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Applications of Data Envelopment Analysis (DEA) in Empirical Studies Regarding the Croatian Tourism

Abstract

Tourism is one of the largest and continuously booming economic sectors globally that significantly contributes primarily to GDP, employment, and prosperity. The efficiency of this sector is, therefore, closely researched and investigated by scholars across the globe. Data Envelopment Analysis (DEA henceforward) is one of the leading non-parametric methodologies that evaluates the performance and relative efficiency of complex and homogeneous entities called Decision-Making Units (DMUs).

The main aim of this study is to explore, identify and present different applications of DEA in Croatian tourism, which is one of the sectors that contributes the most to the economy. Other goals are to present ten surveyed papers that employ the DEA methodology. To identify the surveyed studies, an extensive literature review has been conducted, and the Scopus, Web of Science, and CROSBI (Croatian Scientific Bibliography) databases have been browsed, with the keywords "DATA ENVELOPMENT ANALYSIS", "TOURISM" and "CROATIA". Furthermore, the study of Neralić and Gardijan Kedžo (2019) has been used as a foundation of the literature review. The key findings indicate that most of these ten surveyed papers employ the DEA BCC output-oriented model, and most of the analyzed time frame is from 2011 onwards.

Keywords: data envelopment analysis, literature review, non-parametric method, tourism, Croatia

1. Introduction

Tourism today enjoys the status of "one of "one of the biggest, most dynamic and complex socio-economic phenomena in the modern world" (Cvetkoska & Barišić, 2014) and is, without doubt, "one of the most complex modern phenomena" (Baldigara et al., 2012). In 2017, tourism had a share of 7% of the global trade, a 10% share of the world GDP, and was the third largest export category of the world economy after chemicals and fuels, and ahead of automotive products and food (Alkier et al., 2021; Barišić & Cvetkoska, 2020; World Tourism Organization [UNWTO], 2019). The tourism industry is one of the key contributive industries to Croatia's economy due to its impact on the Croatian GDP, employment, and, therefore, the country's development and prosperity. Any research and new insights on the efficiency of Croatian tourism are invaluable. According to Gržinić (2017), tourism is defined as "a human activity with demand for and supply of product and the usage of resources that may result in either positive or negative socio-economic consequences at both the national and international level". Tourism plays a vital role in the economic growth and development of countries worldwide since it represents 10% of the global GDP (Harchandani et al., 2021). Croatian economy today relies on its main economic activities, which are tourism, industry, civil engineering, and agriculture (Denona Bogovic & Grdic, 2020). Moreover, tourism is considered to be the most relevant economic activity in Croatia, which makes this research that much more interesting.

In this research, the authors have identified all of the publications by Croatian researchers implementing the Data Envelopment Analysis (DEA) in Croatian tourism. The main goal is to present all the possible

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ways in which the DEA methodology can be used and what aspects of Croatian tourism have thus far been investigated, as well as to present the findings and provide new insights for academia, the public, and the government.

The remainder of the paper is structured as follows: section 2 introduces the concept of DEA methodology and focuses on the ten surveyed papers that employ the DEA methodology regarding Croatian tourism, section 3 opens a discussion and tackles the practical implications of this study and the conclusions appear in the last section (section 4) of the paper.

2. Application of DEA methodology in the Croatian tourism sector

This research revolves around the applications of DEA in Croatian tourism. DEA is one of the leading non-parametric methodologies in the field of Operational Research (OR). It has gained a lot of attention in the efficiency measurement of entities known as Decision-Making Units (DMUs). These DMUs are the entities in the sample whose efficiency and productivity are evaluated. They should be homogeneous, i.e., they ought to use the same input variables and the same output variables (Barišić & Cvetkoska, 2020). DEA was introduced by Charnes et al. (1978) in their seminal paper titled "Measuring the efficiency of decision-making units", but many scholars (Hodžić & Jurlina Alibegović, 2019; Barišić et al., 2020; Cvetkoska et al., 2021) claim it was Farell (1957) who set the foundations for the technical efficiency measurement.

DEA is a linear mathematical programming method and a frontier approach that has developed into a powerful quantitative analytical tool for measuring and evaluating technical efficiency by measuring the efficiency scores of the decision-making units (Vincova, 2005; Wong, 2021). Its categorization in non-parametric approaches occurs due to its non-requirement of an a priori assumption for the analytic form of the production function (which is also one of its main advantages) (Naumovska & Cvetkoska, 2016). As one of the frontier methods, DEA uses an efficiency frontier to classify the different DMUs in the analyzed sample. "The efficiency frontier is based on real observations, and only the cases of best practices belong to it. All DMUs that are not on the frontier are considered inefficient" (Jorda et al. 2012). By using this approach, relative efficiency can be measured, and thus, DMUs can be compared with each other (Škrinjarić, 2018). The efficiency scores range from 0 to 1 (0 to 100%), with a score of 1, meaning the DMU is relatively efficient, and a score below 1, meaning the DMU is relatively inefficient. These efficiency scores are relative because they depend on the involved units in the sample (DMUs) and the used input and output variables (their number as well as structure) (Barišić & Cvetkoska, 2020).

DEA today is an extensively used approach for the evaluation and measurement of production efficiency. The reasons for its continued popularity and ever-increasing interest are likely to be found in the fact that this methodology is interdisciplinarily applicable in: education, health, banking, military forces, sports, market research, agriculture, retail, the efficiency of organizations, transport, hospitality, construction, selection of candidates, etc. (Cvetkoska, 2011).

The main objective of this manuscript is to present and analyze the applications of the DEA methodology in different areas of Croatian tourism. In order to find all the published papers in this area, an extensive literature review has been conducted to summarize past findings regarding DEAs' application in different aspects of Croatian tourism. First, the relevant databases for our research have been identified, and the decision to focus on papers that have been published in peer-review journals that are cited in Scopus and Web of Science (SSCI and SCI papers) has been met. Furthermore, the Croatian Scientific Bibliography (known as CROSBI) has been identified as a key database since this research revolves around Croatian tourism. Notwithstanding, the study of Neralić and Gardijan Kedžo (2019) has been used as a backbone for the identification and selection

of relevant tourism-related DEA applications. Namely, Neralić and Gardijan Kedžo (2019) have systemized and published a survey of all the studies published from 1978 to 2018 that implement the DEA methodology and that have been written by Croatian academics and researchers.

The search in Scopus and Web of Science databases using keywords: "DATA ENVELOPMENT ANALYSIS", "TOURISM" and "CROATIA" resulted in 4 and 33 papers, respectively, whereas the browsing of the CROSBI database using the keywords "DATA ENVELOPMENT ANALYSIS" and "TOURISM "resulted in 7 hits. The DEA methodology has not been extensively used by scholars and researchers in the tourism industry, which is in line with the findings of Rabar & Blažević (2011) and Emrouznejad & Yang (2018), who have conducted bibliometric research of published papers with the application of DEA methodology in different areas in the period 2015-2016, and their findings show that DEA is mostly applied in five areas of research: agriculture, banking, supply chain, transportation, and public policy. For comparison, the search in Scopus and Web of Science databases using keywords: "DATA ENVELOPMENT ANALYSIS" and "BANKING" resulted in 1078 and 1904 papers, respectively. These same databases present only 291 and 490 papers, respectively, for a search using the keywords: "DATA ENVELOPMENT ANALYSIS" and "TOURISM". Therefore, this research represents an incentive for academic members and researchers to employ this methodology on a more regular basis in the tourism industry.

In this research, after surveying the Scopus, WoS, and CROSBI databases, additional consultation with the survey conducted by Neralić & Gardijan Kedžo (2019) has been conducted, which resulted in a complete overview of the ten applications of DEA in different aspects of the Croatian tourism. These studies, the models and variables they used, as well as their findings, are presented in Table 1 as follows.

Table 1
The DEA applications regarding Croatian tourism

Author/s and year of publication	Application	Time frame	Country	Used variables (inputs and outputs)	DEA model	Results
Rabar & Blažević (2011)	*Evaluation of the tourist efficiency of Croatian counties*	2008 2004-2008	CRO	3 inputs: number of beds, number of seats, and number of employees, and 3 outputs: number of arrivals, number of stays, number of nights, revenue in thousands of kuna - HRK.	CCR and BCC output-oriented DEA model + window analysis	BCC: 13 efficient and 8 inefficient counties, CCR: 10 efficient and 11 inefficient counties in 2008. The average efficiency was 0.910 (CCR) and 0.964 (BCC). No county has been efficient in the whole period of 5 years.
Cvetkoska & Barišić (2014)	*Measuring the efficiency of 15 European countries in tourism*	2004-2013	15 European countries	2 inputs: visitor exports and domestic travel and tourism spending, 2 outputs: travel & tourism ttl contribution to GDP and travel & tourism ttl contribution to employment.	DEA window analysis technique	No country from the sample is relatively efficient every year in every window. The year with the highest efficiency results is 2004, and 2011 is the year with the lowest efficiency results.
Jardas Antonić & Pavlić Skender (2015)	*Measuring the relative efficiency of the Croatian passenger seaports*	2012	CRO	2 inputs: coast length and number of employees. Output: passenger turnover (1st analysis). 2 inputs: revenues and number of employees. Output: passenger turnover (2nd analysis).	BCC and CCR DEA models	Only one passenger port is relatively efficient in both their analyses, and that is the port of Zadar. The least efficient of all passenger ports was the port of Ploče.
Poldrugovac et al. (2016)	*Measuring efficiency in the hotel industry in Croatia*	2013	CRO	Inputs: energy expenses, room expenses, F&B expenses, expenses associated with other services, and labor expenses as input variables and outputs: total revenue and occupancy rate.	Output-oriented BCC model	The average efficiency of the sample of 105 Croatian hotels was 73%. Small-sized hotels are more efficient than medium-sized hotels

Table 1 ***(continued)***

Cvetkoska & Barišić (2017)	*Measuring the efficiency of the tourism industry in the Balkans*	2010-2015	11 Balkan countries	2 inputs: visitor exports and domestic travel and tourism spending, 2 outputs: travel and tourism total contribution to GDP and employment.	DEA window analysis model with VRS	No country from the sample was efficient every year in every window. However, Albania, Croatia, Romania, and Turkey are the "most efficient countries in tourism".
Kordić & Šimundić (2017)	*Evaluation of the efficiency of health tourism in Croatia*	2015	CRO	2 inputs: material and human and 1 output: number of discharged patients (in their final model).	Output-oriented CCR and BCC DEA models	According to the CCR model, one health institution is efficient. The results of the BCC model show 5 institutions as relatively efficient.
Škrinjarić (2018)	*Assessment of the efficiency of the environmentally-conscious tourism industry of 21 Croatian counties*	2011-2015	CRO	Variables: number of beds, number of rooms, municipal waste, current expenditures on environment protection, ttl investments on environment protection, number of tourist arrivals, number of overnight stays, ttl GDP and the surface of each county, tourism pressure, reciprocal value of municipal waste, % of current expenditures in, % of total investments in GDP and undesirable output municipal waste.	Developed four DEA models in order to assess the efficiency of the Croatian counties concerning environmental consciousness	Tourist arrivals in all Croatian counties are satisfactory, but changes regarding the expenditures on environmental protection are needed for all the counties to become relatively efficient.
Hodžić & Jurlina Alibegović (2019)	*Measuring the relative efficiency of the "regional government expenditures in smart tourist destinations "*	2011-2016	CRO	2 inputs: average expenditures for tourism and average expenditures for recreation, culture, and religion, and 2 outputs: total tourist arrivals and total tourist nights.	Input-oriented CCR and BCC DEA models	Only one county (Lika-Senj) appears to be efficient. The findings show an exact number of coastal and inland Croatian counties in the regional government expenditure efficiency.
Hodžić et al. (2020)	*Measuring the efficiency of the restaurant sector in Croatian counties*	2013-2017	CRO	Inputs: entrepreneurs in the restaurant sector, the average number of employees, and expenses for employee wages and contributions. Outputs: total revenues from the restaurant sector, net profits, and tourist nights in commercial accommodation.	CCR and BCC DEA models	CCR: only 4 counties (Lika-Senj, Zadar, Istria and Dubrovnik-Neretva) have been continuously efficient over the whole observed period. The year with the best results is 2013. BCC: 12 counties were relatively efficient in 2013 and 2016.
Barišić & Cvetkoska (2020)	*Analyzing the efficiency of travel and tourism in the European Union*	2017	28 EU states	Two inputs: internal travel and tourism consumption and capital investment. Two outputs: travel and tourism's total contribution to GDP and employment.	Output-oriented BCC DEA model	13 out of 28 EU countries were relatively efficient in 2017, and 15 were not. The average efficiency of the whole sample is 0.9441, with maximum efficiency of 1 and a minimum of 0.7406.

There are many different applications of DEA regarding Croatian tourism, which, once more, shows the wide application possibilities for this methodology. The results from this research show that most of these ten surveyed papers employ the DEA BCC output-oriented model, whereas almost half of them have employed both the CCR and BCC DEA models (i.e., Rabar et al., 2011; Jardas Antonić et al., 2015; Kordić et al., 2017, Hodžić et al., 2020). Jardas Antonić and Pavlić Skender (2015), Poldrugovac et al. (2016), Kordić and Šimundić (2017), and Barišić and Cvetkoska (2020), have chosen a single year for a time frame for the research, namely 2012, 2013, 2015 and 2017, respectively. Additionally, Rabar and Blažević (2011) have analyzed solely the year 2008 with their CCR and BCC output-oriented DEA model but have also employed the DEA window analysis for the time frame 2004-2008. Most of the analyzed time frames are from 2011

onwards. Furthermore, this study gives insights in all the possible ways and efficiency perspectives of tourism that the DEA methodology could be used for (the tourism efficiency of Croatian counties in Rabar and Blažević, 2011; the efficiency of the environmentally-conscious tourism industry of 21 Croatian counties in Škrinjarić, 2018; the efficiency of "regional government expenditures in smart tourist destinations" in Croatian counties in Hodžić & Jurlina Alibegović, 2019; the efficiency of the restaurant sector in Croatian counties in Hodžić et al., 2020; analysis of the efficiency of the health tourism in Croatia in Kordić & Šimundić, 2017; the efficiency of the Croatian passenger seaports in Jardas Antonić & Pavlić Skender, 2015; the efficiency in the hotel industry in Poldrugovac et al., 2016; the cross-country studies that analyse the efficiency of 15 European countries in tourism in Cvetkoska & Barišić, 2014; the efficiency of the tourism industry in the Balkans in Cvetkoska & Barišić, 2017, and the efficiency of travel and tourism in the European Union in Barišić & Cvetkoska, 2020).

3. Discussion and practical implications

The DEA methodology is a widely applied mathematical programming approach that has been used in many industries but has not been widely implemented in studies regarding tourism. Namely, in the Scopus and Web of Science databases, there are 116.990 and 176.222 hits, respectively, for studies with the keyword "TOURISM", whereas 291 and 490, respectively, for the combination of keywords "DATA ENVELOPMENT ANALYSIS" and "TOURISM". Even though studies written by Croatian scholars implementing the DEA methodology show an upward trend, its publishing "should speed up in order to close the gap with the global trends" (Neralić & Gardijan Kedžo, 2019). The presented review of the literature shows different applications of DEA in various aspects of Croatian tourism and helps highlight the broad possible use of this methodology. The fact that there are only ten DEA applications published by Croatian scientists regarding Croatian tourism shows how neglected DEA methodology in this area of research still is.

The ongoing COVID-19 pandemic has imposed travel restrictions that impacted various sectors of the economy but mostly affected the tourism sector since it is almost completely "dependent on the transport and hospitality sectors, both of which were among the first to be affected by the corona crisis" (Šimović et al., 2021). UNWTO (2020) stated that tourism should be the main recovery sector and that it can "play the key role in future recovery efforts". The impact the COVID-19 pandemic had on the tourism industry is something worth tackling in future research, especially regarding the Croatian economy.

4. Conclusion

The goal of this research was to identify, present and analyze all the published studies that employ the DEA methodology regarding Croatian tourism. Notwithstanding, the study successfully addresses and presents its findings. Although the majority of studies regarding tourism generously present the positive economic impact of tourism on the whole economy, some economists consider the possibility of tourism crowding out other industries, and they emphasize the overreliance of the Croatian economy on tourism (Šimundić et al., 2021; Dujmović et al., 2020). Šimović et al. (2021) warn about the unsustainability of the current Croatian economic model, thus highlighting the necessity to minimize the dependency of the Croatian economy on tourism due to climatic, socio-political, and other reasons. Fortunately, there are authors (Orsini & Pletikosa, 2019) who claim that, in the case of Croatia, the crowding-out scenario does not apply. Due to such contrasting points of view, studies that investigate different aspects of tourism efficiency are valuable.

Additional goals of this research were to inspire other scholars and practitioners to acknowledge the DEA methodology and its possible application in the investigation of the efficiency of different aspects of the tourism (and any other) industry.

The findings of the extensive literature review show that most of these ten surveyed papers employ the DEA BCC output-oriented model, whereas almost half of them have employed both the CCR and BCC DEA models. Four of these studies have analyzed solely one year in their study (i.e., Jardas Antonić & Pavlić Skender, 2015; Poldrugovac et al., 2016; Kordić & Šimundić, 2017; and Barišić & Cvetkoska, 2020), and the majority of the surveyed papers' time frame is from 2011 onwards. This extensive literature review gives new insights regarding the implementation of DEA in many different efficiency perspectives that have been analyzed in Croatian tourism, such as the tourist efficiency of Croatian counties, the efficiency of the environmentally-conscious tourism industry of 21 Croatian counties, the efficiency of "regional government expenditures in smart tourist destinations" in Croatian counties, the efficiency of the restaurant sector in Croatian counties, analysis of the efficiency of the health tourism in Croatia, to the efficiency of the Croatian passenger seaports, the efficiency in the hotel industry, to the cross-country studies that analyze the efficiency of 15 European countries in tourism, the efficiency of the tourism industry in the Balkans and the efficiency of travel and tourism in the European Union.

This study, however, is not without limitations. The authors cannot guarantee that all the published studies regarding Croatian tourism with an application of DEA have been identified, presented, and analyzed. There is a possibility that this extensive literature review is incomplete.

In future research, the authors plan to analyze the applications of DEA in efficiency evaluation globally and empirically assess the efficiency of EU and non-EU countries and the impact the COVID-19 pandemic had on the tourism industry. Additionally, the authors plan to explore the efficiency of the environmentally-conscious tourism industry in Croatia following Škrinjarić (2018).

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