normalization [2]. Transformation of coefficients iz done by relation , where are values of weights according to the requirements of multi-criteria analysis method (Table 1). Exactly this evaluation of criteria importance in the model will be subject of re-evaluation by application of appropriate mathematical and statistical methods.

After evaluating the level of compliance with of these criteria, municipalities are given a detailed report with recommendations, which clearly defines how indicators are rated in terms of friendly business climate.

Certified municipalities have the right to use the *BFC* trade mark and get standard promotional package that includes the info-sheet about the local investment potentials, advertisements, posters and advertising signs, which the municipality stands out from others and makes them distinctive [3].

For research conducted in this paper, the sample includes five municipalities that have received certificates of favorable business environment (Table 2). To protect the interests of cities, will not be presented below an explicit information about cities and the analysis will be done without high-

Table 1. The importance of criteria according to the methodology of local governments

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
Relative Importance (w_j)	1.250	0.900	0.670	1.190	0.660	0.710	1.000	0.750	1.080	1.210	1.500	0.830
Relative Weights (w_j*)	0.106	0.077	0.057	0.101	0.056	0.060	0.085	0.064	0.092	0.103	0.128	0.071

Table 2. The level of criteria fulfillment in municipalities surveyed according to BFC program

Criterion Type	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
	max	*max*	*max*	*max*	*max*	*max*	*max*	*max*	*max*	*max*	*max*	*max*
City 1	80.00%	105.90%	100.00%	73.20%	87.50%	100.00%	100.00%	73.30%	63.60%	82.90%	100.00%	125.00%
City 2	62.50%	94.70%	80.00%	94.10%	85.70%	118.20%	90.00%	75.00%	66.70%	94.00%	92.90%	110.00%
City 3	90.00%	82.40%	87.50%	100.00%	95.00%	100.00%	100.00%	70.00%	68.20%	75.60%	100.00%	75.00%
City 4	100.00%	61.80%	100.00%	78.00%	60.00%	66.70%	100.00%	60.00%	59.10%	97.60%	83.30%	125.00%
City 5	100.00%	105.90%	75.00%	93.90%	90.00%	94.40%	100.00%	86.70%	90.90%	79.30%	100.00%	125.00%
Averige Level in %	**86.50%**	**90.14%**	**88.50%**	**87.84%**	**83.64%**	**95.86%**	**98.00%**	**73.00%**	**69.70%**	**85.88%**	**95.24%**	**112.00%**

lighting their names. The level of satisfaction of all relevant criteria in the observed municipalities is presented in Table 3.

Table 3. The level of satisfaction of relevant criteria in the observed municipalities

City/Municipality	Average level of criteria satisfaction
City 1	90.95%
City 2	88.65
City 3	86.98%
City 4	82.63%
City 5	95.09%

Presented data shows that these municipalities have achieved the required level of satisfying the criteria. However, detailed analysis that would determine the importance of criteria in relation to its level achieved, or further in relation to its effectiveness to achieve a larger amount of investment in the municipality, is possible only by applying appropriate statistical and mathematical tools, which will be presented in the remainder of this paper.

3. Statistical approach to determining the weights of criteria in the model for certification cities

Using analysis of variance or so called factorial experiment, it is possible to test not only the importance and influence of one measure of an isolated factor, but also influence many relevant factors variability and their interaction. Factorial experiment is based on an analysis of variability of means of randomly selected samples [4]. "Analysis of variance represents statistical method for comparing the means of several populations. The method is often referred by its acronym: *ANOVA*. The aim of *ANOVA* is to detect differences among several population means, and the technique requires the analysis of different form of variance associated with the random samples under study – hence the name *analysis of variance*" [5].

In a sample of the five cities was carried out analysis of variance of all levels of satisfying the relevant criteria, including the level of fulfillment of all sub-criteria which are considered as relevant factors of variability in applying *ANOVA*. Results have been obtained using the software package SPSS 14.0.0 (Table 4)

Table 4. ANOVA results for the relevant criteria in the observed cities

C_1	Sum of Squares	df	Mean Square	F	Sig.
Regression	474896344276,004	1	474896344276,004	,117	,755(a)
Residual	12205087499057,190	3	4068362499685,733		
Total	12679983843333,200	4			
C_2	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	8606669532050,520	1	8606669532050,520	6,339	,086(a)
Residual	4073314311282,674	3	1357771437094,225		
Total	12679983843333,200	4			
C_3	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	1144405386225,557	1	1144405386225,557	,298	,623(a)
Residual	11535578457107,640	3	3845192819035,882		
Total	12679983843333,200	4			
C_4	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	279757907085,639	1	279757907085,639	,068	,812(a)
Residual	12400225936247,560	3	4133408645415,855		
Total	12679983843333,200	4			
C_5	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	2245035238732,187	1	2245035238732,187	,645	,481(a)
Residual	10434948604601,010	3	3478316201533,672		
Total	12679983843333,200	4			
C_6	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	292484138666,180	1	292484138666,180	,071	,807(a)
Residual	12387499704667,020	3	4129166568222,341		
Total	12679983843333,200	4			
C_7	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	1228993008243,199	1	1228993008243,199	,322	,610(a)
Residual	11450990835090,000	3	3816996945030,001		
Total	12679983843333,200	4			
C_8	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	8242674825667,930	1	8242674825667,930	5,573	,099(a)
Residual	4437309017665,266	3	1479103005888,422		
Total	12679983843333,200	4			
C_9	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	6623464945031,360	1	6623464945031,360	3,281	,168(a)
Residual	6056518898301,840	3	2018839632767,281		
Total	12679983843333,200	4			
C_{10}	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	3059204166681,125	1	3059204166681,125	,954	,401(a)
Residual	9620779676652,070	3	3206926558884,026		
Total	12679983843333,200	4			
C_{11}	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	5017335719137,350	1	5017335719137,350	1,964	,256(a)
Residual	7662648124195,840	3	2554216041398,615		
Total	12679983843333,200	4			
C_{12}	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	3216261471365,756	1	3216261471365,756	1,020	,387(a)
Residual	9463722371967,440	3	3154574123989,149		
Total	12679983843333,200	4			

Table 5. The importance of the criteria established in accordance with the F parameters of ANOVA

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
F Parameters	0.117	6.339	0.298	0.068	0.645	0.071	0.322	5.573	3.281	0.954	1.964	1.020
Relative Weights (w_j*)	0.006	0.307	0.014	0.003	0.031	0.003	0.016	0.270	0.159	0.046	0.095	0.049

Using the normalization of *F* parameters, it could be calculated relative weights of all criteria according to demands of multi-criteria models [6] as it is already described (Table 4).5

The difference in the results that are observed by comparing Table 1 and Table 4 5 was created as a consequence of the fact that in the first table, in evaluating the significance is not included achieving a certain level of criteria, but the score was performed on the basis of previous experience on the importance of sub-criteria. Inclusion of additional information provide the solution at a higher level of credibility which represents the real situation at a time, for the observed level of fulfillment of the criteria in the cities who have received certificates of favorable business environment.

4. Mathematical approach for determining the importance of criteria based on their effectiveness

Mathematical approach to determining the weights in multi-criteria model of certification of cities include an evaluation of criteria in terms of their efficiency. As a reference parameter of efficiency of criteria is determined the amount of investment in the observed cities. Evaluation of efficiency was performed using the method of Data Envelopment Analysis - *DEA*.

"The Data envelopment analysis (*DEA*) is increasingly popular non-parametric method for relative efficiency evaluation" [7]. *DEA* method is a set of many approaches and techniques, whose essence is as follows: for each observed Decision Making Unit (*DMU*) is formed a linear optimization model, whose solution allows assessment of the relative efficiency of the observed units, as well as its comparison with other units [8].

Optimization procedure using the *DEA* method means the maximum possible level of outputs with minimal involvement or spending of inputs. As in multi-criteria model of certification cities, attributes are actually qualitative estimate of the level of compliance with certain criteria and they are benefit type, because a higher level of compliance with the criteria is directly in accordance with the decision-maker preferences on the achieving business friendly environment. Therefore, it is necessary to transform the criteria using the Likert scale with five levels of preference, which is in this case in vice versa conformity with decision maker preferences and means that the most preferred level of actually getting the minimum grade on a scale (Table 5)6

Table 5.6 Scale of qualitative assessment of criteria compliance [9]

The level of fulfillment of criteria	Description of preference importance	Qualitative assessment
More than 95%	Extremely level of preference	1
From 85 to 94%	Very high preference	2
From 75 to 84%	Important preference	3
From 65 to 74%	Low in importance of preference	4
Less than 64%	Not important preference	5

Table 6. 7Qualitative assessment of compliance with the criteria in the observed cities

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
Criterion Type	*min*	*min*	*min*	*min*	*min*	*min*	*min*	*min*	*min*	*min*	*min*	*min*
City 1	3	1	1	4	2	1	1	4	5	3	1	1
City 2	5	1	3	2	2	1	2	3	4	2	2	1
City 3	3	3	2	1	1	1	1	4	4	3	1	3
City 4	1	5	1	3	5	4	1	5	5	1	3	1
City 5	1	1	3	2	2	2	1	2	2	3	1	1

Based on data from Tables 2 and scale evaluation presented in Table 5, it is formed a table of criteria that can be used as inputs into the *DEA* model (Table 6). Because of comparability of data, the amount of investment, as the output parameter in model, is also adapted by the adequate Likert-type scale. In accordance with the nature of output, mentioned scale is benefit type which means that a higher level of preference corresponds to a higher grade at the scale (Table 7).

Table 7. The amount of investments in the observed cities, source: Statistical Office of the RS [12]

City/ Municipality	Investments in RSD	%	Qualitative assessment
City 1	4,163,364.00	30.15%	4
City 2	1,770,640.00	12.82%	2
City 3	1,504,476.00	10.89%	2
City 4	1,212,435.00	8.78%	1
City 5	5,160,093.00	37.36%	5
Total	**13,811,008.00**	**100.00%**	

Using *DEA* method is possible to obtain data on the effectiveness of all surveyed cities and municipalities in the model, as well as evaluating the effectiveness of individual criteria in the context of their contribution to the realized amount of investment (Table 8). Based on partial data on the effectiveness of certain criteria, it is possible to determine their relative importance in terms of contribution to the realized amount of investment [10]. Thus, in contrast to the *ANOVA*, which was observed all the sub-criteria and their level of achievement, now it comes to individual contributions to the observed relation to a given output parameter. For solving the *DEA* model used is a software package *DEA Frontier* [11].

Efficiency rating of surveyed cities in terms of amount of investment in their territories is given in Table 9. It is important to note that, despite the fact that all cities and municipalities in the sample have a certificate of a business friendly environment, they are not all effective in terms of the amount of investments in their territory [13]. Namely, the five cities surveyed, only two showed efficacy in terms of the amount of realized investment.

Another important result of applying the *DEA* method is to calculate the importance of each criterion compared to the same output parameter.

Table 8. Evaluation of efficiency criteria in relation to the amount of investment in the municipality according to the DEA method

Input-Oriented
CRS Model Target

DMU No.	DMU Name	Efficient Input Target												Efficient Output Target
		C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*	*C12*	*C13*
1	City 1	3.00000	1.00000	1.00000	4.00000	2.00000	1.00000	1.00000	4.00000	5.00000	3.00000	1.00000	1.00000	4.00000
2	City 2	0.88889	0.44444	0.88889	1.33333	0.88889	0.66667	0.44444	1.33333	1.55556	1.33333	0.44444	0.44444	2.00000
3	City 3	0.40000	0.40000	1.20000	0.80000	0.80000	0.80000	0.40000	0.80000	0.80000	1.20000	0.40000	0.40000	2.00000
4	City 4	0.20000	0.20000	0.60000	0.40000	0.40000	0.40000	0.20000	0.40000	0.40000	0.60000	0.20000	0.20000	1.00000
5	City 5	1.00000	1.00000	3.00000	2.00000	2.00000	2.00000	1.00000	2.00000	2.00000	3.00000	1.00000	1.00000	5.00000

Table 9.10 Evaluation of efficiency of municipalities in relation to the amount of investments according to the DEA method

DMU No.	DMU Name	Input-Oriented CRS Efficiency	Sum of lambdas	RTS	Optimal Lambdas with Benchmarks			
1	**City 1**	**1.00000**	1.000	Constant	1.000	City 1		
2	City 2	0.66667	0.444	Increasing	0.222	City 1	0.222	City 5
3	City 3	0.80000	0.400	Increasing	0.400	City 5		
4	City 4	0.60000	0.200	Increasing	0.200	City 5		
5	**City 5**	**1.00000**	1.000	Constant	1.000	City 5		

Table 10.11 The importance of criteria in accordance with determined efficiency ratios of DEA method

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
Average Values of Efficiency	1.098	0.609	1.338	1.707	1.218	0.973	0.609	1.707	1.951	1.827	0.609	0.609
Relative Weights (w_j*)	0.077	0.043	0.094	0.120	0.085	0.068	0.043	0.120	0.137	0.128	0.043	0.043

Based on these values, by appropriate normalization of coefficients is determined relative importance of criteria in terms of contribution to achieving a larger amount of investment in the territory of the observed city or the municipality. Weights based on the results of *DEA* methods are given in Table 10.11

5. Conclusion

By applying the methodology that is currently used in the certification of cities, based on previous experience it was found that the greatest importance in order to achieve a preferred level of all relevant criteria and certification of a favorable business environment with the following criteria: *C11* - Transparent policies on local taxes and incentives for doing business , which weight in multi-criteria model is 0.13, *C1* - Strategic planning of local economic development in partnership with businesses with weight of 0.11, while the criteria *C10* - Adequate infrastructure and reliable communal services and *C4*- Efficient and transparent system for acquiring construction permits are on the third place with relative weights of 0.10 (Figure 1).

By applying statistical approaches and *ANOVA*, it is determined the significance of criteria in terms of their achievement in the observed municipalities.

Assuming that all presented approaches are equally relevant, by their integration is possible to obtain weights of criteria that represent the importance of all three aspects, summarized. Integrated weighting coefficients [14] are obtained as mean values of results obtained by applying methodologies used by *NALED*, *ANOVA*, and *DEA* (Figure 3). Graphical presentation of results clearly shows that with the integration of aspects criteria of are highest importance: *C8* - Investing into the development of local workforce with relative weight of 0.151, *C2*- Special department in charge of *LED*, *FDI* promo-

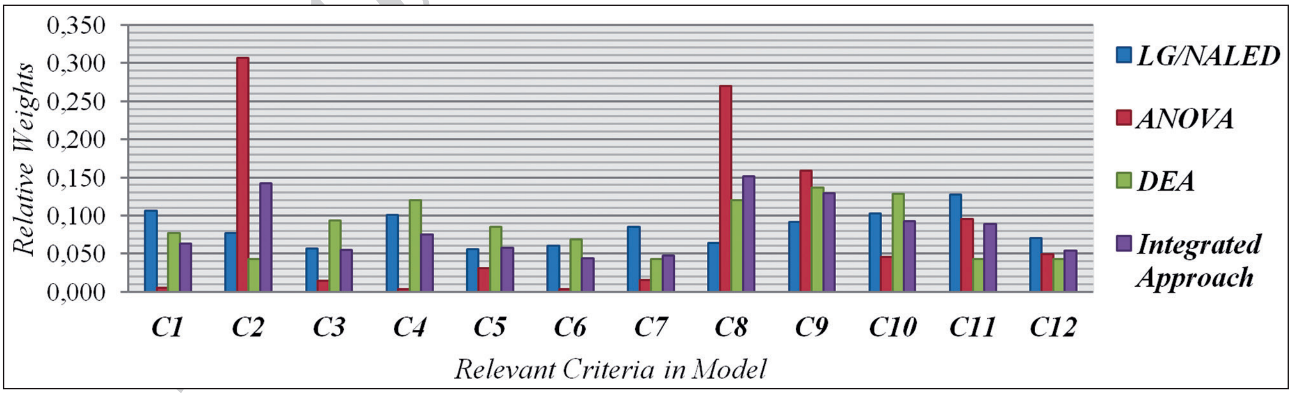

Figure 1. Comparative results of application different methodologies for calculating the weights

tion and business support with relative importance of 0.142 and *C9* - Cooperation and joint projects with local business which relative weight is determinate as 0.129. This conclusion is particularly significant in terms of eliminating the inefficiency of the municipalities, because the ultimate goal of certification is to increase the amount of city investment in the territory of the municipality, and better business results and reduce unemployment.

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