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Measuring efficiency of secondary healthcare providers in Slovenia

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Abstract: The chief aim of this study was to analyze secondary healthcare providers' efficiency, focusing on the efficiency analysis of Slovene general hospitals. We intended to present a complete picture of technical, allocative, and cost or economic efficiency of general hospitals.

Methods. We researched the aspects of efficiency with two econometric methods. First, we calculated the necessary quotients of efficiency with the stochastic frontier analyze (SFA), which are realized by econometric evaluation of stochastic frontier functions; then, with the data envelopment analyze (DEA), we calculated the necessary quotients that are based on the linear programming method.

Results. Results on measures of efficiency showed that the two chosen methods produced two different conclusions. The SFA method concluded Celje General Hospital is the most efficient general hospital, whereas the DEA method concluded Brežice General Hospital was the hospital to be declared as the most efficient hospital.

Conclusion. Our results are a useful tool that can aid managers, payers, and designers of healthcare policy to better understand how general hospitals operate. The participants can accordingly decide with less difficulty on any further business operations of general hospitals, having the best practices of general hospitals at their disposal.

Keywords: Technical efficiency; Allocative efficiency; Cost efficiency; DEA; SFA

1 Introduction

The first definition of the term efficiency in economic theory was originally offered by Farrell [1]; it was based on the works of Debreu [2] and Koopmans [3]. Farrell introduced the new term of relative efficiency, in which the efficiency of a decision-making unit could be compared to the efficiency of another unit. He defined three different types of efficiency: technical efficiency, allocative efficiency, and cost (economic) efficiency.

Providers are considered technically efficient if they can provide the maximal extent of output, accounting for the technology and production factors or inputs at their disposal. Technical efficiency therefore refers to a provider's ability to produce the greatest possible range of outputs with the inputs given to the provider to enable him to secure this outcome. Providers can be described as technically efficient on the same terms – when they use the minimal possible range of production factors or inputs during the production of the appointed extent of output, considering the available technology the provider has at his disposal. When we use the first definition, we are discussing the measuring unit of output-oriented technical efficiency. The second definition discusses the measuring unit of input-oriented technical efficiency [4-7].

In his work, Koopmans [3] clearly states that a provider can be declared as technically efficient if he must decrease at least one of the remaining outputs to increase an individual one, or in case he must increase the amount of at least one of the inputs it used. Koopmans [3] continues his thesis with a statement that a provider is technically efficient if it must increase one of the used inputs when one of the inputs is decreased, or in case it must decrease the amount of at least one of the produced outputs. A technically efficient provider can produce the

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chosen level of output with a decreased amount of inputs. Another option is to produce a higher level of output with the given amount of inputs [8].

Allocative efficiency demands we ask the following questions: "What is the optimal combination of production factors or inputs that can produce an output with the minimum possible cost? By how much can we increase the income if we bring into effect a simple reallocation of inputs or use another combination of inputs?" Allocative efficiency demands that a provider choose a combination of inputs in accurate proportions relative to their prices; this enables provision of the chosen output with minimal average costs. If the provider is allocative efficient, he also achieves maximum profit. In such a case, it will select a combination of production factors that will cause minimal cost per production unit [6,9].

Allocative efficiency can be evaluated if we are familiar with input prices. In other words, allocative efficiency evaluation without input prices can be very demanding. Several researchers, for example Farrell [1], renamed allocative efficiency into price efficiency exactly for such a purpose, as it relates to the provider's ability to optimally select a combination of inputs in relation to their prices. If we have input prices at our disposal, and if the provider follows the concept of minimizing the costs and maximizing the profit, we can define measuring units for allocative efficiency. An allocative efficient provider, when selecting inputs, chooses a suitable combination of production factors, for example labor and capital, which then enable him to produce a certain amount of product with minimal average costs by accounting for the prevailing prices of material and labor resources [8].

Allocative and technical efficiency together form a joint unit of cost efficiency, sometimes called economic efficiency [1]. Cost or economic efficiency is defined as a product between the technical efficiency and allocative efficiency. No provider is technically and allocative efficient if it does not use the minimal amount of production factors for producing a chosen amount of output, while also not having the minimal costs possible. This statement explains that cost efficiency can be achieved only by the provider's using the minimal amount of inputs necessary for production, and by combining inputs in a way that secures the production of a chosen amount of output with the minimal costs possible. Providers are therefore required to provide optimal amounts and combinations of inputs with the minimal costs available [4-7].

A provider's cost inefficiency has two possible causes. The first reason is a case of technical inefficiency, meaning the provider is using amounts of inputs too vast for the chosen production of output. The second reason is a case of allocative inefficiency, meaning the provider does not have the ability to attain the minimal possible costs of production. The provider cannot be recognized as cost efficient if he uses a technically effective combination of inputs that is not suitable considering relative prices of inputs. The provider would, in such a case, be technically efficient, but would not attain the standards necessary to achieve allocative efficiency. Based on this statement, we can determine there are two components of joint cost efficiency. The first component is technical efficiency, the second allocative efficiency. We can now recognize there is more than one source of cost inefficiency – it can be a consequence of either technical or allocative inefficiency [6,7].

The efficiency of general hospitals certainly affects their ownership. Depending on who exercises property rights over healthcare organizations that employ physicians and other medical staff state-owned organizations, organizations with a non-profit, non-state owner and organizations with private, profit-seeking owners can be distinguished. Healthcare providers often also deliver services as independent, self-employed professionals or private entrepreneurs. In reality, these pure form mix. Physicians, for example, may spend some of their time working under one form of ownership and some of it under another. In Slovenia, it is not unusual for a doctor to work both in a state-owned hospital or a health center and as a self-employed professional. It is also possible for a private practice to offer certain services within state organizations and collect fees for these services, while paying rent for the premises. Another such example is a state or non-profit hospital that may contract certain tasks out to privately owned, for-profit organizations. In our study, we focused on general state-owned hospitals, which have a non-profit motive.

The chief aim of this study was to analyze the secondary healthcare provider's efficiency; our focus was to analyze the efficiency of Slovene general hospitals. In our study, we focused on hospital services, since the secondary level of healthcare is the main consumer of resources in most countries. Presuming that the healthcare sector is going to receive an equal amount of resources per year as it does now for at least some years in the future, given the recent economic crisis and restrictive fiscal politics limiting budget spending, we must increase the efficiency of healthcare system if we do not wish to bring healthcare development and progress to a standstill. Hospital services will, despite gaining influence of the primary healthcare level, demand a large portion of financial resources meant for healthcare. In relation to this, examining and researching hospital services and their functioning is

crucial, because we could help create significant savings in the healthcare system through optimizing the secondary level of healthcare.

The key contribution of this article was to examine of general hospital efficiency with two alternative methods; the SFA method and DEA method. This way we are enabled to wholly explain the technical, allocation, and cost (economic) efficiency in Slovene general hospitals, with our theory supported by the findings of modern economic theory on efficiency. With such results, we meet the needs of our aim, which was to identify the most efficient Slovene general hospital and compare our results of efficiency measuring units, gained by methods SFA and DEA. Quotients were obtained by the SFA method, realized through the econometric evaluation of stochastic frontier functions. Quotients of efficiency, based on the linear programming method, were realized through the DEA method.

2 Methods

The field of healthcare clearly indicates that the two most frequently used approaches to the providers' efficiency evaluation are the parametric approach and the nonparametric or deterministic approach. The most frequently used method of the first-mentioned approach is the SFA method, which is used to evaluate parametric stochastic models, while the most frequently used method of the second approach is the DEA method, which we employ to evaluate nonparametric or deterministic models [10,11]. Both methods, SFA and DEA, belong to a category of rigorous analytical methods of benchmarking, which employs the use of the so-called distance function, measuring thereby the efficiency of an individual healthcare provider in relation to an efficient provider, situated on the frontier production function or frontier cost function [6]. The methods differ because they use different approaches to evaluate frontier functions. The SFA method can calculate quotients for measuring efficiency based on the econometric evaluation of stochastic frontier functions; on the other hand, the DEA method can calculate quotients for measuring efficiency, based on the linear programming method. When defining limits of production possibilities, both methods provide different suppositions regarding random errors or the white noise process and inefficiency.

The SFA method is also known as the stochastic method because it enables us to separate provider's inefficiency from random errors (or white noise) that are a direct result of methodological errors. Among such errors, we place, for example, a selection of the wrong function form, an impact of a variable we unintentionally omitted within the chosen model, data errors and so on [10,11]. The DEA method is classified as a nonparametric method, which prevents us from distinguishing between the effect of efficiency and the effect of white noise [6]; all perceived deviations from the production possibility limit are attributed to providers' inefficiency. Authors very frequently state that the chief advantage of the DEA method over the SFA method (speaking of research that measures efficiency) is that it does not require that the function form of frontier function be defined, for in such case all frontier functions merely illustrate deterministic functions of surveyed values [11]. The DEA method is relatively undemanding and therefore easy to comprehend; this is the main reason we find so many studies pertaining to providers' efficiency using this method in literature.

Our analysis is based upon the contribution of Bauer and his co-authors [12]; they defend the thesis that when choosing methodology, many different approaches ought to be used, meaning we do not have to reach the decision on the most proficient method of measuring efficiency. In our analysis of secondary healthcare providers' efficiency, we used both the DEA and SFA method. We used both methods to verify the consistency of our results.

Ethical approval: The conducted research is not related to use of either human or animals.

2.1 Efficiency evaluation with the SFA method

Each definition of econometric model of stochastic frontier function first demands that a decision on the functional relation between outputs and inputs must be reached. Based on the economic, econometric, and mathematical theory and our gathered data, we decided to use the following principle when defining the chosen model: providers of secondary healthcare provide one business impact or output (q) with two production factor; labor (L) and capital (K). When defining the term output, we followed the recommendations given by Coeli and his co-authors (2005); they state that the providers' output must be defined as a unified aggregated business impact. In accordance with this, we can define the provider's production function i:

$$q_i = q(L_i, K_i)$$

With the cost function, we assumed all production factors to be variable on the long term, meaning that providers can select different combinations of labor and capital. We took into consideration that providers follow the concept of cost minimization, namely trying to provide effectively with minimal average costs. The cost function of provider i can be defined as

$$c_i = c(q_i, P_{L,i}, P_{K,i})$$

To define the model of stochastic frontier production and cost function, we must first define the functional form of relation between the independent variable and explanatory variables. In our study, we used the Cobb-Douglas function form, which is presumed to be theoretically consistent, because we assume that the function is linearly homogenous, concave, and non-decreasing. The previously mentioned Cobb-Douglas function form is not locally flexible, but is very often used in studies of production and cost functions, due to its ability to easily interpret results and its simplicity [5,6,13].

The model of stochastic frontier production function has the specification:

$$\ln q_i = \ln \beta_0 + \beta_L \ln L_i + \beta_K \ln K_i + v_i - u_i$$

This model follows the assumption that all providers have constant u_i returns to scale, that the random variable of inefficiency assumed to follow a half-normal distribution v_i and that the random error to account for statistical noise is identically distributed random error with a zero mean and variance σ_v^2. Parameters β were calculated based on the maximum likelihood method. Equation 3 includes the Cobb-Douglas function form, based on the specification defined by Equation 1. Taking into consideration the duality of the production and cost function – consequently also that of the Cobb-Douglass function form of frontier production function and the Cobb-Douglass function form of frontier cost function, we also defined the model of stochastic frontier cost function with the specification:

$$\ln c_i/P_{K,i} = \ln \beta_0 + \beta_q \ln q_i + \beta_{P_L} \ln P_{L,i}/P_{K,i} + v_i + u_i$$

With this model, we assume all providers have constant returns to scale. Equation 4 includes the Cobb-Douglass function form, based on the specification defined with Equation 2. Most stochastic frontier analyses are oriented toward predicting various effects of inefficiency. The measuring unit of technical efficiency can be defined as

$$TE_i = \frac{q_i}{\exp(x_i'\beta + v_i)} = \frac{\exp(x_i'\beta + v_i - u_i)}{\exp(x_i'\beta + v_i)} = \exp(-u_i)$$

In our case, the measuring units of technical efficiency occupy value between 0 and 1. A technically efficient provider holds the value of technical efficiency at 1. Based on the above specification we can see how technical efficiency measures the provider's output i in relation to the output provided by a provider whose technical efficiency is absolute. Therefore, we obtain the relation between the surveyed value of a provider's production and maximum value of production, which is defined by the stochastic frontier production function.

Using the exact way that we defined the measuring units of technical efficiency, we can than define the measuring units of cost efficiency. The measuring unit of cost efficiency can be presented as

$$CE_i = \frac{\exp(x_i'\beta + v_i)}{c_i} = \frac{\exp(x_i'\beta + v_i)}{\exp(x_i'\beta + v_i + u_i)} = \exp(-u_i)$$

In this case, the measures of cost efficiency are again situated between values 0 and 1. A provider considered to be cost efficient must have the measuring unit of cost efficiency equal to one. Equation 6 defines cost efficiency as a relation between the minimal possible costs provider i can achieve in the environment illustrated by independent variables, and the surveyed costs of provider i. Cost efficiency therefore measures minimal possible costs in relation to actual costs

We defined allocative efficiency as a relation between cost efficiency and technical efficiency. We calculate allocative efficiency as

$$AE_i = \frac{CE_i}{TE_i}$$

In such case, all measures are situated within the interval between 0 and 1; value 1 represents a provider that is allocative efficient, all values lesser than 1 represent an allocative inefficient provider.

2.2 Efficiency evaluation with the DEA method

The model we used within the DEA method is the input-oriented model of constant returns to scale. Orientation towards inputs was assumed for the simple fact that the volume of outputs of secondary healthcare providers is prearranged every year—based on the general

and sectorial arrangement between the payer and healthcare provider. In such case, the output providers have at their disposal is determined by an outside factor, meaning they can only really influence the actual range of chosen inputs. We also presupposed the constant returns to scale, as we aimed to define the most efficient providers regardless of their actual size. This way we took into consideration that an individual inefficient provider could achieve greater efficiency adapting and rearranging the inputs in use, as well as adapting its size to attain the highest production possible. Using those criteria, we could determine efficient providers based on the actual use of inputs and their size.

The input-oriented model of constant returns to scale was first employed by Charnes, Cooper and Rhodes [14]. The DEA model can be presented by a mathematical form, illustrating the relation of inputs and outputs [5]:

$$min_{\theta,\lambda}\ \theta,$$

$$St\ -q_i + Q\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0,$$

$$\lambda \geq 0.$$

The efficiency frontier of this segment represents the isoquant, which is determined based on our gathered data points, namely based on the providers being observed in our sample. The presented model enables us to calculate measures of technical inefficiency with assessing the provider's distance from the efficient frontier. This model is also known as the Farrell model, as scalar θ represents the Debreu-Farrell measure of technical efficiency [15].

Providers' cost efficiency can be defined in a similar way as technical efficiency. In case of the input-oriented model of constant returns to scale, we are able, based on equation 8, which displays providers' technical efficiency, define the input-oriented model of constant returns to scale representing providers' cost efficiency:

$$min_{\lambda,x_i^*}\ w_i', x_i^*$$

$$St\ -q_i + Q\lambda \geq 0,$$

$$x_i^* - X\lambda \geq 0,$$

$$\lambda \geq 0.$$

The collective cost efficiency of provider i can be calculated with an equation supplied by Coelli and other authors [5]:

$$CE = \frac{w_i', x_i^*}{w_i', x_i}$$

Cost efficiency represents the relation between minimal costs and actual costs of provider i.

When we have input prices at our disposal, we are then able to calculate allocative efficiency as well. Allocative efficiency can be defined as the relation between the cost efficiency model of constant returns to scale, oriented toward inputs, and the technical efficiency of the model of constant returns to scale, oriented toward inputs. The allocative efficiency of the model of constant returns to scale that is input-oriented can be mathematically defined as [5]:

$$AE = \frac{CE_i}{TE_i}$$

All measuring units of allocative efficiency occupy a value within the interval between values 0 and 1. An allocative efficient provider's measuring unit of allocative efficiency is always equal to 1; the measuring unit of an allocative inefficient provider is always less than 1.

2.3 Sample and data

Our analysis is focused on evaluating technical, allocative, and cost efficiency of twelve Slovene general hospitals that represent all general hospitals located in Slovenia. We excluded specialized hospitals from our data base following the chosen methods of research, the SFA and DEA method, as both methods demand homogeneity of all units under observation. The sample of Slovene general hospitals is therefore composed of twelve hospitals. For our analysis, we used the data we acquired from expert yearly reports on the twelve analyzed general hospitals for a ten-year period, namely between 2005 and 2014. When researching the efficiency of Slovene general hospitals, we used the so-called panel data, which represent a combination of cross-sectional data and time series. This way we have one hundred and twenty observations at our disposal, in accordance with a fact we have observed twelve Slovene general hospitals during the mentioned ten-year period. Therefore, we have sufficient surveyed units within the DEA and SFA method at our disposal.

To calculate technical, allocative and cost efficiency within the SFA method, the single unified business impact must be included as output, while the DEA method allows for a larger number of separate outputs. When performing this process, we heed recommendations of Golany and Roll [16], Dyson and other authors [17], who state that when we determine the number of outputs, the number of surveyed units at our disposal must be at least twice

as high as the product of the total number of inputs and outputs. We employed two different output sets within the DEA method, namely the specialist outpatient services and the specialist inpatient services. To define the quantity range of outpatient services, we used data formed as some cases in outpatient sector, represented by the number of treated patients. To satisfy the requirements for defining the quantity range of inpatient services, we used the number of acutely discharged patients. In doing so, we accounted for the total number of diagnosis related groups, which in our case is equivalent to the number of acutely discharged patients.

To meet the requirements of the SFA method, it was necessary to aggregate various outputs into one unified business impact. The outpatient services output and the inpatient services output were united over the number of treated patients. This is in accordance with the fact found in literature, stating that the aggregated business impact is most commonly defined in the form of a total number of patients that hospitals treat in a single year [18]. All more recent studies performing research of hospital efficiency also define the number of treated patients as a hospital output [19-21]. The SFA method therefore defines output as the number of patients treated, representing the total number of patients that hospitals treat with the specialist outpatient services and specialist inpatient services.

Besides data on output range we also required data on the range of used inputs. In accordance with the classic economic theory, we defined inputs in the form of labor input and capital input. We illustrated the labor input with the average number of employees, estimated based on working hours. In efficiency analyses, this is the most frequently used measure of the labor production factor [5]. We illustrated the capital input range in the form of value of tangible fixed assets (denominated in euro]. The values of all individual fixed assets allotted to hospitals are defined in accounting records, among which we used the data on the value of property, equipment, and other tangible assets. Using the data on the value of tangible fixed assets, we disregarded the deprecation rate of equipment. The range of capital input is therefore calculated as a sum of property values, equipment and other tangible fixed assets.

To calculate allocative and cost efficiency we required – in addition to data on the range of spent inputs – data on input prices. The price of labor input was calculated relative to the yearly labor cost of an individual hospital and the average number of employees, calculated based on working hours. The price of capital is dependent on the definition of capital input range. We defined the capital input range in the form of tangible fixed assets, which are freely used by individual hospitals. In accordance with the previous statement, we calculated the data on capital input (denominated in euro) by dividing the sum of depreciation costs in financial expenses with the value of fixed tangible assets.

3 Results

The SFA method has shown that through the entire observation period, Celje General Hospital has undeniably been the most technically efficient general hospital in Slovenia; its average value of technical efficiency was 0.963. General Hospital Celje was followed by Murska Sobota General Hospital, the average quotient of technical efficiency of which was 0.909, and Brežice General Hospital with the average measure of technical efficiency of 0.0883. The lowest value of technical efficiency through the entire observation period was held by Slovenj Gradec General Hospital; our results showed that Slovenj Gradec General Hospital should, on average, reduce the extent of production factor employment by 53.9% while the range of output would have to remain unchanged. Nova Gorica General Hospital was in a similar position, whereby it should reduce the extent of production factor employment by 43.8% to be brought to the frontier of production possibilities. The SFA method also concluded that the highest value of allocative efficiency has been achieved by Izola General Hospital, its average value of allocative efficiency was 0.913. Izola General Hospital was followed by the University Medical Centre Maribor, its average quotient of allocative efficiency was 0.907, and Celje General Hospital, the average value of allocative efficiency of which was 0.895. The results showed that Trbovlje General Hospital had the lowest quotient of allocative efficiency. To become allocative efficient, the costs of production factors should be, on average, reduced by 15.7% with the output remaining unchanged. The same principle applies to University Medical Centre Ljubljana; its actual costs of production factors ought to be reduced by 14.7% to operate on the line of minimal costs.

The DEA input-oriented model of constant returns to scale has shown that Brežice General Hospital was technically efficient through the entire observation period, indicating it attained the value of 1 in every year of the period. It was followed by Trbovlje General Hospital with the average value of technical efficiency 0.991, and Izola General Hospital with its quotient of 0.949. The lowest value of technical efficiency through the entire observation period belonged to University Medical Centre Lju-

bljana, which indicates this hospital should reduce the extent of labor and capital employment by 41.3% with the output remaining unchanged, to meet the standards of technical efficiency. The University Medical Centre Maribor is itself in a similar position, for it should reduce the extent of production factor employment by 31.7% to operate at the frontier of production possibilities; this would make it technically efficient. The input-oriented DEA model of constant returns to scale showed Brežice General Hospital as the hospital with the highest value of allocative efficiency: its average value of allocative efficiency was 0.965. It was followed by Trbovlje General Hospital with the average quotient of 0.965 and Jesenice General Hospital with the average value of 0.896. Our results showed the lowest quotient of allocative efficiency belongs to the University Medical Center Maribor; to attain allocative efficiency, the hospital should, on average, reduce the costs of production factors by 34.3% with the output remaining unchanged. A similar statement can be applied to Izola General Hospital, which should reduce its actual costs of production factors by 28.8% to operate on the line of minimal costs.

Results on efficiency measures of general hospitals showed that the most cost (economically) efficient secondary healthcare provider is the one achieving the highest measures of technical and allocative efficiency. This is in accordance with the fact that technical and allocative efficiency of general hospitals present unified economic efficiency, meaning the two types of efficiency present two components of unified economic efficiency. The results on quotients of economic efficiency measures therefore represented the product of technical and allocative efficiency.

Results of the SFA method clearly has shown that Celje General Hospital was the most efficient Slovene general hospital throughout the observation period – its average value of economic efficiency was 0.862, an unsurprising fact if we take into consideration that Celje General Hospital was concurrently the most technically efficient general hospital in Slovenia. It was followed by Murska Sobota General Hospital, which had the average economic efficiency quotient of 0.812, and Brežice General Hospital, with its average value of economic efficiency 0.761. Directly following these two hospitals, the highest average value of efficiency belonged to Izola General Hospital, its measure of economic efficiency was 0.761. Izola General Hospital followed Novo Mesto General Hospital, its average economic quotient was 0.703, and Jesenice General Hospital with the average measure of economic efficiency 0.697. The lowest value of efficiency throughout the entire observation period was belonged to Slovenj Gradec General Hospital—the average value of this hospital's economic efficiency was 0.410. Slovenj Gradec General Hospital was inefficient because of too great an amount of input consumption, and because it did not operate on minimal average costs. This indicates the hospital should use smaller quantities and different combinations of inputs to become an economic efficient general hospital. Nova Gorica General Hospital was in a similar position, with its average measure of cost efficiency 0.496, which indicates that cost inefficiency could be eliminated if the given level of output was produced with a smaller amount of inputs. Simultaneously, the given level of output should be produced with the lowest costs possible.

The DEA input-oriented model of constant returns to scale demonstrated, with regards to the length of our observation period, the superior efficiency of Brežice General Hospital. Its average value of economic efficiency was 0.986. Trbovlje General Hospital followed Brežice general Hospital with the average economic efficiency value of 0.957. Next to these two hospitals, the highest average value of economic efficiency belonged to Jesenice General Hospital, its quotient was 0.808, and Murska Sobota General Hospital, its economic efficiency measure was 0.724. The lowest values of economic efficiency, predominantly through all years under observation, belonged to University Medical Centre Ljubljana and the University Medical Centre Maribor, the latter having the lower economic efficiency value of 0.446, while Lljubljana University Medical Centre's value was 0.510. This indicates the University Medical Centre Maribor was economically inefficient because of too great an amount of input consumption and because it did not produce with minimal average costs. The same observation applies to Ljubljana University Medical Centre; its economic inefficiency could be reduced if the given level of output was produced with a smaller quantity of inputs, while simultaneously producing the given level of output with minimal possible costs.

To increase the readability of Table 1 we can added graphic elements. This way, the precise numeric data are listed, while a quick visual comparison between hospitals, methods and years will also become possible.

Our results, as obtained by the SFA method, showed that average values of general hospitals' technical efficiency lie in the range of 0.644 to 0.667; the DEA method, on the other hand, displays the average values of economic efficiency lie in the range of 0.641 to 0.778. The results on evaluation of efficiency measures gained by the SFA method was noticeably lower than the results on evaluation of efficiency measures gained by the DEA method in practically every case. This indicates inefficiency measures (or deviations from the frontier of production and cost function) was higher inside the SFA method than

Table 1: Average values of technical, allocative and cost efficiency of general hospitals, estimated by the SFA method and DEA method

	SFA method			DEA method		
Hospital	Average TE	Average AE	Average CE	Average TE	Average AE	Average CE
GHB	0.883	0.864	0.762	1,000	0.986	0.986
GHC	0.963	0.895	0.862	0.915	0.725	0.647
GHI	0.834	0.913	0.761	0.949	0.712	0.677
GHJ	0.780	0.893	0.697	0.900	0.896	0.808
UMC LJ	0.727	0.853	0.621	0.587	0.866	0.510
UMC MB	0.585	0.907	0.531	0.683	0.657	0.448
GH MS	0.909	0.893	0.812	0.936	0.773	0.724
GH NG	0.562	0.883	0.496	0.822	0.818	0.671
GH NM	0.789	0.890	0.703	0.879	0.763	0.666
GHP	0.659	0.878	0.578	0.895	0.730	0.649
GH SG	0.461	0.891	0.410	0.845	0.694	0.585
GHT	0.763	0.843	0.643	0.991	0.965	0.957

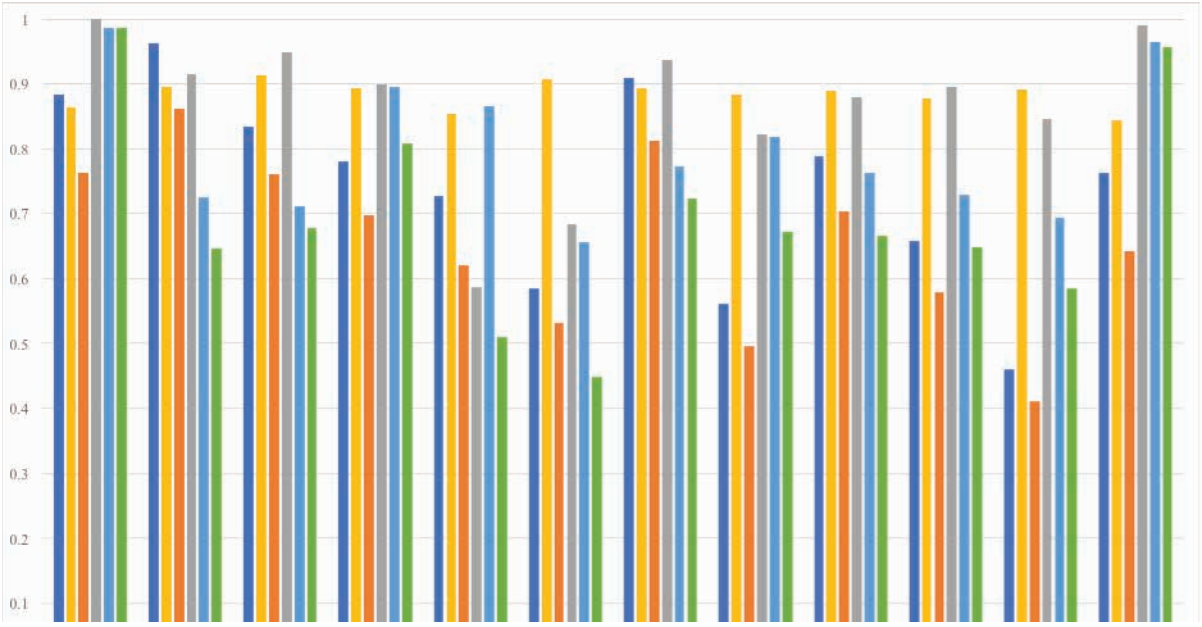

Figure 1: Average values of technical, allocative and cost efficiency of general hospitals, estimated by the SFA method and DEA method

inside the DEA method. The average values of technical, allocative and cost efficiency for general hospitals per year, estimated by the methods SFA and DEA, are displayed in Table 2.

To increase the readability of Table 2 we can added graphic elements. This way, the precise numeric data are listed, while a quick visual comparison between hospitals, methods and years will also become possible.

The chosen methods SFA and DEA displayed approximately equivalent trends of efficiency measures increasing and decreasing during a given range of years. Quotients of economic efficiency calculated by the SFA method on average increased throughout the first six years; their value in 2010 was 0.661, indicating the equivalents reach 66.1% on the efficiency scale of efficient general hospitals. A similar conclusion is presented by quotients calculated by the DEA method, which on average increased throughout the first six years of observation: the value in 2010 was 0.735, and this year the quotients reached 73.5% on the efficiency scale of efficient general hospitals. In the next two years, measures of economic efficiency calculated by the SFA method on average decreased, they reached the highest value of 0.667. The quotients of economic efficiency practically did not change at all in 2014, indicating

Table 2: Average values of technical, allocative and cost efficiency of general hospitals for each individual year, estimated by the SFA method and DEA method

	SFA method			DEA method		
Year	Average TE	Average AE	Average CE	Average TE	Average AE	Average CE
2005	0.752	0.880	0.663	0.858	0.753	0.648
2006	0.736	0.885	0.651	0.882	0.727	0.641
2007	0.735	0.881	0.647	0.872	0.738	0.642
2008	0.729	0.883	0.644	0.883	0.793	0.699
2009	0.735	0.879	0.646	0.868	0.799	0.699
2010	0.748	0.884	0.661	0.845	0.864	0.735
2011	0.738	0.895	0.660	0.867	0.838	0.732

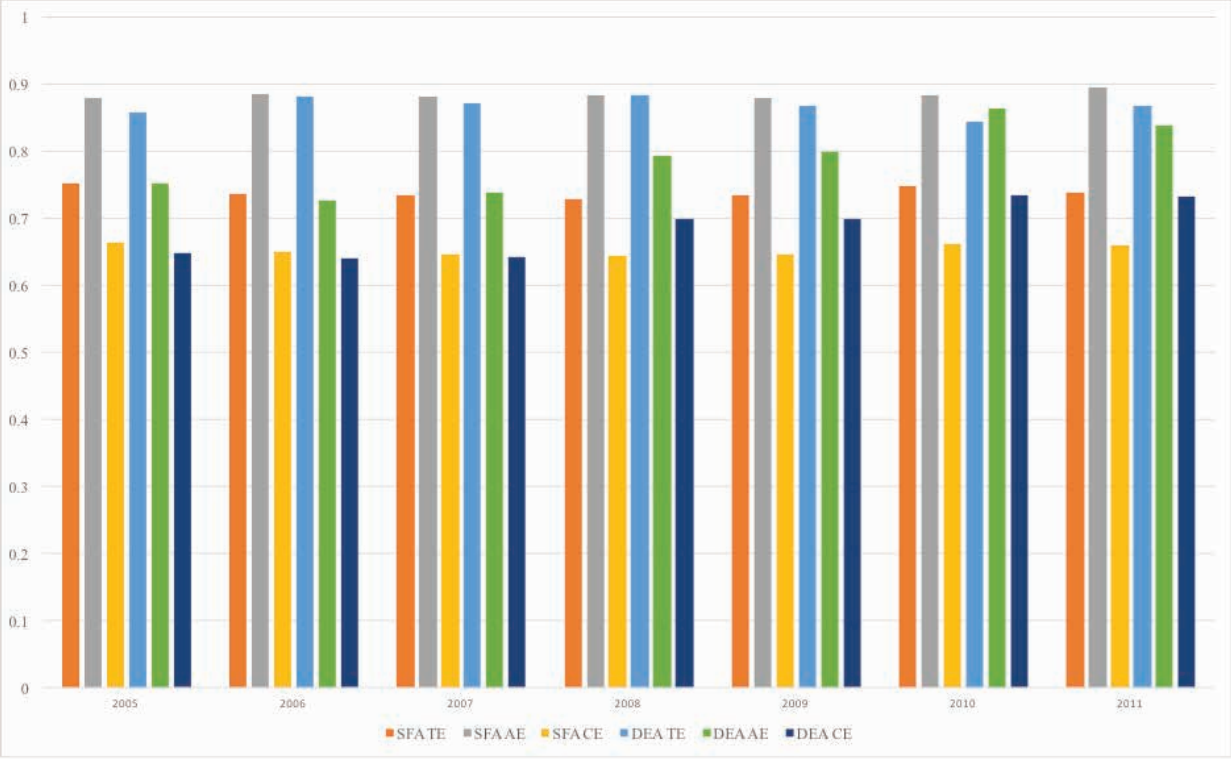

Figure 2: Average values of technical, allocative and cost efficiency of general hospitals for each individual year, estimated by the SFA method and DEA method

they remain relatively at the same level of 66.5% on the efficiency scale of efficient general hospitals. The measures of economic efficiency calculated by the DEA method were in a similar position, their value decreased after 2010, however, in the last year of survey they reached their highest value of 77.8% on the efficiency scale of efficient general hospitals.

4 Discussion

Measures of efficiency estimated with both the SFA and DEA methods show quotients of technical, allocative, and cost efficiency in each hospital did not change fundamentally during our observation period. Hospitals with the highest quotients share similarly high measures of efficiency throughout all years under observation, and hospitals with the lowest efficiency have similarly low measures of efficiency throughout all years under observation. The acquired estimations of measures of efficiency are there-

fore, based on the SFA method and DEA method, consistent throughout the entire observation period, indicating a specific general hospital that was inefficient in the first year of survey remained inefficient the next nine years under observation. Similar conclusions are also mention by other studies on efficiency of general hospitals [22].

Our results show the general level of economic efficiency displayed by the SFA method is, in most cases, somehow lower than the one presented by the DEA method. Such an outcome is not in accordance with the expectations raised by each method's techniques on measuring efficiency. The DEA method uses a deterministic approach, meaning it ascribes any deviation of a defined unit under observation from the frontier function entirely to inefficiency [6]. On the other hand, the SFA method uses a stochastic approach, meaning it splits any deviation of a defined unit under observation from the frontier function into two parts, namely into a stochastic error and an inefficiency measure [10,11]. According to this information, we ought to expect the SFA method to present higher efficiency measures of providers under observation. Several other authors agree [23].

Despite such expectations, similar results are mentioned by numerous other studies [24-29]. In our case, the difference in our results is a direct consequence of the fact that the stochastic frontier function, which is defined inside of the SFA method, lies above the data envelopment of data, in other words above the frontier function that is determined by the DEA method. It is therefore obvious that the stochastic frontier function, which is defined inside the SFA method, does not match our data the way a frontier function defined by the DEA method usually does. A similar conclusion is mentioned in several other studies, not only in the field of healthcare economics, but also in the field of agriculture efficiency evaluation [23,30,31]. Within the SFA method, we should choose the function form of the frontier production unction and frontier cost function; this supposition is not necessary with the DEA method, as the method determined the two just stated functions by itself.

Our results of the measures of efficiency estimated by the DEA method show several general hospitals are located exactly on the frontier function or at least in its immediate proximity. According to this, two general hospitals were habitually estimated as efficient during the observation period. Our results are therefore not in accordance with the measures of efficiency calculated based on the SFA method. The SFA method does not recognize any general hospital under observation as efficient; in other words, no general hospital can claim the value of 1, indicating no general hospital is located directly on the stochastic frontier function. This situation is a direct consequence of the fact each method defines the frontier function differently. The DEA method uses the actual observation for determining the data envelopment of data, meaning at least one general hospital will always be located directly on the frontier function. The SFA method uses observation only as a supporting factor for determining the stochastic frontier function. This is confirmed by most results supplied by efficiency analysis studies that analyze efficiency of providers with the SFA method and DEA method [29,32,33].

Between the results gained by the SFA method and the ones gained by the DEA method, there exists another very important difference. The measures of efficiency inside the DEA method vary more than the ones inside the SFA method. Similar observations are mentioned by Theodorifdis and Psychoudakis [34] and by Theodoridis and Anwar [23]. The SFA method can estimate the error illustrating methodological errors, among which are the wrong choice of function form, an impact of a variable we unintentionally omitted within the chosen model, data errors, environmental factors and so on [7]. In accordance with this statement, the results gained by the DEA method have greater variability than the ones supplied by the SFA method. As mentioned before, inefficiency is excluded from the measures of efficiency inside the SFA method, for it is labelled a consequence of a random error (white noise).

Parametric methods certainly have several advantages if we compare them to nonparametric methods. If there is a prior supposition we are dealing with a sample of data that suits the criteria of the intervallic (rational) scale, the parametric methods render it possible for us to have a better insight into differences amongst individual hospitals. A considerable difference in the measures of efficiency between Celje General Hospital and Slovenj Gradec General Hospital inside the SFA method is very likely a consequence of the existing measure of economic efficiency, which is demonstrated by the optimal usage of inputs, depending on the chosen output. On the other hand, the considerable difference in the measures of efficiency between Brežice General Hospital and the University Medical Center Maribor inside the DEA method could perhaps be a consequence of the methodological approach based on ranks; the differences caused by this approach do not always present the actual existing situation, only the difference in rank between the two hospitals. In case the acquired sample of data are precisely defined and measured with consistency, the SFA method will deliver the necessary information; it not only presents us with the conclusion on which hospital is the most efficient, it also

tells us how inefficient other hospitals are by comparison. The DEA method will deliver a similar conclusion, but it is better to rely on ranks and alphabetical order rather than on the differences in measures of efficiency that usually does not exist, because the DEA method can create a huge difference due to the nonparametric approach. Numerous authors have revealed that the DEA method delivers more reliable results in case the number of units in a survey is relatively small; parametric tests become reliable only in case the number of observations is relatively extensive [10,26-28].

In case both methods deliver similar results, efficient secondary healthcare providers are relatively easy to locate. A problem arises when the two methods reach different conclusions; one method deliver proof on efficiency of certain hospitals, while the other method provides proof on efficiency of different hospitals. In our case, the results are not accordant; the SFA method declares Celje General Hospital to be the most efficient one, but the DEA method states Brežice General Hospital to be the most efficient hospital. In cases such as this one, a decision on the actual quality of data used for the analysis in question must be reached. The more we believe the data to be of high quality, the easier it is to conclude the analysis based on the SFA method. Several other authors agree, for they state researchers should be careful during interpretation of results they present to the designers of healthcare policy [25,36,37].

Most studies of efficiency in the field of health are state neither of the two methods can be labelled as the prevailing method of the healthcare providers' efficiency evaluation, and that it is only reasonable to use as many methods and approaches as possible [38-41]. In the field of healthcare economics, we can also find several studies that indicate the SFA method and DEA method are, along with several other approaches, an acceptable alternative for the analysis of influence of environmental variables and dynamic effects on efficiency of hospitals; the usage of both methods enables us to gain similar, but more consistent results of healthcare providers' efficiency analysis [29,32,42,43].

Our results on measures of efficiency of Slovene general hospitals supplied by our two chosen methods (SFA and DEA) are a useful tool that can aid managers and payers (of healthcare services) to better understand economic efficiency and its connection to healthcare providers. Accordingly, the decision makers in healthcare can decide with less difficulty on the continuing business operations of general hospitals, supported by the provided examples of best practises that were declared as the most efficient hospitals by our analysis. The analysis of measures of efficiency of Slovene general hospitals is, however, especially useful for designers of healthcare policy. Extensive knowledge of measures of efficiency of general hospitals and their variations through time should considered a basis for ensuring they are always resources for the continuing operating of general hospitals, and a basis for the formation of secondary healthcare frontispiece of everything this sector can offer.

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