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THE EFFICIENCY OF HEALTHCARE SYSTEM EXPENDITURES: EVIDENCE FROM CROATIA

Abstract

Offering an efficient healthcare system is one of the main focuses of economic development for every country in the world, including Croatia, in order to achieve a better quality of life and healthcare protection. As a result, there is also a higher standard of living for the citizens. The healthcare system in Croatia has undergone a number of reforms. For each of the implemented reforms, the objective was to optimize the healthcare system in line with the government's budget to achieve sustainability in the long run. Therefore, the healthcare financing system and sustainability play an important role. The objective of this paper is to evaluate and analyze the efficiency of average healthcare expenditures in twenty Croatian counties by applying the data envelopment analysis approach. The analysis was conducted for the 2010-2017 period. To assess the performance of the counties, we used three inputs and three outputs. The results revealed significant differences in the efficiency of healthcare expenditures among the Croatian counties. Therefore, the results of scale efficiency showed that, among the twenty Croatian counties, only six counties (Brod-Posavina, Koprivnica-Križevci, Lika-Senj, Međimurje, Vukovar-Srijem and Zagreb) operate at the maximum score.

Keywords: Healthcare system expenditures, efficiency, data envelopment analysis, Croatia

1. Introduction

European countries, including Croatia, have restricted the amount of funds available to the healthcare system due to budget restrictions. Therefore, the lack of private funding leads to a question of the financial sustainability and efficiency of the national healthcare systems, the quality of healthcare services and health protection. By achieving all the aforementioned goals, the landscape of healthcare management in Europe, and thus Croatia, will be improved.

In theory, there are three models to finance a healthcare system: the Beveridge model, the Bismarck model and the market or national health insurance model. In the first model, healthcare is ensured and financed by the government through tax payments. The second model uses an insurance system financed jointly by employers and employees through payroll deduction and the third model places an emphasis on private-sector providers and is financed by a government-run insurance program that every citizen pays into. In light of its characteristics regarding financing, the Croatian healthcare system can be categorized partly as the Bismarck model and partly as the Beveridge model. Within the Beveridge model, there is a social security contribution which differs among countries. According to the Act on Contributions[1], the rate for compulsory health insurance is 16.5 percent, except for special contributions for using the healthcare insurance abroad, where the rate is 10 percent. The central organisation for financing and providing healthcare services is the Croatian Health Insurance Fund. This organisation is involved in the work of the State Treasury, which means that the funds for healthcare services performed are reimbursed out of the budget to hospitals and other healthcare providers. The main activities that are financed out of the budget are primary healthcare services for general or family medicine, infant and preschool child care services, women's health care service, health visitors service, home care service, dental and oral health service, emergency medical service, and school health service. In the budget structure, most of the expenditures are for healthcare protection, which includes primary healthcare protection, urgent medical assistance and medical transport, medical implantation and others (76 percent), followed by expenditures for maternity benefits (12 percent) and other expenditures (2 percent) for 2012 (Kovač, 2013: 557). Croatia is not the only country that has a problem with providing an efficient allocation of resources for its healthcare system. The share of healthcare expenditures as a percentage of the gross domestic product (GDP) for the period 2010-2016 on average for the 28 Member States of the European Union[2] is presented in Figure 1 (see Appendix). Based on the observed results, the countries whose healthcare expenditures constituted the highest share of the GDP are France (11.39 percent), Germany (10.94 percent) and Sweden (10.61 percent), while the countries with the lowest results are Romania (4.93 percent), Latvia (5.71 percent) and Estonia (6.19 percent). The results for Croatia reveal that 7.05 percent of the GDP is spent on healthcare expenditures.

Based on all the observed facts and problems in this paper, we evaluated and analyzed the efficiency of the healthcare expenditures of twenty Croatian counties by using the Data Envelopment Analysis (DEA) mathematical model. The counties covered by our analysis are Zagreb, Krapina-Zagorje, Sisak-Moslavina, Karlovac, Varaždin, Koprivnica-Križevci, Bjelovar-Bilogora, Primorje-Gorski Kotar, Lika-Senj, Virovitica-Podravina, Požega-Slavonija, Brod-Posavina, Zadar, Osijek-Baranja, Šibenik-Knin, Vukovar-Srijem, Split-Dalmatia, Istria, Dubrovnik-Neretva and Međimurje. The City of Zagreb was excluded because of its dual status of a city and a county, and because of its unique status with regard to other territorial self-governing units within the Republic of Croatia. The analysis was conducted for the period 2010-2017. Therefore, our main objective was to identify the most efficient counties, taking into consideration three input variables (healthcare expenditures, the number of doctors and the number of hospital beds) and three output variables (the vital index, the number of examinations and the number of patients per bed) in each county. Finally, the paper contributes to research evidence with respect to the differing efficiency rates among Croatian counties concerning average healthcare expenditures in the period 2010-2017.

The structure of the paper is organized as follows. After the introduction, Section 2 provides a brief literature review on healthcare system efficiency in the world and the European Union. Section 3 briefly describes the methodology and data that was used, while Section 4 presents the empirical results. The last section provides concluding remarks and recommendations for further research.

2. Literature Review

While researching the existing literature, it became evident that there are quite a number of various studies that measure the efficiency of government expenditures on healthcare by applying different methodologies. However, some of the studies evaluated and compared healthcare system expenditures at the country level or among different countries. In addition, different approaches, like parametric or non-parametric analytical techniques, for instance the stochastic frontier analysis model and DEA, were applied.

Asandului et al. (2014) evaluated the efficiency of healthcare systems in Europe by applying a non-parametric method – DEA. By observing 30 European states in 2010, they found that there are more inefficient countries despite the number of both developed and developing countries on the efficiency frontier. Lo Storto and Goncharuk (2017) conducted a benchmarking study of healthcare systems in 32 European countries in the period

2011-2014 by using two-dimensional models – efficiency and effectiveness within the DEA model. The results of the research showed that a group of countries like the Ukraine, Bulgaria, Switzerland, Lithuania and Romania have the lowest performing healthcare systems and thus healthcare reforms are inevitable. Moreover, the aims of these reforms are to reduce resource intensity and increase the quality of medical services. According to Medeiros and Schwierz (2015), there is widespread inefficiency in the healthcare systems among the European Union countries. They used three models with the following combinations of inputs (expenditure on healthcare, physical inputs and environmental variables) and outputs (life expectancy, healthy life expectancy and amenable mortality rate). Their results showed that the Czech Republic, Lithuania and Slovakia had the lowest efficiency scores. Mitrović et al. (2016) also conducted similar research to evaluate the efficiency of the healthcare system of Serbia in comparison with European countries by applying DEA. They used three outputs representing mortality rates and three inputs representing healthcare expenditures and healthcare human resources. The results showed that the healthcare system of Serbia ranks 15th out of the 21 analyzed systems. Using a sample of 24 OECD countries, Bhat (2005) examined the influence of specific financial and institutional arrangements on national healthcare system efficiency by using the DEA model. The author found that healthcare systems which are public-contract and public-integrated are more efficient than those based on public-reimbursement. Later on, De Cos and Moral-Benito (2014) examined which determinants are the most important for healthcare efficiency across 29 OECD countries by performing the DEA and stochastic frontier analysis from 1997 to 2009. Hsu (2013) evaluated the efficiency of health spending in 46 countries in Europe and Central Asia for the period 2005-2007. In addition, the productivity is also evaluated over time for 46 countries in Europe and Central Asia. To evaluate efficiency, DEA was applied, while for productivity, the Malmquist productivity index was utilized. In a later stage of research, the Tobit model examined the relationship between technical efficiency and country-specific characteristics. The results showed that countries in both Europe and Central Asia need to improve their technical efficiency with regard to healthcare expenditures. In addition, the average level of overall technical efficiency is 98.8 percent, while the productivity growth decreased on average by 7.7 percent per year over the period 2005-2007. Using a Chinese sample, Han and Miao (2010) analyzed local health expenditure efficiency employing the two-stage framework of the DEA-Tobit model based on panel data for 31 provinces from 1997 to 2007.

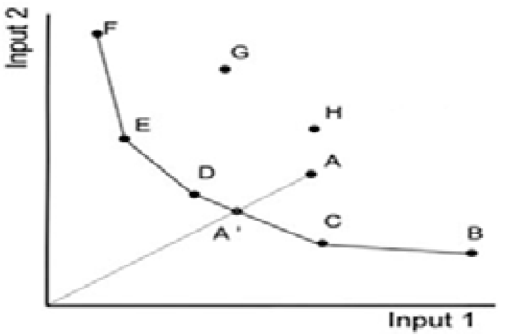
Rivera (2010) found that an increase in public healthcare expenditures would automatically lead to an improvement in the self-estimated health status. A study of Payne et al. (2007) showed that increased life expectancy represents a pressure factor for health expenditures, if morbidity is not decreased or kept constant. Joumard et al. (2010) found that institutional characteristics, such as the allocation of resources between in and out-patient care and the payment schemes, have a significant impact on efficiency.

3. Methodology and Data

To evaluate the relative or technical efficiency of comparable entities based on empirical data on their inputs and outputs, we applied the non-parametric DEA mathematical model. This is a non-parametric method based on mathematical, more accurate linear programming. Farnell laid down the foundations for the DEA model in 1957, which was later developed by Charnes et al. (1978). This method identifies the most efficient units in a given set, without assuming any type of functional relationship between inputs and outputs. Data on selected inputs and outputs are included for all analyzed decision-makers (DMs) in a linear program representing the selected DEA model. By doing so, it evaluates the efficiency of a single decision-maker within a set of comparable decision-makers, i.e. those that convert multiple inputs into multiple outputs identical to those of the observed decision-maker. Since the efficiency of a decision-maker is measured in relation to other decision-makers, it is about relative efficiency, the value of which lies between 0 and 1, and deviations of 1 are attributed to a surplus of input or a lack of output. DEA determines the empirical boundary of efficiency (the boundary of production options) by reducing the input from below and the output from the top. Given that it is determined by the best existing decision-makers, the efficiency limit is an achievable goal to be sought by inefficient decision-makers. Unlike typical statistical approaches which are based on average values, DEA is based on extreme perceptions by comparing each decision-maker with only the best ones. Fundamental models of data envelopment analysis that are also commonly used are the Charnes-Cooper-Rhodes (CRS) model (abbreviated as CCR) and the Banker-Charnes-Cooper (BCC) model (abbreviated as VRS). The choice of model does not depend completely on theoretical settings but also on the context and purpose of the analysis, as well as on the long-term or short-term consideration (Rowena et al., 2006: 103). Generally, for a basic data envelopment analysis (CCR and BCC models), there are some general rules and assumptions. It is not necessary to capture inputs and outputs on the same unit of measurement. The method works equally well using different units of measurement and this is one of its greatest advantages. Moreover, other advantages are that this is a dynamic analytical decision-making tool that indicates possibilities for improving relative efficiency. It uses the benchmarking approach to measure decision-making unit efficiency relative to others in their group and can assist in identifying the best-practice or the most efficient decision-making unit as well as the inefficient decision-making units within the group.

Therefore, the efficiency curves created units that are relatively efficient compared to other observed units, by maximizing their output variables with specified input variables. In addition, there is a test for each unit regarding whether it is able to cover its inputs from the "bottom" (with lower input values to reach a given output), without excluding the remaining input values. The model also analyzes output variables from the "top" (whether it is able to reach larger output values with the given input values). Units that are included in data processing are considered relatively inefficient compared to other units that were excluded. The excluded units form an efficiency curve or marginal production function. The efficiency curve (frontier) is composed of units that utilize resources in the best possible way in order to achieve outputs. This curve also represents the goal the inefficient units are seeking to achieve. Inefficient units may achieve their efficiency by representing their inputs and outputs values on the curve. Figure 2 presents the efficiency frontier, input-oriented model.

Figure 2 Efficient unit



Source: Zhu, J. (2002)

The general relationship that we will test in terms of public expenditure of healthcare system efficiency can be expressed by the following function of each commune *i*:

$$Y_i = f(X_i),\ i = 1,2,3, \ldots, n \qquad (1)$$

where Y_i is an output measure of public expenditure of the healthcare system, and X_i is the level of public expenditures of each county *i*.

According to Rowena et al. (2006), the choice of the model (CCR or BCC) does not depend solely on theoretical settings, but also on the context and purpose of the analysis, as well as on the long-term or short-term consideration. Overall, for the basic data sharing analysis models (CCR and BCC models) there are certain general rules and assumptions. They do not require the input and output values to be the same measurement units of the method to function equally using different measurement units, and this is one of their greatest advantages.

When choosing a type of model, the characteristics of the data and knowledge of the yield type characteristic of the analyzed process are decisive. Coelli et al. (2005) found that results obtained by the CRS and VRS models decompose technical efficiency scores calculated under the constant returns-to-scale assumption into pure technical efficiency and efficiency that stems from scale efficiency.

For the purpose of conducting this research and exploring the efficiency of healthcare system expenditures, with special emphasis on Croatian counties in the period 2010-2017, the CCR and BCC models were employed in this paper, as was scale efficiency (SE).

3.1 The CCR Model

Charnes et al. (1978) were pioneers in defining the efficiency formula. Later, this went through its first revision in 1984. The CCR model implies constant returns-to-scale. This means that output variables increase proportionally with input variables (Cooper et al., 2006). This model assumes constant yields with respect to the scope of the action, and due to the modification of this assumption, other data-limiting models have emerged, including the BCC model (Rowena et al., 2006).

This model is specified in the following way:

$$\max\theta_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \tag{2}$$

Subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \quad (j = 1,2,\ldots,n) \tag{3}$$

$$u_1, u_2, \ldots, u_s \ge 0; v_1, v_2, \ldots, v_m \ge 0 \tag{4}$$

The above constraints specify that the ratio of output to input should not exceed 1 for each decision-making unit. Furthermore, the objective is to get assigned weights by which the ratio is maximized for a particular decision-making unit that is being analyzed. Because of the setup of the actual constraints, the optimal value is 1.

3.2 The BCC Model

The BCC model was established by Banker, Charnes and Cooper in 1984. This model assumes increasing returns-to-scale. Unlike the CCR model, which is represented by a straight line, the BCC model is represented by a convex efficiency frontier.

The model is specified in the following way:

$$\max h_k = \sum_{r=1}^{s} u_r y_{rk} + u* \tag{5}$$

Subject to:

$$\sum_{i=1}^{m} v_i x_{ik} = 1 \tag{6}$$

In order to determine which counties operate at maximum scale or not, scale efficiency has been calculated. Scale efficiency is determined for each county in every model as follows:

$$SE = \frac{TE_{CRS}}{TE_{VRS}} \tag{7}$$

Where:

TE_{CRS} is the technical efficiency of a county under constant returns to scale; and

TE_{VRS} is the technical efficiency of a county under variable returns to scale.

If the value of SE is equal to 1, then the county is scale efficient, meaning that it operates at maximum scale.

Studies like Cooper et al. (2006) and Emrouznejad and Podinovski (2004) provide serious comparative analyses between the two models briefly explained above. The BCC model assumes variable yields on the scope of action, and the production boundary that is trampled with a convex shell of decision-makers with linear and concave characteristics. In the case of rising or decreasing yields, in which the proportional increase in input results in more or less than a proportional increase in output, the BCC model should be selected.

The most important step in the formulation of a DEA model is the selection of input and output variables, because it could significantly improve the quality of results in subsequent steps. Before this difficult step, the best way is to research literature to find all the potential input and output variables used in research papers and studies. Therefore, the inputs include all the resources, while the outputs include all relevant activities for analysis. Moreover, the important element is also the ratio of the number of input and output variables and the number of units to be analyzed. According to theoretical suggestions, the number of units should be at least three to five times greater than the total number of input and output variables.

For each county, the underlying inputs and outputs are included in the analysis. All the variables, as well their definitions and data sources, are presented in Table 1.

Table 1 Definition of variables

Variable	Role	Definition	Data sources
Healthcare expenditures	**Input**	Healthcare expenditures consist of expenditures from the local budget plus from the average expenditures per patient from the Croatian Institute of Public Health in HRK	Croatian Health Service Yearbook[3]; Ministry of Finance
Number of doctors	**Input**	The number of persons who have a degree in medicine at the university level and who are licensed to practice; interns and resident physicians; salaried and self-employed physicians delivering services irrespective of the place of service provision	Croatian Health Service Yearbook
Number of hospital beds	**Input**	The number of hospital beds which are regularly maintained and staffed and immediately available for the care of admitted patients; both occupied and unoccupied beds are included.	Croatian Health Service Yearbook
Vital index	**Output**	The ratio between the number of live-born children and the number of deceased persons, i.e. the number of live-born children in relation to 100 deceased persons	Croatian Health Service Yearbook
Number of examinations	**Output**	The number of preventive medical care examinations provided to adults by the General Medical Service	Croatian Health Service Yearbook
Number of patients per bed	**Output**	The number of patients who are formally admitted to an institution for treatment and/ or care per bed	Croatian Health Service Yearbook

Source: Prepared by the authors

Based on the described data, inputs and outputs were processed as part of the data analysis, with a view to using the DEA method to determine the healthcare system expenditure efficiency, represented by counties, in the 2010-2017 period on the average deviation level.

4. Results

The descriptive statistics for all the variables used in the DEA analysis are presented in Table 2.

Table 2 Descriptive statistics on input/output data

	Mean	St. Dev.	Min	Max
Healthcare expenditures per patient	103.82	39.39	35.95	222.05
Number of doctors	196.62	147.03	14.5	524.38
Number of hospital beds	5.10	2.56	0.78	11.09
Vital index	71.69	15.01	44.71	99.48
Number of examinations	4056.84	2973.85	377.63	11092.88
Number of patients per bed	30.57	9.78	8.72	48.40

Source: Authors' calculation

According to the data analysis based on the DEA model and the average deviation level in the form of an input-oriented model, the efficiency estimation produced some interesting results. The results are presented in Table 3.

Table 3 Efficient scores

	CRS	VRS	SE
Bjelovar-Bilogora	0.528	0.598	0.883
Brod-Posavina	1	1	1
Dubrovnik-Neretva	0.857	1	0.857
Istria	0.696	0.719	0.967
Karlovac	0.662	0.785	0.843
Koprivnica-Križevci	1	1	1
Krapina-Zagorje	0.992	1	0.992
Lika-Senj	1	1	1
Međimurje	1	1	1
Osijek-Baranja	0.832	0.907	0.918
Požega-Slavonija	0.668	0.685	0.976
Primorje-Gorski Kotar	0.472	0.562	0.840
Šibenik-Knin	0.514	0.718	0.716
Sisak-Moslavina	0.295	0.322	0.916
Split-Dalmatia	0.691	0.774	0.893
Varaždin	0.403	0.433	0.931
Virovitica-Podravina	0.815	0.885	0.920
Vukovar-Srijem	1	1	1
Zadar	0.477	0.519	0.919
Zagreb	1	1	1

Source: Authors' calculation
Note: SE denotes scale efficiency

Based on Table 3, we observed that, on average in the 2010-2017 period, the following six counties operate at maximum scale (Brod-Posavina, Koprivnica-Križevci, Lika-Senj, Međimurje, Vukovar-Srijem and Zagreb). By observing only, the CRS or the CCR model, the same counties have high values of scale efficiency. On the other hand, the most inefficient counties are Sisak-Moslavina, Varaždin and Primorje-Gorski Kotar. This means that output variables (vital index, number of examinations and number of patients per bed) increase proportionally with input variables. In the VRS or the BCC model, the most efficient counties are Brod-Posavina, Dubrovnik-Neretva, Koprivnica-Križevci, Krapina-Zagorje, Lika-Senj, Međimurje, Vukovar-Srijem and Zagreb, while the most inefficient counties are Sisak-Moslavina, Varaždin and Zadar. According to the empirical results, most of the counties are inefficient. This can be explained by the fact that, due to sickness, more and more people need to have more detailed medical examinations within primary healthcare services, indicating the need for more medical professionals and longer stays in hospitals. Therefore, the central government needs to ensure more funds to provide higher wages for doctors and investments in hospitals, medical equipment and the digitalization of systems. Similar research was conducted by Jafarov and Gunnarrson (2008), where they analyzed the efficiency of social spending and service delivery in

Croatia by using DEA. They found that inefficiencies in healthcare spending relate to high pharmaceutical spending, long stays in hospitals and low levels of both out-of-pocket spending and private participation (p. 302). In addition, they suggested measures to increase the efficiency of healthcare. These measures include shifting resources to more affordable outpatient care, increasing the role of the private sector in the provision of healthcare services, rationalizing the hospital network and reducing subsidization of pharmaceuticals (Jafarov and Gunnarrson, 2008: 314).

5. Conclusion

The basic objective of financing a healthcare system is to primarily ensure resources for healthcare protection. By providing these resources, insured persons have the right to an individual approach when using healthcare services. The Croatian healthcare system financing scheme is partly like a Bismarck model and partly like a Beveridge model, which is in line with economic theory. Besides this, Croatia has had numerous healthcare reforms with the aim of reducing healthcare expenditures and increasing healthcare efficiency and healthcare outcomes. Despite the aforementioned reforms, the Croatian healthcare system constitutes a 7.05 percent share of the GDP for healthcare expenditures for the period 2010-2016. To make most of the healthcare services publicly available, the counties invest a huge effort and financial resources to achieve a more efficient healthcare management system. Moreover, the important determinant of an efficient healthcare system is the allocation of revenues and expenditures.

The objective of this paper is to evaluate and analyze the efficiency of average healthcare expenditures in twenty Croatian counties by applying the DEA approach for the period 2010-2017. Since most of the studies concentrate on the benchmarking of healthcare system expenditures among countries in the world, this paper makes a contribution to the existing literature by analyzing the efficiency of the healthcare system expenditures among Croatian counties.

The results of the empirical analysis showed the prevailing inefficiencies among twenty Croatian local government units, i.e. counties in using their healthcare expenditures. Therefore, we concluded that, among the twenty counties, the most efficient in scale efficiency are only six counties (Brod-Posavina, Koprivnica-Križevci, Lika-Senj, Međimurje, Vukovar-Srijem and Zagreb). By observing specific input and output variables, this means that their healthcare systems operate at the maximum score. This can be explained by the fact that the expenditures for the healthcare system have been increasing every year due to new healthcare technologies, among others, new medical equipment, clinical procedures, new medicaments and others. Due to limited budget resources, this cannot be financed, nor can government grants be awarded. In order to increase healthcare expenditure efficiency, our recommendation would be to organize better administrative healthcare organisations, to continue with more detailed reforms regarding providing and funding healthcare services and to ensure efficient primary healthcare services. Since there is no single international recipe for efficient healthcare reform, every country, including Croatia, first needs to boost economic and financial possibilities with the aim of providing improved healthcare services. The limitations of this research are that efficiency is only measured in twenty Croatian counties and only a few input and output variables are utilized. For further research, the study should be expanded to all hospitals (private and public) in Croatia and it should offer a benchmark with respect to other European Union Member States.

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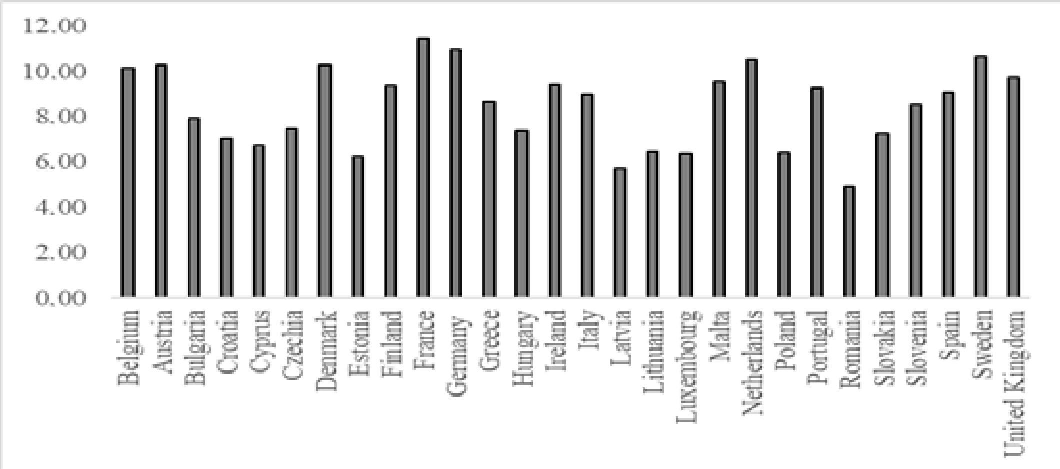
APPENDIX

Figure 1 Average healthcare expenditure as percentage of gross domestic product in EU-28



Source: Eurostat, healthcare expenditure statistics, 2018

Endnotes

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Učinkovitost rashoda sustava zdravstvene zaštite: Primjer Republike Hrvatske

Sažetak

Jedno od glavnih žarišta ekonomskog razvoja svake zemlje u svijetu, uključujući i Republiku Hrvatsku, je učinkovit zdravstven sustav kojemu je svrha ostvarenje bolje kvalitete života i zdravstvene zaštite. Rezultat toga je viši životni standard građana. Sustav zdravstvene zaštite u Republici Hrvatskoj prošao je kroz brojne reforme. Prilikom provođenja svake reforme, cilj je bio optimizirati sustav zdravstvene zaštite u skladu s državnim proračunom kako bi se postigla njegova održivost u dugom roku. Stoga, financiranje zdravstvenog sustava i održivost imaju važnu ulogu. Cilj je ovog rada ocijeniti i analizirati učinkovitost prosječnih rashoda za zdravstvenu zaštitu u 20 županija Republike Hrvatske primjenjujući analizu omeđivanja podataka. Analiza je obuhvatila razdoblje od 2010. do 2017. godine. Za ocjenu učinkovitosti rashoda za zdravstvenu zaštitu, korištene su tri ulazne (input) i tri izlazne (output) varijable. Rezultati empirijske analize prikazali su značajnu razliku u učinkovitosti rashoda za zdravstvenu zaštitu među županijama. Rezultati ljestvice učinkovitosti prikazali su da unutar 20 županija, samo 6 županija (Brodsko-posavska, Koprivničko-križevačka, Ličko-senjska, Međimurska, Vukovarsko-srijemska i Zagrebačka) ostvaruju svoj maksimum u svojim rashodima za zdravstvenu zaštitu.

Ključne riječi: rashodi sustav zdravstvene zaštite, učinkovitost, analiza omeđivanja podataka, Republika Hrvatska