The EU Countries' Assessment with Respect to the Prevalence of Severe Material Deprivation and Determinants of Poverty: Application of Non-parametric DEA Approach

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Original scientific paper
UDK: 364.662(4-6EU)
doi: 10.3935/rsp.v30i3.1840
Received: May 2021

Reduction of poverty or social exclusion belongs to the priorities of the EU countries defined in the Europe 2020 Strategy. This priority was defined as being interrelated with the priorities focused on employment and education. Numbers of people living in poverty varied between the EU countries, which also varied in the progress towards achieving their national targets concerning poverty reduction. The aim of the paper was to assess the EU countries with respect to the prevalence of poverty and its determinants in the context of the priorities of the Europe 2020 Strategy. Two methods were used to meet the aim of the paper – the correlation analysis and the Data Envelopment Analysis (DEA), including also the Malmquist Index. Results of the DEA revealed that all EU countries were not assessed as being fully efficient. A number of efficient countries first declined between the years 2008-2010, then it started to increase and reached the maximum value in 2017. Between the years 2010-2014, 11 countries improved their productivity, but between the years 2017-2019, improvement was identified only for five countries. Results of correlation analysis confirmed the importance of policies focused on households' incomes and employment for the successful reduction of poverty.

Keywords*:* DEA, determinants of poverty, EU countries, poverty, severe material deprivation.

INTRODUCTION

Increasing risk of poverty or social exclusion due to the pandemic of COVID-19 is a subject of importance of these days. As the pandemic has worsened economic and social situation in all European Union (EU) countries, economists speak about the worst crisis since the end of the WW2. This crisis hit the EU countries in the final year of the Europe 2020 Strategy, which introduced ambitious targets of the European Union in the fields of research and development, climate and energy, employment, education and poverty. Strategy was adopted in response to global economic and financial crisis, and aimed to *turn the EU into a smart, sustainable and inclusive economy delivering high levels of employ-*

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ment, productivity and social cohesion (European Commission, 2010: 3). The EU committed itself to reducing the number of Europeans living below the national poverty lines by 25% (in comparison with the year 2008) and to lift over 20 million people out of poverty. However, the number of people living at risk of poverty or social exclusion was reduced by 11.974 million for the EU27 between the years 2008 and 2019. The main responsibility for the policies contributing to the reduction of poverty and social exclusion is assigned to the EU countries. The EU countries introduced not only their own plans concerning the reduction of poverty, social exclusion and unemployment, but also tools they would use to meet them.

Although the COVID-19 pandemic has affected the fulfilment of the Europe 2020 Strategy, the majority of the EU countries were far from reaching their targets related to the reduction of poverty and social exclusion at the end of the year 2019. These countries would not meet their targets regardless the COVID-19. However, the fulfilment of the Strategy was also affected by a global economic and financial crisis that hit the EU countries in the first years of the strategic period, and economic recovery was too long and slow. Some EU countries also adopted too ambitious plans concerning the reduction of poverty or social exclusion, as all determinants of poverty are not under the direct control of the national policy-makers. Assessment of the EU countries reflecting the prevalence of poverty and its determinants can bring deeper insight into differences existing among these countries.

The EU countries' assessment can be addressed with the use of Data Envelopment Analysis (DEA), which enables the assessment of the relative efficiency of countries with respect to certain input and output variables. As the EU targets are formulated as being interrelated, the space for the application of DEA exists. To comply with the Strategy, employment and employability rates and educational levels can be regarded as inputs to the production process and rates of poverty can be considered the outputs. However, other factors can also contribute to the level, in which poverty occurs in the EU countries. At least, attention has to be paid to incomes and income inequality that primarily affect the material well-being of the EU citizens.

The aim of the paper is to assess the European Union countries with respect to the prevalence of poverty (expressed with the rates of severe material deprivation) and its determinants in the context of the priorities of the Europe 2020 Strategy. Two methods are used to meet the aim of the paper – the correlation analysis and the Data Envelopment Analysis (including also the Malmquist Production Index). The Pearson Correlation Coefficient is used to measure the strength of the relationship between input and output variables and to confirm of correctness of selected variables and assumptions required for the application of the second method. Technical efficiency scores are calculated with the DEA, which enables the measurement of relative efficiency of individual countries with respect to input and output variables. An output-oriented model with constant returns to scale is formulated for the years 2008, 2010, 2014, 2017 and 2019 which represent the period covered by the Europe 2020 Strategy (defined as the period of years 2010–2020). To meet the aim, the paper is structured as follows: (I) the concepts of poverty and its measurement are addressed; (II) the design of the analysis, used data and applied methods are introduced; (III) results of the analysis are presented; (IV) results are discussed with respect to the limits of the applied meth-

ods and policy implications are indicated. The analysis is led with the ambition to show that differences in technical efficiency scores of the EU countries exist and to show whether any improvements in the EU countries can be identified.

THEORETICAL BACKGROUND

Although the terms poverty and social exclusion are used together within the terminology of the Europe 2020 Strategy, both terms have distinctive meanings, as individuals can be poor without being socially excluded, and *vice versa*. In general, poverty refers to a situation of material deprivation that individuals live in, while social exclusion means a situation when individuals do not participate fully in the life of society because of various reasons. Being poor means to face a lack of money and material possessions (Estivill, 2003; Atkinson T., 1998; Room, 1995), objective economic deprivation, low economic welfare, or standard of living (Ravallion, 2019). Social exclusion is viewed to cover a remarkably wide range of socio-economic problems (Sen, 2000). Being socially excluded means to suffer from a combination of linked problems such as low incomes, unemployment, poor skills, poor housing, high crime environment, poor health and family breakdowns (Social Exclusion Unit, 2001). However, low incomes are generally understood as one of the most important causes of poor living. If poverty is considered the absence, lack or denial of advantage (Dean, 2016), social exclusion is understood as a multidimensional disadvantage (Room, 1995). Multidimensionality and the dynamic nature of social exclusion make its measuring difficult. Therefore, no standard measure of social exclusion exists. However, measures of poverty based on individuals' incomes or consumption are well-described and well-developed. Traditionally, income poverty is measured with the use of so-called income poverty lines. These lines can be defined as absolute or as relative measures (Ravallion, 2019). Since the 1960s, relative poverty measures have prevailed. Relative poverty measures usually refer to Townsend (1979: 31) who considered poor individuals those whose *resources are so seriously below those commanded by the average individual or family that they are, in effect, excluded from ordinary living patterns, customs and activities.* Alkire and Foster (2009) regarded the poverty measures dealing with incomes as the unidimensional ones, to which they added their own technique measuring poverty from a multidimensional perspective.

In 2010, the EU adopted the Europe 2020 Strategy that put forward three mutually reinforcing priorities (European Commission, 2010: 8*)*, when the third priority was called *inclusive growth* and it committed the EU to reduce the number of people living in poverty or social exclusion by 20 million by the year 2020, and this commitment was declared as one of the five headline targets of the Strategy. Strategy introduced the targets concerning employment and education as well, when the EU aimed to increase the employment rate to 75%, reduce the school drop-out rate by 10% and increase to a minimum of 40% the participation rate in the tertiary education for the 30 to 34-year-old citizens (Daly, 2012). The Strategy considered targets concerning poverty, employment and education as interrelated, as *better educational levels help employability and progress in increasing the employment rate helps to reduce poverty* (European Commission, 2010: 9). In response to the Europe 2020 Strategy, the EU countries set their national targets for the reduction of poverty or social exclusion, and they were allowed to

choose the most appropriate indicators for the measurement of the progress towards these targets. Respecting their national targets and policies, the EU countries have to contribute to the fulfilment of the EU targets (Nolan and Whelan, 2011). Details concerning the national targets of the EU countries are presented in Appendix 1.

The EU measures of poverty conceptually refer to the definition of poverty adopted by the Council of the EU in December 1984, according to which poor individuals are those *whose resources (material, cultural and social) are so limited as to exclude them from the minimum acceptable way of life in the Member States in which they live* (Council of the EU, 1985, Article 1, paragraph 2). Fusco et al. (2010) explained that the Council's definition covered both poverty elements: input elements (lack of resources) and outcome elements (exclusion from the minimum acceptable way of life). At the EU level and at the level of the majority of the EU countries, progress in the reduction of poverty or social exclusion is measured using a composite indicator, called at risk of poverty or social exclusion rate. This indicator covers three aspects of poverty – risk of poverty, severe material deprivation and living in households with very low work intensity. In general, measures of income poverty and material deprivation are considered to be complementary (Copeland and Daly, 2014; Fusco et al., 2010), and they are defined at the EU level as follows:

- At-risk-of-poverty rate expresses the proportion of population, whose equivalised disposable incomes after social transfers are below the at-risk-of-poverty threshold defined at 60% of the national median equivalised disposable income after social transfers (Eurostat, 2019). This measure of income poverty deals with poverty within the national framework because of the use of national income thresholds (Atkinson A. B., 2010).
- Material deprivation is understood as a lack of ordinary necessities, which are indicated to be the decent standard of living in the EU society. These necessities include *enforced inability to pay for at least four of the following nine items: unexpected expense, one week of annual holiday away from home, arrears, meal with meat or fish every other day, heating to keep the home adequately warm, washing machine, colour TV, telephone, and car* (Lecerf, 2016: 4). In its severe form, material deprivation is described as a lack of four of these nine necessities. Material deprivation deals with poverty in the EU context because it is based on a common set of items accepted in all EU countries (Atkinson A. B., 2010; Fusco, et al., 2010).

However, the composite indicator of poverty or social exclusion also reflects the number of people living in households with very low work intensity, which is quite questionable because jobless households are not necessarily poor households (Copeland and Daly, 2014; Nolan and Whelan, 2011). In general, low incomes are considered a key determinant of poverty and material deprivation, but other determinants of poverty must be considered in EU countries as well. They include education and employment (European Commission, 2010); quantity and quality of work having an impact on incomes (Herman, 2014) or structural inequality European Anti-poverty Network (2018). When the monetary determinants are considered, the key role of taxes and social transfers is emphasized among the policies contributing to the reduction of poverty (Darvas, 2017). Therefore, the EU measures of income poverty deal with the incomes after social transfers.

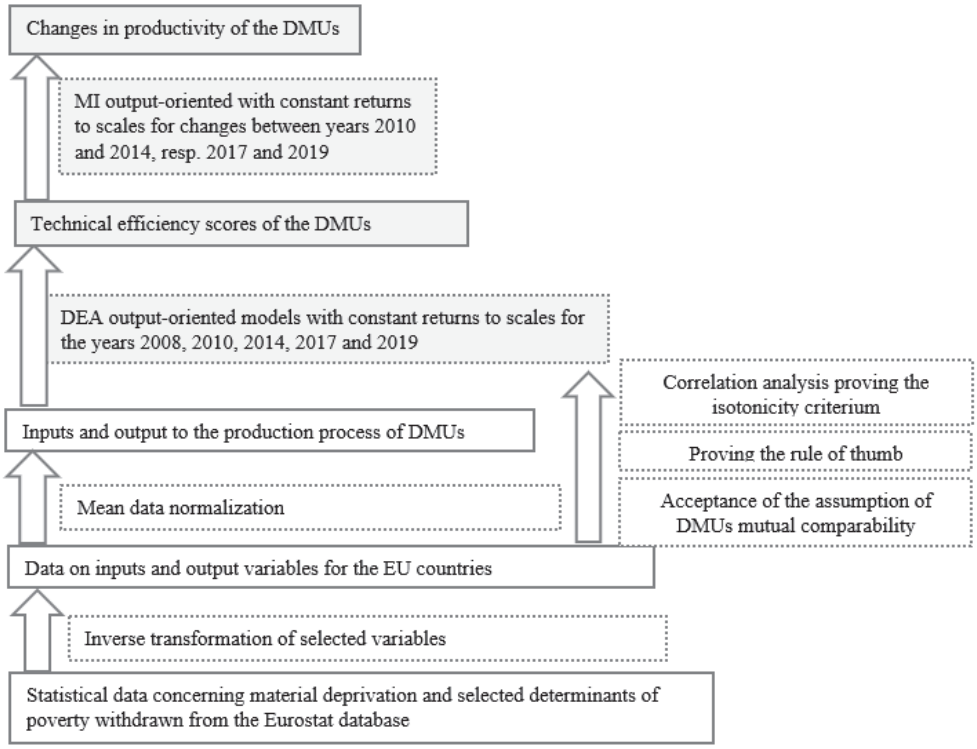
Poverty and material deprivation in the EU countries are quite frequent topics examined with different consequences and with the use of different methods. When the determinants of poverty are considered, multi-criteria decision-making methods (Łuczak and Kalinowski, 2020; Bárcena-Martín et al., 2020; Herman, 2014); methods measuring efficiency (Vall Fonayet et al., 2020; Habidov and Fan, 2010); methods of regression and correlation analysis (Bosco and Poggi, 2019; Dudek and Sedefoglu, 2019; Miežiené and Krutulienė, 2019; Kis and Gábos, 2016; Duiella and Turrini, 2014; Nolan and Whelan, 2011); or methods of multilevel analysis (Bosco and Poggi, 2019; Saltkjel, 2018) seem to be the most common ones. However, methods assessing the relative efficiency are less common than the other ones. An important part of the research dealing with poverty aims to identify relations and interrelations between the drivers or determinants of poverty and poverty or material deprivation rates (defined as the proportion of citizens living in poverty, resp. material deprivation). The commonly used determinants are population structure, long-term unemployment, educational levels, incomes, income inequality, expenditures on social benefits and social protection (Bosco and Poggi, 2019; Dudek and Sedefoglu, 2019; Balvociute, 2019; Israel and Spannagel, 2018).

RESEARCH OBJECTIVE, DATA AND METHODS

The EU countries differ when the proportions of citizens living in conditions of income poverty are considered, which results not only from different socio-economic situations in these countries but also from the definition of income poverty lines. More comparable is thus the prevalence of severe material deprivations as material deprivation is based on a common list of items that is accepted in all EU countries. Differences are also visible when the values of indicators referring to the determinants of poverty are compared. Therefore, the aim of the paper is to assess the European Union countries with respect to the prevalence of poverty (expressed with the severe material deprivation rates) and its determinants in the context of the priorities of the Europe 2020 Strategy.

Relative efficiency of the EU countries is measured for the years 2008, 2010, 2017 and 2019 that are chosen to represent the period, for which the Europe 2020 Strategy was adopted. The year 2008 represents the reference year for the assessment of the fulfilment of the targets of the Strategy; the year 2010 is the initial year of the strategic period; the year 2014 means the year when most EU countries recovered from the global economic and financial crisis and achieved positive rates of economic growth; the year 2017 means the last year for which data for all EU countries included into the analysis are available; and the year 2019 is the year with the latest data on material deprivation and determinants of poverty not affected with COVID-19 pandemic. Assessment is done for all EU countries with available data concerning input and output variables. Malta must be excluded from the analysis in all specified years because of the lack of data concerning the incomes. Croatia had to be excluded from the analysis done for the year 2008, Bulgaria and Luxembourg from the analysis done for the year 2019 because of the lack of data. The EU countries are considered to be homogenous decision-making units (DMUs), which use the same inputs to produce the same output. The design of the analysis is presented in Figure 1.

Figure 1
Design of the analysis



Source: author own processing.

Characteristics of statistical data

With respect to the literature review presented in Section 2, efficiency analysis deals with the standardized EU data concerning material deprivation (replacing poverty in the analysis) and determinants of poverty. Statistical data used in the analysis are taken from the Eurostat database. Indicators relating to employment, work intensity of households, adjusted gross disposable incomes, income inequality and share of individuals with tertiary education are considered the determinants of material deprivation (the input variables), and the material deprivation rates express the output variables. Available indicators used as the input variables X_2 and X_4, and output variable Y are transformed (inversed) to meet the assumption specified for the application of DEA (isotonicity criterion). Therefore, in fact, the efficiency of the EU countries refers to the percentage of citizens not being severally materially deprived. Input and output variables are specified in Table 1.

Table 1
Input and output variables for DEA

Input variables	**Specification**
X_1: Employment rate (EM_R)	for the persons aged 20 to 64 (in %)
X_2: Percentage of citizens not living in households with very low work intensity – rate (NLWI_R)	aged less than 60 (in %)
X_3: Adjusted gross disposable income of households (AGDI_M)	reflecting the PPS and accounting also for social benefits (per capita)
X_4: Income quintile share (IQS_I)	total income received by the 20% of population with the lowest income to that received by 20% population with the highest one
X_5: Percentage of population with tertiary educational attainment (PTE_R)	for persons aged 30 to 34 (in %)
Output variable	**Specification**
Y: Percentage of citizens not severely materially deprived (NSMD_R)	total population (in %)

Source: author with the use of Eurostat data (2021).

Statistical data concerning the input and output variables were first characterized with the use of the methods of descriptive statistics (see Appendix 2). Calculated mean, maximum and minimum values of the input variables and their fundamental trends in their development indicate the effect of global economic and financial crisis on the determinants of poverty in the first years of the examined period and later the economic recovery. Characteristics of the output variable indicate declining proportions of the EU countries' citizens affected by the severe material deprivation.

Data concerning the input and output variables are then examined to show whether they meet the isotonicity criterion of DEA and whether they are not significantly mutually correlated. Both tests are done with the use of the correlation analysis when the Pearson Bivariate Correlation Coefficients (PCC) are calculated with the use of SPSS for all variables of all DMUs and for all years from the period 2008-2019. Values of PCC confirm the correct selection of the input and output variables and the fulfilment of the isotonicity criterion that is necessary for the application of DEA (see Table 2).

Table 2
Results of the correlation analysis

	X_1 EM_R	**X_2 NLWI_R**	**X_3 AGDI_M**	**X_4 IE_I**	**X_5 PTE_R**	**Y NSMD_R**
EM_R	---					
NLWI_R	0.509**	---				
AGDI_M	0.469**	0.038	---			
IE_I	0.388**	0.216**	0.376**	---		
PTE_R	0.409**	0.110**	0.442**	0.135**	---	
NSMD_R	0.547**	0.179**	0.741**	0.530**	0.421**	---

Note: **Correlation is significant at the 0.05 level (2-tailed).

Source: own processing of Eurostat data (2021).

To avoid the imbalances in the data sets of input and output variables, the mean normalization of data was done. The process of normalization consisted of two steps – calculation of the mean values of the data and the division of values of input and output variables by the mean values of these variables (Sarkis, 2007). This normalization was done for all variables in all years.

Data Envelopment Analysis and Malmquist Index

Data Envelopment Analysis (DEA) dealing with the relative technical efficiency of certain productive entities, which can be defined as countries or territories as well, is an appropriate technique to assess the EU countries with respect to the prevalence of poverty and its determinants. DEA belongs to the methods of linear programming, and its essence lies in measuring the relative efficiency of the entities (called the Decision-Making Units, or DMUs) with respect to defining input(s) and output(s). DEA does not require specification of the functional form of the production frontier (Rayeni et al., 2010), as DEA model constructs it as a non-parametric production frontier, respectively empirically determines it with the use of observed values of input and output variables. Similarly, DEA requires no prior designation of the weights of inputs and outputs because they are determined by the model itself (Rabar, 2017). DEA model can be formulated when several assumptions are accepted, the fundamental are: (I) homogeneity or at least mutual comparability of the DMUs (DMUs should consume the same inputs and produce the same outputs); (II) the rule of thumb (number of DMUs has to be at least twice as large as the total number of input and output variables); (III) the isotonicity criterion (outputs have to be at least the same and do not fall when the inputs are increased) (Melecký et al., 2019; Rabar, 2017; Saljoughian et al., 2013; Sarkis, 2007).

When the countries' relative efficiency is assessed, an output-oriented DEA model with constant returns to scale (CRS) is preferred (Melecký et al., 2019). Models with the CRS are appropriate if all DMUs operate at the optimal scale (Huguenin, 2012). As the countries' scales are fixed and cannot be changed, models with CRS are preferred. These models refer to Charnes et al. (1978). Output-oriented DEA model ex-post assesses the relative technical efficiency (TE) in terms of the DMUs' ability to achieve maximum output(s) with a given sum of input(s). DMUs are assessed with respect to the multiple inputs and outputs and classified into efficient and inefficient ones. In general, values of TE scores range from 0 to 1, but in output-oriented DEA models calculated efficiency scores are higher than 1, therefore the TE scores in the output-oriented DEA model must be transformed to range from 0 to 1 with the use of ratio $\frac{1}{\theta_k}$. Technical efficiency scores are calculated in general as follows (Charnes et al., 1978; Huguenin, 2012):

Primal equation of CRS output-oriented model (1)

$$Minimize \sum_{i=1}^{m} v_i x_{ik}$$

$$Subject\ to$$

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \geq 1 \quad j = 1, \dots, n$$

$$\sum_{r=1}^{s} u_r y_{rk} = 1$$

$$u_r, v_i > 0 \quad \forall r = 1, \dots s \;\; i = 1, \dots, m$$

y_{rk} is the quantity of output produced by DMU k
x_{ik} is the quantity of input i consumed by DMU k
u_r is the weight of output r

Dual equation pf CRS output-oriented model (2)

$$Maximize\ \theta_k$$

$$Subject\ to$$

$$\theta_k y_{rk} - \sum_{j=1}^{n} \lambda_j y_{rj} \leq 0 \quad r = 1, \dots, s$$

$$x_{ik} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0 \quad i = 1, \dots, m$$

$$\lambda_j \geq 0 \quad \forall j = 1, \dots, n$$

$\frac{1}{\theta_k}$ *and* θ_k *represent the technical efficiency scores of* DMU_k

v_i is the weight of input i
n is the number of evaluated DMUs
s i the number of outputs
m is the number of inputs

The DEA model does not enable to compare changes in the DMUs' efficiency over time. Therefore, they must be supplemented with the Malmquist (Productivity) Index (MI) that measures productivity changes between two moments (years), further denoted by *t* and *t+1*. MI was introduced by Caves et al. (1982) and popularized by Färe et al. (1994). *MI is standardly defined on a benchmark technology satisfying constant returns to scale, which is to be distinguished from a best practice technology allowing for variable returns to scale. This convention enables it to incorporate the influence of scale economies, as a departure of the best practice technology from the benchmark technology* (Lovell, 2003, p. 440). When the year *t* technology is used as the benchmark technology, then the output-oriented MI is defined as follows (Lovell, 2003; Coelli et al., 2005):

$$MI_O^{t,t+1} = (x^t, y^t, x^{t+1}, y^{t+1}) = \left[\frac{D_{O(x^{t+1},y^{t+1})}^{t}}{D_O^t(x^t,y^t)} \cdot \frac{D_O^{t+1}(x^{t+1},y^{t+1})}{D_o^{t+1}(x^t,y^t)} \right]^{1/2} \tag{3}$$

Where *D* refers to the output distance function, the MI can be decomposed into two parts, changes in technical efficiency and shifts of scale efficiency, which are defined as follows (De Borger et al., 2002):

$$MI_o^{t,t+1} = \frac{D_O^{t+1}(x^{t+1},y^{t+1})}{D_O^t(x^t,y^t)} \cdot \left[\frac{D_O^t(x^{t+1},y^{t+1}}{D_O^{t+1}(x^{t+1},y^{t+1})} \cdot \frac{D_O^t(x^t,y^t)}{D_O^{t+1}(x^t,y^t} \right]^{1/2} \tag{4}$$

Change in technical efficiency between two years (*t* and *t+1*) is represented with the first part of the decomposed MI, whereas its second part stands for the technological change between these two years. Values of MI are interpreted as follows: MI > 1 productivity improves; MI < 1 productivity declines; MI = 1 productivity remains the same (Coelli et al., 2005). A similar interpretation is applied

to the components of MI (De Borger et al., 2002). Technical efficiency scores as well as Malmquist indexes are calculated with the use of DEAFrontier in MS Excel.

RESULTS OF THE ANALYSIS

The EU countries were assessed with the use of the above-specified DEA model processing the data on five input variables and one output variable. The output orientation of the DEA model was used as such model measures the relative efficiency of DMUs in terms of the output maximalization in the conditions of the given sum of inputs. The production possibility frontier was empirically determined by the model itself considering the values of input and output variables of all EU countries included in the analysis. Countries that were classified or assessed to be efficient in comparison with the rest of the DMUs, were assigned TE scores of 1, which means 100% efficiency. When the DMUs were not located in the production possibility frontier, their TE scores were higher than 1, after transformation lower than 1. It means that these countries did not operate efficiently. Values of their TE scores were calculated as the distance between the points representing their values of input and output variables and points representing the projection of these points on the efficient frontier (assuming constant returns to scale and an output orientation of the model). The EU countries with TE scores lower than 1 could increase their outputs (percentage of citizens not being severally materially deprived) with the given inputs and improve thus their technical efficiency to be fully efficient with the given sum of inputs.

In the examined years, the numbers of efficient and inefficient EU countries differ, and overall results reveal that the EU countries were affected by the global economic and financial crisis in the first years of the examined period as the highest number of inefficient countries was reached in the year 2010 (see Table 3).

Table 3
Overall results of TE scores calculated for the EU countries

Number of:	2008	2010	2014	2017	2019
efficient DMUs	15	9	10	12	8
inefficient DMUs	10	17	16	14	15
included DMUs	25	26	26	26	23
Excluded DMUs	Croatia, Malta	Malta	Malta	Malta	Malta, Bulgaria Luxembourg

Source: own processing of Eurostat data (2021).

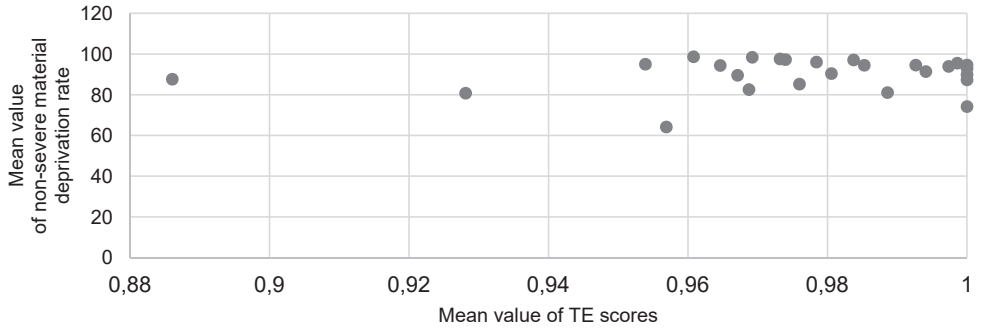
Only five EU countries met TE scores of 1 in every year in which they were included in the analysis (Croatia, Ireland, Italy, Romania, and Spain), and eleven EU countries were assessed as efficient in three years at least. As the values of slacks equalled 0, these countries can be regarded as the fully efficient ones. Eight EU countries did not meet TE scores of 1 in any examined year. The overall results of the TE scores calculated for the EU countries also revealed that the assessment of the EU countries was worsened in the year 2019 as a higher number of countries were assessed as being inefficient. On the other hand, the lowest TE score reached in this year was the highest one in comparison with the lowest TE scores reached in other examined years. TE scores of all EU countries in all examined years are presented in detail in Appendix 3.

The DEA method assesses the relative efficiency of DMUs (and not the absolute efficiency), which means that the DEA as-

sesses whether the country reaches the maximum output with the given inputs in relation to other analysed DMUs. Therefore, the EU countries recognized as the efficient ones did not have to be the countries with the lowest prevalence of material deprivation (see Figure 2). This was the case of Bulgaria and Romania which were identified as efficient DMUs in the analysis although they were the two countries most seriously affected by poverty. However, in all EU countries either efficient or inefficient, there is still space for improvements when poverty reduction has been a reaffirmed target of their national policy-makers.

Figure 2 demonstrates the relationship between the mean values of TE scores and the proportions of citizens not being severely materially deprived (for the years 2008–2019). The lowest mean values of TE scores were measured by Cyprus (0.8861), Hungary (0.9281) and France (0.9539), whereas the lowest mean rates regarding the proportions of citizens not being materially deprived were reported by Bulgaria (63.21%), Romania (74.24%) and Hungary (80.82%). It is obvious that no significant relationship exists between these two variables.

Figure 2
Relation between mean values of TE scores and non-severe material deprivation rates



Source: own processing of Eurostat data (2021).

The results of DEA reveal which countries are efficient, and which are inefficient, but they show nothing about the improvements in countries' efficiency over time. To consider the time factor, the Malmquist index is calculated as it enables identifying whether the efficiency of the EU countries was improved, remained the same or even declined between two years. Malmquist index is used to show the changes in efficiency between the years 2010 and 2014, and then between the years 2017 and 2019.

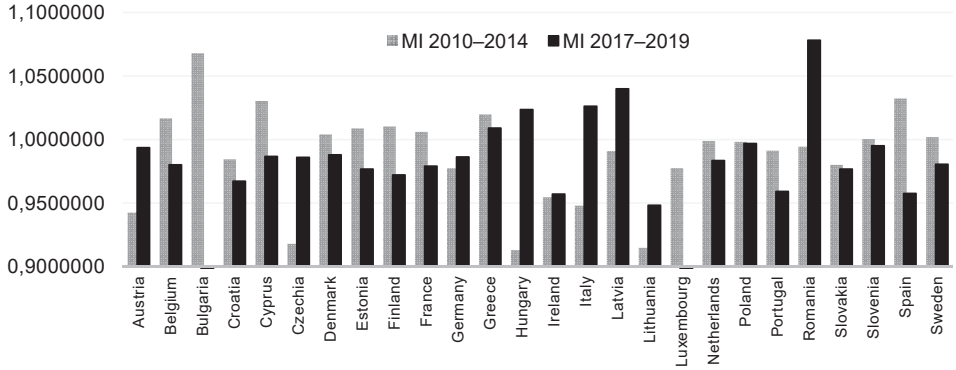
Table 3
Overall results of the MI calculated for the EU countries

Number of DMUs:	2010 – 2014	2017 – 2019
with improved performance	11	5
with decreased performance	15	19
included DMUs	26	24
Excluded DMUs	Malta	Malta, Bulgaria Luxembourg

Source: own processing of Eurostat data (2021).

The values of MI calculated for the EU countries confirmed their declining efficiency which was indicated by the increased number of countries assessed as being inefficient when the results of DEA for the years 2017 and 2019 were compared. Between the years 2010 and 2014, eleven EU countries improved their productivity, but between the years 2017 and 2019, improvement was identified only for five countries (Greece, Hungary, Italy, Latvia, and Romania). Values of MI for all EU countries are presented in Figure 3 and in detail in Appendix 4.

Figure 3
Values of the Malmquist index calculated for the EU countries



Source: own processing of Eurostat data (2021).

Between the years 2010 and 2014, the highest value of the MI was reached by Bulgaria (1.0680). Bulgaria's mean value of severe material deprivation rate measured during the period 2010–2014 was the highest one among the EU countries, and thus the proportion of Bulgarian citizens not being severely materially deprived was the lowest one among all EU citizens. However, Bulgaria increased the proportion of this population by 9 p.p. between 2010 and 2014. The lowest value of MI was reached by Hungary (0.9130). The case of Lithuania indicated that there was no direct relationship between the increasing proportion of the non-severely materially deprived and the values of MI. In Lithuania, the proportion of non-severally materially deprived citizens increased by 6 p.p., but its value of MI was the second lowest (0.9148). Values of MI measured for the changes between the years 2017 and 2019 indicated the highest improvement in Romania (1.0783), the highest deterioration for Lithuania, although the proportion of Lithuanian citizens not being severely deprived increased by 3 p.p. The most significant improvement in terms of reduction of severe material deprivation rate was again identified for Bulgaria, but MI of Bulgaria could not be calculated because of the lack of data for Bulgaria in the year 2019.

Decomposition of the MI enables to identify how the technical efficiency and the frontier shift changed between the years 2010 and 2014, resp. 2017 and 2019, in the EU countries. The fist component – the efficiency change refers to the change in efficiency of each EU country between these two specified years. It can be called as the catch-put effect. The second component – the frontier shift explains the change in the best practice between two examined years. Table 4 shows the EU countries classified according to the reached values of the MI components.

Table 4
Overall results of the MI decomposed for the EU countries

Number of DMUs with:	2010 – 2014	2017 – 2019
efficiency change > 1	12	12
efficiency change = 1	8	7
efficiency change < 1	6	5
frontier shift > 1	8	2
frontier shift < 1	18	21
included DMUs	26	24
Excluded DMUs	Malta	Malta, Bulgaria Luxembourg

Source: own processing of Eurostat data (2021).

Between the years 2010 and 2014 as well as the years 2017 and 2019, positive change in the technical efficiency was measured for 12 EU countries. On average, the technical efficiency was increased by 2.82%. The technical efficiency remained the same for 8 countries and a decrease was found for 6 countries. Their technical efficiency was decreased by 4.83%. Between the years 2017 and 2019, the EU countries with increased technical efficiency reached the average increase of 1.56%, while the EU countries with decreased technical efficiency reached the average decrease of 1.58%. Both average percentage changes were thus lower than the changes identified between the years 2010 and 2014. The values of MI components are presented in details in Appendix 4.

DISCUSSION AND CONCLUSIONS

The aim of the paper was to assess the European Union countries with respect to the prevalence of poverty (expressed with the severe material deprivation rates) and its determinants in the context of the priorities of the Europe 2020 Strategy. The analysis was led with the ambition to show that the EU countries differed with respect to the prevalence of poverty and its determinants in the examined years (2008, 2010, 2014, 2017 and 2019), and to show whether any improvements in the EU countries could be identified.

The EU countries were assessed with the use of Data Envelopment Analysis, which is a genuine technique of performance measurement, which enables dealing with multiple inputs and outputs. The limitations of the DEA model have to be seen in the DEA fundaments because DEA is a statistical and non-parametric technique. DEA cannot compare TE scores achieved in two different years and assess the achievements of the countries with respect to their plans and targets. The results of the DEA model enable only to classify or assess countries into efficient and inefficient ones. Moreover, the assessment is further limited by the fact that DEA measures the relative and not the absolute efficiency. To consider the time factor in DEA models, the Malmquist Productivity Index must be added to the analysis. MI enables comparing efficiency of DMUs in two different moments (years). The optics of the DEA assumptions and limitations have to be considered when the results are interpreted, and conclusions are formulated.

Employment rate, percentage of the population not living in households with very low work intensity, adjusted gross disposable incomes, inequality measure of income quintile shares and percentage of the population with tertiary education were used as the input variables (X_1–X_5) in

the DEA model as they determine the socio-economic standard of living in the EU countries. Rates of severe material deprivation were used as the output variable Y in the DEA model. To meet the assumptions of DEA, the input variables X_2, X_4 and Y had to be inverted, thus the output expressed the percentage of citizens not being severally material deprived. Results of the correlation analysis showed that the output variable was positively strongly correlated with the input variables X_3 (PCC 0.741), X_1 (PCC 0.547), X_4 (PCC 0.530) and X_5 (PCC 0.421), which confirmed the importance of incomes and employment within the policies focusing on reduction of poverty.

Assessment of the EU countries based on the prevalence of material deprivation and selected determinants of poverty showed that the numbers of (in)efficient countries differed when the results were compared between the examined years. The lowest percentage of inefficient countries was identified for the year 2008 (40%), which is the reference year for the evaluation of the achievement of the targets defined in the Europe 2020 Strategy. In other years, the percentage of inefficient countries exceeded 50%, when this percentage first declined from 65% to 62% between years 2010 and 2014, and then it increased from 54% to 65% between years 2017 and 2019. These results indicated that the number of EU countries performing below their capacity increased at the end of the period framed with the Europe 2020 Strategy. Only five EU countries met technical efficiency scores of 1 in every examined year, in which they were included in the analysis (Croatia, Italy, Ireland, Romania, Spain), and eleven EU countries were assessed as efficient ones in three years at least. Eight EU countries did not meet the efficiency scores of 1 in any examined year (Austria, Cyprus, France, Greece, Luxembourg, Netherlands, Slovakia, Slovenia, and Sweden). Progress in the EU countries' productivity was measured with the use of Malmquist index. Its values showed that 42% of the EU countries improved their productivity between the years 2010 and 2014. However, between the years 2017 and 2019, improvement was identified for only 21% of the EU countries.

The fulfilment of the EU countries' national targets concerning the reduction of poverty or social exclusion was assessed in Appendix 1. Results presented there showed that only 21 EU countries formulated their targets concerning the reduction of poverty or social exclusion in line with the EU targets and used standard EU measures. Only nine of these 21 countries achieved their national targets by the year 2019. However, no relationship between the mean values of the technical efficiency scores and the fulfilment of nations' objectives was identified, which indicated that there was a space for improvements also in countries meeting their targets. Results of the Data Envelopment Analysis confirmed that the outputs of some EU countries were below their possibilities when the given sums of inputs were considered. How could these countries increase their efficiency? As the strong positive correlation was identified for the variables concerning adjusted gross disposable incomes after social transfers and the percentage of people not being severely materially deprived, policy implications can be seen in better targeting of social transfers provided to people facing some form of material poverty. This kind of improvement would increase the countries' efficiency scores as it would increase the proportions of citizens not being severally materially deprived.

Since the crisis of the COVID-19 pandemic has had an impact on employ-

ment, incomes as well as on education, it also affected the fulfilment of the Europe 2020 Strategy's targets during the year 2020. However, the pandemic was not the only reason that limited the European Union and the EU countries' possibilities to achieve the targets formulated for the reduction of poverty and social exclusion. The World Bank (2020: 11) estimated that *at least one in five households in EU countries are likely to suffer income losses because of a reduction or loss of employment in the lockdown phase of the crisis*, which will have a significant impact on the prevalence of poverty and social exclusion in the European Union. The World Bank expected that the at-risk-of-poverty rates could rise by 3–4 percentage points for the year 2020. The effects of COVID-19 on the poverty prevalence in the EU countries stay beyond the scope of this paper because of the lack of data, but they will be addressed by the author's further research.

Acknowledgement

This paper was created within the project SGS SP2021/51 titled *Complex Use of Quantitative Methods in Economic Disciplines* that was conducted at the Faculty of Economics, VŠB–Technical University of Ostrava, Czechia.

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Appendix 1

National targets of the EU countries for the poverty reduction

Country	ARoPE	ARoP	MD	LWI	Other	Target Europe 2020		Results 2019	Target met yes/no	Mean	Efficient (number of years)
						Reduce by/to	Target (persons thousands / proportion %)				
Austria	✔	✘	✘	✘	✘	by	235 000	- 227 000	No	0.9784137	0
Belgium	✔	✘	✘	✘	✘	by	380 000	+ 3 000	No	0.9852693	2
Bulgaria	✘	✔	✘	✘	✘	by	260 000	- 46 0000	No	0.9568861	1
Croatia	✔	✘	✘	✘	✘	to	1 222 000	939 000	Yes	1	4
Cyprus	✔	✘	✘	✘	✘	to	19.30%	22.3%	No	0.8860462	0
Czechia	✔	✘	✘	✘	✘	by	100 000	-260 000	Yes	0.9926521	3
Denmark	✘	✘	✘	✔	✘	by	22 000	+ 33 000	No	0.9837366	1
Estonia	✘	✔	✘	✘	✘	to	15.00%	21.7%	No	0.9973699	4
Finland	✔	✘	✘	✘	✘	to	770 000	849 000	No	0.973975	1
France	✔	✘	✘	✘	✘	by	1 900 000	- 262 000	No	0.953886	0
Greece	✔	✘	✘	✘	✘	by	450 000	+ 116 000	No	0.9687326	0
Hungary	✔	✘	✘	✘	✘	by	450 000	- 986 000	Yes	0.9281081	1
Italy	✔	✘	✘	✘	✘	by	2 200 000	+ 306 000	No	1	5
Lithuania	✔	✘	✘	✘	✘	by	170 000	- 176 000	Yes	0.9759748	3
Luxembourg	✔	✘	✘	✘	✘	by	6 000	50 000	No	0.9607863	0
Malta	✔	✘	✘	✘	✘	by	6 560	+ 16 000	No	N/A	N/A
Poland	✔	✘	✘	✘	✘	by	1 500 000	- 4 800 000	Yes	0.9671037	1
Portugal	✔	✘	✘	✘	✘	by	200 000	- 542 000	Yes	0.9940948	4
Romania	✔	✘	✘	✘	✘	by	580 000	- 3 042 000	Yes	1	5
Slovakia	✔	✘	✘	✘	✘	to	17.20%	16.4%	Yes	0.9805599	2
Slovenia	✔	✘	✘	✘	✘	by	40 000	- 68 000	Yes	0.9646156	0
Spain	✔	✘	✘	✘	✘	by	from 1 400 000 to 1 500 000	979 000	No	1	5
Germany	✘	✘	✘	✘	✔ *	**reduce by 20% number of long-term unemployed people*				0.9986105	4
Ireland	✘	✘	✘	✘	✔ *	** reduce by a minimum of 200 000 people in combined poverty*				1	5
Latvia	✘	✘	✘	✘	✔ *	**reduce number of people ARoP or with LWI by 21 %*				0.988603	3
Netherlands	✘	✘	✘	✘	✔ *	**reduce by 100 000 number of people living in a jobless households*				0.9731851	0
Sweden	✘	✘	✘	✘	✔ *	**reduce below 14 % of people who are not in labour foce, long-term unemployed, long-term sick leave*				0.9764571	1

Appendix 2
Statistical description of the used input and output variables

2008	EM_R	NLWI_R	AGDI_M	IQS_I	PTE_R	NSMD_R
Mean value	71.50	92.12	17 912.68	0.22	31.96	90.00
Max. value	80.40	95.50	31085.00	0.30	47.90	99.30
Min. value	61.50	86.30	7626.00	0.14	15.40	58.80
St. deviation	5.02	2.42	5 731.99	0.05	10.49	9.65
2010	EM_R	NLWI_R	AGDI_M	IQS_I	PTE_R	NSMD_R
Mean value	68.20	90.37	17 497.42	0.22	34.50	88.97
Max. value	78.10	95.10	29509.00	0.29	51.40	99.50
Min. value	59.90	77.10	7880.00	0.14	18.30	54.30
St. deviation	5.19	3.50	5 515.56	0.05	10.11	10.50
2014	EM_R	NLWI_R	AGDI_M	IQS_I	PTE_R	NSMD_R
Mean value	68.74	89.09	18 606.08	0.21	39.76	89.41
Max. value	80.00	93.90	32368.00	0.29	54.60	99.00
Min. value	53.30	79.00	9754.00	0.14	23.90	66.90
St. deviation	6.15	3.62	5 721.59	0.05	9.05	8.25
2017	EM_R	NLWI_R	AGDI_M	IQS_I	PTE_R	NSMD_R
Mean value	72.27	90.71	19 940.23	0.21	42.16	91.93
Max. value	81.80	94.60	32514.00	0.29	58.00	98.90
Min. value	57.80	83.80	10875.00	0.12	26.30	70.00
St. deviation	5.57	3.04	5 421.07	0.05	9.12	6.93
2019	EM_R	NLWI_R	AGDI_M	IQS_I	PTE_R	NSMD_R
Mean value	74.53	91.89	21 301.29	0.22	43.65	94.18
Max. value	82.10	95.80	30333.00	0.30	58.80	98.20
Min. value	61.20	86.20	14969.00	0.14	25.80	83.80
St. deviation	5.49	2.68	4 571.57	0.05	8.85	3.81

Appendix 3
Technical efficiency scores of the EU countries

EU Country	Technical Efficiency Scores				
	2008	2010	2014	2017	2019
Austria	0.976341	0.98952	0.966851	0.972396	0.98696
Belgium	1	0.945376	0.98277	0.9982	1
Bulgaria	0.981118	0.875140	0.971287	1	N/A
Croatia	N/A	1	1	1	1
Cyprus	0.896543	0.845315	0.870301	0.902592	0.915479
Czechia	1	1	1	0.979593	0.983668
Denmark	1	0.964374	0.988693	0.974953	0.990663
Estonia	1	1	1	1	0.986849
Finland	0.972764	0.933232	0.966152	1	0.997726
France	0.977134	0.925825	0.948906	0.956384	0.961182
Germany	1	0.993053	1	1	1
Greece	0.994207	0.958559	0.964061	0.95487	0.971966
Hungary	1	0.932881	0.849798	0.90506	0.952802
Ireland	1	1	1	1	1
Italy	1	1	1	1	1
Latvia	1	0.979654	0.96336	1	1
Lithuania	1	1	0.905366	1	0.974508
Luxembourg	0.998911	0.946538	0.927952	0.969744	N/A
Netherlands	0.994203	0.942741	0.965868	0.975832	0.987282
Poland	1	0.954956	0.938024	0.964929	0.977611
Portugal	1	1	1	1	0.970474
Romania	1	1	1	1	1
Slovakia	1	0.994029	1	0.958604	0.950166
Slovenia	0.974523	0.957380	0.959293	0.956211	0.975671
Spain	1	1	1	1	1
Sweden	0.977994	0.936790	0.963766	0.976515	0.990986

Appendix 4
Values of Malmquist index calculated for the EU countries

EU country	2010–2014			2017–2019		
	MI, output oriented			MI, output oriented		
	Malmquist index	Efficiency Change	Frontier Shift	Malmquist Index	Efficiency Change	Frontier Shift
Austria	0.9424509	0.9770906	0.9645481	0.9936530	1.0149779	0.9789898
Belgium	1.0166001	1.0395541	0.9779194	0.9801737	1.0018032	0.9784095
Bulgaria	1.0679582	1.1098651	0.9622414	N/A	N/A	N/A
Croatia	0.9845152	1	0.9845152	0.9673117	1	0.9673117
Cyprus	1.0303327	1.0295588	1.0007516	0.9867768	1.0142776	0.9728862
Czechia	0.9179109	1	0.9179109	0.9860663	1.0041597	0.9819815
Denmark	1.0040801	1.0252169	0.9793831	0.9880699	1.0161131	0.9724015
Estonia	1.0088119	1	1.0088119	0.9768313	0.9868493	0.9898485
Finland	1.0103030	1.0352748	0.9758790	0.9722362	0.9977264	0.9744517
France	1.0060769	1.0249306	0.9816049	0.9791750	1.0050167	0.9742873
Germany	0.9774887	1.0069961	0.9706976	0.9863877	1	0.9863877
Greece	1.0197886	1.0057395	1.0139689	1.0090985	1.0179039	0.9913495
Hungary	0.9130179	0.9109396	1.0022815	1.0236476	1.0527505	0.9723554
Ireland	0.9546194	1	0.9546194	0.9571218	1	0.9571218
Italy	0.9479709	1	0.9479709	1.0262662	1	1.0262662
Latvia	0.9909567	0.9833676	1.0077174	1.0399384	1	1.0399384
Lithuania	0.9148120	0.9053658	1.0104335	0.9483288	0.9745080	0.9731359
Luxembourg	0.9775397	0.9803640	0.9971191	N/A	N/A	N/A
Netherlands	0.9989311	1.0245325	0.9750117	0.9834817	1.0117331	0.9720763
Poland	0.9982354	0.9822695	1.0162541	0.9969431	1.0131430	0.9840103
Portugal	0.9913048	1	0.9913048	0.9592336	0.9704742	0.9884174
Romania	0.9944100	1	0.9944100	1.0782713	1	1.0782713
Slovakia	0.9801129	1.0060072	0.9742603	0.9768621	0.9911977	0.9855371
Slovenia	1.0004150	1.0019984	0.9984198	0.9951844	1.0203515	0.9753349
Spain	1.0323225	1	1.0323225	0.9576516	1	0.9576516
Sweden	1.0020070	1.0287966	0.9739602	0.9806191	1.0148185	0.9662999

Sažetak

PROCJENA ZEMALJA EU-A S OBZIROM NA RASPROSTRANJENOST TEŠKE MATERIJALNE DEPRIVACIJE I DETERMINANTE SIROMAŠTVA: PRIMJENA NEPARAMETRIJSKOG DEA PRISTUPA

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Smanjenje siromaštva ili socijalne isključenosti spada u prioritete zemalja EU definirane u Strategiji Europa 2020. Ovaj je prioritet definiran kao međusobno povezan s prioritetima usmjerenim na zapošljavanje i obrazovanje. Brojevi ljudi koji žive u siromaštvu razlikovali su se između zemalja EU-a, što se također razlikovalo u napretku u postizanju njihovih nacionalnih ciljeva u vezi sa smanjenjem siromaštva. Cilj rada bio je procijeniti zemlje EU a s obzirom na prevalenciju siromaštva i njegove odrednice u kontekstu prioriteta Strategije Europa 2020. Dvije metode korištene su za postizanje cilja rada - korelacijska analiza i Analiza obuhvaćanja podataka (DEA), uključujući i Malmquistov indeks. Rezultati DEA otkrili su da nisu sve zemlje EU procijenjene kao potpuno učinkovite. Broj učinkovitih zemalja prvo se smanjio između 2008. i 2010. godine, a zatim se počeo povećavati i dosegao je maksimalnu vrijednost u 2017. godini. Između 2010. i 2014. godine 11 zemalja poboljšalo je svoju produktivnost, ali između 2017. i 2019. godine poboljšanje je utvrđeno samo za pet zemalja. Rezultati korelacijske analize potvrdili su važnost politika usmjerenih na dohotke i zaposlenost kućanstava za uspješno smanjenje siromaštva.

Ključne riječi: DEA, odrednice siromaštva, zemlje EU, siromaštvo, ozbiljna materijalna deprivacija.