Ravi Sharma

Data Envelopment Analysis Applications in Tourism Management Research: The Evolution, Trends and Future Directions

Abstract

Tourism operations and businesses depend on various indicators defining their competitiveness and eco-efficiency. The Data Envelopment Analysis (DEA) is one of the tools widely recognized for evaluating the performance and benchmarking of the tourism industry domain sectors and services. Over time, the DEA methodology application has witnessed different interactions and inter-connectedness across the tourism sector. Through a systematic literature review and historiography using the HistCite™ tool, the study highlighted the trends and associations across the tourism management research. This will help contribute to the knowledge domain in this area, helping to understand the trends and define the path for DEA model application in tourism research. The results depict the scope of the DEA model's application in environmental and sustainability performance evaluations in tourism management. Study results will be of great significance for researchers formulating methodologies and strategies for sustainable tourism considering the current global environmental challenges.

Keywords: DEA application, tourism management, ecoefficiency, sustainable tourism, historiography, clustering, systematic literature review

1. Introduction

Sustainable development and environmental efficiency are now significant boosts for the economies. Different approaches and solutions towards sustainable development and reinstating an equilibrium balance between environmental and socio-economic domains are the challenges that organizations must deal with in the current era of businesses. The integration of triple-bottom-line pillars and sustainable development goals has been the forethought of leading enterprises, sectors and operations management (Venkatraman & Nayak, 2015). The other challenge is quantifying the sustainability initiatives attained by the system considering all the triple bottom-line aspects concurrently (Galán-Martín et al., 2016). The approach for assessing sustainability and efficiency varies from more straightforward to complex. The simplest method of assessment would be sustainability metrics (qualitative or quantitative) based on assigning preference weights to different sustainability indicators and applied for sustainable transport and logistic operations (Hernández et al., 2023); trade-off rules among the environmental and socio-economic criteria (Ünal & Sinha, 2022) to a very complex coupled with mathematical programming techniques (Grossmann & Guillén-Gosálbez, 2010) or system analysis approach (Bodini et al., 2012), or flow analysis approach through resource utilization efficiency (Campbell & Garmestani, 2012) to list only a few.

Tourist industries depend on environmental and socio-economic indicators like other manufacturing units or business operations. The impacts of this industry are multifaceted and affect different triple-bottom-line domains. Tourism destinations are coupled with products and services (Azmi et al., 2023). Like other business

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operations, the goal of tourism management is to assess the efficiency and sustainability of its offerings and services for a better visitor experience in a sustainable way (Myronov & Myronova, 2021). Tourism agencies and operating units should improve operating efficiencies, including service and environmental quality, to report sustainability in their operations. Tourist satisfaction is regarded as a customer-driven performance of destination performance (Kozak, 2002). The service quality efficiency for sustainable inbound tourism requires a long-term commitment and balancing between tourism supply and tourists' demands. The tourist's satisfaction and visit experience are also directly related to the environmental quality and acceptance of the local community (host). These all-inclusive provide the key indicators to measure tourism performance and efficiency for sustainability (Škrinjarić, 2018). Therefore, valuing the efficiency of tourism management under various facets and considering the set of relevant factors (both inputs and outputs) is crucial to valuing the performance of a management strategy in terms of socio-economic and environmental factors. To solve this issue and derive efficiency from the set of indicators, the insights can be derived through data envelopment analysis (DEA), which was first applied by Charnes et al. (1978) for measuring the relative efficiency of multiple decision-making units (DMUs). DEA is a mathematical programming technique widely used to calculate the relative efficiency of decision-making units (DMUs) in various fields, including tourism management research.

DEA applications are commonly found in banking, healthcare, agriculture, transportation, and education, as reported by Liu et al. (2013), including the transportation and service sectors (Rostamzadeh et al., 2021). Its widespread use extends to measuring performance and efficiency in energy-related industries (Sueyoshi et al., 2020) and environmental sustainability (Jahani & Kordrostami, 2021). The tourism and hospitality industry is no exception, with numerous studies analyzing performance and efficiency based on input and output indicators (Li, 2014; Hwang & Chang, 2003). DEA is also employed for the strategic development of tourism destinations, guiding countries with inefficient policies on enhancing their tourism efficiency (Škrinjarić, 2018).

Estimating environmental efficiency provides prominence to producing the maximum possible outputs using the minimum resources while minimizing the potential environmental impacts. Studies and reviews have also been conducted in the transport sector to study DEA's state–of—art and its applications. Studies in the transport sector explore DEA's applications, including a comprehensive literature review on transport activities (Markovits-Somogyi, 2011) and a review of DEA and bibliometric analysis from 1989 to 2016 (Cavaignac & Petiot, 2017). Assaf and Josiassen (2016) emphasize using dynamic and heterogeneous frontier models like DEA in tourism. Overall, DEA holds the potential for evaluating tourism management and countries with considerations for economic and environmental sustainability paradigms. The authors believe that the bibliometric analysis using a scientific and technical approach to the DEA application in tourism management research will benefit the academic and research fraternity in exploring the new dimensions in theory building related to performance and efficiency measurement in tourism studies. The present work will be influenced by the specific research works, theories proposed, authors' and co-authors' citations, and journal trends or by exploring the new dimensions that are functional in contributing to tourism management in future studies.

The present research assumes that a field's future advancements largely depend upon the existing scholarly literature and the contemporary work generated by the various contributors, adding new value and knowledge to the field. The analysis will focus on the comparison between the years 1998 and 2022. It will consider only published articles, for which the purpose of a document citation and co-citation analysis, visualization graphs will serve as fundamental approaches to derive confidently and illustrate the trends and future areas of research in tourism management. The present review study seeks to contribute to a better understanding of DEA knowledge in the tourism business. It will aid in identifying the consolidated effort for the future evolution of the field using historiography trends and clustering of domain areas of application, providing direction for influential research.

TOURISM
An International Interdisciplinary Journal

Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
Vol. 72/ No. 4/ 2024/ 620 - 634

621

This review paper is structured as follows: The section preceding this introduction discusses the DEA overview and literature review of DEA applications under different scenarios and areas of tourism management. This section elaborates on past studies with the highlights and identification of their importance in tourism management. After reviewing the literature on DEA applications, the following section presents the methodology for retrieving data and its analysis procedures. It deals with the data collection sources, database selection, content analysis, different approaches, and tools for deriving the final data for presentation and analysis. Henceforth, the results and analysis section describes chronological graphs, matrix analysis outcomes, and visual representations of trends that illustrate the clusters and associations. The final section applies the conclusions part, where the analysis summary, insights, and significant research future directions are presented.

2. DEA applications and tourism management: A bibliography

The DEA is recognized as an efficient tool amongst the performance /efficiency measurement tools. It is widely used in transportation, public policy, banking, agriculture and supply chain (Emrouznejad & Yang, 2018). Instead, it is a powerful operation research and management sciences tool for efficiency evaluation. Recently, there has been an increase in DEA applications in many sectors and domains of research, as discussed in the earlier section. In the past, DEA review bibliographies have been reported and prevailed in the scholarly research works of literature (Emrouznejad & Yang, 2018). It is reported that after the seminal work on DEA (Charnes et al., 1987), the total number of DEA journal papers has only reached 10,300 in the last four decades (Emrouznejad & Yang, 2018). The pertinent bibliometric review of performance analysis of DEA and Stochastic Frontier Analysis (SFA) tools was performed, where it is reported that DEA is the most adopted tool in operation research while SFA is in economics (Lampe & Hilgers, 2015). This bibliometric analysis explores the significant aspects of DEA in different fields regarding efficiency measurements but lacks tourism operations. A curated performance modelling was presented in another study, which delves into the bibliometric analysis of tourism research, exploring the status of frontier methods in tourism research focusing on essential issues such as dynamic formulation, heterogeneity, and wrong outputs with specific relations to tourism destination areas (Assaf & Tsionas, 2019). Recently, it has been observed that most studies focus on measuring the efficiency of hotel industries (Schalk-Nador & Rašovská, 2024). The critical review of performance management considering the progress on ontological and epistemological issues in the hospitality and tourism industry suggests the paucity of literature and concrete structure in the field (Altin et al., 2018). In another study, benchmarking the hotel industry in Oman through a three-stage DEA-based procedure was performed to identify the environmental factors that influence the operational efficiency of hotels (Oukil & Al-Zidi, 2018). Apart from environmental factors, another study by Herrero-Prieto and Gomez-Vega (2017) determined that cultural resources are a factor in defining the technical efficiency of regional destinations in Spain. The application for destination performance evaluation (Yen et al., 2021; Barros et al., 2011) and global network of several destinations (Lozano & Gutiérrez, 2018; Alzua-Sorzabal et al., 2015) along with the tourism competitiveness evaluation (Karakitsiou et al., 2020; Cracolici et al., 2008) were the other subcategories of the DEA application demonstrated in the field of tourism management research.

The empirical studies and reviews done in performance management and tourism research elucidate the potential of DEA application in deriving the performance of tourism management, considering both economic and environmental paradigms. Anthropogenic and physical factors of the tourism destinations are the inputs of the tourist production process. From this point, the outputs are affected by factors like the influx rate of tourists, occupancy rates, employment generated, revenue, customer satisfaction, and infrastructure, including resources (Cracolici et al., 2008) as indicators defining technical efficiency. A review conducted by Sainaghi et al. (2017) identifies the evolution of measurement approaches for tourism performance concepts. It determines efficiency, competitiveness, tourism productivity, metrics in use, and performance measurement system approaches as major evolved approaches in tourism performance evaluations.

TOURISM
An International Interdisciplinary Journal

Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
Vol. 72/ No. 4/ 2024/ 620 - 634

622

Hence, there are a considerable number of studies on efficiency and productivity analysis in the available literature. Its applications in tourism management research can help managers and policymakers make informed decisions about resource allocation, performance improvement, and policy implementation. Despite enough contributions in using different performance methods for tourism performance and efficiencies, the literature still lacks methodological rigor and a proper technical review of DEA application for the tourism field. The earlier analysis also advocates pitfalls associated with the earlier research relative to performance measurement in tourism and supports systematic research in this field (Sainaghi et al., 2017; Sainaghi et al., 2019). The study does not question the earlier studies or comment on the quality. However, the current study provides a more scientometric approach to presenting and exploring a multidimensional relationship of the DEA application with tourism management studies. The study was also conducted using quantitative tools to analyze linkages and trends. The trends and associations of DEA application in the tourism management sector are presented through the evolution pattern using historiography and clustering of the critical studies sorted based on the local citation score. It will assist in establishing the outcomes for describing the present gaps, future trends, and value in addition to the literature on tourism management. The present study, with the blended approach in the application of techniques, will be essential to establish the outcomes for describing the intellectual structure in the domain of research, diffusion of the knowledge and evolution of the knowledge in its emerging literature and inter-disciplinary nature and will present the conceptual and impact dynamics. Accordingly, this aggregation will provide a robust research trajectory with a holistic approach for future investigations, which was not covered in earlier studies in tourism management reviews.

3. Method

3.1. Study design

Bibliometrics plays a vital role in analyzing publication sources and permits the evaluation of the growth of a given research field (Ellegaard & Wallin, 2015). For this current study, the systematic process of screening and sorting relevant literature using a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) approach was adopted to review and analyze (Moher et al., 2009). For the analysis, the database was generated from the Clarivate Analytics core collection citation indexes that include the Social Science Citation Index (SSCI), Emerging Sources Citation Index (ESCI), and Science Citation Index Expanded (SCI-Expanded), supported by Web of Science (WoS). The study relies on a single database, WoS in this case, ensuring consistency in the data retrieval and minimizing potential discrepancies that may arise from overlapping and variations in article indexing criteria between different databases. This approach enhances the analysis's internal validity, providing a more reliable basis for drawing conclusions and comparing the datasets. In addition, the HistCite™ software used for the study is well integrated with the WoS database. Its functionalities are optimized for seamless retrieval and visualization of data specifically from this source, enhancing the accuracy and coherence of the findings. The search terms 'Data Envelopment Analysis,' 'DEA 'Tourism,' and 'tourism management' were used with different syntax combinations for 1998- 2022 to retrieve the raw data for further screening. The selected timeframe was carefully aligned with the objectives and scope of the study. This timespan allows for the inclusion of a significant timeframe for the development and proliferation of the DEA methodologies while ensuring the relevance of the analysis to contemporary research in tourism. The timespan accounts for recent developments, emerging trends, and the ongoing relevance of the DEA application within the tourism sector. The inclusion and exclusion criteria were applied to the additional screening of the relevant articles. The inclusion criteria include articles published only in English, subject consideration and journal articles. The exclusion criteria include screening the articles for their non-relevancy through the available published title, abstract and keywords. They were also checked for any redundancy and repetition, if any. This has resulted in a total of 484 articles. The literature was further screened for cluster analysis using the Least Citation Score (LCS). LCS provides a way to understand the linkages based on the

TOURISM
An International Interdisciplinary Journal

Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
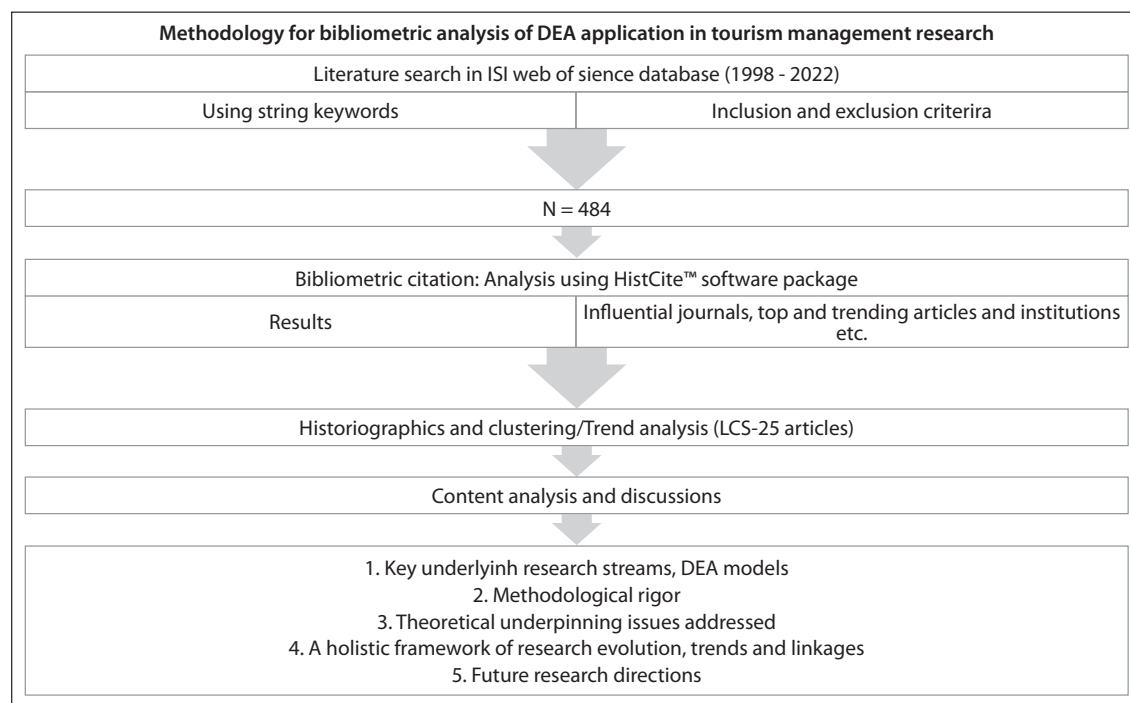Vol. 72/ No. 4/ 2024/ 620 - 634

623

number of times the articles are referenced within the sample articles. The purpose is to identify works that exerted a substantial impact on or served as inspiration for the focal research. An LCS greater than 25 was used to draw the articles' clustering. The computation of articles based on LCS offers insights into the knowledge landscape and theories that have contributed to the field (Linnenluecke et al., 2020).

3.2. Data processing and analysis

The Bibliometric information from the sorted 484 articles will present a large and efficient historiographic structure of the domains (Garfield et al., 2003; Garfield et al., 2006). This historiography is the graphical structure that maps the emerging knowledge information and visualizes the trajectory of trends using the citation network through the application of HistCite™. The graphical structure generated through the Hist-Cite™ software will aid in preparing clusters according to their trajectory path and interconnected research trends using cluster aggregations. The HistCite™ is used for analyzing and exploring the visual direct citation linkages between published scientific papers to explore trends and interconnections. The historiography will represent the article linkages using the local citation score (LCS) and Global citation score (GCS) over some time. It will present the chronological and relative influence of articles. Based on the historiography visual results and the analysis of each article, the relationship of interconnectedness in terms of its domain areas and emphasis of the articles and chronology are clustered. These relevant clustering will assist in discussing the research through gap identification, the evolution of concept and application, and the recent trend in the application of DEA in the tourism industry, which will be analyzed. The historiography generated four relevant clusters, which were labelled according to their relevance and study inter-connectedness.

The analysis of clusters was further done to explore its underlying stream, the theoretical underpinning of issues and the DEA model application, providing a holistic review of research evolution, trends and linkages leading to future research directions (Figure 1).

Figure 1
Methodology for screening on DEA application in tourism management

Methodology for bibliometric analysis of DEA application in tourism management research

Literature search in ISI web of sience database (1998 - 2022)	
Using string keywords	Inclusion and exclusion crterira

N = 484

Bibliometric citation: Analysis using HistCite™ software package	
Results	Influential journals, top and trending articles and institutions etc.

Historiographics and clustering/Trend analysis (LCS-25 articles)

Content analysis and discussions

1. Key underlyinh research streams, DEA models 2. Methodological rigor 3. Theoretical underpinning issues addressed 4. A holistic framework of research evolution, trends and linkages 5. Future research directions

TOURISM
An International Interdisciplinary Journal

Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
Vol. 72/ No. 4/ 2024/ 620 - 634

624

4. Results and discussion

4.1. DEA applications in tourism management research

The literature review and the study explore that the DEA application in tourism management research has emerged as a versatile tool. Most studies reveal its capability to provide valuable insights into the efficiency and performance of various aspects and domains within the industry. The tool is widely applied for multiple decision-making units (DMU), such as the hotel sector, tourism destinations, aviation and airlines and tour operators, etc., for assessing the relative efficiency of such units (Lin & Hong, 2020; Shieh et al., 2020). The application of DEA thereby provided a comprehensive framework for evaluating the effectiveness of managerial applications, resource allocation, opportunities for improvement, and guiding strategic decision-making (Tsai et al., 2009). By utilizing DEA in tourism research, practitioners and scholars have reported gaining a deeper understanding of the influencing factors towards the sustainability and effectiveness of tourism operations, thereby paving the way for enhanced performance, competitiveness, and informed policy interventions.

The broad application of DEA in tourism management research covers mainly efficiency, performance evaluations, the impact of tourism policies, competitiveness and effectiveness of tourism destinations, services and allied operations. The historiography of the various scientific published articles reveals inter-connectedness and trends of these domains of DEA applications and usage in tourism management (Figure 2).

The historiography trends reveal the critical domains of aspects covered using the DEA as a tool in tourism research. The key lines of the evolution of the DEA application are:

A. Hotel industry evaluation, performance and efficiency assessment using the DEA tool:

The critical contribution of interactions in this cluster includes formulating competitive marketing strategies, strengthening corporate operations and upgrading the quality of services. The aspects covered under this domain for the hotel industry are of paramount importance. The hotel sector is a crucial component within the broader tourism ecosystem, irrespective of the volume or type of tourism. It contributes significantly and is a vital driver for visitors' experience and destination competitiveness. DEA application in this context for evaluating hotel performance and efficiency assumes excellent significance and competitive advantage by providing a comprehensive and inclusive assessment that considers the considerable heterogeneity and complexities involved in hotel operations and multiple inputs, processes, outputs, environmental characteristics and markets inherent in hotel services and procedures (Chiang, 2006; Tan & Despotis, 2021).

The interconnected interactions of published articles under this cluster suggest that the DEA provides a nuanced understanding by apprehending the interplay between inputs such as staff and infrastructure, financial resources, and various outputs such as occupancy rates, quality of service and customer satisfaction. The DEA evaluation accounts for the factors that impact hotel performance, including facilitating evidence-based decision-making crucial for benchmarking performance and identifying best practices (Nurmatov et al., 2021). Moreover, the inclusivity of DEA permits the hotel's evaluation across different scales, ownership structures, and categories of hotels, fostering a more comprehensive analysis of efficiency and performance. The DEA application and the results insights for the hotel industry can drive improvements in processes, services and operations, strategic planning and formulation of policies, ultimately enhancing the competitiveness and sustainability of the hotel industry within the broader spectrum of the tourism landscape (Nurmatov et al., 2021). The hotel sector has Recently emphasized sustainability practices due to growing concerns about environmental and climate change issues and the growing demand for responsible tourism. By measuring eco-efficiency and ecological performance, DEA offers a valuable framework for incorporating sustainability dimensions into hotel performance and benchmarking studies (Higuerey et al., 2020; Huang et al., 2017). For future applications, the DEA in sustainability practices will aid in promoting accountability and transparency

TOURISM
An International Interdisciplinary Journal

Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
Vol. 72/ No. 4/ 2024/ 620 - 634

625

in the sector, fostering healthy competition and continuous industry improvement. With the growth of eco-tourism, nature-based tourism, and responsible tourism strategies, integrating DEA to measure performance and efficiency will foster the sustainable development of the hotel sector.

B.   Travel & services effectiveness measurement by applying DEA as a tool

The domain reveals the progress of DEA application in the travel and aviation sector, including the service industry, for measuring the efficiency and comparing the performance of different entities or decision-making units (DMUs). The cluster's results and trend depict critical insights into the potential areas of improvement by identifying inefficient DMUs in their overall performance and identifying competitors' performance, aiding them in comparing with other travel and service agencies. Such efficiency analysis of travel services and agencies is essential for stakeholders, investors, financing institutions, business partners, and public institutions to understand the potential of this sector. Identifying competitors' performance, which could include service effectiveness and productivity, can lead managers to select appropriate benchmarking of hotels and gauge the performance of their operations (Yu & Lee, 2009). This will also help in making decisions related to allocating resources, monitoring and evaluating expenditures, and ensuring quality of service delivery (Fuentes, 2011).

The various applications of DEA in the travel and service sector of tourism are generally associated with the multidimensional analysis considering multiple aspects such as quality of service, satisfaction of customers, financial resources, resource utilization and productivity, providing a comprehensive assessment of effectiveness and productivity. The other applications include benchmarking of best practices, performance improvement, decision support, sector-wise analysis, transparency and accountability, which are essential for the complex entities of this sector in tourism management.

C.   Tourist destination evaluation, performance and competitiveness studies

When assessing destination competitiveness using the DEA tool, several components of different decision-making units (DMUs) within a destination related to performance and efficiency can be effectively covered. The various components for destination valuation covered using DEA were inputs (physical and anthropogenic factors), outputs (examples may include employment generation, tourist arrivals and expenditures, tourism product diversity, revenue generation, and overall visitor satisfaction), stakeholder analysis (for the competitiveness assessment), destination management and marketing, and sustainable practices including promoting competitive advantage.

Recently, the notion of destination competitiveness measurement has gotten increasing attention due to increasing competition in the tourist market and transitioning traditional tourism into customized tailored tourism. These transition shifts have resulted in a better understanding of visitors' specific attitudes and needs to make the destinations more competitive in the future (Cracolici et al., 2008). These studies have revealed through their outcomes that the transition to new nature-based tourism can achieve destination competitiveness and sustainability (Murayama et al., 2022). Through its application, DEA evaluates the efficiency of the destinations and can identify the key factors influencing destination attractiveness, which is essential for any destination's competitiveness and performance (Barros et al., 2011). The recent trend explored in the cluster was benchmarking and determining critical indicators of tourism and destination performance (Assaf, 2012; Benito et al., 2014). As a tool in destination competitiveness assessments, the DEA explores holistic evaluations, efficiency-driven components, benchmarking and comparing performance evaluations, and evidence-based decision-making for stakeholders involved in destination management.

D.   Tourism and destination eco-efficiency measurement studies

The recent trend in the cluster of historiography results indicates the focus on eco-efficiency studies using the DEA, which includes the impact of technological interventions, environmental efficiency, and sustainability performance of the tourism destinations (Peng et al., 2017; Chaabouni, 2019). The destination eco-efficiency

TOURISM
An International Interdisciplinary Journal

Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
Vol. 72/ No. 4/ 2024/ 620 - 634

626

Figure 2
Historiography inter-connections and trends of DEA application in tourism research
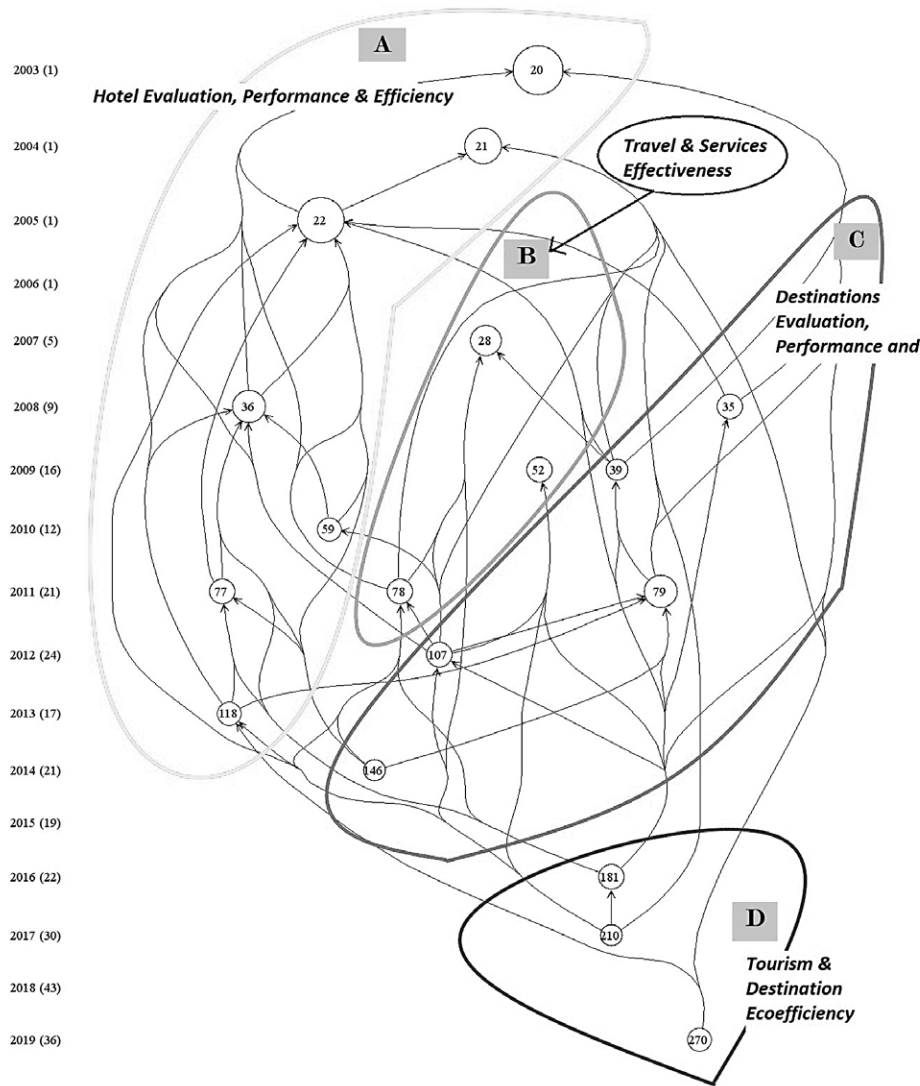
Nodes: 18, Links: 59
LCS >= 25; Min: 27, Max: 126 (LCS scaled)

		LCS	GCS
1.	20 Hwang SN, 2003, TOURISM MANAGEMENT, V24, P357	126	329
2.	21 Chiang WE, 2004, ANNALS OF TOURISM RESEARCH, V31, P712	70	148
3.	22 Barros CP, 2005, ANNALS OF TOURISM RESEARCH, V32, P456	108	302
4.	28 Koksal CD, 2007, TOURISM MANAGEMENT, V28, P830	52	86
5.	35 Cracolici MF, 2008, TOURISM ECONOMICS, V14, P325	34	115
6.	36 Barros CP, 2008, INTERNATIONAL JOURNAL OF HOSP, V27, P438	57	128
7.	39 Botti L, 2009, EUROPEAN JOURNAL OF TOURISM R, V2, P5	27	57
8.	52 Yu MM, 2009, TOURISM MANAGEMENT, V30, P571	36	102
9.	59 Assaf A, 2010, INTERNATIONAL JOURNAL OF HOSP, V29, P468	31	64
10.	77 Assaf AG, 2011, TOURISM ECONOMICS, V17, P73	37	83
11.	78 Fuentes R, 2011, TOURISM MANAGEMENT, V32, P75	37	67
12.	79 Pestana BC, 2011, TOURISM MANAGEMENT, V32, P141	55	140
13.	107 Assaf AG, 2012, TOURISM MANAGEMENT, V33, P1122	37	63
14.	118 Oliveira R, 2013, TOURISM MANAGEMENT, V36, P641	29	67
15.	146 Benito B, 2014, TOURISM ECONOMICS, V20, P987	28	50
16.	181 Assaf AG, 2016, JOURNAL OF TRAVEL RESEARCH, V55, P612	37	77
17.	210 Peng HS, 2017, TOURISM MANAGEMENT, V60, P201	27	82
18.	270 Chaabouni S, 2019, JOURNAL OF DESTINATION MARKET, V11, P183	29	67

TOURISM
An International Interdisciplinary Journal

Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
Vol. 72/ No. 4/ 2024/ 620 - 634

627

using DEA focuses on ecological indicators and sustainable practices related to the destinations. In contrast, the destination competitiveness discussed earlier covers a broader range of components and stakeholders during the assessment. Destination eco-efficiency studies concentrate on assessing factors such as water consumption, energy usage, waste management, emissions, and other practices related to environmental indicators to measure the sustainability performance of the destinations. As a recent trend, the destination eco-efficiency assessment generally complements destination competitiveness, effectiveness and performance studies and develops a broader perspective of sustainable destination and tourism practices.

The current application of the DEA is to measure the efficiency of the nation's regional-level tourism industry (Haibo et al., 2020; Chaabouni, 2019). The domain area trends indicate that the DEA application has shifted from unit-level efficiency or evaluation measurement to sector and regional-level studies over the decades. The recent trend is to understand the overall factor inputs to tourism growth and operational efficiencies at the national/regional basis, which includes various components of efficiency, covering technology, labour, capital, resources and environmental effects (Sánchez-Sánchez et al., 2022; Alberca & Santos, 2021; Zha, Zhu et al., 2020). This depicts the recent trend followed to measure the eco-efficiency of the tourism sector to develop sustainable tourism strategies.

Hence, the clustering of the DEA application studies in tourism management depicts the journey of domain areas and can be derived that the application's insights and outcomes can inform industry stakeholders, policymakers and managers in shaping sustainable tourism policies, regulations and standards. Overall, the application of DEA in the assessment of the tourism sector empowered them to evaluate, enhance, and communicate their sustainability performance effectively. The mapping of studies, if done, will reveal their contribution to the ongoing transformation of the tourism industry towards more sustainable and responsible practices, further aligning with global sustainable development goals and meeting the expectations of environmentally conscious visitors.

4.2. The trending DEA models in tourism management research

In parallel to understanding the trends and lineages of the DEA application journey of the domain research, the study analyzed the trending DEA models and the obsolete DEA models applied in tourism management studies. The trending DEA models and their applications in tourism research yielded new and innovative ways of evaluating the efficiency of selected DMUs accounting for different types of uncertainties and complexities in the tourism sectors (Table 1).

Table 1
Key DEA models application in tourism management research

Type of DEA model	Purpose	Importance	References
Network DEA	They were used to evaluate the efficiency of a complex system where multiple DMUs with interdependent relationships are involved.	Managerial implications of the tourism industry; Tourism supply chain; Destination accessibility; determinants of efficiency; tourist and environmental attractions	Bi et al., 2011; Huang, 2018; Yen et al., 2021; Tan & Despotis, 2021; Zha, Zhu et al., 2020
Metafrontier DEA	They are ideally used to evaluate the relative efficiency of DMUs across different regions or groups.	Efficiency & eco-efficiency analysis; Tourism growth; hotel efficiency, technological and environmental efficiencies; Performance evaluations	Zha, Yuan et al., 2020; Assaf et al., 2010; Lee et al., 2019; Yu & Chen, 2018
Dynamic DEA	Evaluates the efficiency of selected DMUs over a different period	Environmental efficiency analysis; Benchmarking, effectiveness	Shieh et al., 2017
Hybrid DEA or multi-criteria decision models	Combination of DEA models with other optimization techniques like neural networks, fuzzy logics, etc., while accounting for uncertainty or non-linearity	Operational efficiency, uncertainty conditions, scenario analysis, influencing factors, quality and reliability evaluations	Huang et al., 2012; Huang, 2017
Robust DEA	It is designed to handle the variability and uncertainty of the presented data.	Decision-making, scenario modelling, uncertain environmental conditions	Omrani et al., 2021

TOURISM
An International Interdisciplinary Journal

Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
Vol. 72/ No. 4/ 2024/ 620 - 634

628

There are no such inherently obsolete DEA models in tourism studies, as applying these models as a tool remains relevant and outcome-oriented for evaluating the efficiency of DMUs related to the tourism sectors. However, some DEA models have grown over time and become less common in applications as newer models capable of dealing with more complex scenarios and challenges are developed. Some examples of these less common models include the super-efficiency DEA model, the variable return to scale (VRS) model, and the Free Disposal Hull (FDH) model. Over time, these models are amalgamated or formulated with the other DEA models to provide unified linear frameworks or hybrid models. The choice of models depends on the research requirements and specific context based on outcomes and objectives.

In any domain area of research, formulating new DEA models is an ongoing process, and tourism research is no exception for reasons. The researchers continue to explore new applications, and application techniques are presented in an extended form based on the development of the field. Still, there are some possibilities for the growth of DEA models in the current context transition of the tourism industry, considering the focus of the sectors on sustainability, enhancing value chains, and responsible tourism. Some potential future DEA models beneficial for the tourism domain area would be those focusing on the environmental eco-efficiency of the destinations or businesses. The 'Green DEA' model's category concentrates on reducing the environmental impacts and achieving key sustainability parameters to meet the international or national commitments that would benefit the sector. The inter-relationship between tourism and green development will be conducive to producing a sustainable co-existence between both. Measuring the green development efficiency and super-efficiency concepts will be the trending future DEA applications in tourism management (Wu et al., 2022), helping businesses identify and develop strategies to deal with global environmental challenges like climate change. As climate change and other ecological issues are uncertain and change over some time, the dynamic DEA models, which can evaluate efficiency and performance over a period incorporating both temporal and network aspects of the tourism data, return the potential to highlight changes and linkages over time will be the trending tools of future. This will potentially evaluate the efficiency of tourism networks more holistically and comprehensively. Considering technological advancements, the DEA models' future success and realization capability will be determined by their ability to assess efficiency using blockchain and machine learning technologies. Such DEA tools are expected to improve the reliability and accuracy of the data, resulting in better execution of decisions and sustainable practices.

5. Conclusion

The literature review and its interconnections over a while highlight the DEA tool's significance and versatility in tourism management research, broadly emphasizing its capability of providing valuable insights into efficient and inefficient determinants and indicators of performance across various domains. It is also highlighted that the DEA tool has been widely recognized and applied to assess the DMUs such as tourism services, hotels, the travel and aviation sector, tourism destinations, and tour operators. This has enabled the evaluation of relative efficiency and benchmarking performance, facilitating evidence-based decision-making. DEA practice has resulted in identifying and formulating determinants influencing effectiveness and sustainability, thereby enhancing performance, competitiveness, and stakeholders with an informed policy intervention. The study also highlighted key areas where DEA as a tool had been implemented to understand the multi-complex scenarios related to efficiency and performance evaluations, the competitiveness of destinations, the impact of tourism policies, and tourism growth at the regional and national levels.

In conclusion, the study also discusses the importance of incorporating eco-efficiency analysis in tourism evaluations to promote sustainable and responsible tourism practices. However, there are some gaps and areas for further exploration, such as addressing the environmental and sustainability challenges through the development of green DEA, capturing temporal, geographical and network aspects using the dynamic DEA models, and developing the enhanced reliability and accuracy of data through the incorporation of blockchain

and machine learning technologies. Considering these gaps in the future scope of studies will result in DEA as a tool contributing to the transformation of the tourism industry towards more sustainable practices, aligning with global sustainable development goals and fulfilling the expectations of environmentally conscious stakeholders. With the advancements of future DEA applications and models, it is expected that the models will be equipped with machine learning and the integration of new evolving techniques, resulting in more accurate forecasting for the tourism industry. This will aid certification agencies and investors in making efficient and reliable decision-making for promoting sustainable tourism. The businesses will anticipate demands and position their operations, accordingly, leading to eco-efficient ventures.

The study results cover some of the primary applications of DEA in tourism management but also found that there is a need to broaden the scope of tourism products and other essential tourism services, e.g., nature-based tourism, adventure tourism and ecotourism. New-age tourism and tourism product typologies are evolving daily, and therefore, the interests and behavior of tourists are also changing. The advanced DEA models and studies are thus required to explore the competitiveness and eco-efficiencies of these new evolving tourism typologies. As nature-based and other allied tourism growth impacts the environment and global issues, the DEA application will boost the understanding of tourism growth and the interaction of this tourism development on the environment, helping businesses make informed decisions to cater to global environmental commitments.

The study's limitations are contingent upon the availability and quality of data due to its dependency on a single database. The inclusion and integration of other available research databases will provide valuable additions to the presented knowledge and fill the inaccuracies or gaps that may impact the robustness of the findings. The study also acknowledges a need to broaden the scope of DEA applications to encompass a more comprehensive array of tourism products and services. Limitations arise from the evolving nature of tourism products, necessitating ongoing research to capture emerging trends and preferences.

The study also proposes the future scope of work could include the theoretical aspects and mapping of sustainable practices using the DEA applications in tourism management research. Considering the recent focus of researchers on understanding the sustainability and environmental indicators of tourism efficiencies and performance measurement, future research could delve into developing and applying DEA models to address sustainability challenges more explicitly. Considering theoretical aspects and mapping sustainable practices within DEA applications will contribute to a more comprehensive understanding of the theoretical frameworks guiding eco-efficient and sustainable tourism management. This approach will contribute to a more nuanced understanding of eco-efficiency in the context of sustainable tourism practices. The proposed future scope of work will further narrow down this study's gaps and limitations and result in a holistic understanding of eco-efficiency and sustainability indicators required for the sustainable tourism industry.

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Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
Vol. 72/ No. 4/ 2024/ 620 - 634

630

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Vol. 72/ No. 4/ 2024/ 620 - 634

631

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An International Interdisciplinary Journal

Ravi Sharma
Data Envelopment Analysis Applications in Tourism Management Research
Vol. 72/ No. 4/ 2024/ 620 - 634

634