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Tourism, hospitality, and DEA: Where do we come from and where do we go?

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ABSTRACT

The primary goal of this paper is to present a literature survey on the application of data envelopment analysis (DEA) in tourism and hospitality studies. The secondary goal is to categorize the studies by tourism products and tourism industries according to the United Nations World Tourism Organization (UNWTO). The tertiary goal is to identify the gaps and challenges in the field. The paper presents a comprehensive review of 350 tourism-related articles that use DEA methodology and highlights several key issues. The publications were statistically classified by methodological innovation, input-output variables, sources of publications, and several other relevant attributes. The investigation reveals the importance of the DEA methodology in the study of the productivity and efficiency of hospitality and tourism. The results also show a high degree of industrial (hotel sector) and geographical (Europe and Asia) concentration of studies. Cultural aspects, tourism sustainability, as well as the efficiency of tourism destinations, have attracted much interest recently. In addition, the new DEA models are increasingly gaining ground in the literature. Finally, the present review highlights the limitations of existing studies and provides important directions for future research.

1. Introduction

Tourism is a service activity that constitutes an essential driver of trade and is a contributor to economic growth. The volume of the tourism and hospitality business is equal to, or even surpasses, the volume of export of oil, food, or automobiles (United World Tourism Organization (UNWTO, 2018a, 2018b). The World Tourism and Travel Council (World Travel and Tourism Council (WTTC, 2019) claims that tourism is one of the largest economic sectors in the world; it creates jobs, drives exports, and generates prosperity across the globe. It accounted for 10.4% of global GDP and 319 million jobs (10% of total employment) in 2018.

In a general equilibrium setting, tourism interacts with other sectors of the economy (Sinclair and Bote Gómez, 1996; Cleverdon and Kalisch, 2000; Nowak et al., 2003). As an example, culinary tourism (*food and beverage serving activities*) uses local resources and ingredients that have an impact on agricultural practices (*livestock and arable farming*) (Hashimoto and Telfer, 2006; Smith and Xiao, 2008). Similar interrelations have been found in the *wine* sector (Hall et al., 2009; Asero and Patti, 2009), *passenger transportation* (Hawken et al., 1999; Urry, 2004; Yeoman et al., 2007; Fernández et al., 2018), *construction* and the *financial* sector (Rutherford and O'Fallon, 2007; Winter, 2007), among others.

The study of the performance of tourism has attracted considerable attention in recent years. However, measuring the productivity and efficiency of tourism is not an easy task. To delve into the tourism performance of agents, products, and destinations, researchers have used mathematical, statistical, and econometric techniques. Among the wide spectrum of benchmarking techniques, the frontier analysis has become the most noteworthy approach in tourism and hospitality literature. Frontier analysis can be roughly divided into two different methodologies: the parametric Stochastic Frontier Analysis (SFA) (Aigner et al., 1977) and the non-parametric Data Envelopment Analysis (DEA) (Charnes et al., 1978).

The DEA is, by far, the most commonly used operations research (OR) technique to assess efficiency and productivity both globally (Emrouznejad and Yang, 2018) and in the sectors related to hospitality and tourism (Assaf and Josiassen, 2016). The election of DEA as a worldwide accepted OR tool to analyze tourism performance is a result of, on the one hand, its technical advantages and, on the other, its flexibility to deal with tourist variables.

As far as we found, in extant tourism and hospitality literature, there

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is only one survey (Assaf and Josiassen, 2016) on the application of frontier analysis techniques. Assaf and Josiassen (2016) reviewed 57 studies that utilize frontier analysis spanning the period of 1997–2014, of which 35 out of 57 used the DEA method. There are broader studies (e.g., Sainaghi et al., 2017 and Altin et al., 2018, within the tourism performance literature) that include frontier analysis among study methodologies. However, these studies do not provide the number of DEA studies within the literature. Finally, there are extensive DEA surveys (such as Seiford, 1996; Tavares, 2002; Liu et al., 2013a, 2013b, and Emrouznejad and Yang, 2018, among others) published with tourism included within them.

This study aims to present the current state of the art of DEA application in the field of tourism. It is intended to answer the following questions: What is the number of DEA application papers in the tourism literature? What fields of tourism and hospitality (products and industries) have been studied with DEA methodology, and in what depth? What are the major contributions of the DEA methodology to the hospitality and tourism literature, and where have they been published? How has the study of hospitality and tourism been approached in terms of input-output variables and models? Lastly, what are the gaps and challenges for future research in a context of changes like the current one? To this end, this paper discloses the most comprehensive list of DEA tourism studies between 1978 and 2018. We reviewed more than 15000 studies and identified 350 publications that use DEA-like techniques to estimate various measures of tourism efficiency. These studies were published in approximately 200 journals, of which 50 concentrate almost 60% of the publications. More than 70% of the articles were published in journals with scientific influence (*Scimago Journal Rank* and/or *Journal Citation Reports*). The most frequent sources of publication are *Tourism Economics* (22), *Tourism Management* (16), and the *International Journal of Hospitality Management* (11).

The contributions of this study lie in three aspects. First, this study focuses exclusively on DEA applications and offers an updated survey reflecting a recent trend of interest in DEA applications, whereas previous reviews (i.e., Assaf and Josiassen, 2016) included both DEA and SFA applications. Second, for a better understanding of the fields of applications, the publications are categorized by tourism products and tourism industries according to the United Nations World Tourism Organization (UNWTO, 2021). Third, the DEA applications are discussed from both the theoretical and empirical perspectives. Thus, the publications are reviewed in terms of inputs and outputs, commonly used approaches, contextual factors, geographical coverage, and bibliometric analysis (time, authors, journals, citations, subject areas, etc.). The authors posit that such a review will greatly serve researchers to identify tourism categories and subject areas of the current literature where potential contributions can be made. This literature review is also intended to help researchers in choosing the method, selecting and justifying the model variables, and finding the most appropriate journal for publication.

The paper is structured as follows. The second section describes the DEA theoretical background. The third section makes an overview of the most important topics that deal with tourist literature and the DEA method. The fourth section highlights the statistics of the DEA method in tourism, and the last section presents a discussion regarding the results and conclusion.

2. Methodology

Based on the principles of the production and the linear programming theory, DEA is a mathematical programming technique used for the development of production frontiers and the measurement of efficiency relative to these frontiers. The first naïve method of single output/single input efficiency measure was introduced by Farrell (1957). Later, Charnes et al. (1978) use linear programming to extend Farrell's ideas. The Charnes et al. (1978) methodology is a non-parametric approach for determining the relative performance of a set of similar organizational units (DMUs) by using sets of inputs and outputs. In other words, it evaluates how efficient a country, region, firm, organization, agency, or such other unit uses available resources (input) to generate a set of output data relative to other units in the data set (Ramanathan, 2003; Silkman, 1986). To assess efficiency, DEA provides a benchmark (frontier) against which competitors can identify areas of "best practices" associated with high measures of performance. A DMU can be operating either on or within the frontier, with the distance to the border reflecting inefficiency (Mantri, 2008).

The first naïve understanding of DEA method offered by Charnes et al. (1978) includes cost per unit, profit per unit, satisfaction per unit, and so on, which are measures stated in the form of a ratio like the following,

$$\frac{Output}{Input} \tag{1}$$

The focus is to optimize the ratio of outputs to inputs. Mathematically:

$$\max_{v,u}\theta = \frac{u_1y_1 + u_2y_2 + \ldots + u_sy_s}{v_1x_1 + v_2x_2 + \ldots + v_mx_m} \tag{2}$$

where θ is efficiency score (value ranges between zero and one), x, y are inputs and outputs. u, v are the weights to be calculated as to reach the maximum fraction value, and s, m are the numbers of outputs and inputs.

Geometrically, such a model should show the efficiency/inefficiency of the DMU's activity through the definition of Efficient Frontier. An illustrative example of such an optimization problem is shown in Fig. 1. The line through the efficient DMUs *B*, *C*, and *D* represents the efficient frontier or the areas of *best practices*. For example, DMU *A* classified as ineffective in this sample, and it will have to expand to *A*1 at the border before it can also be called efficient (Avkiran, 2006).

It is important to note that, at the beginning, this method was based on the names of the founders, as the Charnes, Cooper, and Rhodes (CCR) method (Charnes et al., 1978). However, since the process is based on a benchmark, a geometric interpretation (Fig. 1) showed how the efficiency frontier *envelops* the calculated inputs and outputs; they began to call it Data Envelopment Analysis (DEA) (Cooper et al., 2006). By adding a constraint of convexity on the model (Variable Returns to Scale), one can find the technical efficiency arising from optimal management practices, called pure technical efficiency (Banker et al., 1984).

2.1. Input- and output-oriented DEA model

Depending on the interest of the analysis, the DEA can be identified as an input- or output-oriented model. An objective of the input-oriented DEA model is to maximize the ratio of virtual output to virtual input while keeping the ratios for all the DMUs not more than one. This

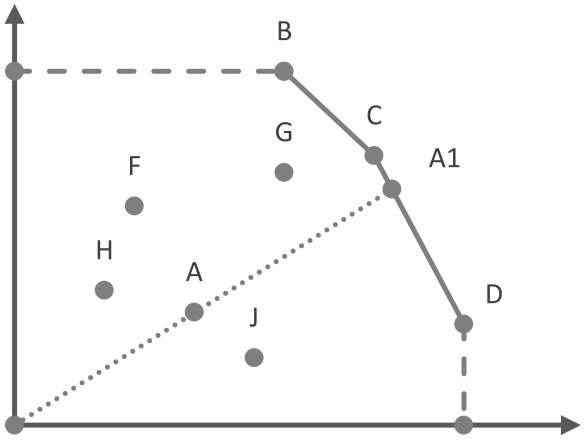

Fig. 1. Illustration of a two-output, one-input DEA analysis.

problem can be further transformed into an equivalent *output maximization* linear programming problem as presented below in form (3).

$$Max \sum_{m=1}^{M} u_m y_{mo} \tag{3}$$

subject to

$$\sum_{n=1}^{N} v_n x_{no} = 1$$

$$\sum_{m=1}^{M} u_m y_{mk} \leq \sum_{n=1}^{N} v_n x_{nk}$$

$$k = 1, \cdots \cdots, K;\ m = 1, \cdots \cdots, M$$

$$u_m, v_n \geq 0,\ n = 1, \cdots \cdots, N$$

where K is the number of DMUs in the data set; N is the number of inputs; M is the number of outputs; y_{mk} and x_{nk} are known outputs and inputs of the k -th DMU and they are positive; and $u_m, v_n \geq 0$ are weights to be determined by the solution of this optimization problem. Model (3) is known as the CCR in multiplier form. The efficiency scores of DMU_1 to DMU_K can be derived by solving K in such models. A *DMU* is called CCR efficient if its objective value in the form (3) is equal to unity.

The objective of Model (3) is to maximize the DMU's outputs while keeping at least the given input levels. However, efficiency scores could be calculated based on its dual problem as follows:

$$Min\ \theta \tag{4}$$

subject to

$$\sum_{k=1}^{K} x_{nk}\lambda_k \leq \theta x_{no},\ n = 1, \cdots \cdots, N$$

$$\sum_{k=1}^{K} y_{mk}\lambda_k \geq y_{mo},\ m = 1, \cdots \cdots, M$$

$$\lambda_k \geq 0,\ k = 1, \cdots \cdots, K$$

where θ is the *DMU* efficiency score. Model (4) is known as the input-oriented CCR in envelopment form (sometimes referred to as the *Farrell model*). Its objective is to proportionally contract DMU inputs while not decreasing the level of outputs. Model (4) maintains a close relationship with the input distance function introduced by Shepherd (1970).

2.2. Strengths and limitations of DEA

In this section, we list the strengths and limitations of DEA. Advantages of DEA are as follows (Ozbek et al., 2009; Ramanathan, 2003; Rouse, 1997):

1. The main strength of the DEA is its objectivity. DEA provides performance estimates based on the solution of some formulations that provide optimal input and output weights for DMUs using numerical data. This does not require a priori weights for the variables. Thus, such performance evaluations are not based on the subjective opinions of investigators.
2. DEA identifies the efficient units that define the efficient frontier, quantifies the inefficiency of each of the remaining units, and also identifies those units' peers.
3. DEA can handle multiple inputs and outputs (Bell and Morey, 1995; Morey and Dittman, 1995).
4. In the DEA model, each input and output can be measured in different units.
5. DEA is nonparametric and, ergo, does not require an explicit functional form linking inputs to outputs.
6. DEA takes into account differences in scale of operations.

However, despite these strengths, DEA is also subject to some limitations. Limitations of DEA are as follows (Ramanathan, 2003; Rouse, 1997):

1. DEA applications require a separate linear program for each DMU in the data set. When there are many DMUs, the calculation can be unwieldy. However, this limitation has been minimized with the development of software that addresses explicitly to DEA issues.
2. Statistical hypothesis tests are difficult to measure to determine the validity of the results because DEA is a non-parametric method.
3. Because DEA is an extreme point technique, errors in the measurement or recording of data can lead to significant problems. Special care should be taken to ensure that input-output data is accurate.
4. The DEA technique is not always flexible in the selection of variables. Thus, the combination of different scale types' variables (e.g., ratio and non-ratio) may not be appropriate in DEA Models (Ozbek et al., 2009).
5. As DEA performance evaluations are obtained by running a series of linear software formulations, it becomes difficult to explain the DEA process to non-technical audiences (decision-makers) for cases where there are more than two inputs and outputs in the model. An audience that has no experience in linear programming may find it difficult to understand its results. However, this problem can be managed by explaining the DEA process in more straightforward terms and by using simpler plots of its results.

2.3. DEA in tourism

Regarding its nature, tourism is defined as a service sector. Measuring efficiency in service sectors is not an easy task. As stated by Avkiran (2006), the measures, such as productivity ratios, and time and motion studies, borrowed from the manufacturing sector, are deficient in capturing the interaction between multiple service variables. Furthermore, the regression analysis cannot easily handle multiproduct sectors. Thus, to handle the complexities of productivity measurement in the service sector, it is necessary to go beyond accounting and ratio measures or regression analysis. Thus, DEA is the most used tool for measuring efficiency in service sectors such as banking (Berger and Humphrey, 1997; Fethi and Pasiouras, 2010; Paradi and Zhu, 2013), education (Witte and López-Torres, 2017), healthcare (Kohl et al., 2018), and transport (Cavaignac and Petiot, 2017).

The history of the DEA in tourism begins in the mid-1980s. The pioneering authors were interested in studying the efficiency, from a micro-economic perspective, of Restaurants (Banker and Morey, 1986; Andersson and Hartman, 1995) and Hotels (Parkan, 1996). At the macro-economic level, the first published works focus on the study of the demand (Nozick et al., 1998) and productivity (Fuchs et al., 2002) of tourist destinations.

As DEA is a non-parametric approach, it does not need any parametric form for the solution of the specified model. Therefore, any variable can be included in the model without the need to define functional or parametric relationships. However, in the case of tourism, due to its wide range, a spectrum of input and output variables cannot be specified precisely. Eventually, the choice of outputs must reflect the objectives and set of services of the DMU, and the inputs must be traceable to these outputs (Avkiran, 2006). Physical and monetary measures of capital (Cracolici et al., 2008; Lozano and Gutiérrez, 2011; Cuccia et al., 2013; Barros et al., 2011) and human resources (Assaf and Dwyer, 2013; Ben Aissa and Goaied, 2017) constitute the main inputs of a (virtual) tourist *production process*. There is also some consensus on the use of physical and monetary measures of production as output variables (Ouerfelli, 2008; De Jorge and Suárez, 2014; Benito et al., 2014; Brida

et al., 2012; Guccio et al., 2017). Some authors also include quality measures (like customer satisfaction) to approximate the output (Chen et al., 2018). However, as stated by Nurmatov et al. (2020), the identification of inputs and outputs in tourism is still an open question in tourism. Little has been discussed so far about the inclusion of environmental variables (such as weather and natural resources) in the estimation of DEA models. In addition, variables related to heritage and culture do not seem to have received enough attention in the literature.

Despite the extensive DEA bibliographic publications on tourism and hospitality literature, there is only one survey (Assaf and Josiassen, 2016) on the application of frontier analysis techniques (SFA and DEA). Assaf and Josiassen (2016) present a comprehensive review of frontier studies during the period 1997–2014. Other studies include the DEA within the tourism performance literature (Sainaghi et al., 2017; Altin et al., 2018) but without analyzing it separately. There are other interesting survey studies published with tourism within it, such as Seiford (1996); Tavares (2002); Emrouznejad et al. (2008); Liu et al. (2013a, 2013b), and Emrouznejad and Yang (2018). However, none of the previous surveys fully addresses the questions raised in the introductory section of this study.

3. Survey approach

Following the UNWTO glossary of tourism terms (2018), tourism is a social, cultural, and economic phenomenon that entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes. Therefore, tourists need a wide range of services and activities: transportation; allocation and accommodation (hotels, specialized accommodation facilities, etc.); food (restaurants, cafes, bars, canteens, etc.); and entertainment (parks, theaters, circuses, museums, etc).

According to the basic glossary of the UNWTO, based on the *Tourism Satellite Account*, tourism is the cluster of production units in different industries that provide consumption goods and services demanded by visitors. Hence, a field of searching keywords for bibliography construction is determined by tourists' demand and satisfaction. Both goods and service fields of tourists' requests have been considered. Scanning was made only for journal articles that met the specified requirements mentioned above and use DEA-like techniques in the evaluation. Other working papers, dissertations, monographs, and other publication outcomes that did not meet the requirements were not considered. The paper considers only publications that are written in English (or English and native language) between the years 1978 and 2018.

All search words were compiled by the list of categories of tourism industries (the basic glossary of the UNWTO[1]). As shown in Table 1.

Leading keywords such as *Tourism*, *Data Envelopment Analysis*, *DEA, Tourism Efficiency*, and a combination of additional keywords referring to tourism in general were used in searches for tourism-related articles that use the DEA method. Due to its fee-free paper access to the wide public under the UNWTO glossary categories, and more opulent additional details from *Publish or Perish* (2018) metric access, the survey has been made in one of the largest scientific publication databases, *The Google Scholar*. Additional studies have been conducted and collected manually.

4. Data and basic statistics

In general, except main (*Tourism, Data Envelopment Analysis, DEA, and Tourism Efficiency*) keywords, the survey construction has used 12 tourism-related keywords *(Tourism, Travel, Accommodation, Hotel, Hostel, restaurant, Bar, Beach, Cruise, Attraction, Transport, Service)*. Altogether, revision has been done for 15718 publications (articles, monographs, book chapters, etc.) from 1978 to 2018. From them, 350 articles have been identified as tourism and hospitality-related articles that used DEA methodology (from now on tourDEA).

Table 1
List of categories of tourism characteristic products and tourism industries.

#	Products	Industries
1.	Accommodation services for visitors	Accommodation for visitors
2.	Food and beverage serving services	Food and beverage serving activities
3.	Railway passenger transport services	Railway passenger transport
4.	Road passenger transport services	Road passenger transport
5.	Water passenger transport services	Water passenger transport
6.	Air passenger transport services	Air passenger transport
7.	Transport equipment rental services	Transport equipment rental
8.	Travel agencies and other reservation services	Travel agencies and other reservation services activities
9.	Cultural services	Cultural activities
10.	Sports and recreational services	Sports and recreational activities
11.	Country-specific tourism characteristic goods	Retail trade of country-specific tourism characteristic goods
12.	Country-specific tourism characteristic Services	Other country-specific tourism characteristic activities

As far as the authors found, papers in tourDEA started in 1986. We can roughly classify three periods of trends for tourDEA articles. First period (1986–2005): there is a slow but stable growth in the number of published tourDEA articles. In this period the number of tourDEA publications increased by 23.53%. Second period (2005–2011): shows exponential growth in publication, more than +76.47% from the year 2005. Third period (2011–2018): shows a decrease in the number of publications, -18.75% started from the year 2011. Visual demonstration of the whole period of publications can be viewed in Fig. 2.

4.1. Tourism-related DEA statistics by journals

In total, we found 199 journals with tourDEA articles. From all journals, more than 77% have only one article. The distribution of relation between journals and published articles in them is split into two parts, less than two tourDEA articles per one journal and two or more articles per one journal.

Due to a wide range between articles' numbers within the journals that have two or more tourDEA article (*per 1 journal*), we can approximately identify them as the journals that contain *more than five articles per one journal* (hereinafter Mt5), *less than five articles per one journal* (hereinafter Lt5), *less than three articles per one journal* (hereinafter Lt3), and journals that published only one tourDEA article (hereinafter 1to1).

Height (4.02%) journals with 87 (24.86%) tourDEA articles were found in the Mt5 range. Most of them appear in the top five journals. They are *Tourism Economics, Tourism Management, International Journal of Hospitality Management, The Service Industries Journal,* and *Asia Pacific Journal of Tourism Research.* The distribution of the top five journals that published the most tourDEA articles over the study period (1978–2018) is shown in Table 2.

The 263 (75.14%) remaining tourDEA articles are in the range of Lt5, Lt3, and 1to1 (95.98%), distributed from one to seven per journal. In total, in Lt5 range, nine (4.52%) journals with 39 (11.14%) tourDEA articles were found. In Lt3 range, 32 (16.08%) journals with 74 (21.14%) tourDEA articles were found. The rest of tourDEA articles are within the range of 1to1. Descriptive statistics on the number of remaining journals with corresponding numbers of tourDEA articles are shown in Table 3.

[1] International Recommendations for Tourism Statistics, 2008 (IRTS 2008, 1.2), UNWTO basic glossary. https://www.unwto.org/glossary-tourism-terms; list of categories of tourism characteristic consumption products and tourism characteristic activities (tourism industries) pp.42. https://unstats.un.org/unsd/publication/Seriesm/SeriesM_83rev1e.pdf#page=12

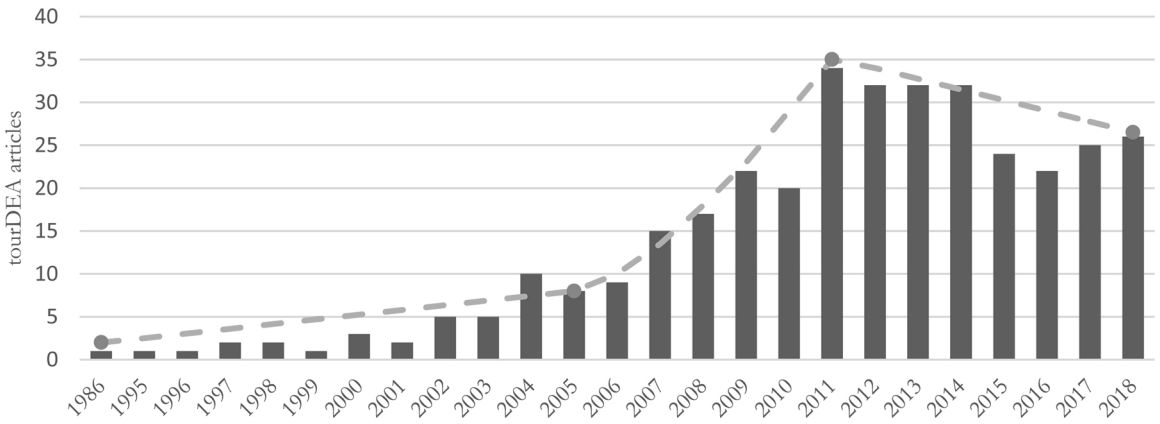

Fig. 2. Distribution of tourDEA articles by year (1978–2018).
Note: the source is self-developed.

Table 2
Distribution of journals with the highest number of tourDEA articles (1978–2018).

#	Journal	Numbers of papers	% of papers	% of all papers
1.	Tourism Economics	22	31.88%	6.29%
2.	Tourism Management	16	23.19%	4.57%
3.	International Journal of Hospitality Management	11	15.94%	3.14%
4.	The Service Industries Journal	11	15.94%	3.14%
5.	Asia Pacific Journal of Tourism Research	9	13.04%	2.57%
Total		69	100%	19.71%

Note: the source is self-developed; *% of papers* denotes the percentage of articles in one journal within the top 5 journals; *% from all papers* denotes the percentage of articles in one journal within all investigated journals.

Table 3
Descriptive statistics on journals and tourDEA articles (1978–2018).

#	Number of Journals	Number of papers per 1 journal	% of journals	% of papers	% of journals by range	% of papers by range
1.	1	22	0.50%	6.29%		
2.	1	16	0.50%	4.57%		
3.	2	11	1.01%	6.29%	4.02% (Mt5)	24.86% (Mt5)
4.	1	9	0.50%	2.57%		
5.	3	6	1.51%	5.14%		
6.	3	5	1.51%	4.29%	4.52% (Lt5)	11.14% (Lt5)
7.	6	4	3.02%	6.86%		
8.	10	3	5.03%	8.57%	16.08% (Lt3)	21.14% (Lt3)
9.	22	2	11.06%	12.57%		
10.	150	1	75.38%	42.86%	75.38% (1to1)	42.86% (1to1)
Total	199	350	100%	100%	100%	100%

Note: the source is self-developed.

More than 80% of all published tourDEA articles are shallow in the count. About 75% of the articles found are published in the range 1to1. Most of them are published in journals that are insufficiently known to the wide public. Conversely, the most significant number of tourDEA articles appears in high-impact journals (to date, 2018).

From all 350 tourDEA articles, 246 (70.29%) are found as indexed in the Scopus database (SCOPUS, 2019). The Scopus indexed articles were published in 16 different sub-subject areas. The most Scopus indexed articles were found in the Tourism, Leisure and Hospitality Management (47.56%) sub-subject area, followed by Business, Management and Accounting (19.92%) and Economics, Econometrics and Finance (7.72%) sub-subject areas. The percentage of remaining publications in the rest sub-subject areas are shallow in count and cannot exceed 5%.

The rest 104 (29.71%) from all 350 tourDEA articles are not indexed in the Scopus sub-subject areas. We identified them in three main areas, such as Non-indexed (JCR or SJR) papers, Conference papers, Book chapters. The most non-indexed in the Scopus tourDEA articles are in the Non-indexed (JCR or SJR) papers (56.73%), followed by Conference papers (24.04%). Descriptive statistics on articles indexation/non-indexation in the Scopus database are shown in Table 4.

4.2. Tourism-related DEA statistics by keywords

In all, tourDEA articles used 757 unique keywords. The greatest number of used keywords is *Data Envelopment Analysis, DEA, Efficiency,*

Table 4
Descriptive statistics on articles indexation in the database Scopus.

#	Scopus Subject Area	%	Number of articles	Total number of articles
1.	Tourism, Leisure and Hospitality Management	47.56%	117	
2.	Business, Management and Accounting	19.92%	49	
3.	Economics, Econometrics and Finance	7.72%	19	
4.	Management Science and Operations Research	4.07%	10	
5.	Transportation	3.66%	9	
6.	Social Sciences	3.25%	8	
7.	Geography, Planning and Development	2.85%	7	246
8.	Engineering	2.03%	5	
9.	Decision Sciences	1.63%	4	
10.	Computer Science	1.63%	4	
11.	Applied Mathematics	1.63%	4	
12.	Earth and Planetary Sciences	1.22%	3	
13.	Environmental Science	1.22%	3	
14.	Arts and Humanities	0.81%	2	
15.	Energy	0.41%	1	
16.	Public Health, Environmental and Occupational Health	0.41%	1	
	Non-Scopus Subject Area			
1.	Non-indexed (JCR or SJR) papers	56.73%	59	104
2.	Conference papers	24.04%	25	
3.	Book chapters	19.23%	20	
Total				350

Note: the source is self-developed; *Conference papers* – tourDEA articles related to a conference; *Book chapters* – tourDEA articles published in books.

Hotel, Tourism, and so on. Table 5 shows the top 10 keywords that have been used in tourDEA articles throughout the investigation (1978–2018).

From the analysis of the keywords, a large degree of concentration of studies can be induced both at the industrial level and at the geographical level. At the industrial level, the hotel sector has concentrated much of the research interest. Thus, 174 (60%) keywords of the 295 that refer to the tourism industry contain the word "hotel". However, transport services and cultural services have received little attention in the tourDEA literature. At the geographical level, tourism has been studied with the DEA methodology in a relatively small number of countries (29). In addition, a high degree of concentration can be appreciated. Of the total keywords in which a country is referred (94), 19% refer to Taiwan, 14% refer to China, and 9% refer to Spain. Latin America and Africa have barely received attention in the study of tourism with DEA methodology.

4.3. Tourism-related DEA statistics by authors

In general, all the tourDEA articles found were written by 1032 distinct authors. The minimum number of authors for an article is one, and the maximum is seven. For all investigated years (1978–2018) the average number of authors is 2.46. This number is similar to that found in general DEA surveys (Emrouznejad et al., 2008; Emrouznejad and Yang, 2018). Approximately 18% of all tourDEA articles were written by one author, 32% by two authors, and 36% by three authors. Less than 1% of articles have been written by six/seven authors. Table 6 presents descriptive statistics of tourDEA articles by the number of authors for the period of investigation (1978–2018).

4.4. Tourism-related DEA statistics by categories of tourism products and tourism industries

From all 350 investigated tourDEA articles, 268 (76.57%) articles were identified within the list of categories of tourism industries from the basic glossary of the UNWTO. As the number of remaining 82 (23.43%) tourDEA articles do not fit with the list of categories of tourism industries by their context, we classified them as *Nonspecified tourism industry (product)* papers. Visual illustration and descriptive statistics on categories of tourism characteristic products and tourism industries are shown in Table 7.

In accordance with the results obtained in section 4.2, most tourDEA publications belong to the *Accommodation (services) for visitors* category. The following categories with the largest number of articles within the UNWTO list are less for 78.38% and 89.73% from the category of *Accommodation (services) for visitors*. This difference may be explained by the association that has been made between tourism and activities in places outside their usual environment, with overnight stays (United World Tourism Organization (UNWTO, 2018a, 2018b). The second-largest number of tourDEA articles found (*Nonspecified tourism industry (product)*) are not on the list of the categories by the UNWTO. Here, in most studies, the DEA method was used to evaluate tourism from a different perspective than that of product or industry (macro--related studies, destination benchmarking, tourism sustainability, tourism advertising, etc). The third-largest number of articles are in the category of *Cultural* and *Sports and recreational (services) activities* followed by *Food and beverage serving (services) activities*. There are tourist categories that have hardly been studied. Thus, the categories related to tourist transport services, despite representing a third of tourism expenditure (Statistical office of the European Union (Eurostat, 2020), have seldom received any attention in the tourDEA literature.

Starting years and numbers of published tourDEA articles differ in each category. Most tourDEA articles in different categories were started from the year 2005. Descriptive statistics of published tourDEA articles by categories of tourism characteristic products and tourism industries

Table 5
Descriptive statistics on 10 of the most used keywords by tourDEA papers (1978–2018).

#	Keywords	Numbers of publications	% of keywords	% of all keywords
1.	Data envelopment analysis, DEA, Data Envelopment Analysis (DEA), Data envelopment analysis (DEA), (DEA), Data Envelopment Analysis Model, DEA (Data Envelopment Analysis), DEA method, DEA Model, DEA (Data Envelopment Analysis)	296	51.66%	18.20%
2.	Efficiency	96	16.75%	5.90%
3.	Hotel	48	8.38%	2.95%
4.	International tourist hotel	30	5.24%	1.85%
5.	Tourism	27	4.71%	1.66%
6.	Productivity	18	3.14%	1.11%
7.	Benchmarking	16	2.79%	0.98%
8.	Technical efficiency	16	2.79%	0.98%
9.	Hotel industry	15	2.62%	0.92%
10.	Taiwan	11	1.92%	0.68%
Total		573	100%	35.24%

Note: the source is self-developed; *% of keywords* denotes the percentage of articles in one journal within the top 5 journals; *% of all keywords* denotes the portion of articles in one journal within all journals.

Table 6
Descriptive statistics of tourDEA articles by the number of authors (1978–2018).

#	Number of articles	% of articles	Number of authors per 1 article	Number of authors	% of authors	Cumulative % of authors
1.	60	17.14%	1	60	3.57%	3.57%
2.	113	32.29%	2	226	7.14%	10.71%
3.	128	36.57%	3	384	10.71%	21.43%
4.	41	11.71%	4	164	14.29%	35.71%
5.	5	1.43%	5	25	17.86%	53.57%
6.	1	0.29%	6	6	21.43%	75%
7.	2	0.57%	7	14	25%	100%
Total	350	100%	28	879	100%	

Note: the source is self-developed.

Table 7
Descriptive statistics on categories of tourism characteristic products and tourism industries.

#	Industries (Products)*	Number of articles	% of papers
1.	Accommodation (services)* for visitors	185	52.86%
2.	Food and beverage serving (services)* activities	19	5.43%
3.	Railway passenger transport (services)*		
4.	Road passenger transport (services)*		
5.	Water passenger transport (services)*	9	2.57%
6.	Air passenger transport (services)*		
7.	Transport equipment rental (services)*		
8.	Travel agencies and other reservation (services)* services activities	12	3.43%
9.	Cultural (services)* activities	40	11.43%
10	Sports and recreational (services)* activities		
11.	Retail trade of (country-specific tourism characteristic goods)*	1	0.29%
12.	Other (country-specific tourism characteristic goods)*	2	0.57%
	Nonspecified tourism industry (product)	82	23.43%
Total		350	100%

Note: the source is self-developed; * – value shows the item related to categories of tourism characteristic products of UNWTO.

by years and amount are shown in Fig. 3.

4.5. Tourism-related DEA statistics by used input/output and used methods

The examination reveals that a wide variety of DEA models (22 different models) have been estimated in the tourDEA literature between 1978 and 2018. The original DEA models (*CCR* and *BBC*) lead the ranking among the most used models (they were estimated, together or separately, in 52.13% of papers), followed by *Bootstrap DEA model* (11.15%) and the *Slacks-Based-DEA model* (8.52%). Table 8 shows a descriptive statistic on used DEA models.

The DEA-like models by the UNWTO list of categories are shown in Table 9. Standard DEA models (CCR and BCC) rank first in all categories. However, the level of methodological innovation is not similar in all sectors. While new DEA models gain strength in some categories (*Accommodation (services) for visitors* and *Travel agencies and other reservation (services) activities*), others (*Food and beverage serving (services) activities* and *Other (country-specific tourism characteristic goods)*) remain unrelated to methodological innovations.

An examination of used inputs and outputs in the surveyed articles reveals a wide variety of variables (more than 1100 inputs and 700 outputs). On average, one paper uses 3.65 inputs and 2.30 outputs. A classification of the input and output variables by typology reveals that most of the articles make a productive approach to tourism. Thus, proxy variables of *Capital* (40% of total inputs), *Labor* (24%), and *Intermediate Consumption* (26%) are the most used inputs in tourism modeling with DEA techniques. On the Output side, the proxy variables of *production* represent more than 85% of the variables used in the literature. For the approximation of the tourism production process, both physical variables (55%) and monetary variables (37%) have been used. Quality measures have, at the moment, less importance (4.5%) in the tourDEA literature. The analysis of the input-output variables reveals significant differences in foci by categories. In some categories (*Accommodation (services) for visitors*, *Food and beverage serving (services) activities*, …) a micro-level approach has been fundamentally followed, while in others (*Cultural (services)* activities*, *Sports and recreational (services)* activities*, *Food and beverage serving (services) activities*) a macro-level approach is the majority. Tables 10 and 11 illustrate descriptive statistics on inputs and outputs by categories of tourism products and tourism industries.

Table 8
Descriptive statistics on top used DEA-like models.

#	Names	Number of articles	%
1.	CCR and BBC DEA models	106	34.75%
2.	CCR DEA model	38	12.46%
3.	Bootstrap DEA model	34	11.15%
4.	Slacks-Based-DEA model	26	8.52%
5.	Multistage DEA	18	5.90%
6.	BCC DEA model	15	4.92%
7.	Window DEA model	11	3.61%
8.	Network DEA model	11	3.61%
9.	Cross Efficiency DEA model	8	2.62%
10.	Super Efficiency DEA model	6	1.97%
11.	Other DEA models (Hierarchical DEA model; Multi-component DEA model; Metafrontier-DEA; Virtual Frontier DEA model; Context-Dependent DEA; Stochastic DEA model; Fuzzy DEA model; Additive DEA model; Hybrid DEA model; DEA Rasch model; Robust DEA model; Integer DEA)	32	10.49%
Total			100%

Note: the source is self-developed. 45 articles are not included since the authors have not been able to access their complete content.

4.6. Tourism-related DEA statistics by cites

Up to the year 2018 for the identified 350 tourDEA articles in the scientific databases, *The Google Scholar* has found 12319 cites to other publications. The minimum number of cites for an article is zero, the maximum is 1468. For all the 1986 to 2018 period, the average number of cites is 32.2. Descriptive statistics on cites by categories of tourism characteristic products and tourism industries for years between 1986 and 2018 can be viewed in Table 12.

Despite the most considerable number of cited articles being in the category of hotel service (*Accommodation for visitors*), we found that the most cited article is in the category of food service (*food and beverage serving activities*). This metric can also show the most influential articles in the domain between the investigated period. Table 13 presents the 10 most cited articles in the tourDEA literature during the research period (1978–2018). These articles represent a third of the citations received by the entire sample of articles.

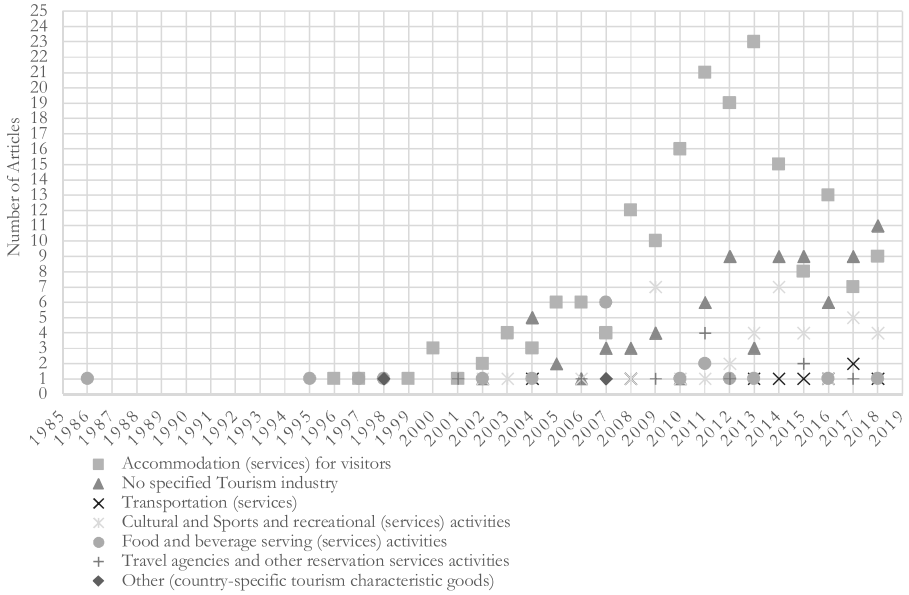

Fig. 3. Descriptive statistics on published tourDEA articles by categories of tourism characteristic products and tourism industries by years.
Note: the source is self-developed.

Table 9
Descriptive statistics on top used DEA-like models by categories of tourism characteristic products and tourism industries.

Industries (Products)*	Names	Number of articles	% of DEA methods
AC	CCR and BBC models	42	29.58%
	CCR DEA model	20	14.08%
	Slacks-Based-DEA model	17	11.97%
	Bootstrap DEA model	14	9.86%
	Multistage DEA	7	4.93%
	Network DEA model	6	4.23%
	Other DEA models (Cross Efficiency DEA model; Window DEA model; BCC DEA model; Context-Dependent DEA; Metafrontier-DEA; Stochastic DEA model; Fuzzy DEA model; Multi-component DEA model; Hybrid DEA model; Hierarchical DEA model; Super Efficiency DEA model; Robust DEA model; Integer DEA; DEA Rasch model)	37	25.35%
FB	CCR and BBC models	8	42.11%
	CCR DEA model	4	21.05%
	BCC DEA model	3	15.79%
	Other DEA models (Bootstrap DEA model; Cross Efficiency DEA model; Multistage DEA)	4	21.05%
TR	CCR and BBC models	4	22.22%
	Other DEA models (Super Efficiency DEA model; Network DEA model; Bootstrap DEA model; Slacks-Based-DEA model)	5	27.78%
TRAS	CCR and BBC models	4	33.33%
	Bootstrap DEA model	3	25.00%
	Other DEA models (Virtual Frontier DEA model; Multistage DEA; BCC DEA model; Super Efficiency DEA model; Window DEA model)	5	41.67%
CSA	CCR and BBC models	13	32.50%
	CCR DEA model	5	12.50%
	Multistage DEA	4	10.00%
	Other DEA models (BCC DEA model; Bootstrap DEA model; Slacks-Based-DEA model; Cross Efficiency DEA model; Network DEA model; Super Efficiency DEA model; Multi-component DEA model; Additive DEA model; Window DEA model; Hierarchical DEA model)	18	45.00%
CSTG	CCR and BBC models	1	50.00%
	CCR DEA model	1	50.00%
RCSTCG	Bootstrap DEA model	1	100%
Nonspecified Tourism	CCR and BBC models	33	41.77%
	Bootstrap DEA model	10	12.66%
	CCR DEA model	8	10.13%
	Window DEA model	5	6.33%
	Multistage DEA	5	6.33%
	Slacks-Based-DEA model	5	6.33%
	Other DEA models (BCC DEA model; Network DEA model; Virtual Frontier DEA model; Metafrontier-DEA; Super Efficiency DEA model; Multi-component DEA model; Additive DEA model; Hierarchical DEA model)	13	16.46%

Note: the source is self-developed; ; * – value shows the item related to categories of tourism characteristic products of UNWTO; AC - Accommodation (services) for visitors; FB - Food and beverage serving (services) activities; TR - Transportation (services); TARS - Travel agencies and other reservation (services) services activities; CSA - Cultural and Sports and recreational (services) activities; CSTG - Other (country-specific tourism characteristic goods); RCSTCG - Retail trade of (country-specific tourism characteristic goods); Nonspecified Tourism - Nonspecified tourism industry (product); *Number of articles* denotes the number investigated articles in each UNWTO category. 45 articles are not included since the authors have not been able to access their complete content.

4.7. Current studies, future trends, and recommendations

Keyword data and methods used may show in which direction the DEA research is heading (Emrouznejad and Yang, 2018). In order to delve into the current studies and future trends of tourDEA research, we further examined the journal articles published in the last two years (2017 and 2018). Table 14 lists the top 5 most popular research keywords that appeared in the tourDEA articles published in the last two years.

In recent years, the number of papers that study the productivity and efficiency of tourist destinations is growing. In addition, there is a greater interest in the determinants of tourism efficiency, cultural tourism, and sustainability.

Table 15 presents the most used DEA methods in 2017 and 2018. Methodological innovations have become important in recent years. Thus, the new DEA models are present in 74% of the current articles in the tourDEA literature.

In line with the above results, we highlight several limitations in the extant literature that should be addressed and suggest recommendations for future research to improve the outcomes of tourDEA studies.

First, it would be advisable to broaden the scope of the DEA applications in tourism and hospitality. DEA applications have mainly focused on the study of tourism production (Table 10). However, the DEA methodology can easily be applied to other fields of research. DEA can be viewed as a tool for multiple-criteria evaluation problems where DMUs are alternatives (Cook et al., 2014). Thus, any process that involves a transformation (decision making, strategic management, product or service consumption, value generation, etc.) can be analyzed through an input-output perspective. We recommend that future studies take into consideration the versatility of the DEA and broaden its scope to study, for example, the decision-making process in hospitality and tourism.

Second, there is a need for more variability in the geographical distribution. The analysis of the keywords shows a high degree of geographical concentration of tourDEA studies. Of the 29 countries for which tourDEA studies have been found, three (China, Taiwan, and Spain) have received most of the research interest. On the contrary, Latin America and Africa have barely received attention in the study of tourism with DEA methodology. This recommendation was previously raised by Assaf and Josiassen (2016) and is especially important for future research work.

Third, there are tourism products and tourism industries that need more attention. The DEA methodology has clearly contributed to the study of the productivity and efficiency of the *Accommodation (services) for visitors* category. This category has been the most studied (53% of paper and 51% of authors) and the one that had the greatest influence (55% of citations) within the tourDEA literature. However, the contribution of the DEA methodology in other tourism categories is much lower. For example, despite the importance of transport in tourism, the categories related to transportation have seldom received attention in the tourDEA literature.

Fourth, more attention to model specification is required. After reviewing the literature, and in accordance with Assaf and Josiassen (2016), it is evident that the model specification is an area to improve. It must be done based on scientific evidence, understanding of the process, and the logic of the data. DEA applications should be able to answer the following questions (Cook et al., 2014): What is the purpose of the performance measurement? What are the inputs and outputs and the decision-making units (DMUs)? Is the relationship between the number of DMUs and the number of inputs and outputs correct? How are the data to be included in the input-output sets statistically (different scale types' variables, existence of outliers)? What is the appropriate orientation? What is the appropriate scale specification? If the purpose of the

Table 10
Descriptive statistics on main input/output by categories of tourism characteristic products and tourism industries.

Indust. (Prod.)*	Input type	#	%	Output type	#	%	N. of articles
AC	*Capital*	*196*	*36.7%*	*Production*	*300*	*88.5%*	143
	Accommod. capacity (beds, rooms,…)	95	17.8%	Revenue (turnover, income, sales, tips,…)	216	63.7%	
	Physical space (surface, area)	50	9.4%	Occupancy (overnight stays, rate, length of stay,…)	61	18.0%	
	Assets (Book value)	21	3.9%	Tourists arrivals (visitors, reservations, stays, …)	20	5.9%	
	N. of establishments (hotels, F&B, subsidiaries, franchises,…)	14	2.6%	Value Added	3	0.9%	
	Others (N. of seats, N. of other fac., Invest., …)	16	3.0%	*Production Quality*	*17*	*5.0%*	
	Labour	*151*	*28.3%*	Satisfaction	14	4.1%	
	Employees (N., hours, share)	120	22.5%	Complaints	3	0.9%	
	Labour cost	31	5.8%	*Benefits* (Profit)	*9*	*2.7%*	
	Intermediate Consumption	*140*	*26.2%*	*Other* (Catering, Capacity, liabilities, G. lettings…)	*11*	*3.2%*	
	Operat. expenses (maintenance, materials, elect., pub., …)	117	21.9%				
	Tourist arrivals (visitors, reservations, stays,…)	14	2.6%				
	Others (Tourists act., res. consumpt., health consumpt., …)	9	1.7%				
	Quality	*27*	*5.1%*				
	Quality of service	25	4.7%				
	Quality of establishments	2	0.4%				
	Price	*13*	*2.4%*				
	Service Price (room, F&B, ticket)	9	1.7%				
	Others (Capital price, Labour price)	4	0.7%				
	Competition	*2*	*0.4%*				
	Others (Owner's equity, liquidity, Depreciation and amortization)	*5*	*0.9%*				
FB	*Capital*	*34*	*36.6%*	*Production*	*35*	*81.4%*	19
	N. of seats (F&B, transport,…)	14	15.1%	Revenue (turnover, income, sales, tips,…)	33	76.7%	
	Physical space (surface, size, floor space)	9	9.7%	N. of customers	2	4.7%	
	N. of other facilities	6	6.5%	*Production Quality* (Satisfaction)	4	9.3%	
	Other (Assets, Environmental Endow., N. of establish., …)	5	5.4%	*Benefits* (Profit)	2	4.7%	
	Labour	*30*	*32.3%*	*Other* (Financial outcome, Interest and tax)	2	4.7%	
	Employees (N., hours, share)	18	19.4%				
	Labour cost	12	12.9%				
	Intermediate Consumption	*16*	*17.2%*				
	Operat. expenses (maintenance, materials, elect., pub., …)	13	14.0%				
	Other (cooking time, economic activity)	3	3.2%				
	Quality (Experience, Quality of establishments)	*6*	*6.5%*				
	Price (Service Price)	*2*	*2.2%*				
	Competition	*5*	*5.4%*				
TR	*Capital*	*17*	*47.2%*	*Production*	*16*	*84.2%*	9
	Length of roads	5	13.9%	Revenue (turnover, income, sales, tips,…)	8	42.1%	
	Physical space (surface, area)	3	8.3%	Amount Transported (passenger or freight)	7	36.8%	
	Other (N. of seats, Invest., Assets, Transport el., …)	9	25.0%	N. of operations	1	5.3%	
	Intermediate Consumption	*12*	*33.3%*	*Benefits* (Profit)	*1*	*5.3%*	
	Operat. expenses (maintenance, materials, elect., pub., …)	7	19.4%	*Other*	*2*	10.5%	
	Economic activity	5	13.9%				
	Labour	*3*	*8.3%*				
	Employees (N., hours, share)	2	5.6%				
	Labour cost	1	2.8%				
	Price (Capital)	*1*	*2.8%*				
	Other (amount sold, sales)	*3*	*8.3%*				
TARS	*Capital*	*18*	*45.0%*	*Production*	*17*	*94.4%*	12
	N. of establishments (hotels, F&B, subsidiaries, franchises,…)	5	12.5%	Revenue (income, sales, tips, …)	8	44.4%	
	Assets (Book value)	5	12.5%	Overnight stays	6	33.3%	
	Other (Cult. endow., Investment, Acc. capacity, N. of beds, …)	8	20.0%	N. of costumers	2	11.1%	
	Labour	*10*	25.0%	Value Added	1	5.6%	
	Employees (N.)	8	20.0%	*Benefits* (Profit)	*1*	*5.6%*	
	Labour cost	2	5.0%				
	Intermediate Consumption (Operating expenses)	*10*	25.0%				
	Other (agency potential, service potential)	*2*	*5.0%*				
CSA	*Capital*	*51*	*43.6%*	*Production*	*87*	*88.8%*	40
	Human endowment (cult., educ., health, safety, hospitality)	12	10.3%	Sports results (goals, points, walks, shots, turns,…)	18	18.4%	
	Econ. and tech. resources (GDP, commerce, infrast., TIC's…)	11	9.4%	Won medals (Gold, silver, bronze)	16	16.3%	

(*continued on next page*)

Table 10 (*continued*)

Indust. (Prod.)*	Input type	#	%	Output type	#	%	N. of articles
	Accommod. capacity (beds, rooms,…)	10	8.5%	Occupancy (overnight stays, rate, length of stay,…)	16	16.3%	
	Other (Investment, Surface, Environmental Endowment)	18	15.4%	Soc. and Econ. Out. (business, jobs, educ., health,…)	13	13.3%	
	Intermediate Consumption	*36*	*30.8%*	Revenue (tournover, income, sales, tips,…)	11	11.2%	
	Game activity (goals, points, walks, shots, turns, min. spend,…)	11	9.4%	Environmental outcome (impact)	7	7.1%	
	Tourist arrivals (visitors, reservations, stays,…)	9	7.7%	Tickets	4	4.1%	
	Other (Operating expenses, Resource consumption, Time,…)	16	13.7%	Tourists (arrivals, expenditure)	2	2.0%	
	Labour	*20*	*17.1%*	*Production Quality* (Talent)	*1*	*1.0%*	
	Employees (N., hours, share)	9	7.7%	*Other* (Area, festival days, N. of golfers, fees,…)	*10*	*10.2%*	
	Labour cost	6	5.1%				
	Athletes (N., cost)	5	4.3%				
	Price (Capital price, Service Price, Labour price)	*5*	*4.3%*				
	Competition	*2*	*1.7%*				
	Other	*3*	*2.6%*				
CSTG	*Capital* (Investment)	*2*	*40.0%*	*Production*	*4*	*100.0%*	2
	Competition	*1*	*20.0%*	N. of Guests	2	50.0%	
	Other (Tourism Development Index, background conditions)	*2*	*40.0%*	Environ. Endow. (nat. attractions, climate, beaches,…)	1	25.0%	
				Amount Transported (passenger or freight)	1	25.0%	
RCSTCG	*Labour* (Employees)	*1*	*100.0%*	*Production* (overnight stays)	*1*	*100.0%*	1
Nonsp. Tourism	*Capital*	*138*	*46.2%*	*Production*	*148*	*79.6%*	79
	Human endowment (culture, educ., health, safety, hospitality)	38	12.7%	Revenue (turnover, income, sales, tips,…)	45	24.2%	
	Accommod. capacity (beds, rooms,…)	26	8.7%	Tourist arrivals (visitors, reservations, stays,…)	26	14.0%	
	Eco. and tech. resources (GDP, commerce, infrast., TIC's…)	21	7.0%	Occupancy (overnight stays, rate, length of stay,…)	26	14.0%	
	N. of establishments (hotels, F&B, subsidiaries, franchises,…)	19	6.4%	Soc. and Econ. Out. (business, jobs, educ., health,…)	23	12.4%	
	Other (Environmental Endowment, Assets, Investment, …)	34	11.4%	Tourists expenditure	13	7.0%	
	Intermediate Consumption	*83*	*27.8%*	N. of customers	6	3.2%	
	Operat. expenses (maintenance, materials, elect., pub., …)	33	11.0%	Environmental outcome (impact)	4	2.2%	
	Resource consumption (water, petrol., gas, land, electricity,…)	14	4.7%	Value Added	3	1.6%	
	Tourist arrivals (visitors, reservations, stays,…)	14	4.7%	Amount Transported (passenger or freight)	2	1.1%	
	Other (Tourists activit., Econ. activity, health consump., …)	22	7.4%	*Production Quality*	*23*	*12.4%*	
	Labour	*47*	*15.7%*	Satisfaction	22	11.8%	
	Employees (N., hours, share)	32	10.7%	Talent	1	0.5%	
	Labour cost	15	5.0%	*Benefits* (Profit)	*7*	*3.8%*	
	Quality	*16*	*5.4%*	*Other* (Success, work output, physical outputs, Food)	*8*	*4.3%*	
	Quality of service	9	3.0%				
	Quality of establishments	7	2.3%				
	Price (Capital)	*5*	*1.7%*				
	Competition	*4*	*1.3%*				
	Other (liabilities, resources, heating degree days, access to inf.,…)	*6*	*2.0%*				
		1125			706		305

Note: the source is self-developed; * - value shows the item related to categories of tourism characteristic products of UNWTO; # - number of inputs and outputs; AC - Accommodation (services) for visitors; FB - Food and beverage serving (services) activities; TR - Transportation (services); TARS - Travel agencies and other reservation (services) services activities; CSA - Cultural and Sports and recreational (services) activities; CSTG - Other (country-specific tourism characteristic goods); RCSTCG - Retail trade of (country-specific tourism characteristic goods); Nonsp. Tourism - Nonspecified tourism industry (product); *Number of articles* denotes the number investigated articles in each UNWTO category. 45 articles are not included since the authors have not been able to access their complete content.

DEA model is to estimate a production function, the scale specification must be done carefully. For example, the CRS assumption is very restrictive and assumes that all firms in the sample operate at an optimal scale, which lead to the assumptions of perfect competition or monopolistic behavior in the market (Coelli et al., 2005). If the purpose of the DEA is to estimate the efficiency of a process (without having a real production function), the meaning of efficiency is no longer the distance to the frontier but the distance to the best-practices.

Fifth, methodological innovations should be generalized in the tourDEA literature. The examination revealed 22 different types of DEA-like techniques in the literature. Almost all methodological breakthroughs have already been applied to the tourism and hospitality. However, the classic DEA models (CCR and BBC) are still the most used in tourism and hospitality applications. This may be due to the wide variety of DEA models, the difficulty in understanding them, and choosing the appropriate one. However, it is crucial that the model fits the nature of the study process. In addition, the new DEA models provide methodological and analytical improvements (statistical properties of the efficiency scores, model sensitivity, hypothesis testing, results validation, etc.).

Sixth, researchers specialized in DEA should take advantage of the research opportunities offered by the current situation (COVID-19 pandemic) within the hospitality and tourism sector. We live in a time of change, in which new values and needs arise. The standards,

Table 11
Descriptive statistics on average number of inputs/outputs used by tourism industry and product category.

#	Industries (Products)*	Average of inputs	Average of outputs
1.	Accommodation (services)* for visitors	3.73	2.36
2.	Food and beverage serving (services)* activities	4.89	2.26
3.	Railway passenger transport (services)*		
4.	Road passenger transport (services)*		
5.	Water passenger transport (services)*	4	2.11
6.	Air passenger transport (services)*		
7.	Transport equipment rental (services)*		
8.	Travel agencies and other reservation (services)* services activities	3.33	1.50
9.	Cultural (services)* activities		
10.	Sports and recreational (services)* activities	2.30	2.45
11.	Other (country-specific tourism characteristic goods)*	2.50	4
12.	Retail trade of (country-specific tourism characteristic goods)*	1	1
	Nonspecified tourism industry (product)	3.65	2.27

Note: the source is self-developed; * – value shows the item related to categories of tourism characteristic products of UNWTO.

Table 12
Descriptive statistics on cites by categories of tourism characteristic products and tourism industries.

#	Industries (Products)*	Average of cites	Number of cites	% of cites
1.	Accommodation (services)* for visitors	36.5	6754	54.83%
2.	Food and beverage serving (services)* activities	126.32	2400	19.48%
3.	Railway passenger transport (services)*			
4.	Road passenger transport (services)*			
5.	Water passenger transport (services)*	21.33	192	1.56%
6.	Air passenger transport (services)*			
7.	Transport equipment rental (services)*			
8.	Travel agencies and other reservation (services)* services activities	37.5	450	3.65%
9.	Cultural (services)* activities			
10.	Sports and recreational (services)* activities	27.08	1083	8.79%
11.	Other (country-specific tourism characteristic goods)*	51.5	4	0.84%
12.	Retail trade of (country-specific tourism characteristic goods)*	4	1333	0.03%
	Nonspecified tourism industry (product)	16.26	450	10.82%
Total		316.49	12319	100%

Note: the source is self-developed; * - value shows the item related to categories of tourism characteristic products from UNWTO.

instructions, and recommendations of national public authorities and global international organizations (such as United Nations (2021); World Health Organization (2021), UNWTO, etc) should be integrated into scientific frameworks and evaluated to identify strengths and weaknesses. The DEA is a very flexible tool that can easily be adapted (incorporation of new processes, new variables, etc.) to the study of the research challenges posed by the current context.

5. Conclusions

Through a survey of 350 DEA application studies in the tourism field, the current paper strives to present a state-of-the-art map on the subject, which aims to be useful to researchers entering this exciting field. As a primary guide, we use the list of categories from the UNWTO glossary to analyze the publications in our dataset.

The bibliometric analysis reveals that the "most frequent article" in the tourDEA literature (1986–2018) measures the efficiency of the hotel

Table 13
Descriptive statistics on top 10 cited categories of tourism characteristic products and tourism industries.

#	Authors	Names	UNWTO Industries (Products)*	ECC	Cites Per Year	Cites Per Author
1.	Banker and Morey (1986)	Efficiency analysis for exogenously fixed inputs and outputs	FB	1468	45.88	734
2.	Hwang and Chang (2003)	Using data envelopment analysis to measure hotel managerial efficiency change in Taiwan	AC	553	36.87	277
3.	Barros (2005)	Measuring efficiency in the hotel sector	AC	478	36.77	478
4.	Donthu and Yoo (1998)	Retail productivity assessment using data envelopment analysis	FB	370	17.62	185
5.	Chiang et al. (2004)	A DEA evaluation of Taipei hotels	AC	232	16.57	77
6.	Barros and Mascarenhas (2005)	Technical and allocative efficiency in a chain of small hotels	AC	209	16.08	105
7.	Hsieh and Lin (2010)	A performance evaluation model for international tourist hotels in Taiwan - An application of the relational network DEA	AC	208	26	104
8.	Johns et al. (1997)	The use of data envelopment analysis to monitor hotel productivity	AC	189	9	63
9.	Barros and Alves (2004)	Productivity in the tourism industry	NSTI	187	13.36	94
10.	Önüt and Soner (2006)	Energy efficiency assessment for the Antalya Region hotels in Turkey	AC	186	15.5	93

Note: the source is self-developed; CitesPerYear - Set to citation count divided by the age of the article; the result is rounded to 2 decimal digits; CitesPerAuthor - Set to citation count divided by the number of the authors, rounded to the nearest whole number; ECC - Estimated citation count.
FB - Food and beverage serving (services)* activities; AC - Accommodation (services)* for visitors; NSTI - Nonspecified tourism industry (prod.).

Table 14
Top 5 research keywords in 2017 and 2018.

#	Research keywords
1.	**DEA** (*DEA, Data envelopment analysis, Data Envelopment Analysis (DEA), Data envelopment analysis (DEA), (DEA), Data Envelopment Analysis Model, DEA (Data Envelopment Analysis), DEA method, DEA Model, DEA (Data Envelopment Analysis)*)
2.	**Performance** (*Efficiency, Productivity, Competitiveness, Performance, Benchmarking*); **Tourism** (*tourism, tourism efficiency, Tourism sector, tourism industry, Tourism destination, Sustainable tourism, Cultural tourism, educational tourism in agriculture, International tourism hotels, tourism employment, tourism farms, Tourism promotion, Tourism eco-efficiency, Medical tourism, Pro-Poor Tourism, Travel and Tourism, Low-carbon tourism, urban tourism, tourism development, Tourism supply chain*)
3.	**Hotel** (*Hotel, hotel efficiency, Hotel industry, International tourism hotels, hotel distribution channels, hotel revenue management, Star hotels, Taiwanese international tourist hotels*)
4.	**Destination** (*Destination; Destination competitiveness; Destination performance; Tourism destination; Cultural destinations; Destination quality; destination efficiency; Destination management organizations; virtual reference destination*)
5.	**Cultural** (*Cultural tourism, Cultural participation, Cultural destinations, happiness industry*); **Sustainable** (*sustainable tourism, sustainable festivals, educational tourism in agriculture; agritourism; Tourism eco-efficiency, Low-carbon tourism, Pro-Poor Tourism*); **Regional** (*Regions, Regional analysis, Regional tourist competitiveness; Greek regions*); **Determinants** (*Efficiency determinants, Environmental determinants, Exogenous factors, efficiency evaluation, Performance evaluation, financial factors*)

Note: the source is self-developed.

Table 15
Top DEA methods in 2017 and 2018.

#	Names	#	%
1.	CCR and BBC models	10	20.41%
2.	Slacks-Based-DEA model	8	16.33%
3.	Bootstrap DEA model	7	14.29%
4.	Multistage DEA	5	10.20%
5.	Network DEA model	5	10.20%
6.	Other DEA models (Virtual Frontier DEA model; CCR DEA model; Metafrontier-DEA; Hybrid DEA model; Robust DEA model; Super Efficiency DEA model; Stochastic DEA model; BCC DEA model)	15	30.61%

Note: the source is self-developed.

sector by estimating the CCR and BCC models with 4 inputs and 2 outputs. The "most frequent article" is written by 3 authors and gets an impact of 32 citations.

Beyond the first overview, other remarkable aspects are appreciated. The analysis shows an exponential increase in the number of articles since the first publication in 1986, reaching a maximum in 2011. However, from 2011 to 2018 the number slowly decreases. Furthermore, 37% of the DEA applications were published between 2011 and 2014. From all 350 tourDEA articles, 246 (70.29%) are found as indexed in the bibliographic database Scopus. Based on statistics of journals, some degree of specialization is observed in a small group of journals, ranking *Tourism Economics*, *Tourism Management*, *International Journal of Hospitality Management*, *The Service Industries Journal*, and the *Asia Pacific Journal of Tourism Research* in the top-five sources of tourDEA publications.

In recent years, the study of tourism with DEA techniques is moving from an industrial orientation to a geographical orientation. The *Accommodation (services) for visitors* category is losing research interest, while the study of tourist destinations is gaining more importance. The cultural perspective of tourism as well as its sustainability are becoming increasingly relevant.

This study also revealed that most of the articles make a productive approach to tourism. For the approximation of the tourism production process, both monetary and non-monetary variables have been used, as well as both micro-level and macro-level approaches. Furthermore, the classic DEA models (CCR and BBC) continue to be the most used in the tourism and hospitality literature, although there is a growing trend in the application of new DEA models in recent years.

This survey covers four decades of scientific literature. Reading this study may bring new research ideas to both scientists and practitioners who intend to study tourism from a comparative perspective. The results of the study can, above all, be considered as an essential guide for building future research in the domain. However, we must not forget that since 2020, the world has faced the threat of the COVID-19 pandemic. The COVID crisis can break the trends set by the 40 years of tourism literature and dictate new values in the understanding of sustainability and in the approach to studying tourism and hospitality. It must be borne in mind that the current crisis is leaving marks on the thinking and feelings, and therefore on the behavior of tourists (Kock et al., 2020) and industry (Hao et al., 2020). Furthermore, crises can cause a paradigm shift at the scientific level. Future studies may use new theoretical frameworks such as resource dependence, safety theory, or a new institutional theory to provide insight into implementation-related topics (Aladag et al., 2020). The study of tourism and hospitality may have to be adapted to the changes that bring the values of the new normal.

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