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The performance of Croatian hotel companies – DEA window and Malmquist productivity index approach*

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Abstract

The hospitality industry operates in a dynamic and competitive environment where efficiency and productivity are crucial for sustainable success. The main goal of this paper is to assess the dynamic changes in the efficiency and productivity of large and very large Croatian hotel companies and to investigate whether their location influences these factors. It also aims to determine how resilient the companies are to macroeconomic shocks and to identify the causes of inefficiency and productivity changes separately for each location. The analysis is conducted for 70 large and very large hotel companies in total and separately for those in coastal and the continental Croatia from 2017 to 2022 using the Window Data Envelopment Analysis and the Malmquist Productivity Index. The results show a slight decrease in relative efficiency in 2020 due to the impact of the COVID-19 pandemic. The main cause of inefficiency for coastal hotel companies throughout the period is management performance and other exogenous factors. Conversely, the main cause of inefficiency for continental hotel companies shifted from non-optimal production size to management and other exogenous factors after 2020. Productivity declined between 2019 and 2020 due to the decline in technological change for companies in both locations. Prior to 2020, coastal and continental hotel companies followed a similar trend. While coastal hotels recovered faster in 2021, continental hotels recovered more steadily and achieved higher productivity in 2022. This research provides valuable insights for hotel managers and academics seeking to navigate the ever-changing field of hotel management.

Keywords: *hotel companies, efficiency, productivity, Malmquist Productivity Index (MPI), Window Data Envelopment analysis,*

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1. Introduction

The hotel industry is one of the most important economic sectors driving socio-economic development worldwide, especially in Mediterranean countries such as Croatia, where the travel and tourism sector accounts for 25.8% of GDP which is by far the largest share in the EU (Statista 2023). However, traditional hotels face the challenge of maintaining and improving efficiency as the accommodation industry has been affected by the pandemic in 2020 (Dogru et al., 2023; Ozdemir et al., 2021). Accordingly, all accommodation providers in Croatia experienced a decline in tourist arrivals and overnight stays compared to the last year's period. Hotels recorded the sharpest decline in overnight stays, with a drop of 60.7% in July 2020 compared to the same month in 2019 (Rašić, 2020).

Efficiency and productivity are of the utmost importance in the Croatian hotel industry given the increasing demand for high-quality services. Highly efficient companies achieve greater increases in market share and profits through international trade than their less efficient counterparts (Melitz, 2003). Efficient hotel management not only ensures that day-to-day operations run smoothly but also contributes to the country's positive image in tourism. Streamlining processes, from reservation systems to check-in/out procedures, not only improves the guest experience but also enables hotels to manage the growing influx of visitors smoothly. In addition, the productivity of hotels has a direct impact on the economic benefit to local communities. Well-managed hotels create employment opportunities, promote economic growth, and provide jobs for many people. Focusing on productivity also means that the use of resources contributes to sustainability efforts and is in line with Croatia's commitment to responsible tourism. Leveraging technological advancements, investing in staff training, and adopting sustainable practices are crucial steps to ensure Croatian hotels remain at the forefront of the hospitality industry. This will not only raise the country's tourism profile but also promote economic growth and cultural exchange.

This paper aims to evaluate the dynamic changes in the efficiency and productivity of large and very large Croatian hotel companies. In this way, the causes of inefficiency and productivity of these companies will be identified. The results will provide managers with valuable insights into the factors that influence the efficiency and productivity of these hotel companies.

There are two common methodological approaches to evaluating hotel efficiency and productivity: the parametric (stochastic frontier), where estimates are made using econometric techniques, and data envelopment analysis (DEA), a non-parametric approach based on mathematical programming (Oukil et al., 2016). The DEA is the most commonly used method for assessing efficiency and productivity in sectors associated with hospitality and tourism (Assaf and Josiassen, 2016). Researchers evaluating hotel efficiency and productivity prefer DEA because it offers more flexibility in terms of the assumptions imposed on the estimated production function (Chatzimichael and Liasidou, 2019). The key advantage of this approach is the ability to evaluate the efficiency of individual hotels and identify the factors that explain differences in efficiency. This paper measures the efficiency and productivity of Croatian hotel companies within the Data Envelopment Analysis (DEA) framework. The DEA window analysis is used to assess efficiency and the Malmquist Productivity Index (MPI) is used to assess the change in total factor productivity of each hotel between two periods from 2017 to 2022.

The geographical location of hotels can contribute to the differences in their efficiency. Different locations often have different levels of economic development, labor costs, and market demand, all of which can affect the efficiency of hotels (Cordero and Tzeremes, 2017; Zhou et al., 2008). Accordingly, this paper attempts to offer new empirical insights into hotel companies in two major Croatian regions, the coastal and the continental regions. In particular, the focus is on evaluating their efficiency and productivity over six years (2017–2022) characterized by significant changes in the tourism industry due to the COVID-19 pandemic, which has slowed down foreign and domestic demand.

This paper consists of 6 sections. After the introduction, the rest of the paper is structured as follows. Section 2 reviews the relevant literature on efficiency and productivity evaluation in the hotel industry. Section 3 presents the methodology used, i.e. the window DEA and the MPI, while Section 4 focuses on the model specification, variable selection, and empirical analysis. Section 5 contains the results and a discussion, while Section 6 concludes the paper.

2. Literature review

The importance of measuring efficiency and productivity in the tourism industry has been repeatedly emphasised in the relevant literature. Efficiency and productivity assessment has become an important improvement tool for hotel companies to measure hotel performance. Chen (2007) argues that evaluating hotel efficiency is important from a strategic perspective because it enables performance comparisons between competing hotels, provides control over organizational outcomes, and facilitates the comparison of profits generated by different inputs. The hotel industry is facing increasing global competition, which is impacting hotel profitability and emphasising the need to increase efficiency (Assaf and Cvelbar, 2011). Early on, Lee-Ross and Ingold (1994) pointed out the need to develop appropriate productivity indices that would allow researchers to accurately capture the various productivity changes in hotel operations. Given the need for such methodological tools, DEA has emerged as one of the most widely used methods for assessing the production frontier of hotels.

The first application of DEA to the hospitality industry, in particular the restaurant sector, was in 1986 by Banker (1986) and Morey and Johns (1997), who used DEA to evaluate and benchmark the productivity of a chain of 15 hotels. Assaf and Agbola (2011) applied the double bootstrap DEA approach to evaluate the technical efficiency of Australian hotels from 2004 to 2007. The results indicate a gradual improvement in the average technical efficiency of Australian hotels. The most important determinants influencing the technical efficiency of Australian hotels are the number of years in business, location, star rating and physical size. Xu and Chi (2017) used a DEA window analysis to evaluate the operating efficiency of US hotels and found that hotels with higher operating efficiency had better financial performance. Tekiner (2023) used the CRS and VRS input-oriented DEA to evaluate the efficiency of 88 hotels in Cappadocia, Turkey, in 2020 during the Covid-19 pandemic period and found that revenue per available room is one of the main reasons for inefficiency.

The MPI (Caves et al., 1982) has been used to measure changes in productivity over time. The first applications of the MPI approach based on DEA to measure and decompose the productivity of different hotel sectors were carried out by Hwang and Chang (2003) and Barros and Alves (2004). Sun et al. (2015) applied the MPI to examine the productivity of the tourism industry in China from 2001 to 2009. Their results show that the most important factor for productivity changes is technological change. Barros and Alves (2004) used an output-oriented MPI based on DEA to evaluate the efficiency of 42 hotels of a Portuguese publicly owned hotel chain in the period 1999-2001. They found that most hotels underwent efficient technical change but did not experience technological change. Tourism is an industry that reacts very sensitively to crises and economic shocks. Cordero and Tzeremes (2017) evaluated the productivity of hotels in the Spanish Balearic and Canary Islands between 2004 and 2013. Their results show that the economic crisis had a significant negative impact on hotel productivity, especially in 2008 and 2009, after which hotels experienced a renewed increase in productivity due to technological advances and other innovations. Frančeškin and Bojnec (2023) used the MPI to evaluate the performance of Slovenian hotel companies from 2001 to 2018. The results show a decrease in total factor productivity, primarily due to the challenges of introducing new production technologies, which were exacerbated by the economic crisis in 2008. Like global economic crisis, Covid-19 pandemic had a strong negative impact on the global tourism and led to a decline in tourism productivity worldwide in 2020 (Kim et al., 2021). These studies have shown that the MPI not only evaluates the efficiency changes for each DMU, but also provides insights into the causes of these changes.

The application of DEA at the regional level is only found to a limited extent in the literature. Differences in regional economic development, market demand, and labor costs influence the efficiency of hotels. Several researchers evaluated hotel efficiency taking into account their location. Solana-Ibanez et al. (2016) found that Spanish hotels on the coast are more efficient than hotels in other locations. Lado-Sestayo and Fernandez-Castro (2019) also evaluated the efficiency of hotels in different regions of Spain and found differences in efficiency between them. Barros et al. (2011) found significant differences in the efficiency of French tourism regions. Barros (2005a, 2005b) used DEA to examine the factors that influence efficiency within a Portuguese hotel group and found a statistical relationship between establishment location and the efficiency achieved. Pulina et al. (2010) applied DEA window analysis to assess and analyze dynamic changes in the efficiency of the Italian hotel industry. Their study suggests that Sardinia could be considered as a region *falling further behind*, while certain regions in northern and central Italy could be considered *moving ahead*. A similar study was conducted by Karakitsiou et al. (2020) who evaluated the efficiency of the hotel and restaurant industry in all thirteen regions of Greece using the DEA. Their results show that Attica and South Aegean can be classified as *progressing* regions, while regions such as Thessaly, Central Macedonia, Central Greece, and Epirus can be considered *declining* regions.

As for Croatia, most studies focus on assessing the efficiency of the tourism industry when Croatia is one of the countries observed (Cvetkoska and Barišić, 2014; 2017) or at the level of Croatian counties (Rabar and Blažević, 2011; Hodžić and Alibegović, 2019), using data at the country or county level. Only a few studies have been conducted on the efficiency and productivity of Croatian hotels, using data at the company level. Poldrugovac et al. (2016) used an output-oriented BCC model and applied it to the hotels' internal accounting data. The results show that the average efficiency is high and that there is a significant relationship between size and hotel efficiency. Pervan and Babic (2021) conducted a study on a sample of 69 large and medium-sized hotels operating in Croatia in 2019. In the first stage, they used the DEA to assess hotel efficiency, and in the second stage, they conducted a truncated regression model using the results obtained in the first phase as the dependent variable and hotel ownership, age, location, size, and star rating as independent variables. The study results showed that all the variables analyzed (except age) play a significant role in determining the level of efficiency achieved.

Although the existing literature has made remarkable progress in the study of hotel efficiency, there is still room for further progress in this area. Furthermore, research on efficiency and productivity at the level of Croatian hotel companies is scarce or non-existent. To the best of the author's knowledge, there are no studies on efficiency using the window DEA analysis and productivity using the MPI within the DEA framework for Croatian hotel companies, as well as efficiency and productivity analyses at the hotel company level that take into account the location of a company. In view of this, this paper aims to fill that gap.

3. Methodology

Data Envelopment Analysis (DEA) is a widely recognized method originally introduced by Charnes et al. (1978) to evaluate the efficiency of a group of similar decision making units (DMUs) considering multiple inputs and outputs. It is a non-parametric method based on linear programming that measures relative efficiency by calculating the ratio between weighted inputs and weighted outputs for each DMU, which in this paper are large and very large hotel companies in Croatia. The efficiency score can vary between 0 and 1. DMUs with an efficiency score of 1 are considered efficient, and DMUs with an efficiency score below 1 are considered relatively inefficient. Relatively efficient DMUs cannot increase their output without either increasing some inputs or decreasing other outputs, and conversely they cannot decrease their input without either decreasing some outputs or increasing other inputs. DEA was originally developed to measure efficiency in the public sector, but due to its advantages, such as the ability to accommodate multiple inputs and multiple outputs in different units, it was soon recognized and used in the private sector as well. It is important to emphasize that DEA measures relative and not absolute efficiency. This means that DMUs that are considered relatively efficient serve as a benchmark for the relatively inefficient DMUs. The best-known DEA models are the CCR model and the BCC model. The CCR model (Charnes et al.,1978) assumes constant returns to scale (CRS) ($u_0 = 0$), i.e. if inputs increase, outputs also increase proportionally. They presented the following model:

$$\max \theta = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_r x_{i0}}$$

$$\text{Subject to } \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_r x_{i0}} \leq 1, \quad j = 1, \dots, n; \tag{1}$$

$$\text{with } u_r, v_i > 0, \quad i = 1, \dots, m; \; r = 1, \dots, s$$

Where y_{rj}, $x_{ij} > 0$ represent input and output for DMU j, θ stands for relative efficiency, $(x_{1j},...,x_{mj})$ is input vector of DMUj with the input weight vector $(v_1,...,v_m)$, and $(y_{1j},...,y_{qj})$ is the output vector of DMUj with the output weight vector $(u_1,...,u_q)$.

This method was further extended by Banker et al. (1984) (BCC model), who assume variable returns to scale (VRS) ($u_0 \neq 0$), where an increase in inputs does not necessarily have a proportional effect on output.

$$\max \theta = \frac{\sum_{r=1}^{s} u_r y_{r0} - u_0}{\sum_{i=1}^{m} v_r x_{i0}}$$

$$\text{Subject to } \frac{\sum_{r=1}^{s} u_r y_{r0} - u_0}{\sum_{i=1}^{m} v_r x_{i0}} \leq 1,\ j = 1, \ldots, n;\ u_r, v_i \geq 0 \quad (2)$$

with u_0 unrestricted in sign.

In addition to the choice of model, the orientation of the model must also be selected when performing a DEA. Two main types of DEA orientation are input-oriented and output-oriented models. The orientation of the DEA should be chosen based on the goals of the DMUs. In an input-oriented model, the goal is to minimize inputs while producing a certain level of outputs, while in an output-oriented model, the goal is to maximize outputs for given inputs.

A fundamental guideline in the DEA application is to ensure that the number of DMUs exceeds three times the sum of inputs and outputs. Failure to comply with this criterion can lead to the formation of numerous seemingly efficient units, which reduces the discriminatory power of the model. The window DEA analysis is used for addressing this issue. It evaluates the efficiency of DMUs compared to their historical values and other DMUs over different periods. Selecting an optimal window size is crucial to avoid unfair comparisons over time. Asmild et al. (2004) emphasize that while the window should be as small as possible to minimize temporal differences, it must also be large enough to obtain an adequate sample size. This balance ensures a robust and fair assessment of DMU performance and increases the DEA model reliability in capturing efficiency variations over time.

The application of DEA covers many different areas, including banking (Kamarudin et al., 2019; Učkar and Petrović, 2021) education (Arbula Blecich, 2020; Arbula Blecich and Tomas Žiković, 2016; Navas et al. 2020), health (Dukić Samaržija et al., 2018; Top et al., 2020), R&D (Arbula Blecich, 2021; Du and Seo, 2022), energy (Vlahinic-Dizdarević and Šegota, 2012) among others.

3.1. Window DEA

A major limitation of the DEA was the inability to track efficiency fluctuations over time. Among the various methods that address this problem, window DEA analysis proves to be a robust approach to assess changes dynamically in DMU efficiency. Unlike conventional DEA models such as the CCR and BCC models, which evaluate relative efficiency within a single period, window DEA analysis is a dynamic method in which individual DMUs are treated as different units over different periods. This framework allows the inclusion of a relatively larger number of inputs and outputs compared to the number of DMUs, which increases discriminatory power, especially in scenarios with a limited number of DMUs

(Halkos and Tzeremes, 2009). It also allows a comparative analysis of the efficiency of each DMU in a given period compared to their performance in other periods.

In order to clarify and articulate the dynamic shifts in the efficiency of selected DMUs, the window DEA relies on the moving average method. This means that when observing changes over time, the first (oldest) period in each shift window is replaced by the following period. The window DEA method is used to evaluate the relative efficiency of hotels in successive time periods. A moving time window is defined and efficiency scores are calculated for each hotel company within this window. The dynamic nature of the analysis allows efficiency trends to be identified over time.

A set of DMUs N (n = 1,…, N) uses r inputs to produce s outputs in a time period T (t = 1,…, T). DMU_n^t indicates the quantity of inputs or outputs for DMUn in time period *t*. The input vector (X_n^t) and the output vector (Y_n^t) are represented as follows (Jia and Yuan, 2017):

$$X_n^t = \begin{bmatrix} x_n^{1t} \\ \vdots \\ x_n^{rt} \end{bmatrix} \qquad Y_n^t = \begin{bmatrix} y_n^{1t} \\ \vdots \\ y_n^{st} \end{bmatrix} \tag{3}$$

If we assume that the window starts at time k (1 ≤ k ≤ T) and the window length is p (1 ≤ w ≤ T-k), then the input (Xkw) and output (Ykw) matrices of each window (kw) are as follows (Jia and Yuan, 2017):

$$X_{kw} = \begin{bmatrix} x_1^k & x_2^k & \cdots & x_N^k \\ x_1^{k+1} & x_2^{k+1} & \cdots & x_N^{k+1} \\ \vdots & \vdots & \ddots & \vdots \\ x_1^{k+w} & x_2^{k+w} & \cdots & x_N^{k+w} \end{bmatrix}$$
$$Y_{kw} = \begin{bmatrix} y_1^k & y_2^k & \cdots & y_N^k \\ y_1^{k+1} & y_2^{k+1} & \cdots & y_N^{k+1} \\ \vdots & \vdots & \ddots & \vdots \\ y_1^{k+w} & y_2^{k+w} & \cdots & y_N^{k+w} \end{bmatrix} \tag{4}$$

When inputs and outputs of DMU_n^t are substituted into CCR (1) and BCC (2) models, the results of the DEA window analysis are obtained.

The number of data points is calculated as follows:

$$w = k - p + 1 \tag{5}$$

$$\textit{Number of } \text{different } \textit{DMUs (data points)} = n * p * w \tag{6}$$

where:

n = number of DMUs (in our case no. of hotel companies),

p = length of window,

w = number of windows and

k = number of periods

For a 6-year period (2017-2022) and a 2-year window, the calculation of the number of data points is as follows:

$w = 6 - 2 + 1 = 5$

Number of 'different' *DMUs* (*data points*) – *full sample* = 70 ∗ 2 ∗ 5 = 700

Number of 'different' *DMUs* (*data points*) – *coastal Croatia* = 56 ∗ 2 ∗ 5 = 560

Number of 'different' *DMUs* (*data points*) – *continental Croatia* = 14 ∗ 2 ∗ 5 = 140

It can be noted that there are more than enough data points for each sample to conduct the analysis.

CCR efficiency corresponds to Technical Efficiency (TE), which reflects a company's ability to use the given inputs to maximize outputs, assuming an optimal operating size. The BCC model evaluates Pure Technical Efficiency (PTE) ignoring the effects of scale size by comparing a DMU only with a DMU of similar size. PTE evaluates the efficiency of a DMU's resource utilization under exogenous conditions, with a lower PTE indicating that the DMU is managing its resources inefficiently. Using the BCC model, the TE score can be broken down into the PTE and the Scale Efficiency (SE), which is expressed by the following relationship (Al-Refai et al., 2016).

$$SE = \frac{TE}{PTE} \tag{7}$$

Scale Efficiency (SE) evaluates how the size of the operation affects efficiency and provides an indication of management's ability to select the optimal resource size to achieve the expected production level. If the TE score is equal to the PTE score, this means that the SE score is equal to 1 and therefore the optimal size of the operation has been achieved.

3.2. Malmquist Productivity Index

The DEA-based Malmquist Productivity Index (MPI) is used to evaluate changes in total factor productivity in the hotel sector over time. MPI was originally proposed by Färe et al. (1994) and is defined as a linear programming model based on DEA (Oliveira et al., 2023; Örkcü et al., 2016):

$$M(x^t, y^t, x^{t+1}, y^{t+1} = \left[\frac{D^t(x^{t+1}, y^{t+1}}{D^t(x^t, y^t)} \cdot \frac{D^{t+1}(x^{t+1}, y^{t+1}}{D^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} \quad (8)$$

In the previous equation, x represents the input vector and y the output vector. The expression (x^t, y^t) is defined as a function of the distance results, while M is defined as the total productivity change between t and t +1 period.

When comparing the efficiency frontier of one period with the next, the MPI decomposes productivity changes into components related to technical efficiency changes and technological changes and can be presented as follows (Kutlar et al., 2015):

Malmquist productivity index (MPI) =
= Technical Efficiency chalge (TEC) ∗ Technological change (TC) (9)

where:

$$Technical\ efficiency\ change\ (TEC) = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \quad (10)$$

$$Technological\ change\ (TC) = \left[\left(\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^t)}\right)\left(\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \quad (11)$$

The concept of productivity is described in the literature as the product of efficiency changes (representing the catch-up process) and technological changes (indicating a frontier shift). An MPI index of more than 1 indicates growth from one period to another, while a value below 1 indicates a decline in MPI performance or growth compared to the previous period. When calculating the MPI, a production frontier represents the efficient level of output that can be achieved with a given inputs. It is also assumed that this frontier can shift over time. The MPI stands for the growth in Total Factor Productivity (TFP) of a DMU and is defined as the result of the change in efficiency (catch-up) and technological change (frontier-shift); if it is greater than 1, this is an indication of positive TFP growth from one period to the next, while a TFP value of less than 1 indicates a decline in TFP growth compared to the previous year.

Over time, the potential production level of an organization tends to increase as technological advances affect the optimal input-output combination. These technological changes lead to an upward shift in the production possibility frontier so that more output can be achieved with the same level of inputs. Consequently, productivity increases for each DMU within an industry can result either from improvements in technical efficiency (reaching parity with the existing frontier) either from technological advances (gradual upward shift of the frontier), or a combination of both (Al-Refaie et al., 2015). In the presence of inefficiency, the relative movement of a specific DMU over time depends both on its position relative to the corresponding frontier (an indicator of technical efficiency) and on the movement of the frontier itself (an indicator of technical change). If inefficiency were neglected, productivity growth would become indistinguishable between improvements resulting from a DMU reaching its frontier and those resulting from the upward movement of the frontier over time (Al-Refaie et al., 2016). Consideration of the CRS model leads to a change in technical efficiency (TEC) and technological change (TC).

One of the main problems of DEA-based efficiency and productivity studies is their sensitivity to sample characteristics (Assaf and Tsionas, 2018). The excessive sensitivity to extreme values and outliers, as well as the number of DMUs added to or excluded from the model, affects the estimated distance functions and thus the efficiency results, as well as the MPI and its components (Tzeremes, 2021).

The MPI is a powerful tool for the hospitality industry, providing insights into efficiency, benchmarking, and dynamic change. Hotels can use the MPI to benchmark their performance against other hotels or industry standards to identify best practices. The dynamic nature of the MPI enables the assessment of productivity changes over time. The MPI breaks down productivity changes into technical efficiency changes and technological changes, which can help hotels better understand whether productivity improvements are due to better resource utilization or the introduction of new technologies. It also helps with resource allocation and ensures that investments are directed to the areas with the highest potential for productivity improvements. The MPI can serve as a basis for policy and management strategies at different levels, e.g. at the corporate level, hotel chains can develop policies to promote efficiency and innovation in their properties, and at the individual hotel level, managers can implement specific measures to improve operational efficiency and service quality. MPI can contribute to sustainability efforts and cost management. More efficient use of resources can reduce waste and lower operating costs, supporting economic and environmental sustainability goals.

4. Empirical data and analysis

This section explains the variable selection and model specification and presents the results of the dynamic relative efficiency obtained with the DEA window and the findings on the main causes of inefficiency. In addition, this section presents the productivity changes using the MPI.

4.1. Variable selection

In this paper, the production function of a hotel company is defined as the utilization of total employees and total fixed assets in converting them into total revenues (Tzermis, 2021; Pulina et al., 2010; Cordero and Tzeremes, 2017). According to Hwang and Chang (2003) and Tzeremes (2021), the production input of a hotel includes several elements such as materials, capital, machinery, and equipment, all of which are part of the total fixed assets. Together with labor, as measured by the costs of employees, these inputs are essential for providing tangible and intangible services. These services include accommodation, catering, laundry, rental, beauty salons and fitness services, which are ultimately reflected in the revenue generated.

The selection of variables is based on previous studies, in particular, those that have defined the production function of hotel companies in the same way as in this paper, namely those of Tzermis (2021), Cordero and Tzeremes (2017) and Devesa and Peñalver (2013), as well as on the availability of data. In constructing estimated hotel production frontier, costs of employees (measured in thousands of Euros) as a representation of human resources (Devesa and Peñalver, 2013; Lado-Sestayo and Fernandez-Castro, 2019; Pulina et al., 2010) and total fixed assets (measured in thousands of Euros) as a measure of capital investment (Cordero and Tzeremes 2017; Higuerey et al., 2020; Tzeremes, 2019) are considered as inputs, while the main output is represented by the total revenues (measured in thousands of Euros), which is a direct result of the services provided and the achievement of the objectives set (Günaydın et al., 2022; Higuerey et al., 2020; Tzeremes, 2021). When selecting the output data, EBIT was also tested as a possible output variable in addition to the operating income. However, as this variable did not fulfill the isotonic condition in every year observed (Wang et al., 2015), which is one of the prerequisites for the application of DEA, i.e., that the output grows with the growth of the input, it could not be used. Although hotels produce multiple outputs, the lack of detailed data on these does not detract from the importance of focusing on revenue efficiency and productivity changes, which are critical to effective hotel management.

The input and output data are collected from the Bureau van Dijk's (BvD) Orbis Europe database for large and very large companies with NACE code 55.1 (hotels and similar accommodation) operating in Croatia within the 2017-2022 period. This paper applies the size classification provided by the Bureau van Dijk's (BvD) Orbis Europe database. Companies on Orbis Europe are classified as very large or large if they match at least one of the conditions listed below for the respective category:

Table 1: Size classification for large and very large companies (Bureau van Dijk's (BvD) Orbis Europe)

Very Large	Large
Operating revenue >= 100 million EUR (130 million USD)	Operating revenue >= 10 million EUR (13 million USD)
Total assets >= 200 million EUR (260 million USD)	Total assets >= 20 million EUR (26 million USD)
Employees >= 1,000	Employees >= 150
Listed	Not very large

Source: Bureau van Dijk's (BvD) Orbis Europe database

The selected hotel companies had to operate continuously during the entire period and were not allowed to have missing data, which is why some of them were excluded from the sample. The following table contains descriptive statistics, separately for coastal and continental Croatia for the 2017-2022 period.

Table 2: Descriptive statistics

		Coastal Croatia			Continental Croatia		
		Costs of employees th EUR	Tangible fixed assets th EUR	Operating revenue (Turnover) th EUR	Costs of employees th EUR	Tangible fixed assets th EUR	Operating revenue (Turnover) th EUR
2017	Max	72,225.3219	589,152.3203	236,423.5801	10,270.8700	206,758.5700	35,521.6300
	Min	21.0500	1,072.5700	84.1600	63.3100	4,033.9700	231.3500
	Average	5,397.2388	63,214.7135	20,753.0776	1,917.1957	38,524.9614	7,912.2157
	SD	11,199.1245	97,561.0807	40,246.8653	2,467.9712	49,729.0666	8,634.0693
2018	Max	84,045.8714	688,732.2012	267,481.6793	9,785.0500	201,105.4100	39,714.2900
	Min	41.1100	1,035.9700	92.3900	89.1900	1,297.9400	144.0000
	Average	5,992.6721	67,932.4227	22,775.4363	2,063.5714	38,183.9914	8,817.8364
	SD	12,808.0991	111,365.3741	44,843.4335	2,312.6063	48,140.1077	9,199.3931
2019	Max	91,279.1921	743,156.0835	289,121.8097	9,603.4600	196,022.0800	38,694.5500
	Min	67.8100	4,209.3800	191.2855	166.5400	4,136.1100	617.0300
	Average	6,486.8739	71,548.6904	23,891.1488	2,137.3964	38,498.4950	10,071.5750
	SD	13,898.5686	118,577.1685	47,607.2030	2,265.0564	46,541.9376	10,610.9867
2020	Max	30,140.0039	751,203.6007	88,831.1806	7,873.1200	195,941.0100	22,382.2300
	Min	35.8413	4,108.0400	24.1597	134.2300	6,534.7200	223.1200
	Average	3,336.8153	69,419.9406	9,096.7433	1,656.7314	37,845.1243	5,143.0579
	SD	6,001.8681	117,759.2051	17,476.3782	1,868.1518	46,522.3925	5,201.8229
2021	Max	58,413.4362	693,520.9909	216,381.5984	9,810.7700	193,861.9100	27,670.5800
	Min	34.4210	976.4200	340.4900	191.1100	7,092.1000	911.5100
	Average	4,782.9842	68,020.3322	19,642.5182	2,002.2186	44,195.0986	7,494.2971
	SD	9,918.4703	111,279.1272	38,668.0400	2,289.7596	51,476.0999	6,254.8538
2022	Max	109,730.2283	669,778.5485	322,242.7753	13,046.0000	193,695.3300	50,179.0000
	Min	37.6933	962.6100	46.4530	92.1900	7,382.9100	450.1800
	Average	7,381.6960	69,743.3822	27,681.1949	2,522.0486	46,043.3936	13,484.0843
	SD	16,771.9611	113,138.4581	54,709.4563	3,086.4319	52,513.6401	13,210.3309

Source: Authors' calculation

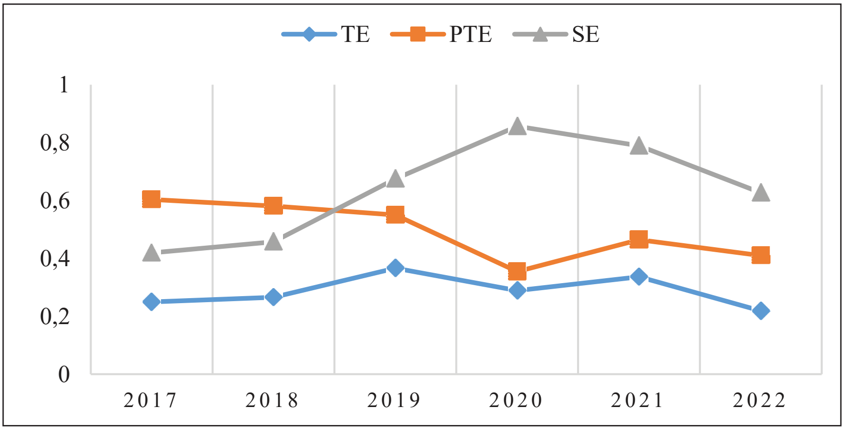
The results obtained are divided into five windows. The windows are formed based on the moving average. For example, the first window covers the period from 2017 to 2018, i.e., the window length is two years. The second window covers the period from 2018 to 2019, the third from 2019 to 2020, the fourth from 2020 to 2021, and the fifth from 2021 to 2022. There is no theoretical basis for choosing the specific window length (Cullinane et al., 2004). However, it should be as small as possible to minimize unfair comparisons over time, but at the same time, large enough to ensure a sufficient sample size (Asmild et al., 2004).

4.2. Window DEA analysis

In recent years, the tourism industry has faced numerous global crises, including the COVID-19 pandemic, political instability, terrorist incidents, economic downturn, and natural disasters. These crises have been attributed to, among other factors, fluctuations in the operational efficiency of hotels. Economic conditions fluctuate from time to time while market dynamics change in terms of customer base, customer expectations, preferences, and needs (Hwang and Chang, 2003).

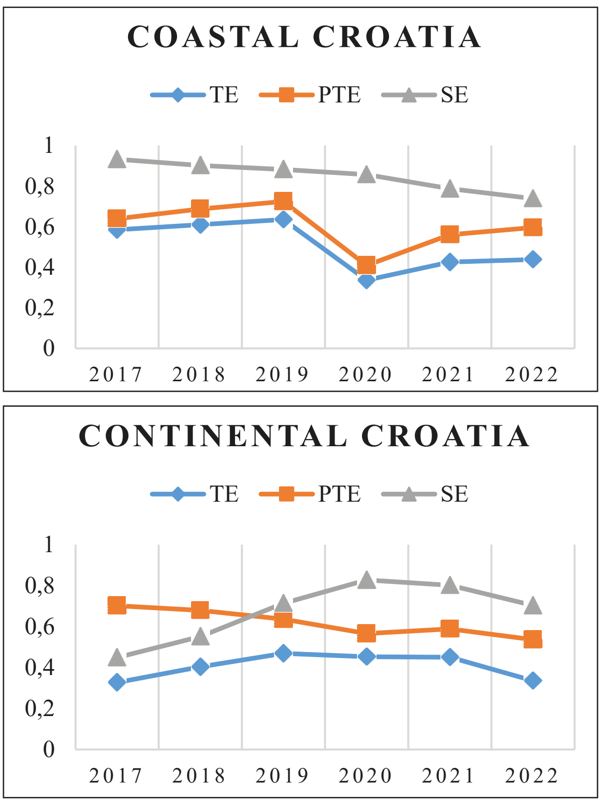
This study spans a six-year period of data collection, which allows the use of a two-year time window. This time frame allows for a more in-depth examination of the stability and trends in the efficiency of Croatian hotel companies. The results are presented for the entire sample (Graph 1), which includes 70 hotel companies from coastal and continental Croatia, and separately for coastal (56 hotel companies) and continental Croatia (14 hotel companies) (Graph 2) to determine whether there are differences in resilience to external influences depending on location. It also aims to identify the sources of inefficiency, i.e. management performance and other exogenous factors or the fact that companies are not operating at an optimal production size. While PTE is affected by management, technology, and other exogenous factors, SE as the ratio between TE and PTE provides information on whether the DMU is operating on the optimum size of resources. For the entire sample (Graph 1), a production frontier includes all observed companies regardless of their location. For the hotel companies located in coastal and continental Croatia (Graph 2), a separate production frontier is used for each sample.

Graph 1: Dynamics of TE, PTE and SE – average by year for the full sample



Source: Author's construction

Graph 2: Dynamics of TE, PTE and SE – average by year for hotel companies located in coastal and continental Croatia



Source: Author's construction

It can be seen that the relative efficiency of hotel companies fell slightly in 2020 for all three samples. It is logically due to the COVID-19 pandemic and the fact that hotels were closed for a certain period, and traveling was much more difficult. Interestingly, the drop in relative efficiency is not as sharp, although it is most pronounced for coastal Croatia. Nevertheless, there is a big difference in the sources of inefficiency. For hotel companies located in coastal Croatia, the main source of inefficiency throughout the period is management performance and other exogenous factors, which are even more pronounced in 2020. For hotel companies located in continental Croatia, on the other hand, the main source of inefficiency before 2019 was the non-optimal production size. In 2020, when the COVID-19 pandemic broke out, management and other exogenous factors were also the main source of inefficiency in continental Croatia, which continued in 2021 and 2022.

Since the DEA measures relative and not absolute efficiency, it is incorrect to compare the results of different samples, as each sample separately forms its frontier. Therefore, the results of the entire sample are used to answer the question of which companies are more efficient depending on their location. Looking at the results for the entire sample, but for hotel companies in coastal and continental Croatia separately on average for the period 2017-2022, it can be seen that hotel companies in continental Croatia are more efficient in all components than those in coastal Croatia, as can be seen in Table 3.

Table 3: TE, PTE and SE of hotel companies located in coastal and continental Croatia – full sample

	Coastal Croatia	Continental Croatia
TE	0.2672	0.3689
PTE	0.4878	0.5189
SE	0.6178	0.7149

Source: Authors' calculation

4.3. Malmquist Productivity Index analysis

The MPI assesses the change in efficiency over time and can be calculated as the product of the c*atch-up* and *frontier shift*. The term *catch-up* refers to the extent to which a DMU increases its efficiency. Meanwhile, the term *frontier shift* refers to the change in the efficiency frontiers surrounding the DMU between the two time periods. The productivity change (MPI) is split into two components: TEC and TC. The results for TEC, TC, and MPI are presented in Table 4 for the full sample during the 2017-2022 period.

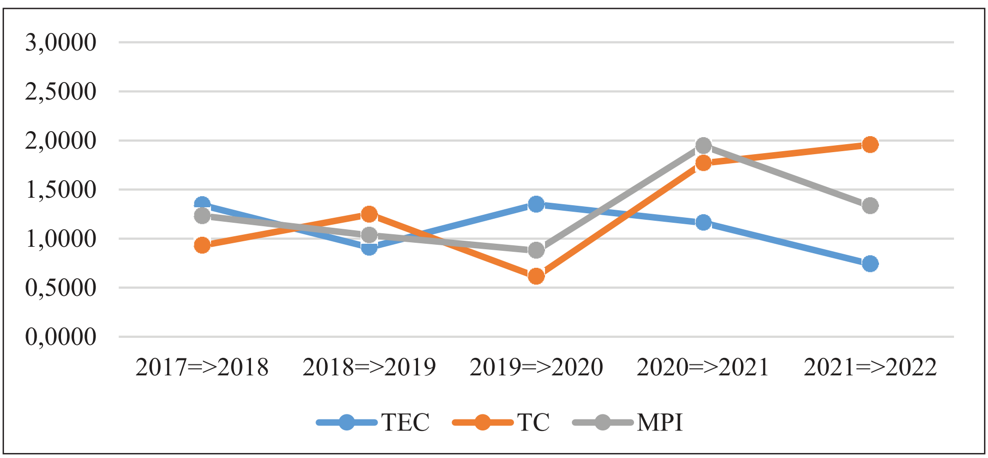
Table 4: TEC, TC amd MPI for the full sample

Period	TEC	TC	MPI
2017=>2018	1.3407	0.9295	1.2308
2018=>2019	0.9102	1.2451	1.0332
2019=>2020	1.3471	0.6119	0.8775
2020=>2021	1.1611	1.7685	1.9440
2021=>2022	0.7403	1.9558	1.3311
Geo. Average	1.0999	1.3022	1.2833
Max	4.8284	1.7760	5.0138
Min	0.7623	1.0157	0.9721
SD	0.5368	0.1328	0.5541

Source: Authors' calculation

The minimum average MPI score for hotel companies in Croatia is 0.9721, while the maximum average score is 5.0138. It is noticeable that hotel companies in Croatia have the highest geometric average of 1.2833, indicating an average increase in MPI of 28.33%. This increase in productivity is due to technological change (30.22%) rather than technical efficiency change (9.99%). When looking at productivity changes over the period, it is noticeable that productivity decreased by 12.25% from 2019 to 2020 due to a technological decrease (38.81%) as a consequence of the pandemic. The average changes in productivity for the entire sample can be seen more clearly in Graph 3.

Graph 3: TEC, TC amd MPI for the full sample



Source: Author's construction

These results underline the importance of investing in technology for effective productivity management which is in line with Peypoch et al. (2021). The most important factor contributing to the productivity level of hotel companies in Croatia and enabling a quick recovery from the pandemic seems to be the sustainable investment in a long-term innovation focused on services and processes.

In the following table, the results are presented individually for coastal and continental Croatia to see if they follow different trends in productivity changes.

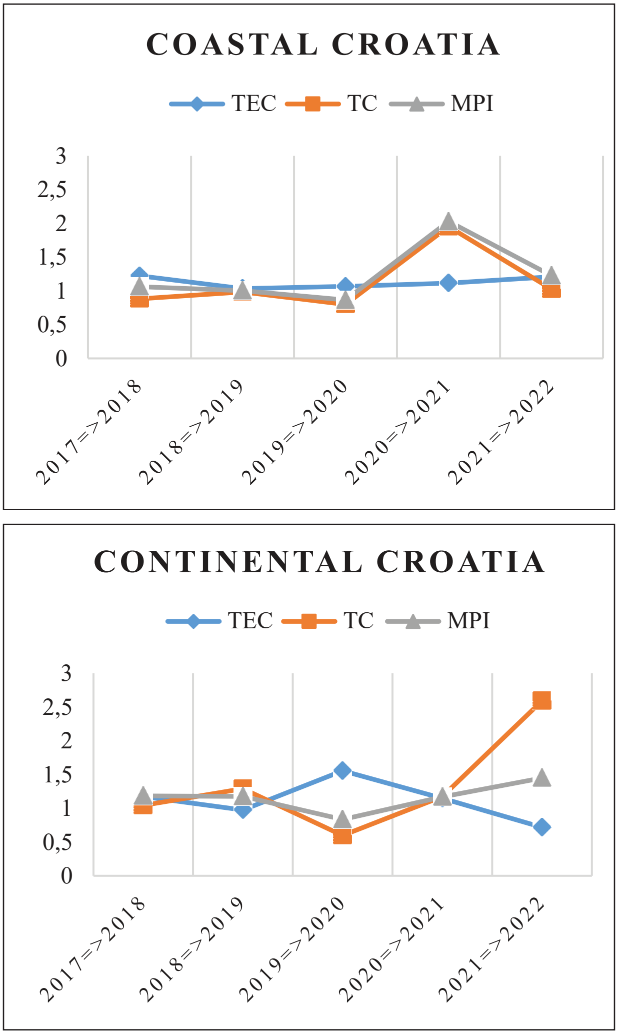
Table 5: TEC, TC and MPI separtely for coastal and continental Croatia

Period	Coastal Croatia			Continental Croatia		
	TEC	TC	MPI	TEC	TC	MPI
2017=>2018	1.2248	0.8821	1.0629	1.1738	1.0436	1.1830
2018=>2019	1.0346	0.9834	1.0022	0.9760	1.2907	1.1760
2019=>2020	1.0662	0.8000	0.8650	1.5547	0.5972	0.8345
2020=>2021	1.1153	1.9524	2.0299	1.1480	1.1746	1.1688
2021=>2022	1.2101	1.0280	1.2271	0.7190	2.5927	1.4495
Geo. Average	1.1302	1.1292	1.2374	1.1143	1.3398	1.1624
Max	3.0720	1.7662	3.7534	2.0599	1.6510	1.8560
Min	0.7972	0.8639	0.9903	0.6978	0.7359	0.7359
SD	0.3259	0.1458	0.3966	0.3470	0.2964	0.2856

Source: Authors' calculation

On average, hotel companies followed a similar pattern before 2020, both in coastal and continental Croatia. Interestingly, hotels on the Croatian coast recovered at a higher rate from the pandemic in 2021 than companies in continental Croatia. On the other hand, hotel companies located in continental Croatia recovered more steadily from the pandemic in the following years having reached a higher level of productivity than hotels on the Croatian coast in 2022. Croatian tourism, especially in the coastal region is highly seasonal. The tourists who come to continental Croatia do not only come during the summer holiday, which makes tourism in continental Croatia more resilient to seasonal changes. However, it should be noted that most hotel companies in continental Croatia are located in Zagreb (71.4%), the Croatian capital, which has a considerable impact on efficiency and productivity results due to market concentration. This is expected since demand has a key role in the efficiency of hotel companies. Hotels located near more populated areas are more efficient because they attract more customers (Barros, 2005b). This is in line with Oukil et al. (2016) who conducted a two-stage DEA application for 58 hotels in the Sultanate of Oman and found that most of the hotels classified as efficient were located in the capital Muscat. Changes in productivity for both samples separately are shown in Graph 4.

Graph 4: TEC, TC and MPI separtely for coastal and continental Croatia



Source: Author's construction

5. Discussion

According to the results of this study, the main conclusion is that the COVID-19 pandemic hit the hotel sector hard resulting in temporary hotel closures and increased travel requirements for tourists. This had a significant impact on their relative efficiency and productivity, which declined in 2020. The inefficiency of hotel companies in coastal Croatia during the entire observation period was primarily due to management performance and other exogenous factors. For hotel companies in continental Croatia, on the other hand, the main source of inefficiency before 2019 was the non-optimal production size, which changed after 2020 due to COVID-19, and the main source of inefficiency became management performance and other exogenous factors. This trend continued in 2021 and 2022.

Looking at productivity changes from one year to the next, the results show that the pandemic caused a decline in productivity in hotel companies from 2019 to 2020 by 12.25% due to technological decrease (38.81%), but only for a short period that is in line with research results of Barros and Alves (2004) and Cordero and Tzeremes (2017). Most hotels were able to recover from this decline fast and improve their efficiency and productivity to maintain their competitive market position. These results are in line with several studies that have examined the dynamics of efficiency during the economic crisis (Baidal et al., 2013; Cordero and Tzermes 2017; Lu, 2015). Although an economic crisis has a significant negative impact on hotel productivity, it is usually followed by a quick recovery. To analyze what influences productivity, the productivity change (MPI) is broken down into two components: technical efficiency change (TEC) and technological change (TC). The results show that the main cause of the decline in productivity is TEC, which is consistent with the findings of Lu (2015). When observing the entire period (2017 to 2022), on average MPI for hotel companies in Croatia increased by 28.33%, mainly due to an increase in TC that is in line with Barros and Alves (2004). Sustainable investment in a long-term innovation strategy focused on services and processes have proved to be a key element in increasing productivity and enabling hotel companies in Croatia to recover quickly from the effects of the pandemic.

Previous research (Cordero and Tzeremes, 2017; Pulina et al., 2010; Karakitsiou et al., 2020; Solana-Ibanez et al., 2016) has shown that the geographical location of hotels is a factor that can have a strong influence on differences in efficiency and productivity due to differences in economic development, market demand, etc. Accordingly, one of the aims of this paper was to investigate how the location of hotel companies affects their efficiency and productivity depending on whether they are located on the coast or the continental Croatia. Interestingly, hotel companies on continental Croatia were less affected by the pandemic than those on the Croatian coast. They also experienced a more steady recovery and reached a higher productivity level in 2022 than their counterparts on the coast. Although continental

Croatia is not known as a tourist destination, the main reason for these results is that 71.4% of hotels in continental Croatia are located in the Croatian capital Zagreb. It is in line with the findings of Barros (2005b) and Oukil et al. (2016), as hotels in more populated areas, have higher efficiency and productivity due to the higher demand for their services.

6. Conclusions

The continuous measurement of hotel productivity remains a major research challenge (Song et al., 2012). This challenge is particularly significant for providing managers and policymakers with an initial evaluation tool to assess the impact of implementing hotel development strategies. The outcomes that result from hotel design and development inevitably influence the overall productivity and efficiency of hotels. Therefore, it is of utmost importance to develop and apply estimators to measure hotel productivity. As the Croatian economy is highly dependent on tourism, hotel efficiency, and productivity have become a key element of the country’s image in the global travel industry.

In 2020, the relative efficiency of hotel companies fell slightly due to the impact of the COVID-19 pandemic. Although this decline was not very large, the cause of inefficiency for hotel companies located in continental Croatia has shifted due to management and other external factors, while for companies on the Croatian coast, management, and other external factors remained the main source of inefficiency throughout the period. The productivity of large and very large Croatian hotel companies has largely declined between 2019 and 2020, regardless of location, which shows the impact of the COVID-19 pandemic on the hotel industry in Croatia. It can be noted that from 2019 to 2020 when the COVID-19 pandemic hit, the main cause of MPI deterioration was a drastic decrease in TC. Despite this sharp decline, hotel companies in Croatia have recovered quickly from the effects of the pandemic. Hotel companies in continental Croatia, mainly located in the Croatian capital Zagreb, have recovered faster than those on the Croatian coast, proving that businesses in more populated areas attract more customers and achieve higher efficiency and productivity levels.

As far as the author knows, this is the first study on efficiency using window DEA analysis and productivity using MPI for Croatian hotel companies. Furthermore, to the authors’ knowledge, this is the first efficiency and productivity analysis at the hotel company level that takes into account the location of a company. The limitations of this paper arise from the availability of comprehensive data on multiple outputs. Despite these limitations, the study focuses on the salient aspects of revenue efficiency and productivity change that are paramount for hotel management. Future studies should focus on taking macroeconomic factors into account and examining the relationship between certain macroeconomic factors and obtained levels of efficiency and productivity. In addition, future studies should consider more detailed data to obtain more specific results. In this paper, only large and very large hotels are analyzed. However, in future research, small and medium-sized hotels should also be included in the sample. A second-stage analysis should be conducted to determine whether size has a significant impact on hotel efficiency and productivity. These results will provide managers with guidance on when to increase or decrease the scale of operations and how to make better use of available resources over time. The implementation of an innovative process leading to changes in TC has an impact on hotel companies and contributes to the strategies of differentiation and customization of tourism demand (Stamboulisa and Skayannisb, 2003). The results can also help policy-makers to present Croatia as a destination in a way that makes it more resilient to negative demand shocks.

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Vrednovanje efikasnosti i produktivnosti poslovanja hrvatskih hotelskih poduzeća – pristup DEA analize prozora i Malmquist indeksa produktivnosti

Andrea Arbula Blecich[1]

Sažetak

Ugostiteljska industrija djeluje u dinamičnom i konkurentnom okruženju u kojem su efikasnost i produktivnost ključni za održivi uspjeh. Glavni cilj ovog rada je procijeniti dinamičke promjene u efikasnosti i produktivnosti velikih i vrlo velikih hrvatskih hotelskih poduzeća te istražiti utječe li njihova lokacija na te čimbenike. Također, cilj rada je i utvrditi koliko su poduzeća otporna na makroekonomske šokove te identificirati uzroke nefikasnosti i promjena produktivnosti zasebno za svaku lokaciju. Analiza je provedena za 70 velikih i vrlo velikih hrvatskih hotelskih poduzeća skupno te posebno za poduzeća koja se nalaze u primorskoj i u kontinentalnoj Hrvatskoj od 2017. do 2022. godine korištenjem DEA analize prozora i Malmquist indeksa produktivnosti. Rezultati pokazuju blagi pad relativne efikasnosti u 2020. zbog utjecaja pandemije Covid-19. Glavni uzrok neefikasnosti za primorska hotelska poduzeća kroz cijelo razdoblje je izvedba menadžmenta i drugi egzogeni čimbenici. Suprotno tome, glavni uzrok neefikasnosti za kontinentalna hotelska poduzeća pomaknuo se s neoptimalne veličine proizvodnje na upravljanje i druge egzogene čimbenike nakon 2020. Produktivnost je pala između 2019. i 2020. zbog smanjenja tehnoloških promjena za poduzeća na obje lokacije. Prije 2020. hotelska poduzća u primorskoj i kontinentalnoj Hrvatskoj slijedila su sličan trend. Dok su se primorski hoteli oporavljali brže u 2021., kontinentalni su se hoteli oporavljali stabilnije i postigli veću produktivnost 2022. Ovo istraživanje pruža vrijedne uvide za menadžere hotela i akademike koji se kontinuirano trebaju prilagođavati stalnim promjenama koje zahtijeva upravljanje hotelima.

Ključne riječi: *hotelska poduzeća, efikasnost, produktivnost, Malmquist indeks produktivnosti, DEA analiza prozora*

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