Institute of Economic Research Working Papers

No. 77/2017

Efficiency Analysis of ERDF and CF Co-financed Programmes Focusing on the Transport in Member States of the European Union

Lukáš Melecký

Article prepared and submitted for:

9th International Conference on Applied Economics Contemporary Issues in Economy, Institute of Economic Research, Polish Economic Society Branch in Toruń, Faculty of Economic Sciences and Management, Nicolaus Copernicus University, Toruń, Poland, 22-23 June 2017

Toruń, Poland 2017

Lukáš Melecký
lukas.melecky@vsb.cz
Department of European Integration, Faculty of Economics, VŠB-Technical University of Ostrava, Sokolská třída 33, 702 00 Ostrava 1, Czech Republic

Efficiency Analysis of ERDF and CF Co-financed Programmes Focusing on the Transport in Member States of the European Union

JEL Classification: *C67; O11; O52; R11; R12.*

Keywords: *DEA; Efficiency; European Regional Development Fund, Ex-post evaluation; Cohesion Fund.*

Abstract

Research background: European Union provides financial support to the Member States through various financial tools currently from European Structural and Investment Funds that represent the main instrument of EU Cohesion Policy to sustain territorial development, to increase competitiveness and to eliminate regional disparities. The overall impact of EU Funds depends on the structure of funding and absorption capacity of the country.

Purpose of the article: Efficiency of funding across EU Member States is a fundamental issue for the EU development as a whole. The author considers determining the efficiency of EU Funds as an issue of high importance and therefore this study provides a contribution to the debate on the role of the EU Cohesion Policy in EU Member States. The paper focuses on the territorial effects of selected EU Funds in programming period 2007–2013 in theme of infrastructure through transport efficiency analysis.

Methodology/methods: Efficiency analysis is based on data at country level originating from ex-post evaluation of Cohesion Policy programmes 2007–2013 representing the input and output variables to analyse whether the goal of fostering growth in the target countries have been achieved with the funds provided and whether or not more resources generated stronger growth effects in transport accessibility. Study deals with comparative cross-country analysis, descriptive data analysis and multicriteria approach to Data Envelopment Analysis (DEA) in the form of output oriented BCC VRS model.

Findings & Value added: The study aims at testing several factors in form of two inputs and five outputs, trying to elucidate the differences obtained by the EU Member States in efficient using of the European Regional Development Fund and the Cohesion Fund in transport sector. Paper determines if the countries have been more efficient in increasing their levels of competitive advantages linked with

transport. Preliminary results reveals that mostly countries with lower amount of funding achieve higher efficiency, especially from the group of EU15.

Introduction

The establishment of the EU marked at the beginning of new area; the European Union (EU) Member States currently enjoy many benefits in this respect: a free market, effective trading, enhanced security, economic cohesion, sustainable development, the protection of human rights, the creation of jobs etc. The European Structural and Investment Funds (ESIF) are basic instruments of the EU Cohesion Policy to promote the overall harmonious development of the EU, to reduce disparities between the levels of development of the various regions, and to strengthen its economic, social and territorial cohesion. ESIF consist of the following five funds, i.e. European regional development fund (ERDF), European social fund (ESF), Cohesion fund (CF), European agricultural fund for rural development (EAFRD) and European maritime and fisheries fund (EMFF). The EU devotes an important part of its resources to financing regional development projects through ESIF which provide subsidy aid to Member States and their regions based on their economic situation, mainly based on the particular region's GDP. How efficiently the Member States apply the funds is a fundamental issue for the development and continuity of the EU Cohesion Policy, and especially so in the context of the economic crisis and the growing number of regions with low levels of development that the incorporation of so called new countries into the EU has supposed. Such circumstances have forced the EU to make huge economic efforts to maintain and increase the resources for the funds, and so it is vital for European authorities to know how efficiently these are being applied (Enguix et al., 2012).

As the key EU objective is deeper market integration among Member States, the construction of efficient and big transport infrastructures was seen as a necessary step toward this goal, i.e. in form of the Trans European Network (TEN) investments. Development of the transport networks causes economic growth and trade, higher employment rate and an increase in the quality of life of the population and other favourable economic aspects. Transport networks are a very important part of the supply chain, because they are a basic influence for the economy in all countries and enable an effective movement of people and flow of goods. The attractiveness of the area can be increased by upgrading the equipment in transport infrastructure. Areas which can be characterized as those with highly developed transport infrastructure, are more attractive for investors (see Górniak, 2016; Sucháček, 2013). Moreover development of transport infrastructure and decrease of efficiency in that branch are one of the important factors of

economic growth. Convenient road, railway, air and water connections result in constant movement of people and goods and they tend to improve the quality of life.

The study focuses on the territorial effects of the EU Funds in programming period 2007–2013 in theme of infrastructure through transport efficiency analysis. Efficiency analysis is based on national data originating from ex-post evaluation of Cohesion Policy programmes 2007–2013 representing the input and output variables to analyse whether the goal of fostering growth in the target countries have been achieved with the funds provided and whether or not more resources generated stronger growth effects in transport accessibility. By analysing the amounts granted to each Member State, efficiency level of using funds is observed based on multicriteria approach of Data Envelopment Analysis (DEA) in the form of output oriented BCC VRS model. Paper determines if the countries have been more efficient in increasing their levels of competitive advantages linked with transport.

Research Methodology

Efficiency of the EU Cohesion Policy policies is an issue of high relevance, although studies on the efficiency of the EU Cohesion Policy through funds have not provided conclusive findings (see overview in Mohl and Hagen, 2010), it is useful to determine whether the huge amounts of resources employed could have given better results. The EU Cohesion Policy should be effective, as is the case of transport policy. Currently, the trend in efficiency studies revolves around the application of non-parametric models, since they allow to consider a multiplicity of outputs and inputs in the analysis, and thus make less severe demands on the whole and the frontier of production. Efficiency measurement has been the challenge of many subjects which have interest to improve their productivity. In 1957, Farrell investigated the question how to measure efficiency and highlighted its relevance for economic policy makers (Farrell, 1957). Since that time techniques to measure efficiency have become more frequent and improved.

Among the non-parametric techniques, Data Envelopment Analysis (DEA) is the most accepted method. DEA is data oriented approach for providing a relative efficiency assessment and evaluating the performance of a set of peer entities called Decision Making Units (DMUs). DEA provides a single measure and easily deals with multiple inputs and multiple outputs; and its aim is to examine DMU if they are efficient of inefficient by the size and quantity of consumed resources and by the produced outputs. In recent years, we have seen a great variety of applications of DEA for evaluating the performances of many different kinds of entities engaged

in many different activities (such as banks, hospitals, universities, cities, courts, business firms, and others, including the performance of countries, regions, etc.); and evaluation of territorial units is topic of interest in this study (for more DEA works about national or regional efficiency see e.g. Staníčková, 2014).

Used DEA model can be distinguished by the scale and orientation of the model. If in order to achieve better efficiency, governments' priorities are to adjust their outputs (before inputs), then an output oriented (OO) DEA model, rather than an input oriented (IO) model, is appropriate in this study. Next step is Returns to Scale (RTS) estimation and based on classifications of countries into RTS, then DEA model choice is characterized, i.e. in most of countries variable returns to scale (VRS) were estimated. For calculations of efficiency it is used output oriented BCC (Banker-Charnes-Cooper) model with variable returns to scale (VRS), see model (1) (Cook and Seiford, 2009):

$$\max \; g = \phi_q + \varepsilon(\mathbf{e}^{\mathbf{T}}\mathbf{s}^{+} + \mathbf{e}^{\mathbf{T}}\mathbf{s}^{-}),$$

subject to

$$\mathbf{X}\boldsymbol{\lambda} + \mathbf{s}^{-} = \mathbf{x}_q,$$

$$\mathbf{Y}\boldsymbol{\lambda} - \mathbf{s}^{+} = \phi_q \mathbf{y}_q,$$

$$\mathbf{e}^{\mathbf{T}}\boldsymbol{\lambda} = 1,$$

$$\boldsymbol{\lambda}, \mathbf{s}^{+}, \mathbf{s}^{-} \geq \mathbf{0},$$

where g is the coefficient of efficiency of unit U_q; ϕ_q is radial variable indicates required rate of increase of output; ε is infinitesimal constant; $e^T\lambda$ is convexity condition; s^+, and s^- are vectors of slack variables for inputs and outputs; λ represent vector of weights assigned to individual units; x_q means vector of input of unit U_q; y_q means vector of output of unit U_q; X is input matrix; Y is output matrix. In BCC model aimed at outputs the efficiency coefficient of efficient DMU equals 1, but the efficiency coefficient of inefficient DMU is greater than 1.

In BCC model, efficiency coefficients of efficient units equal to 1. Depending on chosen model, but also on relationship between number of units and number of inputs and outputs, number of efficient units can be relatively large. Due to the possibility of efficient units' classification, it is used Andersen-Petersen's model (APM) of super-efficiency. Following VRS model is output oriented dual version of APM (2) (Andersen and Petersen, 1993):

$$\max \; g = \phi_{\mathrm{q}} + \varepsilon(\mathbf{e}^{\mathbf{T}}\mathbf{s}_{\mathrm{i}}^{+} + \mathbf{e}^{\mathbf{T}}\mathbf{s}_{\mathrm{i}}^{-}),$$

subject to

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{iq},$$

$$\sum_{j=1}^{n} y_{kj}\lambda_j - s_i^+ = \phi_q y_{kq},$$

$$\mathbf{e^T\lambda} = 1,$$

$$\lambda_q = 0,$$

$$\lambda_j, s_k^+, s_i^- \geq 0,$$

$$j = 1,2,...,n,\ j \neq q; k = 1,2,...,r; i = 1,2,...,m.$$

where x_{ij} and y_{rj} are *i*-th inputs and *r*-th outputs of DMUj; ϕ_k is efficiency coefficient of observed DMU_k; λ_j is dual weight which show DMU_j significance in definition of input-output mix of hypothetical composite unit, DMU_k directly comparing with. Rate of efficiency of inefficient units ($\phi_k > 1$) is identical to model (1); for units identified as efficient in model (1), provides OO APM (2) rate of super-efficiency lower than 1, i.e. $\phi_k \leq 1$.

This study covered 27 Member States of the EU drawing money from the EU during the programming period 2007–2013. Efficiency analysis is based on data at country level originating from ex-post evaluation of the EU Cohesion Policy programmes 2007–2013 (European Commission, 2016). Data represent input and output variables (see Table 1) to analysing whether the goal of fostering growth in the target countries have been achieved with the funds provided and whether or not more resources generated stronger growth effects in transport accessibility. In Table 1 in Annex, data for 27 Member States (DMUs) with two inputs and five outputs are demonstrated in numerical example. With respect to data availability and need for relevancy of gained results, data for 23 Member States come into efficiency analysis through DEA method, i.e. without AT, DK and LU with zero values of indicators, and also without BE only with one-known value of indicators. For other countries, the values are available for all of the indicators, or some indicators show missing data and therefore report zero values. DEA Frontier software tool is used in the study.

Table 1. Input and output indicators for DEA analysis

Inputs
I-1: Road (mld. EUR)
I-2: Rail (mld. EUR)
Outputs
O-1: km of new roads
O-2: km of new TEN roads
O-3: km of reconstructed roads
O-4: km of TEN railroads
O-5: km of reconstructed railroads

Source: European Commission (2016); own elaboration (2017).

Results and Discussion

In the first step, OO BCC VRS model of efficiency should be solved for the EU23 Member States. So, efficient and inefficient countries can be determined. In the second step, OO APM model of super-efficiency should be solved for all the EU23 Member States. Based on results of Andersen-Petersen's model, efficient and inefficient countries can be determined and ranked. Output oriented BCC VRS model of efficiency and OO Andersen-Petersen's model of super-efficiency singled out productive units which are efficient; to the group of these countries belong Bulgaria (BG), Spain (ES), France (FR), Italy (IT), Cyprus (CY), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romani (RO), Finland (FI) and Sweden (SE). Efficient countries are highlighted by bold in Table 2. In this case, the efficiency boundary is a straight line cutting through these DMUs. All other units are inefficient, i.e. they fall short of the efficiency curve. Inefficient countries are Czech Republic (CZ), Germany (DE), Estonia (EE), Ireland (IE), Greece (EL), Latvia (LV), Lithuania (LT), Hungary (HU), Slovenia (SI), Slovakia (SK) and United Kingdom (UK). Inefficient countries are highlighted by italics in Table 2. DEA allows to determine how DMU should change its behaviour to become efficient and rise to the efficiency curve. In the case of inefficient countries, optimal values of inputs and outputs are calculated, i.e. targets for inefficient countries as an instruction for improving their input-output ratio to become efficient (compare Table 2 and Table 1 in Annex with efficient and initial values of indicators).

Table 2. Relative the EU countries' DEA efficiency

EU	OO BCC VRS	OO APM VRS	Efficient input-output target							Rank of countries		
			I1	I2	O1	O2	O3	O4	O5	No.	EU	OO APM VRS
BG	**1,000**	**0,347**	1078,845	341,391	175,000	173,000	1040,480	234,000	234,000	1	FI	0,007
CZ	*1,267*	*1,267*	3796,887	2199,226	519,539	256,480	2557,546	372,628	698,245	2	SE	0,008
DE	*1,143*	*1,143*	2082,771	766,349	335,564	223,901	2049,805	181,547	313,335	3	NL	0,015
EE	*1,842*	*1,842*	290,406	138,908	128,464	48,335	1057,030	16,628	187,483	4	CY	0,214
IE	*4,112*	*4,112*	63,500	16,750	15,600	8,477	135,700	2,111	17,113	5	PL	0,223
EL	*1,159*	*1,159*	1282,721	530,576	345,060	167,330	3066,051	55,554	383,837	6	IT	0,254
ES	**1,000**	**0,895**	2296,862	4139,081	509,750	124,720	2458,100	0,000	1,210	7	MT	0,257
FR	**1,000**	**0,335**	171,837	202,326	28,000	0,000	0,000	57,000	549,870	8	FR	0,335
IT	**1,000**	**0,254**	835,378	2185,181	94,270	0,000	188,070	733,190	1034,960	9	PT	0,345
CY	**1,000**	**0,214**	33,209	0,000	2,900	3,000	3,420	0,000	0,000	10	BG	0,347
LV	*2,783*	*2,783*	483,041	226,137	191,820	81,455	1771,721	28,022	260,446	11	ES	0,895
LT	*1,702*	*1,702*	681,253	315,890	257,011	115,533	2507,102	39,745	335,521	12	RO	0,988
HU	*1,131*	*1,131*	3276,672	1720,107	567,569	271,710	3535,631	51,334	339,480	13	HU	1,131
MT	**1,000**	**0,257**	103,432	0,000	0,000	0,000	13,290	0,000	0,000	14	DE	1,143
NL	**1,000**	**0,015**	8,450	0,424	0,000	0,000	0,000	0,000	0,000	15	SI	1,148
PL	**1,000**	**0,223**	15910,622	5479,094	1886,270	1056,010	7216,230	123,650	482,060	16	EL	1,159

PT	**1,000**	**0,345**	813,206	375,641	300,410	138,220	2996,660	47,550	385,500	17	CZ	1,267
RO	**1,000**	**0,988**	3377,417	1692,047	367,900	313,600	1892,820	21,800	122,260	18	LT	1,702
SI	*1,148*	*1,148*	404,809	184,079	68,835	60,159	369,320	102,668	123,229	19	EE	1,842
SK	*1,860*	*1,860*	1888,527	914,309	393,099	190,023	3023,583	119,609	455,496	20	SK	1,860
FI	**1,000**	**0,007**	9,169	10,198	31,469	0,000	12,238	0,000	70,806	21	LV	2,783
SE	**1,000**	**0,008**	9,272	11,605	36,000	0,000	14,000	0,000	81,000	22	IE	4,112
UK	*4,214*	*4,214*	192,377	65,432	54,778	29,496	185,078	39,334	95,493	23	UK	4,214

Source: own elaboration (2017).

Conclusions

Development of transport network is a very important element for effective functioning of the EU Members States. The increasing demand for goods and movement of people is the reason of successful expansion and modernization of transport infrastructure. Generally it is very important to connect all the EU countries into a functioning system of transportation network. It will promote to movement of people and flow of goods (with consideration of distance). Differences in the levels of accessibility are significant in the new EU countries. They have good prospects for growth of transport infrastructure with regard to the amount of allocations from the European funds and according to the theory of growth due to the effect of catching up of the less developed countries to more developed ones, and there are several reasons for it: (1) the new EU Member States constantly fall into the category of less developed countries based on GDP per head in PPS; (2) threshold defining the level of GDP as a percentage of the EU average was taken as a reference, as it is the criterion for identifying countries that are eligible for funding under the established criteria of the EU Cohesion Policy. The EU funds are an important tool for reducing economic, social and territorial disparities among European countries. Of the total EU budget allocated to the Cohesion Policy, a substantial part is allocated just to the new EU countries, thus significantly supporting their development; (3) the new EU Member States are often significantly dependent on exports to old EU Member States and on the flow of money for this exchange shift, thus freight transport needs adequate transportation network, which is important for these countries in terms of trade relations.

Acknowledgement

The paper is supported by the Faculty of Economics, VŠB-TUO (project no. IP1003311) and the SGS project (SP2017/111), and the Operational Programme Education for Competitiveness – Project No. CZ.1.07/2.3.00/20.0296.

References

Andersen, P. & Petersen, N.C. (1993). A Procedure for Ranking Efficient Units In Data Envelopment Analysis. *Management Science*, 39(10). DOI: http://dx.doi.org/10.1287/mnsc.39.10.1261.

Cook, W.D. & Seiford, L.M. (2009). Data envelopment analysis (DEA) – Thirty years on. *European Journal of Operation Research*, 192(1). DOI: http://doi.org/10.1016/j.ejor.2008.01.032.

Enguix, M.R.M., García, J.G. & Gallego, J.C.G. (2012). An Impact Analysis of the European Structural Funds on the Variation of the Rate of Employment and Productivity in Objective 1 Regions. *European Planning Studies*, 20(4). DOI: http://dx.doi.org/10.1080/09654313.2012.665038.

European Commission (2016). Evaluations of the 2007-2013 programming period: Ex Post Evaluation of the ERDF and CF: Key outcomes of Cohesion Policy in 2007-2013. Retrieved from http://ec.europa.eu/regional_policy/en/information/publications/evaluations?title=Work+Package+1+&themeId=0&tObjectiveId=ALL&typeId=4&countryId=0&periodId=2&fundId=0&policyId=5&languageCode=en&search=1 (20.02.2017).

Farrell, M.J. (1957). The measurement of productivity efficiency. *Journal of the Royal Statistical Society*, 120(3). DOI: https://doi.org/10.2307/2343100.

Górniak, J. (2016). The Spatial Autocorrelation Analysis For Transport Accessibility In Selected Regions Of The European Union. *Comparative Economic Research*, 19(5). DOI: http://dx.doi.org/10.1515/cer-2016-0036.

Mohl, P. & Hagen, T. (2010). Do EU structural funds promote regional growth? New evidence from various panel data approaches. Regional Science and Urban Economics, 40(5). DOI: http://doi.org/10.1016/j.regsciurbeco.2010.03.005.

Staníčková, M. (2014). Measuring the Efficiency of EU13 NUTS 2 Regions based on RCI Approach. In V. Klímová & Žítek, V. (Eds.). In *17th International Colloquium on Regional Sciences*. Brno: Masaryk University.

Sucháček, J. (2013). Investment location from the perspective of urban and regional activities in the Czech Republic. In M. Čulík (Ed.). In *9th International Scientific Conference on Financial Management of Firms and Financial Institutions Location*. Ostrava: VŠB-TU Ostrava.

Toloo, M., Barat, M. & Masoumzadeh, A. (2015). Selective measures in data envelopment analysis. *Annals of Operations Research*, 226(1). DOI: http://dx.doi.org/10.1007/s10479-014-1714-3.

Annex

Table 1. Numerical values of input and output indicators for DEA analysis

Country	I1	I2	O1	O2	O3	O4	O5
~~BE~~	~~14.210~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~
BG	1078.845	341.391	175.000	173.000	1040.480	234.000	234.000
CZ	3796.887	2900.935	311.770	110.750	2017.880	294.000	369.060
~~DK~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~
DE	2082.771	766.349	293.520	100.700	769.900	158.800	248.600
EE	290.406	185.308	69.740	0.000	205.000	0.000	0.000
IE	63.500	16.750	0.000	0.000	33.000	0.000	0.000
EL	4602.952	530.576	144.400	144.400	2645.900	11.400	60.300
ES	2296.862	4139.081	509.750	124.720	2458.100	0.000	1.210
FR	171.837	202.326	28.000	0.000	0.000	57.000	549.870
IT	835.378	2185.181	94.270	0.000	188.070	733.190	1034.960
CY	33.209	0.000	2.900	3.000	3.420	0.000	0.000
LV	483.041	256.300	0.000	0.000	636.570	0.000	0.000
LT	681.253	580.370	0.000	0.000	1473.440	0.000	0.000
~~LU~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~
HU	3276.672	1720.107	501.980	135.200	2521.170	20.000	216.000
MT	103.432	0.000	0.000	0.000	13.290	0.000	0.000
NL	8.450	0.424	0.000	0.000	0.000	0.000	0.000
~~AT~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~	~~0.000~~
PL	15910.620	5479.094	1886.270	1056.010	7216.230	123.650	482.060
PT	813.206	375.641	300.410	138.220	2996.660	47.550	385.500
RO	3377.417	1692.047	367.900	313.600	1892.820	21.800	122.260
SI	404.809	434.568	59.980	52.420	10.650	89.460	89.460
SK	1888.527	1028.793	79.500	40.570	1625.690	64.310	64.310
FI	14.776	10.198	0.000	0.000	0.000	0.000	0.000
SE	9.272	11.605	36.000	0.000	14.000	0.000	81.000
UK	253.055	65.432	13.000	7.000	11.000	2.000	2.000

Source: European Commission (2016); own elaboration (2017).