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TWO-STAGE DEA USE FOR ASSESSING EFFICIENCY AND EFFECTIVENESS OF MICRO-LOAN PROGRAMME

GORDANA POPOVIĆ
MILAN MARTIĆ

Laboratory for Operational Research, Faculty of Organizational Sciences, University of Belgrade, Serbia and Montenegro

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Abstract
In new management approaches outputs, as the first and the most immediate results of project can be stated using numbers and can be clearly distinguished from outcomes, which flows from outputs and could bring changes to organizations, families, etc. In this paper, DEA is applied for evaluation on micro-loan programme realization in 18 municipalities in Serbia. "Micro-finance industry" was established to help poor people and generally to help society in reduction of poverty and unemployment. Micro-loan organizations in Serbia have mainly chosen refugees as their target group. Efficiency assessment is based on exact number of clients, potential clients and the other data concerning observed municipality. For the same municipality, effectiveness is measured based on statistical data obtained from impact evaluation. DEA also could be used for purpose of identification inefficiency or ineffectiveness sources. Results of analysis are very important for developing new micro-loan product more suitable for target group of clients.

1. INTRODUCTION

Data Envelopment Analysis (DEA) is well-known and one of the most successful operational research technique. It was specifically designed to measure the efficiency of complex entities like bank branches, schools, game players and teams, etc.

The aim of this paper is to show how DEA can be use for evaluation of efficiency and effectiveness of micro-loan programme realization in two simultaneously steps. Efficiency, in the economic sense, is defined as ratio of output and input. Inputs generally refer to resources such as labour, raw materials and capital. Outputs are items produced

from these inputs as a result of the transformation process that occurs within the DMU (Decision Making Unit). It can also be said that efficiency is "doing things on right way", e.g. desired outputs should be achieved with minimum of inputs. On the other hand, effectiveness could be defined as ability to achieve right goals, e.g. "doing right things" [4]. This approach is very close to new management theory, which assume for each project definition of the inputs, outputs and outcomes [7]. The project evaluation is based on analysis and comparison of value of realized and planned objectives.

Serbia and Montenegro has been passing through period of transition (including public, industrial and service sectors) and most activities have final aim to perform long-term changes with positive impact on society. One programme with similar objectives is micro-loan (known as micro credit in some countries). Micro-loan is supported by humanitarian organizations in purpose to improve life conditions and help refugees and internally displaced persons to adopt in new environment. Assessment of relative efficiency and effectiveness of micro-loan programme realization in central, west and south municipalities of Serbia is this paper subject.

Detail description of the considered problem will be given in the second chapter of this paper. In the third chapter the attention is paid on DEA models used for solving real problems and obtained results will be shown and analysed.

2. MICROFINANCE INDUSTRY AND MICRO-LOAN PROGRAMME

Microfinance, as an activity, can be defined as the supply of financial services to the low-income population, which normally does not have access to these services through the traditional financial system [6]. The broad concept of financial services includes loans, savings, insurance, etc. This paper covers part of these activities: low-income credit for production and services, known as micro-loan, in which the focus is on financing low-income microentrepreneurs, who use the funds in their professional activity. The supply of appropriate financial services to microentrepreneurs in low-income groups has a positive potential effect on the economy and on the social conditions in the area served. In the short term it contributes to generation of income, and in the medium and long terms it provides a dynamic and strength in the process of bringing those in the informal economy (where companies and labour relations are not registered with authorities) into the formal sector [7].

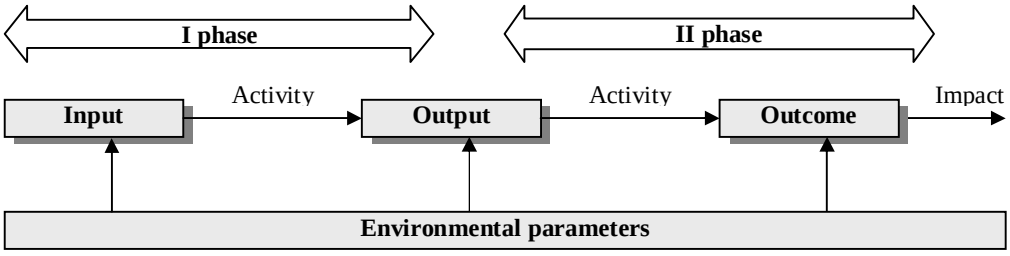
We could talk about microfinancial revolution in transition and developing countries in the last 20 years. 90% of inhabitants in those countries are poor or low-income, but legal financial institutions offer inappropriate services for them. Poor or low-income households have just starting their own business and there are not able to ensure guaranties to secure loan. Besides, financial experts had opinion that poor could not earn enough to repay loan. Therefore, wide space for developing microfinance industry has opened. Micro-loan organizations are one of the most important parts of microfinace industry. The experience of microcredit or micro-loan most known internationally began in 1976, in Bangladesh, an Asian country with an extremely poor population, on the initiative of a university professor called Muhammad Yunus [6]. At present there are microcredit programmemes in 58 countries, on all the continents, with a large number in Central and South America.

In the resent 15 years most countries in Central and Eastern Europe became independent and passing through transition. The Microfinance centre for Central and Eastern Europe and Newly Independent Countries reports that poverty rate increased from 2% to 21% for 10 years. It also says GDP declined during first decade of political and economic reform, but trend reversed after 1999. Reduction of poverty and unemployment depends upon further robust, stable and equitable economic growth. The private sector needs to continue growing and developing until it adequately fills the central role once played by the state and state-owned enterprises. It is small businesses that make up bulk of the private economy, mainly with up to 10 employees. For small entrepreneurs micro-loan is very useful tool in providing resources for founding, improving or expanding their own business [3].

Similar situation is in Serbia. The largest number (688111, UNHCR report form 2002) of refugees and internally displaced people (IDP) in Europe live in Serbia. It is 9% of whole Serbian population and they are hard burden for generally poor economy in transition country. In the aim to help poverty reduction many international humanitarian organizations have opened there branches in Serbia and many NGOs have been founded on the incentive of Serbian people. Several institutions are specialized in micro-loan. This paper covers work of one micro-loan institution. The essential goal of the institution is providing financial support to refugees and IDPs who have entrepreneur‘s ability and idea to start and develop small business.

MICRO-LOAN PROGRAMME GOALS ARE [4]:

- Improving of clients ability for making initiative, realization and developing business ideas,



Picture 2.1

- Giving possibilities for self-employment,
- Improving economic situation and life standard of client’s household,
- Making easier process of integration,
- Making enable permanent access to loan.

The observing institution covers area of Central and West Serbia. They have two main branches and 10 loan assistants charged for one or more municipalities. Working conditions depends on municipality. Basic parameter is number of refugees and IDPs who have shelter in one municipality. The other parameter is environment capability for realizing entrepreneurship ideas. Way of doing business and possibility to be independent and improve life conditions mostly depends on surrounding. That means, loan assistants in poor municipalities have to pay more attention on education of potential clients and

help them to chose right new business in which loan will be invested. Economical and social objectives of micro-loan programme will be fulfilled if the number of approved loan will be as largest as it is possible, but with appropriate using of money. Therefore, loan programme, from the process of collecting applications to the final realization of mentioned objectives, could be divided into two phases (Picture 2.1).

The key of the first phase is to recognize inputs form environment (e.g. number of refugees and IDPs, potential clients, etc.) and estimate of conditions for entrepreneurship. Number of disbursed loan, their amount and number of active clients could be some outputs related with inputs. Activity, which transforms inputs into outputs, is process of approving loans. In the second phase we can observe outcomes obtained based on outputs. They can be defined as percent of approved loan where programme's objectives have been achieved. Activity, which transforms outputs to outcomes, is appropriate way of using loans.

In the case of observing wider and long-term impacts, comparison of present situation and situation at the beginning of loan programme in Serbian municipalities have to be done. Impact evaluation for identifying long-term effects was done in March 2003. Data were gathering by survey of 120 clients and 80 families from control group. Statistical tests confirmed that inquiring group was significant. Obtained results could be used for analysing whole programme, and also together with loan data they could be base for comparative analysis of programme realization's efficiency and effectiveness in the municipalities. Comparative analysis of accomplishing objectives in particular municipalities is very useful for further work, developing and propagating loan programme. DEA is well-known method for assessment of relative efficiency and it is shortly presented in the next chapter.

3. METHODOLOGY FOR EVALUATING EFFECTS OF MICRO-LOAN PROGRAMME

DEA is quickly emerging as a leading method for performance evaluation, in terms of both the numbers of research papers published and the number of applications to real world problems. We used DEA models for evaluating efficiency of primary schools, bank branches, health organizations, project workshops, regions in Serbia [5], etc. In this case DEA is used for evaluation of relative efficiency because of it definition as ratio of obtained outputs and inputs of micro-loan programme.

DEA was introduced by Charnels, Cooper and Rhodes in European Journal of Operational Research in 1978 [2]. Their model, the CCR model, was named after its founders. DEA is a tool for monitoring organizational performance. It defines an organization as a Decision Making Unit or DMU. In that an organization takes certain inputs and transforms them into outputs.

DEA is an extension of Farrell's single input and output method of measuring efficiency. Farrell's Technical-Efficiency measurement method was able to consider more than one output or more than one input simultaneously. His approach allowed an analyst to measure the productivity of an organization in terms of a single input that produces two separate outputs or two inputs used to produce a single output. It was able to plot the efficiency rating of organizations in relation to one another, and created an efficiency frontier, or set of best performers. These best performers could be plotted on the efficient

frontier, since they use their inputs most efficiently to create outputs. This approach however has a limitation of working only for two inputs/outputs simultaneously. The DEA CCR model overcomes this limitation as it allows the consideration of more than two inputs/outputs simultaneously. This approach proved to be very useful, since most DMUs are complex entities that involve more than two inputs and outputs. DEA allows for efficiency studies to be carried out on similar DMUs, that are DMUs having the same inputs and outputs, so it serves as a useful tool in measuring best practices for a particular type of entity. DEA is an econometric tool used to measure efficiency. Efficiency, in the economic sense, is defined as:

Efficiency = Output / Input

Inputs generally refer to resources such as labour, raw materials and capital. Outputs are items produced from these inputs as a result of the transformation process that occurs within the DMU. The aforementioned efficiency equation becomes more complicated when the more realistic scenario of measuring multiple inputs and outputs exists. Within this scenario, efficiency must be defined as:

Efficiency = Weighted Sum of Outputs / Weighted Sum of Inputs

The value of the weights is difficult to determine, since fixing these values will require very strong assumptions that will significantly affect the results of the efficiency calculation, and because each DMU may utilize their inputs and outputs differently. Method supposes constant return to scale. Constant returns to scale implies that a change in the amounts of the inputs leads to a similar change in the amounts of the outputs. For example, if the inputs values for a unit are all doubled, then the unit must produce twice as many outputs. Since the introduction of the CCR model however, DEA has been further extended. One of the more significant extensions of the original CCR model was the development of the BCC model in 1984 by Banker, Charnes and Cooper, after whom the model was named [5]. The BCC model allows for the efficiency measurement of DMUs with a variable returns to scale assumption. It is able to distinguish between technical and scale inefficiency. Technical inefficiency is calculated by measuring how well the unit uses its inputs to create outputs. Scale inefficiency, on the other hand identifies whether increasing, decreasing, or constant returns to scale exist for further exploitation. There are also other commonly used DEA model types like model for measuring superefficiency (Andersen-Petersen's model), which will be addressed in this paper.

DEA offers many advantages over traditional efficiency measurement approaches. Some of the more applicable differences are that DEA provides a single unambiguous measure of performance, it can handle multiple inputs and outputs that have different units of measurement, it focuses on best practice DMUs, and it can offer prescriptive advice. When applied to the area of loan realization measurement, DEA also allows for further opportunities for measuring effectiveness as ratio of outcomes and outputs, additional "what if" scenarios that could be tested, DEA offers recommendations by calculating a virtual DMU for each DMU under study.

3.1. PROBLEM DEFINITION AND DATA REVIEW

In this paper DEA is used for comparative analysis and ranking of total effectiveness in municipalities covers with micro-loan programme. Here, two-stage DEA is applied in correspondence with programme realization phases (in the first phase relative efficiency is assessed and in the second phase programme realization effectiveness is evaluated). Procedure of DEA method applying could be divided into following steps:

1. DMU's definition and choosing,
2. Defining relevant inputs and outputs,
3. Choosing adequate DEA model,
4. DEA model solving, analysing and interpretation of results.

Decision making units in the particular case are 18 municipalities chosen as representative sample for impact evaluation. All necessary data for those municipalities are available.

Goal definition determines *inputs and outputs* noticed in chapter 2. Input 1. is quality of entrepreneurship conditions (QEC). This is categorical variable (scale 1-9) obtained by experienced estimation of deputy project manager. The other inputs are official UNHCR data and they are total number of refugees and IDPs households (RIH) and total number of potential clients (NPC=RIH*0.1). These are non-discretionary variables. Outputs (Total value of disbursed loans in thousands of €–VDL and number of active clients -NAC) are taken over from loan database. Outcomes (data about objectives fulfilling) are gained as impact evaluation results and they are percent of clients who have increased food fund (FF), improved living condition (LC), education (IE) and raised income form loan (PL). Value of inputs, outputs and outcomes are given in Table 3.1.

DMU	Inputs			Outputs		Outcomes (%)			
	QEC	RIH	NPC	CDL	NAC	FF	LC	IE	PL
Aleksinac	1	469	47	9.9	12	55	36	55	18
Arilje	9	84	8	16.5	13	50	50	0	0
Babušnica	1	31	3	1.1	1	88	100	88	50
Bela palanka	1	78	8	12.1	10	83	83	83	50
Čačak	9	1463	146	50.6	94	100	0	0	100
Čajetina	5	111	11	14.3	17	100	0	0	0
Knjaževac	3	175	18	9.9	3	80	40	80	40
Kraljevo	7	5149	515	110	237	83	50	50	50
Kruševac	7	2259	226	34.1	44	60	60	40	20
Niš	3	2831	283	47.3	77	25	75	75	50
Novi Pazar	9	1144	114	14.3	39	70	40	30	10
Pirot	1	176	18	15.4	18	50	0	0	0
Požega	3	230	23	15.4	16	50	50	0	0
Prijepolje	1	262	26	2.2	5	83	50	33	33
Prokuplje	1	1294	129	23.1	21	50	0	0	0
Raška	3	490	49	5.5	20	67	33	33	33

Užice	5	546	55	9.9	19	100	60	20	60
Valjevo	5	605	60	18.7	38	82	59	45	9

Table 3.1

Clearly, there is entire correlation between two inputs (total number of household–QEC and total number of potential clients-NPC). Therefore, one input could be excluded from analysis without loosing significant information. According UNHCR methodology number of potential clients is relevant factor and it will be used in further analysis. In order to do ranking and evaluating efficiency at the same time we used *Andersen-Petersen's model* (1)-(4) [1]. Following constant return to scale (CRS) model is output-oriented dual version, because we have concluded it is possible to raise outputs by better work and education of loan assistants. On the other hand inputs are non-tangible variables conditioned by the environment.

$$(\max)\ \phi_k = \phi_k - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right) \tag{3.1}$$

st.

$$\sum_{\substack{j=1 \\ j\neq k}}^{n} \lambda_j x_{ij} + s_i^- = x_{ik,} \quad i = 1,\ldots,m \tag{3.2}$$

$$\phi_k - \sum_{\substack{j=1 \\ j\neq k}}^{n} \lambda_j z_{rj} + s_r^+ = 0,\ r = 1,\ldots,s \tag{3.3}$$

$$\lambda_j, s_r^+, s_i^- \geq 0;\ j = 1,2,\ldots,n,\ r = 1,2,\ldots,s,\ i = 1,2,\ldots,m,\ Z_k \text{ - unrestricted} \tag{3.4}$$

where x_{ij} and y_{rj} are i-th inputs and r-th outputs of DMU_j. ϕ_k is efficiency index (intensity factor) of observed DMU_k. One linear model (3.1)-(3.4) should be solved for each DMU (municipality) in order to its comparison with the other DMU form the sample. That means, obtained solution is relative efficiency. All inefficient units are enveloped by pr**o**duction frontier and for each of them analyst could find benchmark (real –efficient or virtual-composite peer unit laying on efficiency frontier). Variable λ_j is dual weight which show DMU_j (j = 1,2,…n) significance in definition of input-output mix of hypothetical composite unit, DMU_k directly comparing with. Basic DEA model gives ϕ_k =1 for all efficient unit and ϕ_k>1 for inefficient units. By excluding inputs and outputs DMU_k form constraints (3.2) and (3.3) (the only modification comparing with CCC model) in model (3.1)-(3.4) ranking of efficient units is enabled and intensity factor has value $\phi_k \leq 1$. Besides, model could be expanded with constrain (3.5) and allow variable return to scale. Model (1)-(5) will be used in the second phase with presumption that outcomes percent shouldn't be changed for the same percent as inputs.

$$\sum_{j=1}^{n} \lambda_j = 1 \tag{3.5}$$

In our case of effectiveness evaluating of micro-loan programme 18 models are solved for each phase where ϕ_k could be defined:

Phase I ⇒	Efficiency	$(\phi_{k1}) =$	$\frac{\text{outputs}}{\text{inputs}}$	⇒

Phase II ⇒	Service effectiveness	$(\phi_{k2}) =$	$\frac{\text{outcomes}}{\text{outputs}}$	
	Total effectiveness	$(\phi_k) =$	$\frac{\text{outcomes}}{\text{inputs}}$	$= \phi_{k1} * \phi_{k2}$

3.2 ANALYSIS OF RESULTS

DEA models are solved by using E-DEA [4] software developed in Laboratory for Operational Research, at the Faculty of Organizational Sciences, Belgrade. It is created within *Excel* environmental and accepts data organized as in Table 3.1.

For efficiency assessment in the first phase, model (3.1)-(3.4) is used (output-oriented CRS DEA model for ranking). Model (3.1)-(3.5) is used in the second phase (VRS input-oriented). Calculation of total effectiveness ϕ_k is made by using efficiency ϕ_{k1} and service effectiveness scores ϕ_{k2}. Efficiency scores and municipalities ranks are shown in Table 3.2.

Micro-loan programme is realized efficiently in 5 municipalities (Arilje, Bela palanka, Čajetina, Kraljevo, Pirot and Prokuplje), and desired effects are reached in 4 municipalities (Babušnica, Čačak, Čajetina and Užice). Values ϕ_{k1} and ϕ_{k2} for efficient and/or effective units show which percent of decreasing outputs or outcomes is feasible for DMU_k to remain efficient and/or effective. For inefficient and/or ineffective municipalities these values show for which percent they have to increase outputs or outcomes to became efficient and/or effective. One can see the only Čajetina municipality is efficient and effective. Entrepreneur conditions in Čajetina are average, but there are 17 active clients, means 6 more than official number of potential clients. Hence, this is the best ratio of analysed outputs and inputs, outputs NAC participate with 100% in composing of virtual output. Conclusion is DEA couldn't create unit with better properties then the observed unit has. 100% of clients said they had increased their food fund, so it is effective municipality (FF participate with 100% in creating virtual outcomes).

DMU	Efficiency		Service effectiveness		Total effectiveness			
	ϕ_{k1} (%)	Rank	ϕ_{k2} (%)	Rank	ϕ_k (%)	Rank	ϕ_k' (%)	Rank
Aleksinac	171.50	9	160.42	14	275.12	11	275.12	10
Arilje	**79.48**	5	180.95	15	143.82	8	180.95	6
Babušnica	433.28	18	**10.77**	1	**46.66**	1	433.28	15
Bela palanka	**61.01**	1	102.44	5	**62.50**	2	102.44	2
Čačak	161.84	8	**60.00**	2	**97.10**	5	161.84	5
Čajetina	**89.98**	6	**98.61**	4	**88.73**	4	**100.00**	1
Knjaževac	279.19	13	109.38	8	305.38	13	305.38	11
Kraljevo	**69.67**	3	111.86	9	**77.93**	3	111.86	3
Kruševac	326.19	15	150.79	13	491.86	18	491.86	18
Niš	115.25	7	107.69	7	124.11	6	124.11	4
Novi Pazar	323.65	14	137.25	11	444.21	17	444.21	17

Pirot	**75.39**	4	200.00	17	150.78	9	200.00	7
Požega	185.45	11	180.95	16	335.57	14	335.57	13
Prijepolje	408.60	17	106.88	6	436.71	16	436.71	16
Prokuplje	**68.25**	2	200.00	18	136.50	7	200.00	8
Raška	254.37	12	140.63	12	357.72	15	357.72	14
Užice	330.80	16	**90.40**	3	299.04	12	330.80	12
Valjevo	177.96	10	114.93	10	204.53	10	204.53	9

Table 3.2

An interesting example is inefficient municipality Babušnica (rank 18), and it should increase both outputs for 433.28%. Detail analysis of solution shows Arilje, Bela Palanka and Čajetina are benchmark for municipality Babušnica. Dual weights are λ_2=0,04, λ_2=0,25 and λ_3=0,08, means total value of disbursed loan has to be 0,04*16,5+0,25*1,1+0,08*14,3, e.g. 4,81 thousands of € per year, and number of active loan has to be 4,33 in Babušnica municipality to become efficient. Values for municipality Bela Palanka has the greatest impact in creating virtual value. Municipality Bela Palanka has bad entrepreneurship conditions such as Babušnica, but number of active clients (10) is bigger than potential. If we neglect potential but analysing just outcomes opposite to outputs, index of effectiveness is 10,77% (rank 1). Percent of objectives reaching in Babušnica are more or equal to 50%. This is the only municipality where all clients have improved life conditions and outcome LC mostly participates (92%) in creating of virtual output.

Total effectiveness is calculated on two different ways. Firstly, ϕ_k is calculated as product of intensity factor obtained by solving DEA models for ranking. According results, 5 municipality is totally efficient (Babušnica, Bela Palanka, Čačak, Čajetina i Kraljevo). Analysts can conclude that effects of micro-loan programme realization in those 5 municipalities are very good. Total effectiveness of municipality Babušnica is the best because of small value of efficiency end service effectiveness index. Micro-loan programme realized on efficient and effective way in municipality Čajetina, but both indexes are very close to 100%, which caused its 4th rank. Thats why we introduced assumption that ehe efficiency and effectiveness is calculeted by using CCR output-oriented models [1]. All units have intesity factor eaqual 100%, and inefficiency and ineefectivelly units have the same intensity factors as in the model (3.1)-(3.5). Recalculated ϕ_k' is equal 100% just for Čajetinai, and. Babušnica has rank 15, and the other municipalities' ranks are the same. Results of superefficiency models give better differentiation between municipalities and that model is appropriate for calculating total effectiveness. But ranking is more realistic when we use results of basic DEA models.

4. CONCLUSION

This paper presents two-stage DEA method for efficiency and effectiveness evaluation. The aim of analysis is to demonstrate possibilities of evaluation of realizing project planned effects if project participants are several entities with similar inputs, outputs and outcomes.

The essential aim of micro-loan programme which is the given »project« in this paper is long-term change of life conditions of refugees and internally-displaced persons

and helping their integration in community. Micro-loan impact is not easy for measuring; especially it is difficult to compare its effects in different municipality and regions. Project evaluation allows monitoring of loan effects on single client and impact evaluation giving figure of whole programme. Here, it is shown how DEA could be used for comparing work in different municipalities and potentially how manager could compare index of their loan assistants work effectiveness. Moreover, results of DEA analysis could be base for setting up target values of outputs and for determining further work lines.

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