Modelling, Measurement and Control D
Vol. 45, No. 1-4, December, 2024, pp. 37-42
Journal homepage: http://iieta.org/journals/mmc_d

Study on Accommodation Efficiency in "Pueblos Mágicos", Mexico: An Application of Data Envelopment Analysis (DEA)

Ana Cristina Pacheco-Cedeño, Antonio Kido-Cruz, Gerardo G. Alfaro-Calderón*

Facultad de Contaduría y Ciencias Administrativas, Universidad Michoacana de San Nicolás de Hidalgo, Morelia 58030, México

Corresponding Author Email: ggalfaroc@gmail.com

https://doi.org/10.18280/mmc_d.451-405

Received: 15 July 2024
Revised: 10 September 2024
Accepted: 13 December 2024
Available online: 31 December 2024

Keywords:
Data Envelopment Analysis (DEA), efficiency, "Pueblos Mágicos" (PMs)

ABSTRACT

In recent years, tourists' preferences have shifted toward destinations that offer a connection to local customs and traditions, making rural tourism a popular alternative. In Mexico, the "Pueblos Mágicos" (PMs) program has become the leading rural tourism initiative, promoting a diversified tourism supply and a more equitable distribution of tourism benefits. This study aims to measure the efficiency of the accommodation sector in municipalities designated as "Pueblo Mágico" (PM) in 2012 using a Constant Returns to Scale (CRS) model within the Data Envelopment Analysis (DEA) framework. The methodology enabled the assessment of resource utilization efficiency and objective comparisons between PMs. Results show that average efficiency increased from 0.661 in 2008 to 0.831 in 2013, before slightly decreasing to 0.771 in 2018. The PM designation improved efficiency in 19 out of 24 PMs between 2008 and 2018.

1. INTRODUCTION

Tourism is one of the fastest-growing sectors globally, significantly impacting economies due to the annual increase in travelers [1, 2]. In 2023, Mexico ranked 6th in international tourism arrivals [3, 4], contributed 14.4% to the Gross domestic product (GDP), and accounted for 12.5% of total employment [5]. While Mexico has traditionally been known for its beach destinations, cultural and rural tourism have become increasingly popular over time [6-8]. To diversify the tourism offerings, the "Pueblos Mágicos" (PMs) program was launched in 2001 to showcase the country's cultural richness beyond the typical tourist destinations [9, 10].

A "Pueblo Mágico" (PM) is a town distinguished by its symbols, legends, and stories preserved over time, which embody the national identity [11]. These towns are particularly attractive to both national and international tourists. Since the program's inception in 2001, there are now 177 PMs, with 45 newly designated in 2023 [12]. According to the Organization for Economic Cooperation and Development (OECD), the PM program is one of the most notable tourism initiatives, promoting economic growth and enhancing rural traditions and culture [13]. The designation of a PM is exclusively granted by SECTUR, the federal tourism department, following a process that involves coordination among tourism offices at the federal, state, and municipal levels.

The benefits of the designation seem to be clear: a share of the federal budget, advertising and the effects on the PM's touristic system [14-16] (transport, travel agencies, tour guides, accommodation, food and beverage services, etc.) but, tourism authorities and academics have reported that measuring the impact and evolution of PMs has been complex due to the lack of data, after 20 years of operation by the end of 2018, only 27% of PMs had statistical information [9, 17-19].

Given the program's importance and the rising popularity of PMs, assessing its impact on tourism growth is essential. This assessment focuses on the accommodation sector, as it plays a crucial role in the tourism system by enhancing the tourist experience [20, 21]. Additionally, the distinction between a tourist and a visitor is often marked by overnight stays (lodging services) [22]. This study aims to measure the efficiency of the temporary accommodation sector in municipalities whose PMs were designated in 2012, to achieve this, a Data Envelopment Analysis (DEA) is conducted.

In recent years, numerous studies in the existing literature utilize DEA to assess the efficiency of tourism [23-28].

This paper continues with the following structure: Section 2 provides a detailed examination of the DEA methodology, also including details from the used data and the analysis process; Section 3 presents the most significant results; finally, Section 4 concludes the paper by summarizing the key insights and exploring potential avenues for future research.

2. METHODOLOGY

Efficiency generally refers to the optimal use of resources to achieve specific goals. An efficient entity either increases production with the same resources or achieves the same output with fewer resources [29-31].

Based on Farrell's work [30], Charnes et al. [32] proposed an alternative method for measuring efficiency in 1978, known as DEA. This model allows for the consideration of multiple inputs and outputs for a set of Decision-Making Units (DMUs) [33-35]. The authors introduced a non-parametric model based on Constant Returns to Scale (CRS), which provides a scalar measure of efficiency (CRS ratio) for each DMU using linear programming. The CRS ratio is derived from the relationship between the maximum weighted outputs and weighted inputs, under the constraint that these ratios do not exceed unity [32]. This model does not require pre-assigned weights [36, 37].

The CRS DEA model is based in Eq. (1), it presents an extended nonlinear programming formulation of an ordinary fractional programming problem. It considers a set of DMUs, for each DMU_j (1,…,*n*) using *m* inputs x_{ij} (i=1,…,m) generates *s* products y_{rl} (r=1,…,s); we also have the multipliers *u* and *v* associated to outputs *r* and inputs *i* respectively:

$$\sum_{r=1}^{s} u_r y_{rj} \Bigg/ \sum_{i=1}^{m} v_i x_{ij} \tag{1}$$

The goal is to maximize this ratio, reflecting the efficiency of each DMU [38]. The maximization of Eq. (1) is subject to the condition that the ratios for all DMU's must be less or equal to the unity. It is important to consider also, that inputs x_{ij} and outputs y_{rl} must be all positive; and the respective associated multipliers *u* and *v* more or equal to zero.

To convert the nonlinear problem into a linear one, the inputs must be equal to unity, then the problem becomes to maximize the outputs:

$$\sum_{r=1}^{s} u_r y_{rj}$$

with the restrictions

$$\sum_{i=1}^{m} v_i x_{ij} = 1$$
$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$$
$$u_r, v_i \geq 0$$

2.1 Data

Data were collected from the INEGI economic censuses for 24 municipalities designated as PM in 2012 [39]. Table 1 lists these municipalities and their corresponding PM.

In order to retrieve information from the accommodation sector, the economic activity 721, called Temporary accommodation services, was considered. This sector includes data from hotels (except hotels with casino), motels, cabins, villas, camps, recreational lodges, pensions, guest houses, furnished apartments and houses with hotel services. The variables considered are presented in Table 2.

2.2 Analysis process

The following steps were taken in this work:

Individual Annual Efficiency: The efficiency of each of the 24 DMUs was calculated for the years 2008, 2013, and 2018 using RStudio.

Annual Average Efficiency: The average efficiency across all DMUs was computed for the years 2008, 2013, and 2018.

Identification of Maximum Efficiencies: The highest efficiency scores among the DMUs for each year were identified.

Identification of Minimum Efficiencies: The lowest efficiency scores among the DMUs for each year were identified.

Comparative analysis over time.

Table 1. DMU's considered in DEA

Municipality	Pueblo Mágico (PM)	Code
Tecate	Tecate	TCT
Loreto	Loreto	LRT
Cuatro Ciénegas	Cuatro Ciénegas	CCG
Comitán de Domínguez	Comitán de Domínguez	CDZ
Chiapa de Corzo	Chiapa de Corzo	CHC
Batopilas de Manuel Gómez M.	Batopilas	BTP
Mapimí	Mapimí	MPM
Salvatierra	Salvatierra	SVT
San Luis de la Paz	Mineral de Pozos	MPZ
Yuriria	Yuriria	YRR
Huichapan	Huichapan	HCP
Lagos de Moreno	Lagos de Moreno	LGM
Metepec	Metepec	MTP
Angangueo	Mineral de Angangueo	MAG
Jiquilpan	Jiquilpan de Juárez	JJZ
Tacámbaro	Tacámbaro	TCM
Chignahuapan	Chignahuapan	CGN
Pahuatlán	Pahuatlán	PHT
San Pedro Cholula	Cholula	CHO
Tlatlauquitepec	Tlatlauquitepec	TTQ
Xicotepec	Xicotepec	XCT
Tequisquiapan	Tequisquiapan	TQN
Rosario	El Rosario	ERS
Magdalena	Magdalena de Kino	MKN

Source: Own elaboration

Table 2. Inputs and outputs considered in DEA

Variable		Definition
Inputs	Total employed personnel	It includes all the people who worked during the reference period, whether contractually dependent or not on the economic unit, subject to its direction and control.
	Total expenditures (millions of pesos)	This is the total amount that the economic unit allocated to the consumption of goods, services and other financial and fiscal expenditures and donations without counterpart to individuals and corporations.
Outputs	Total income (millions of pesos)	This is the total amount that the economic unit obtained from the sale of goods, services, interest, other financial income and donations received without compensation.

Source: Own elaboration

3. RESULTS

3.1 Individual annual efficiency

The results of the individual DEA Efficiency Ratios for 2008, 2013, and 2018 are presented in Table 3. A score of one (1) represents the highest level of efficiency. Therefore, the closer a PM's score is to 1, the more efficiently it has performed. Conversely, the further the score is from 1, the less efficient the performance.

Table 3. Efficiency Ratio (DEA)

Pueblo Mágico (PM)	2008	2013	2018
TCT	1	1	1
LRT	0.918	1	1
CCG	0.657	0.760	0.819
CDZ	0.650	0.768	0.729
CHC	0.654	0.767	0.604
BTP	0.441	0.576	0.522
MPM	0.449	0.638	0.615
SVT	0.485	0.933	0.808
MPZ	0.719	0.700	0.772
YRR	0.391	1	1
HCP	0.592	0.870	0.986
LGM	0.578	1	0.655
MTP	0.841	0.906	0.724
MAG	0.494	0.618	0.661
JJZ	0.813	0.875	1
TCM	0.628	0.945	0.718
CGN	1.0	0.878	0.711
PHT	0.467	0.658	0.407
CHO	0.675	0.833	0.775
TTQ	0.564	0.695	0.816
XCT	0.527	0.850	0.736
TQN	0.760	0.917	1
ERS	0.574	0.882	0.606
MKN	0.981	0.873	0.846

Source: Own elaboration

3.2 Annual average efficiency

The analysis of efficiency by group (24 PMs) is a result of the average of individual efficiency ratios, the results are presented in Table 4.

Table 4. Average efficiency ratio

	2008	2013	2018
Average Ratio	0.661	0.831	0.771

Source: Own elaboration

3.3 Maximums identification

In order to identify those PMs with better efficiency performance, Table 5 presents PMs ordered by the maximum efficiency ratio for 2008, 2013 and 2018.

3.4 Minimums identification

The PMs with the lowest efficiency ratio are presented at the top of Table 6, a low efficiency ratio can also be understood as inefficiency.

3.5 Comparative analysis over time

The efficiency performance analysis over time is essential to understanding the impact of designation on the accommodation sector. Figure 1 shows the evolution of the average efficiency for 24 PMs, with a gray dashed line indicating the year of PM designation.

Figure 2 presents the evolution of efficiency ratio for nine PMs, these PMs represents cases where the efficiency ratio increased in 2013, after de designation and increased even more in 2018.

Figure 3 shows the PMs whose efficiency performance improved after the designation but later declined. It also includes cases where the ratio initially decreased following the designation but increased again in 2018.

Finally, Figure 4 presents where PM's efficiency ratio improved only in 2013 (after de designation) but then decreased to even lowest levels than 2008.

Table 5. PMs by maximum efficiency ratio

2008		2013		2018	
TCT	1	TCT	1	JJZ	1
CGN	1	LRT	1	TCT	1
MKN	0.981	YRR	1	LRT	1
JJZ	0.813	SVT	0.933	HCP	0.986
TQN	0.760	TQN	0.917	MKN	0.846
MPZ	0.719	MTP	0.906	CCG	0.819
CHO	0.675	ERS	0.882	TTQ	0.816
CCG	0.657	CGN	0.878	SVT	0.808
CHC	0.654	JJZ	0.875	CHO	0.775
CDZ	0.650	MKN	0.873	MPZ	0.772
TCM	0.628	HCP	0.870	XCT	0.736
HCP	0.592	XCT	0.850	CDZ	0.729
LGM	0.578	CHO	0.833	MTP	0.724
ERS	0.574	CDZ	0.768	TCM	0.718
TTQ	0.564	CHC	0.767	CGN	0.711
XCT	0.527	CCG	0.760	MAG	0.661
MAG	0.494	MPZ	0.700	LGM	0.655
SVT	0.485	TTQ	0.695	MPM	0.615
PHT	0.467	PHT	0.658	ERS	0.606
MPM	0.449	MPM	0.638	CHC	0.604
BTP	0.441	MAG	0.618	BTP	0.522
YRR	0.391	BTP	0.576	PHT	0.407

Source: Own elaboration

Table 6. PMs by minimum efficiency ratio

2008		2013		2018	
YRR	0.391	BTP	0.576	PHT	0.407
BTP	0.441	MAG	0.618	BTP	0.522
MPM	0.449	MPM	0.638	CHC	0.604
PHT	0.467	PHT	0.658	ERS	0.606
SVT	0.485	TTQ	0.695	MPM	0.615
MAG	0.494	MPZ	0.7	LGM	0.655
XCT	0.527	CCG	0.76	MAG	0.661
TTQ	0.564	CHC	0.767	CGN	0.711
ERS	0.574	CDZ	0.768	TCM	0.718
LGM	0.578	CHO	0.833	MTP	0.724
HCP	0.592	XCT	0.85	CDZ	0.729
TCM	0.628	HCP	0.87	XCT	0.736
CDZ	0.65	MKN	0.873	MPZ	0.772
CHC	0.654	JJZ	0.875	CHO	0.775
CCG	0.657	CGN	0.878	SVT	0.808
CHO	0.675	ERS	0.882	TTQ	0.816
MPZ	0.719	MTP	0.906	CCG	0.819
TQN	0.76	TQN	0.917	MKN	0.846
JJZ	0.813	SVT	0.933	HCP	0.986
MTP	0.841	TCM	0.945	JJZ	1
LRT	0.918	TCT	1	TCT	1
MKN	0.981	LRT	1	LRT	1
TCT	1	YRR	1	TQN	1
CGN	1	LGM	1	YRR	1

Source: Own elaboration

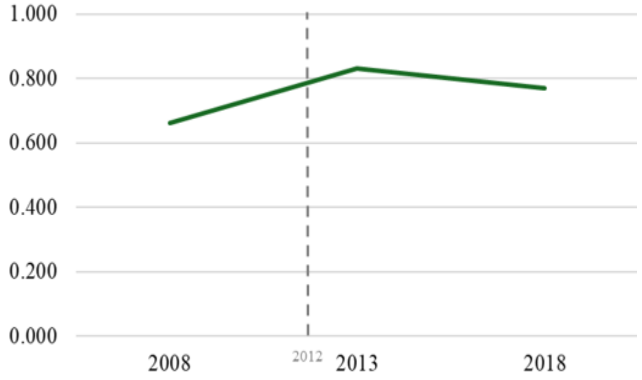

Figure 1. Average efficiency ratio

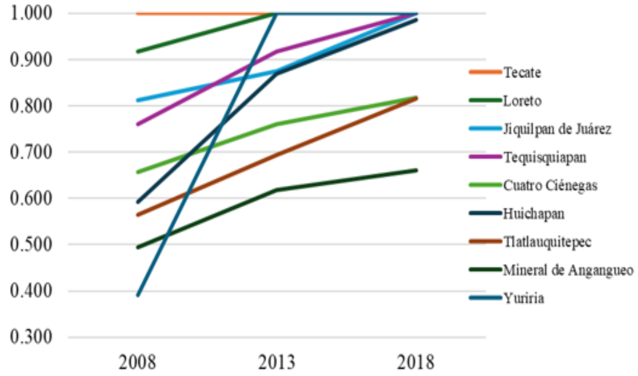

Figure 2. PM with high efficiency performance

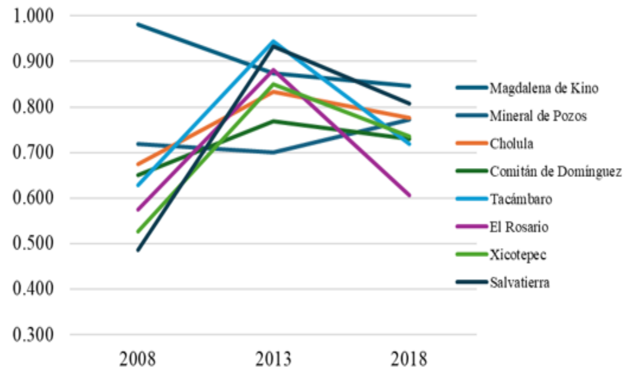

Figure 3. PM with medium efficiency performance

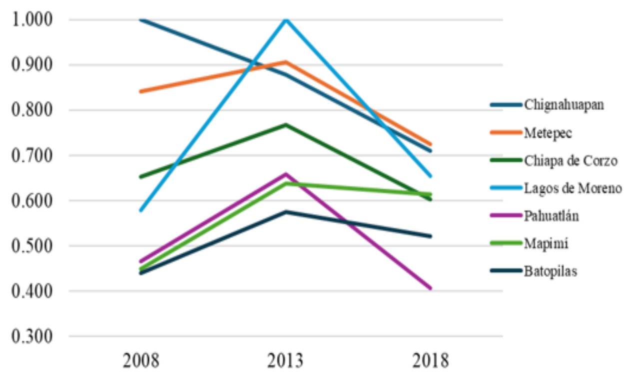

Figure 4. PMs with low efficiency performance

4. DISCUSSION

The analysis of results allowed us to achieve the stated objective: measuring the efficiency of the temporary accommodation sector in municipalities designated as PMs in 2012. A DEA with a CRS model was used for this purpose.

In the efficiency measurements for 2008 (prior to designation), only Tecate and Chignahuapan achieved full efficiency. In 2013, Tecate, Loreto, Yuriria, and Lagos de Moreno reached full efficiency; and in 2018, Jiquilpan de Juárez, Tecate, Loreto, Tequisquiapan, and Yuriria achieved full efficiency. These results indicate that the PM designation positively impacted the number of PMs that improved their efficiency. The analysis of average efficiency shows an increase in the efficiency ratio from 2008 to 2013, followed by a decrease in 2018. This suggests that the designation has a positive impact on increasing efficiency.

The performance analysis over time highlights Tecate, Loreto, Jiquilpan de Juárez, Tequisquiapan, Cuatro Ciénegas, Huichapan, Tlatlauquitepec, Mineral de Angangueo, and Yuriria as PMs that not only increased their efficiency immediately after designation but also maintained or improved it by 2018. Another group, including Comitán de Domínguez, Tacámbaro, El Rosario, Xicotepec, and Salvatierra, saw an increase in efficiency by 2013, but a decline in 2018, mirroring the average trend. Magdalena de Kino, while decreasing in efficiency in both 2013 and 2018, remained above 0.80 in efficiency. Mineral de Pozos saw an initial decrease in efficiency post-designation but recovered by 2018. Lastly, a group of PMs, including Chignahuapan, Metepec, Chiapa de Corzo, Lagos de Moreno, Pahuatlán, Mapimí, and Batopilas, experienced an increase in efficiency post-designation but a subsequent decline in 2018, even falling below 2008 levels.

Notably, Yuriria's efficiency improved dramatically from 0.391 in 2008 to 1.000 in both 2013 and 2018. Salvatierra's efficiency rose from 0.485 in 2008 to 0.933 in 2013, before declining slightly to 0.808 in 2018. Chignahuapan, which had a total efficiency of 1.000 in 2008, saw a decrease in efficiency in the following years.

5. CONCLUSIONS

The application of DEA to assess the efficiency of the accommodation sector within PMs presents several implications.

One of the primary advantages is DEA's ability to objectively evaluate multiple inputs and outputs, offering a comprehensive view of the performance of DMUs. This methodological approach allows for effective comparisons between DMUs and the identification of best practices, which fosters a culture of continuous improvement. By recognizing which DMUs are operating efficiently, stakeholders can learn from their strategies and apply similar practices across the sector, thereby enhancing overall performance.

The most significant challenge in the development of this study was the availability of data for the variables included in the DEA model and for the PMs. Most of 2003 data was not available and resulted in not considering the year on the measurement, since DEA requires a robust dataset to ensure that the efficiency scores accurately reflect the performance of the DMUs.

The findings from this study indicate that there is considerable room for improvement in the efficiency of the accommodation sector in PMs. The analysis revealed that the PM designation has a positive impact on increasing efficiency, but this effect varies over time and among different PMs.

Success cases like Yuriria, Loreto, Tecate, Tequisquiapan, Jiquilpan, and Huichapan saw significant improvements in efficiency post-designation, suggesting that the designation can lead to better resource utilization and service quality. Conversely, other PMs like Chignahuapan did not experience the same positive effect, indicating that additional factors may influence the outcomes.

For future research, it is recommended to individually examine these varying outcomes to understand the specific factors that contributed to their efficiency improvements. Additionally, exploring other methodologies alongside DEA can help to identify the specific impact of each variable and provide a more holistic understanding of the factors influencing efficiency.

Finally, the application of DEA provides valuable insights and a solid foundation for informed decision-making. This analysis will help PM's stakeholders designed after 2012, to consider these variables on the establishment of develop strategies.

ACKNOWLEDGMENT

We would like to thank Universidad Michoacana de San Nicolás de Hidalgo (UMSNH) and Consejo Nacional de Humanidades, Ciencias y Tecnologías (CONAHCYT) in México.

REFERENCES

[1] ONU Turismo. (2024). World Tourism Barometer. http://www.unwto.org/un-tourism-world-tourism-barometer-data.

[2] ONU Turismo. (2024). International tourism recovers pre-pandemic levels in 2024. http://www.unwto.org/news/international-tourism-recovers-pre-pandemic-levels-in-2024.

[3] DATATUR. (2024). Ranking Mundial del Turismo Internacional. https://datatur.sectur.gob.mx/SitePages/RankingOMT.aspx.

[4] ONU Turismo. (2024). Global and regional tourism performance. https://www.unwto.org/tourism-data/global-and-regional-tourism-performance.

[5] WTTC. (2024). Mexico Travel & Tourism Economic Impact Factsheet. https://researchhub.wttc.org/factsheets/mexico.

[6] Baltazar Bernal, O., Zavala Ruiz, J. (2015). El turismo rural como experiencia significativa y su estudio desde la fenomenologia existencial. Revista Mexicana de Ciencias Agrícolas, 6(6): 1387-1401. http://doi.org/10.29312/remexca.v6i6.584

[7] Kieffer, M. (2019). Turismo rural comunitario en México: Apuntes para futuras investigaciones. Dimensiones Turísticas, 3(5): 43-63. https://doi.org/10.47557/XSNY8857

[8] UNESCO. (2024). Esquema turístico maya-mexicano y comunitario muestra el poder de la cultura en encuentro mundial. https://www.unesco.org/es/articles/esquema-turistico-maya-mexicano-y-comunitario-muestra-el-poder-de-la-cultura-en-encuentro-mundial.

[9] SECTUR. (2020). Estrategia Nacional de Pueblos Mágicos. http://www.gob.mx/sectur/acciones-y-programas/estrategia-nacional-de-pueblos-magicos.

[10] SECTUR. (2016). Programa Pueblos Mágicos. http://www.gob.mx/sectur/acciones-y-programas/programa-pueblos-magicos.

[11] SECTUR. (2020). Pueblos Mágicos de México. https://www.gob.mx/sectur/articulos/pueblos-magicos-206528.

[12] SECTUR. (2023). México con 45 nuevos Pueblos Mágicos. https://www.gob.mx/sectur/prensa/mexico-con-45-nuevos-pueblos-magicos.

[13] OCDE. (2012). OECD Tourism Trends and Policies 2012. https://www.oecd-ilibrary.org/industry-and-services/oecd-tourism-trends-and-policies-2012_tour-2012-en.

[14] CONEVAL. (2012). Lugares para visitar: Los Pueblos Mágicos. https://www.coneval.org.mx/Informes/boletin_coneval/marzoabril2012/pueblosmagicos.html.

[15] Bolaños Ortega, R., Lizardi Rojo, V., Roldán Oropeza, N. (2021). Los Pueblos Mágicos y la relevancia de la educación cultural de sus habitantes para fomentar el turismo y el desarrollo local. Revista GEON., 8(2): e-442. http://doi.org/10.22579/23463910.442

[16] Lúgigo, M.G. (2021). El Programa Pueblos Mágicos y algunos de sus efectos locales. Dimensiones Turísticas, 5(8): 131-141. https://doi.org/10.47557/MJCU3028

[17] Enríquez Acosta, J.Á., Vargas Ochoa, R.Y. (2021). El estudio de los Pueblos Mágicos. Una revisión a casi 20 años de la implementación del programa. Dimensiones turísticas, 5(8): 9-38. https://doi.org/10.47557/SYWY9441

[18] SECTUR. (2020). DECRETO por el que se aprueba el Programa Sectorial de Turismo 2020-2024. https://www.gob.mx/cms/uploads/attachment/file/562395/PROSECTUR_2020_2024_Decreto_Programa.pdf.

[19] SECTUR. (2021). Presenta Miguel Torruco el Primer Estudio Económico de Pueblos Mágicos, que aporta nuevos elementos para la toma de decisiones. http://www.gob.mx/sectur/prensa/presenta-miguel-torruco-el-primer-estudio-economico-de-pueblos-magicos-que-aporta-nuevos-elementos-para-la-toma-de-decisiones.

[20] Lohmann, G., Panosso Netto, A., Spolon, A.P.G., Rodrigues, C.B. (2017). Lodging Establishments. In Tourism Theory: Concepts, Models and Systems. Wallingford UK: CABI, pp. 236-242. https://doi.org/10.1079/9781780647159.0236

[21] Gossling, S., Higham, J. (2021). The low-carbon imperative: Destination management under urgent climate change. Journal of Travel Research, 60(6): 1167-1179. https://doi.org/10.1177/0047287520933679.

[22] ONU. (2008). Recomendaciones internacionales para estadísticas de turismo 2008 (Naciones Unidas, Ed.). https://unstats.un.org/unsd/publication/seriesm/seriesm_83rev1s.pdf.

[23] Chaabouni, S. (2019). China's regional tourism efficiency: A two-stage double bootstrap data envelopment analysis. Journal of Destination Marketing & Management, 11: 183-191. https://doi.org/10.1016/j.jdmm.2017.09.002

[24] Kido-Cruz, A., Cruz-Pérez, J.P., Zavala, A.O. (2021). Turismo y pobreza: Un análisis de la envolvente de datos para municipios en México. Inquietud Empresarial, 21(2): 85-95. https://doi.org/10.19053/01211048.12334

[25] Karakitsiou, A., Kourgiantakis, M., Mavrommati, A., Migdalas, A. (2020). Regional efficiency evaluation by input-oriented data envelopment analysis of hotel and restaurant sector. Operational Research, 20(4): 2041-2058. https://doi.org/10.1007/s12351-018-0406-1

[26] Arana-Jiménez, M., Lozano-Ramírez, J., Sánchez-Gil, M.C., Younesi, A., Lozano, S. (2024). A novel slacks-based interval DEA model and application. Axioms, 13(3): 144. https://doi.org/10.3390/axioms13030144

[27] Guo, Y., Cao, Z. (2024). A study on the tourism efficiency of tourism destination based on DEA model: A case of ten cities in Shaanxi province. Plos One, 19(1): e0296660. https://doi.org/10.1371/journal.pone.0296660

[28] Shu, H., Zha, J., Tan, T., Li, C. (2023). How does high-speed railway affect tourism efficiency? An empirical study in China. Current Issues in Tourism, 26(16): 2647-2663. https://doi.org/10.1080/13683500.2022.2091431

[29] Chiavenato, I. (2006). Introducción a la teoría general de la administración. McGraw-Hill InterAmerican-Mua. Google-Books-ID: M1EdAQAACAAJ

[30] Farrell, M.J. (1957). The measurement of productive efficiency. Journal of the royal statistical society series a: Statistics in society, 120(3): 253-281. http://doi.org/10.2307/2343100

[31] Koontz, H., Cannice, M. (2012). Administración: Una Perspectiva Global Y Empresarial (14th ed.). McGraw-Hill.

[32] Charnes, A., Cooper, W., Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, 2(6): 429-444. http://doi.org/10.1016/0377-2217(78)90138-8

[33] Ahmadkhanlou Gharakhanlo, M., Tohidi, G., Azarmir Shotorbani, N., Razavyan, S., Abbasi, R. (2024). Cost, revenue and profit efficiency in multi-period network system: A DEA-R based approach. Communications in Combinatorics and Optimization, 9(4): 725-746. https://doi.org/10.22049/cco.2023.28179.1474

[34] Chen, Y., Ma, X., Yan, P., Wang, M. (2021). Operating efficiency in Chinese universities: An extended two-stage network DEA approach. Journal of Management Science and Engineering, 6(4): 482-498. https://doi.org/10.1016/j.jmse.2021.08.005

[35] Cook, W. D., Tone, K., Zhu, J. (2014). Data envelopment analysis: Prior to choosing a model. Omega, 44: 1-4. https://doi.org/10.1016/j.omega.2013.09.004

[36] Banker, R., Charnes, A., Cooper, W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. Management Science, 30(9): 1078-1092. https://doi.org/10.1287/mnsc.30.9.1078

[37] Pascoe, S., Cannard, T., Dowling, N.A., Dichmont, C. M., Asche, F., Little, L.R. (2023). Use of Data Envelopment Analysis (DEA) to assess management alternatives in the presence of multiple objectives. Marine Policy, 148: 105444. https://doi.org/10.1016/j.marpol.2022.105444

[38] Mozaffari, M.R., Gerami, J., Wanke, P.F., Kamyab, P., Peyvas, M. (2022). Ratio-based data envelopment analysis: An interactive approach to identify benchmark. Results in Control and Optimization, 6: 100081. https://doi.org/10.1016/j.rico.2021.100081

[39] INEGI. (2020). Tabulados Interactivo (SAIC) Censos Económicos. https://www.inegi.org.mx/app/saic/.