International Journal of Hospitality Management 116 (2024) 103620

Contents lists available at ScienceDirect

International Journal of Hospitality Management

journal homepage: www.elsevier.com/locate/ijhm

Unveiling the potential of hotel mergers: A hybrid DEA approach for optimizing sector-wide performance in the hospitality industry

Amar Oukil [a,*], Rowan Elodie Kennedy [b], Abdullah Al-Hajri [a], Ahmed Amin Soltani [c]

[a] Department of Operations Management & Business Statistics, College of Economics & Political Science, Sultan Qaboos University, P.O. Box 20, Al Khoud PC 123, Oman
[b] Department of Marketing, College of Economics & Political Science, Sultan Qaboos University, P.O. Box 20, Al Khoud PC 123, Oman
[c] VESDD Laboratory, Hydraulic Department, University of M'sila, Algeria

ARTICLE INFO

Keywords:
Data envelopment analysis (DEA)
Inverse data envelopment analysis
Mergers
Merger gains
Merger plan
Hotel

ABSTRACT

Mergers and acquisitions (M&A) in the hospitality sector involve consolidating assets among hotels through partnerships. While data envelopment analysis (DEA) has been widely used for hotel efficiency analysis, little attention has been paid to hotel M&A. In this paper, a hybrid DEA methodology consisting of two stages is proposed to identify optimal matches among hotels to enhance sector performance. The initial stage employs an inverse Data Envelopment Analysis (IDEA) model to evaluate the maximum gains that could potentially be generated from pairwise consolidations among hotels. A DEA procedure that incorporates a standard DEA model and a greedy heuristic is developed in the second stage to identify the optimal pairs of hotel mergers. The optimal merger strategy for the entire hotel industry is determined from the complete set of hotels under consideration.

The pertinence of the proposed methodology is shown through a sample of 58 hotels from the Sultanate of Oman

1. Introduction

The global competition for growth among hotel brand firms is unceasingly raging. Within such market dynamics, expansion through acquisition has emerged as a major growth strategy (Pohlman, 2017). Despite recent high-profile mergers and acquisitions (M&A) deals, such as Marriott International acquiring Starwood Hotels & Resorts Worldwide for USD13.6 billion, and the acquisition of Accor Hotels to Fairmont Hotels & Resorts for USD 2.9 billion, most market analysts concur that the hotel sector continues to witness high fragmentation, with no single operator holding a large share of the global market (Zhang et al., 2020). There is no doubt that such fragmentation is likely to stimulate further M&A activity in the hospitality business and, as a result, an intensive aggregation of manifold operating platforms and various corporate cultures; a process that is definitely not without hurdles. Yet, growth through M&A is commonly viewed as more efficient than growth by organic development efforts, which entails only increasing outputs and augmenting sales at individual hotel level (Khairy, 2019).

In practice, the level of required output expansion or/and input reduction can be duly estimated through analyzing the hotel's efficiency with reference to the industry's benchmarks. Data envelopment analysis (DEA) is a frontier efficiency method that is widely recognized for supporting these decisions (Sow et al., 2016). The DEA methodology (Charnes et al., 1978) is based on linear programming and it has the ability to assess the efficiency of decision-making units (DMUs) that operate with numerous inputs and outputs (Oukil, 2018).

The application of DEA spans a wide range of business domains. Recent studies include power generation (Eguchi et al., 2021), open field agriculture (Zalaghi et al., 2021), production scheduling (Oukil and El-Bouri, 2021; Oukil et al., 2022a), carbon emission reduction (Yang et al., 2020), material handling selection (Hassan and Oukil, 2021; Oukil, 2022), greenhouse production (Al-Mezeini et al., 2020), airline performance (Ngo and Tsui, 2022), water quality assessment (Oukil et al., 2022c), irrigation systems (Kamiyama et al., 2021), manufacturing systems (Oukil, 2020), banking (Kamarudin et al., 2019; Moghaddas et al., 2022), ranking football players (Oukil and Govindaluri, 2017) and baseball players (Oukil and Amin, 2015), ranking investment firms (Peykani et al., 2021), stock markets (Amin and Oukil, 2019b), regional transport sustainability (Tian et al., 2020), and faculty academic performance (Oral et al., 2014, 2015), among others.

In the hotel industry, the most prevailing research stream is concerned with the estimation of the hotel efficiency at the firm level. Such studies include, e.g., Kim and Chung (2022), Dolasinski et al. (2019), Sáez-Fernández et al. (2020), Higuerey et al. (2020), Kularatne et al.

* Corresponding author.
E-mail address: aoukil@squ.edu.om (A. Oukil).

https://doi.org/10.1016/j.ijhm.2023.103620
Received 17 May 2023; Received in revised form 26 August 2023; Accepted 12 October 2023
Available online 20 October 2023

(2019), Ang et al. (2018), Mariani and Visani (2019), Lado-Sestayo and Fernández-Castro (2019), Dobrovič et al. (2021), Karakitsiou et al. (2020), El Alaoui et al. (2022), Tan and Despotis (2021), Martins et al. (2021), Nguyen and Nguyen (2019), Zaki (2019), Frančeškin and Bojnec (2022a), Singh et al. (2022), Guo et al. (2019), Li et al. (2021), Bire (2020), and Oukil and Al-Zidi (2018), to mention just the most recent. The DEA Malmquist index has also been used to measure hotel productivity change over a time horizon (e.g., Fang et al., 2020; Tzeremes, 2020; Tzeremes and Tzeremes, 2021; Frančeškin and Bojnec, 2022b; Kim et al., 2021; Peypoch et al., 2021). More advanced DEA models have been developed to handle technological heterogeneity among hotels and other structural forms (e.g. Yu and Chen, -b, 2020a; Chen, 2018; Lee et al., 2019; Chiu and Lin, 2018; Deng et al., 2020).

Surprisingly, despite the plethora of DEA-based studies dealing with efficiency in the hotel industry, studies dedicated explicitly to the efficiency of hotel M&As are almost inexistent. Therefore, the present work is intended to fill this particular gap, among others. Here, we regard M&A as a strategic decision that must be well considered before sealing the deal. It ought to be viewed as a step forward or, possibly, backward for the future of the hotel business. As such, it is extremely important to develop decision tools that are prospective rather than retrospective to support decision makers (DMs) towards the M&A planning process.

Hence, looking at M&A prospectively means helping DMs answer critical questions, such as: (1) How much efficiency gain is likely to be drawn out of a prospective hotel merger? (2) So, is the prospective hotel merger worthwhile?

Several DEA models have been developed to estimate potential merger gains (e.g., Xiao et al., 2017; Shi et al., 2017; Li et al., 2018; Nguyen and Pham, 2020; Xie et al., 2020; Chiu et al., 2021; Ray and Sethia, 2022; Khoveyni and Eslami, 2022; Al Tamimi et al., 2022). However, these models are exclusively focused on the post-merger stage, where the M&A deal is already sealed and the DM is attentive only to the cost and profit efficiency gains that are possible in view of the on-hand input and/or output levels. Instead, the approach that we propose aims to inform the DM at an early stage, i.e., during the pre-merger phase, about the input and/or output levels that would be required to achieve a desired predetermined efficiency goal for the intended merger. Such decisions can be reached through inverse DEA (Wei et al., 2000; Yan et al., 2002).

Conventional DEA is primarily used to calculate efficiency scores for DMUs based on known input and output data. In contrast, inverse DEA (IDEA) seeks to identify the optimal input and/or output levels required to achieve a predetermined efficiency target. In other words, the IDEA problem assumes that the information on the hotel's inputs and/or outputs is not available but it can be found for a targeted efficiency level.

With the exception of a limited number of studies in agriculture production (Oukil, 2023; Oukil et al., 2022b), the applications of IDEA to M&A are primarily focused on the banking sector. These studies include the works of Gattoufi et al. (2014), Gerami et al. (2021), Amin et al. (2019), Amin and Al-Muharrami (2018), Soltanifar et al. (2022b), Ghobadi (2021), Amin et al. (2017a), Kamyab et al. (2019), Amin and Ibn Boamah (2021), Amin et al. (2017b), Amin and Ibn Boamah (2020) and Soltanifar et al. (2022a). Accordingly, the present study is the first application of IDEA to mergers in the hotel industry, where M&A hold significant strategic implications. Using the IDEA model of Amin and Ibn Boamah (2020), we will first estimate the optimal resource gains for prospective hotel mergers with reference to a preset efficiency target. Next, knowing that partnership, which underpins M&A, constitutes the ultimate mirror for potential growth, competition dynamics, as well as prospective gains (Huhtilainen et al., 2022), we develop a procedure for optimal selection of the partners of planned mergers. Though partner selection is another business area where DEA models have also been developed (see, e.g., Amin and Ibn Boamah, 2023, Zhu et al., 2021, Lin et al., 2020, Lozano, 2013), the existing studies confront the problem at isolated pairs of merging entities. In contrast, our study's approach is more encompassing as it involves the entire set of hotels that are candidate for merger and, hence, it attempts to respond specifically to the question: What should be the best partners of prospective hotel mergers that would qualify the whole hotel industry, which is hypothetically represented with the selected sample of hotels, to achieve maximum collective performance? In other words, assuming that each hotel is a candidate to merge with another hotel within the selected sample, the objective is to find the optimal matches among these hotels.

To answer the above question, we develop a methodology that operates over four levels. (1) The IDEA model is initially solved to evaluate the optimal gains that are likely to be generated as a result of pairwise consolidations among hotels. (2) All possibly productive post-merger hotels, i.e., those mergers that have real potential for gains' generation, are duly discerned. (3) The productive post-merger hotels are ranked based on expected post-merger outcomes. (4) The best prospective merger plan is derived for the entire sample of hotels through identifying the best partners of potential post-mergers.

To the authors' best knowledge, there are no previous studies in the literature that have attempted to exclusively address hotel M&A from a DEA efficiency perspective to build the best merger plan for a sample of hotels. As such, the contributions of the present paper to the tourism literature are threefold. (1) This is the first DEA study that is dedicated to hotel M&A. (2) This study introduces for the first time the concept of inverse DEA to the tourism literature. (3) It investigates comprehensively and collectively the problem of identifying the best potential merging partners within the whole hotel industry.

The pertinence of the proposed methodology is shown through evaluating potential merger gains of 58 hotels selected in the Sultanate of Oman prior to developing the associated best prospective merger plan.

The remainder of this paper is structured as follows. Sections 2 and 3 present the methodological background, which comprises DEA concepts, and an IDEA model for the mergers' process. Section 4 briefly introduces the case study prior to a discussion of the results. In Section 5, the best partners' selection approach is described and implemented. We conclude with a discussion of the theoretical and managerial implications of the study, and its methodological and practical limitations. Avenues for future research are also presented.

2. Assessment of a hotel's performance

Hotels are businesses that operate within a competitive market where attracting more customers and achieving higher profits are the key objectives. Therefore, adopting an output-oriented DEA model would be practically the most suitable option. However, the ultimate purpose of the present study consists of estimating resource (input) gains that would potentially be generated from the merger of two or more hotels, assuming the production (output) levels unchanged. Such a purpose assumes implicitly that the input levels are under full control of the DMs and can be reduced as appropriate. Meanwhile, the same assumption might not be as obvious for the hotel outputs, which are mostly market-based and, often, cannot be directly incremented by the DMs. On these bases, the input rather than the output orientation is retained for the DEA modeling in the present study (Emrouznejad et al., 2022).

Furthermore, it is implicitly assumed that all the hotels are offering the same services, which discards the occurrence of economies of scope (Morita, 2003; Sahoo and Tone, 2013) and, subsequently, enhances the homogeneity of the production technology, a requirement for standard DEA models. Per se, the whole methodological approach is restricted to internal economies of scale occurring as results of inputs' reduction rather than outputs' augmentation factors. The latter is again duly reflected through the DEA input orientation.

We consider the evaluation of K hotels, where each hotel T_k is defined with R inputs x_{ik}, $i = 1,.,R$, and S outputs y_{ik}, $j = 1,.,S$. The estimation of the input efficiency score ie_o^* of $T_o = (x_o y_o)$ entails solving the following BCC (Banker et al., 1984) model:

$$ie_o^* = \min \pi$$

$$\text{s.t.} \sum_{k=1}^{K} \delta_k x_{ik} \leq \pi x_{io} i = 1,.,R \quad (1)$$

$$(\text{BCC}) \sum_{k=1}^{K} \delta_k y_{jk} \geq y_{jo} j = 1,.,S \quad (2)$$

$$\sum_{k=1}^{K} \delta_k = 1 \quad (3)$$

$$\delta_k \geq 0 k = 1,.,K$$

In the above BCC model, π measures the ratio of radial reduction of the current inputs x_{io} to levels that would enable hotel T_o to reach the efficiency frontier, assuming its outputs y_{jo} unaltered (Oukil and Govindaluri, 2020). The minimum value ie_o^* of π refers to the efficiency score of hotel T_o. A value $ie_o^* = 1$ indicates that T_o is efficient, i.e., it falls on the efficiency frontier. Meanwhile, $ie_o^* < 1$ means that T_o is inefficient, i.e., it is not utilizing its inputs optimally (Soltani et al., 2021; Oukil et al., 2016).

Constraints (1) and (2) formulate the projection of hotel T_o on the efficiency frontier as linear combination of its peers. The convexity constraint (3) guarantees that the efficiency frontier, which envelops the whole set of hotels, is a convex curve. Here, the intensity vector $\delta_o = (\delta_{1o}\delta_{2o}.\delta_{Ko})$ provides the contribution weight of each peer T_k towards the efficiency evaluation of T_o. An optimum value $\delta_{ko}^* > 0$ means that hotel T_k is a potential benchmark (role model) for T_o (Oukil, 2019). As such, δ_{ko}^* can be viewed as the degree of endorsement held by the benchmark T_k to hotel T_o on its way to achieve full efficiency.

Thus, an inefficient hotel T_o can achieve full efficiency by decreasing its ith input with slack value s_{io}^*:

$$s_{io}^* = ie_o^* x_{io} - \sum_{k=1}^{K} \delta_k^* x_{ik} i = 1,.,R$$

Hence, T_o is strongly efficient if $s_{io}^* = 0$ for all inputs $i = 1,.,R$. Otherwise, T_o is weakly efficient if $ie_o^* = 1$ and $s_{io}^* > 0$ for at least one input $i = 1,.,R$ (Oukil et al., 2021). In other words, s_{io}^* represents the savings of input i that a hotel T_o, identified as inefficient or weakly efficient, is required to achieve if it is willing to upgrade to efficient.

3. Evaluation of the merger of two hotels

Consider a scenario of two hotels T_A and T_B planning to merge into a new hotel M_m..

Assuming that the pre-merger input efficiency scores of T_A and T_B are, respectively, ie_A^* and ie_B^*, the post-merger efficiency score set as a target for hotel M_m can be $\bar{\tau} \geq \max(ie_A^*, ie_B^*)$. Under the merger settings, the strategic goal of M_m's managers is to reach $\bar{\tau}$ with the least amount of the inputs inherited from the merging hotels T_A and T_B while producing the totality of the associated outputs. If ϖ_{iA} and ϖ_{iB} represent the minimum amounts for the ith input, hotel M_m will use $\varpi_{im} = \varpi_{iA} + \varpi_{iB}$ out of the current total usage $x_{im} = x_{iA} + x_{iB}$ $(i = 1,\ldots,R)$ to produce $y_{jm} = y_{jA} + y_{jB}$ $(j = 1,\ldots,S)$. Hence, the objective is to find these levels of inputs, i.e., the values of ϖ_{iA} and ϖ_{iB} for $i = 1,\ldots,R$. This problem can be formulated as follows (Amin and Ibn Boamah, 2020).

$$\min \sum_{i=1}^{R} (\varpi_{iA} + \varpi_{iB})$$

$$s.\,t.$$

$$(\text{IDEA}) \quad \begin{aligned} & \sum_{b \in P} \delta_k x_{ik} + \delta_m x_{im} - \left(\varpi_{iA} + \varpi_{iB}\right) \times \bar{\tau} \leq 0 \quad i = 1,\ldots,R \\ & \sum_{b \in P} \delta_k y_{jk} + \delta_m y_{jm} \geq y_{jm} \quad j = 1,\ldots,S \\ & \sum_{b \in P} \delta_k + \delta_m = 1 \\ & 0 \leq \varpi_{iA} \leq x_{iA}, \ 0 \leq \varpi_{iB} \leq x_{iB} \ i = 1,\ldots,R \\ & \delta_b \geq 0, \ b \in P, \ \delta_m \geq 0 \end{aligned}$$

With the input efficiency $\bar{\tau}$ set a priori, IDEA is an inverse DEA model where the levels of inputs ϖ_{iA} and ϖ_{iB} are unknown and need to be determined for $i = 1,\ldots,R$..

P denotes the set of peers contributing to the assessment of hotel M_m. The consolidation of hotels T_A and T_B into a new hotel M_m entails dropping hotels T_A and T_B from $P$and including M_m instead (Amin and Oukil, 2019a). If the optimal intensity value of M_m is $\delta_m^* = 1$ for $\bar{\tau} = 1$, the merger is identified as a *major consolidation*, where M_m uses the totality of the inputs, $\varpi_{im} = x_{iA} + x_{iB}$, i.e. no input gains are expected from the merger. The reader is referred to Oukil (2023) for a discussion of other merger scenarios.

4. Application and practical scope

4.1. Oman as a tourism destination

The Sultanate of Oman, located in the southeastern part of the Arabian Peninsula (Fig. 1), boasts a diverse topography and a rich cultural heritage (Foreign Ministry of Oman, n.d).

Oman holds a geographically strategic position, bordered by the Sea of Oman to the Northeast and the Arabian Sea and Indian Ocean to the Southeast. Throughout its history, Oman has been deeply involved in trade, exploration, and maritime pursuits, while modernization efforts today are dedicated to preserving its cultural legacy (The Sultanate | Experience Oman, n.d).

The hotel industry in Oman plays a crucial role in the nation's economy and tourism sector. Over the past four years, Oman has experienced substantial growth in the number of hotels, witnessing a 14.3% increase, resulting in a total of 612 hotels in 2021. These accommodations are distributed across different governorates, with Muscat Governorate leading with 205 hotels, followed by South Sharqiyah and Dakhiliya Governorates with 86 and 74 hotels, respectively (National Center for Statistics and Information (NCSI), 2022).

Notably, Oman's hospitality industry has achieved remarkable progress, with a staggering year-on-year growth rate of 90.9%, reaching US$ 0.7 billion in 2022, as per the Alpen Capital report. This growth can be attributed to a 49.5% increase in tourist arrivals during the year and the country's efforts to rebound from the pandemic. Furthermore, Oman's tourism sector is projected to continue expanding, with an anticipated Compound Annual Growth Rate (CAGR) of 6.3% between 2022 and 2026, aiming to attain US$ 0.9 billion (Alpen Capital, 2022).

The potential of the tourism industry is immense for Oman, aligning with the country's economic diversification goals. Oman's Vision 2040 outlines ambitious plans to elevate the tourism sector's contribution to GDP from 2.4% in 2021–5% by 2030, and eventually, to 10% by 2040. To achieve this, the country aims to attract 11.7 million visitors by 2040, necessitating investments totaling $51 billion. This initiative is projected to generate over $9 billion annually from tourism (Oxford Business Group, 2023).

Fig. 1. Map of Oman.

4.2. A case study for mergers

Within the context of the hospitality industry, mergers and acquisitions hold significance for Oman. According to the Gulf Cooperation Council (GCC) Hospitality Industry report by Alpen Capital, the post-pandemic era has witnessed a resurgence of such activities, including in Oman. With companies prioritizing brand acquisitions and aiming to expand market share, the consolidation of the hotel industry is anticipated to intensify. Given escalating competition and the emergence of online platforms and alternative lodging services, Omani hotel entities might consider mergers as a strategic approach to enhance scale and distribution strength (Alpen Capital, 2022).

Using the hotels' database available at the Department of Statistics & Geographic Information, Ministry of Heritage and Tourism (Oman), the records of four outputs and four inputs were collected for the annual activity of 58 hotels.

The outputs consist of *Annual revenue* (y_1), *Number of guests* (y_2), *Number of nights* (y_3), and *Occupancy rate* (y_4). The inputs include *Number of beds* (x_1), *Number of rooms* (x_2), *Number of employees* (x_3) and *Salary of employees* (x_4). Table 1 presents a statistical summary of the hotels' datasets.

With regard to the inputs adopted, the pairs (*Number of employees, Salary of employees*) and (*Number of rooms*, *Number of beds*) are considered for potential substitutability. The correlation coefficients corresponding to these pairs are, respectively, $\rho(x_1, x_2) = 0.9768$ and $\rho(x_3, x_4) = 0.9087$. Though strong correlation holds for both pairs of

Table 1
Statistical summary of the hotels' datasets.

Variables	Unit	Mean	SD	Min.	Max.
y_1	$ /year	6911,989	13,731,079	3004	78,795,452
y_2		17,864	20,273	597	96,877
y_3		23,882	28,091	669	147,084
y_4	%	55	24	2	87
x_1		135	138	23	937
x_2		91	97	13	640
x_3		111	191	4	1193
x_4	$ /year	400,603	845,686	5520	4504,122

inputs, there is definitely no perfect linear relationship. Therefore, none of the inputs is substitutable.

Without loss of generality, we assume that the sample of 58 hotels represents the whole Omani hotel sector.

4.3. Evaluation of the hotels' performance

In the first step of the proposed methodology, the performance of each hotel T_k, $k = 1, ., 58$, is evaluated through its optimal efficiency ie_k^*, computed by solving model BCC. Table 2 summarizes the results.

The results reveal that 20 hotels out of 58 (34.48%) are strongly efficient, i.e., not requiring input savings. Meanwhile, the remaining hotels, which are found inefficient ($e_k^* < 1$), need to improve their performance by benchmarking strongly against efficient hotels (see, e.g., Oukil et al., 2021). In order to reach efficient status, an inefficient hotel T_k must shrink its inputs by the slack values s_{ik}^* $(i = 1, ., 4)$ while keeping its outputs unaffected. Thus, the input savings pattern for the entire sample of hotels is shown in Table 3.

The results unveil that, based on the slack analysis, the input savings rates vary between 21.41% on the salaries of employees and 24.51% on the number of beds. Meanwhile, it is noteworthy that these savings are exclusive of the inefficient hotels, as a requirement to upgrade their efficiency status. In the next section, we will show that, within a M&A framework, savings are possible even if the merging hotels are both strongly efficient.

4.4. Pairwise mergers of the hotels

The evaluation of each potential pairwise hotel merger $M_m = (T_A, T_B)$, $A \neq B$, requires solving model IDEA for an efficiency target $\overline{\tau} = 1$. With a sample of K= 58 hotels, there are 1653 possible pairs. Hence, the optima of IDEA reveal that 83.24% of the mergers are major consolidations, where the merger hotels M_m retain the entire inputs of the merging hotels T_A and T_B, i.e., $\varpi_{iA}^* = x_{iA}$ and $\varpi_{iB}^* = x_{iB}$ for all $i = 1, ., R$, and $\delta_m^* = 1$. As such, input savings are likely for only 277 potential post-merger hotels, which will be identified as productive.

***Definition* 1.** A post-merger hotel $M_m = (T_A, T_B)$, $A \neq B$, is productive if $\delta_m^* = 0$ and $\varpi_{iA}^* < x_{iA}$ or $\varpi_{iB}^* < x_{iB}$ for at least one input i $(i = 1, ., R)$..

Table 3
Input savings for 58 hotels.

Input	Present inputs	Target inputs	Input savings	Savings rate (%)
Number of beds	7856	5930	1926	24.51
Number of rooms	5289	4018	1271	24.03
Number of employees	6418	4990	1428	22.25
Salary of employees ($)	23,234,970	18,261,066	4973,904	21.41

In the interest of space, Table 4 illustrates only 20 pairs of merging hotels.

For example, let's consider M_4, the merger of hotels T_{14} and T_{57}. With an efficiency target $\overline{\tau} = 1$, the minimum input requirements for M_4 are $\varpi_{114}^* = 36$ and $\varpi_{157}^* = 23$ beds, $\varpi_{214}^* = 30$ and $\varpi_{257}^* = 9$ rooms, $\varpi_{314}^* = 44$ and $\varpi_{357}^* = 0$ employees, and $\varpi_{414}^* = \$116,481$ and $\varpi_{457}^* = \$0$ salary of employees. With $\varpi_{357}^* = 0$ and $\varpi_{457}^* = 0$, it appears that the staff of the new business can be reduced by as many as the number of employees of hotel T_{57}.

***Definition* 2.** Given a merger $M_m = (T_A, T_B)$, $A \neq B$, the potential savings of T_A and T_B for input i are $\gamma_{iA} = x_{iA} - \varpi_{iA}^*$ and $\gamma_{iB} = x_{iB} - \varpi_{iB}^*$, respectively.

The pre-merger inputs of hotels T_{14} and T_{57} are as follows: $x_{114} = 36$, $x_{157} = 23$, $x_{214} = 30$, $x_{257} = 18$, $x_{314} = 63$, $x_{357} = 6$, $x_{414} = \$136,176$ and $x_{457} = \$8,322$. Thus, the corresponding savings are $\gamma_{114} = x_{114} - \varpi_{114}^* = 36 - 36 = 0$ and $\gamma_{157} = x_{157} - \varpi_{157}^* = 23 - 23 = 0$ beds, $\gamma_{214} = x_{214} - \varpi_{214}^* = 30 - 30 = 0$ and $\gamma_{257} = x_{257} - \varpi_{257}^* = 18 - 9 = 9$ rooms, $\gamma_{314} = x_{314} - \varpi_{314}^* = 63 - 44 = 19$ and $\gamma_{357} = x_{357} - \varpi_{357}^* = 6 - 0 = 6$ employees, and $\gamma_{414} = x_{414} - \varpi_{414}^* = 136,176 - 116,481 = \$19,695$ and $\gamma_{457} = x_{457} - \varpi_{457}^* = 8,322 - 0 = \$8,322$ salaries. Interestingly, hotels T_{14} and T_{57} have been identified as strongly efficient, that is, no savings are required from either hotel while operating individually. After merging with one other, however, it appears that there is still opportunity for savings. As such, one of the most striking results of this IDEA application is clearly the fact that, among the productive post-merger hotels, there are 30 pairs (10.83%) that involve exclusively strongly efficient hotels.

Definition 3. The cumulative savings of post-merger $M_m = (T_A, T_B)$, $A \neq B$, is $g_{im} = \gamma_{iA} + \gamma_{iB}$ for each input i and the corresponding proportion of savings is $g_{im}/x_{im} \times 100\%$..

Therefore, the cumulative savings expected from M_4 are $g_{14} = \gamma_{114} + \gamma_{157} = 0$ bed, $g_{24} = \gamma_{214} + \gamma_{257} = 9$ rooms, $g_{34} = \gamma_{314} + \gamma_{357} = 25$ employees, and $g_{44} = \gamma_{414} + \gamma_{457} = \$28,017$ on salaries, accounting for not less than 17.78%, 35.76% and 19.39% savings, respectively, on the joint number of rooms, number of employees and salaries allocated separately to hotels T_{14} and T_{57}. In practice, these hotels, in spite of being individually efficient in using their respective resources, have still

Table 2
DEA efficiency results for 58 hotels.

Hotel	ie_k^*	Hotel	ie_k^*	Hotel	ie_k^*	Hotel	ie_k^*	Hotel	ie_k^*
T_{01}	0.730	T_{13}	0.393	T_{25}	1	T_{37}	1	T_{49}	0.774
T_{02}	0.865	T_{14}	1	T_{26}	1	T_{38}	1	T_{50}	0.503
T_{03}	1	T_{15}	1	T_{27}	1	T_{39}	0.847	T_{51}	0.885
T_{04}	1	T_{16}	1	T_{28}	1	T_{40}	1	T_{52}	0.967
T_{05}	0.678	T_{17}	0.801	T_{29}	0.935	T_{41}	1	T_{53}	0.766
T_{06}	0.819	T_{18}	0.490	T_{30}	1	T_{42}	0.671	T_{54}	1
T_{07}	0.743	T_{19}	0.463	T_{31}	1	T_{43}	0.746	T_{55}	0.594
T_{08}	0.974	T_{20}	0.509	T_{32}	1	T_{44}	0.647	T_{56}	1
T_{09}	0.880	T_{21}	0.515	T_{33}	0.747	T_{45}	0.898	T_{57}	1
T_{10}	0.506	T_{22}	0.460	T_{34}	0.231	T_{46}	0.625	T_{58}	1
T_{11}	0.903	T_{23}	0.771	T_{35}	0.771	T_{47}	0.535		
T_{12}	0.742	T_{24}	0.704	T_{36}	0.374	T_{48}	0.318		

Table 4
Potential inputs for 20 productive post-merger hotels.

M_m	T_A	T_B	ϖ^*_{1A}	ϖ^*_{1B}	ϖ^*_{2A}	ϖ^*_{2B}	ϖ^*_{3A}	ϖ^*_{3B}	ϖ^*_{4A}	ϖ^*_{4B}
M_1	T_{14}	T_{27}	36	24	30	10	44	0	117,917	0
M_2	T_{14}	T_{37}	36	29	30	12	40	0	111,555	0
M_3	T_{14}	T_{38}	36	30	30	13	41	0	116,436	0
M_4	T_{14}	T_{57}	36	23	30	9	44	0	116,481	0
M_5	T_{26}	T_{27}	44	0	28	4	9	4	18,260	7406
M_6	T_{26}	T_{57}	38	0	28	2	9	2	18,260	3243
M_7	T_{27}	T_{30}	24	40	18	28	5	7	94,80	23,950
M_8	T_{27}	T_{37}	24	5	17	0	5	0	6727	0
M_9	T_{27}	T_{38}	24	6	17	0	5	0	8327	0
M_{10}	T_{27}	T_{41}	24	39	18	8	5	2	8252	0
M_{11}	T_{27}	T_{54}	24	16	18	4	5	2	8221	0
M_{12}	T_{27}	T_{56}	24	2	18	4	5	2	9144	0
M_{13}	T_{27}	T_{57}	24	6	16	0	4	0	6378	0
M_{14}	T_{27}	T_{58}	24	102	18	56	5	60	9480	168,194
M_{15}	T_{30}	T_{38}	62	0	45	0	11	1	29,858	4911
M_{16}	T_{30}	T_{57}	65	0	46	0	11	1	29,858	2826
M_{17}	T_{37}	T_{38}	29	0	15	3	4	1	5520	2389
M_{18}	T_{37}	T_{41}	30	17	15	10	4	3	5520	3458
M_{19}	T_{37}	T_{54}	30	19	15	10	4	3	5520	3345
M_{20}	T_{37}	T_{56}	30	1	15	9	4	4	5520	4108

more potential for savings in the event of a merger. Table 5 presents the cumulative savings g_{im} along with the corresponding proportions for the selected set of 20 post-merger hotels $M_m, m = 1, .., 20$.

In Table 5, Avg. and Max. denote the average and maximum proportions of savings in the full sample of 277 potential productive post-merger hotels. Though the average gain proportions range between 47.05% and 52.79%, the corresponding maxima hit values as high as 82.81% (M_{22}), 82.44% (M_{179}), 87.91% (M_{179}) and 86.75% (M_{183})for number of beds, number of rooms, number of employees and salary of employees, respectively. In other words, M_{22}, which merges the strongly efficient hotels T_{38} and T_{41}, could achieve a target $\overline{\tau} = 1$ by keeping small proportions of the inputs of the merging hotels. The distributions of these proportions are shown in Fig. 2.

Fig. 2 reveals that all of the proportions exhibit an almost normal distribution, which may be perceptible through the median values that are very close to the means, i.e., 52.00%, 49.41%, 53.21% and 53.68% for number of beds, number of rooms, number of employees and salaries, respectively.

In the meantime, it is noteworthy that most of the 277 potential post-merger hotelsM_m are pairs with possibly shared partners. For example, hotel T_{14} is shown in Table 4 as a partner of T_{27}, T_{37}, T_{38} and T_{57} in the post-mergers M_1 to M_4. In pairwise consolidations, such a scenario is not realistic and, hence, it is important to select, from among the potential candidates, a single partner for T_{14}. Rather than doing this for each hotel separately, we propose an approach that builds the best merger plan, i. e., the set of hotel pairs (T_A, T_B) that enables optimizing the collective performance of the hotel industry.

5. Building the best merger plan

An important step towards building the best merger plan is the selection of the best set of post-merger hotels in the sense that (1) the collective performance of the merger process is maximized and (2) there is no-overlapping among the pairs of post-merger hotels that are included in the merger plan. Since each productive post-merger hotel is defined with four cumulative gains, i.e., number of beds, number of rooms, number of employees and salaries, measuring the collective performance of the merger process can be treated as a multi-criteria decision making problem. Hence, a DEA model is first proposed to rank the post-merger hotels based on the associated relative efficiency. Next, a greedy heuristic is run for selecting the best non-overlapping pairs of post-merger hotels, as explained in the next two sections.

Table 5
Cumulative gains for 20 post-merger hotels with related proportions.

M_m	T_A	T_B	g_{1m}	%	g_{2m}	%	g_{3m}	%	g_{4m}	%
M_1	T_{14}	T_{27}	0	0.00	8	16.59	24	34.57	27,739	19.04
M_2	T_{14}	T_{37}	1	1.83	3	6.99	27	40.83	30,141	21.27
M_3	T_{14}	T_{38}	30	31.33	28	39.82	26	38.50	27,420	19.06
M_4	T_{14}	T_{57}	0	0.00	9	17.78	25	35.76	28,017	19.39
M_5	T_{26}	T_{27}	44	49.48	14	30.56	1	7.98	2074	7.48
M_6	T_{26}	T_{57}	49	56.25	16	34.68	4	26.51	5079	19.11
M_7	T_{27}	T_{30}	41	39.26	26	36.75	4	24.38	5908	15.02
M_8	T_{27}	T_{37}	25	45.82	16	49.14	4	45.83	8273	55.15
M_9	T_{27}	T_{38}	54	64.40	42	70.57	4	39.37	8833	51.47
M_{10}	T_{27}	T_{41}	51	45.16	19	43.04	4	38.15	8353	50.30
M_{11}	T_{27}	T_{54}	32	44.48	13	36.04	3	34.21	10,919	57.05
M_{12}	T_{27}	T_{56}	26	49.64	16	41.86	3	28.06	8546	48.31
M_{13}	T_{27}	T_{57}	17	36.22	20	56.34	7	59.61	11,424	64.17
M_{14}	T_{27}	T_{58}	0	0.00	5	5.91	19	22.72	58,073	24.63
M_{15}	T_{30}	T_{38}	79	56.29	50	53.10	3	17.18	2769	7.38
M_{16}	T_{30}	T_{57}	39	37.39	26	35.89	5	29.90	5496	14.39
M_{17}	T_{37}	T_{38}	61	67.48	38	68.34	3	31.59	5291	40.08
M_{18}	T_{37}	T_{41}	73	61.17	17	40.48	3	26.64	3667	29.00
M_{19}	T_{37}	T_{54}	29	36.86	7	21.50	2	19.40	6315	41.60
M_{20}	T_{37}	T_{56}	27	45.90	11	30.59	1	13.29	4102	29.88
Averages				48.91		47.05		52.79		49.66
Maxima				82.81		82.44		87.91		86.75

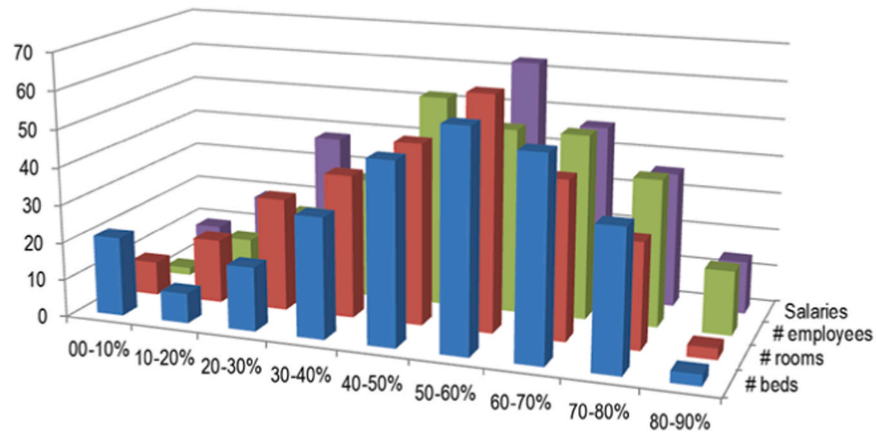

Fig. 2. Frequency distributions of the input savings' proportions for post-merger hotels.

5.1. Ranking the post-merger hotels

Considering the cumulative gains g_{im} $(i = 1, ., 4)$ as outputs of the merger process, each post-merger hotel M_m can be viewed as a DMU defined with four outputs and no inputs. As such, the problem of ranking the post-merger hotels can be formulated as the following output oriented DEA model.

$$E_o^* = \max \psi$$

s.t.

$$\sum_{m=1}^{277} \beta_m g_{im} \geq \psi g_{io} i = 1, ., 4$$

$$\sum_{m=1}^{277} \beta_m = 1$$

$$\beta_m \geq 0 m = 1, ., 277$$

β_m is the intensity variable associated with M_m and E_o^* is its efficiency score. Hence, if $E_o^* = 1, M_o$ is efficient otherwise it is inefficient $(E_o^* > 1)$..

Even with $M = 277$ post-merger hotels and four outputs only, three post-merger hotels, namely M_{99}, M_{184}, and M_{257}, are found to be strongly efficient, which presents full ranking. In order to discriminate among these post-merger hotels, we compute the corresponding benchmarking powers $P_o$presented in Table 6.

Based on the benchmarking powers, there is no doubt that M_{257} is the leading post-merger hotel, followed by M_{184} and M_{99}. The remaining 274 inefficient post-merger hotels are ranked based on the corresponding scores E_k^*..

5.2. Finding a merger plan

Let $\Re$ denote the list of ranked post-merger hotels, where $\Re = \{M^{(r)} = (T_A^{(r)}, T_B^{(r)}) | r = 1, ., 277\}$ and let $\mathfrak{I}$ denote the list of hotels that have already been paired. The following greedy heuristic is implemented to select the list $\aleph$ of post-merger hotels that are best suited for the merger plan.

Iteration 0: $\aleph = \varphi$, $\mathfrak{I} = \varphi$

$r = 1$

Table 6
Ranking of the efficient post-merger hotels.

M_0	T_A	T_B	P_0	Rank
M_{99}	T_{01}	T_{48}	95	3
M_{184}	T_{34}	T_{48}	178	2
M_{257}	T_{48}	T_{50}	217	1

Iteration r: while $(r \leq 277)$ do {.

If $(S_A^{(r)} \notin \mathfrak{I}$ and $T_B^{(r)} \notin \mathfrak{I})$ {

$$\aleph \leftarrow \aleph \cup \left\{ M^{(r)} = \left(T_A^{(r)}, T_B^{(r)} \right) \right\}$$

$$\mathfrak{I} \leftarrow \mathfrak{I} \cup \left\{ T_A^{(r)}, T_B^{(r)} \right\}$$

$$\Re \leftarrow \Re \backslash \left\{ M^{(r)} \right\}$$

}

$$r \leftarrow r + 1$$

}.

Thus, M_{257}, the lead post-merger hotel, is selected in Iteration $r = 1$, i.e., $\aleph = \{M_{257}\} \Rightarrow \mathfrak{I} = \{T_{48}, T_{50}\}$. Although M_{184} ranks in the 2nd position, it is discarded from the list $\aleph$ in Iteration $r = 2$ because it is overlapping on T_{48} with M_{257}. Similarly, M_{99} is discarded in Iteration $r = 3$. In Iteration $r = 4$, M_{96} enters $\aleph$, i.e., $\aleph = \{M_{257}, M_{96}\} \Rightarrow \mathfrak{I} = \{T_{48}, T_{50}, T_{01}, T_{44}\}$..

The above algorithm is run again for $r = 5, ., 277$ based on the rank succession of the remaining 274 pairs of hotels. The final list of post-merger hotels $\aleph$, involves only 11 pairs of hotels, as presented in Table 7.

Thus, 36 hotels have not been paired due to the fact that all pairwise mergers among these hotels are unproductive.

6. Concluding remarks

In this paper, we introduced a hybrid DEA-based methodology to build the best prospective merger plan for a hotel sector on the grounds of the potential gains of individual post-merger hotels. As such, the

Table 7
Merger plan with pairs of hotels and corresponding gains.

M_m	T_A	T_B	Number of beds	Number of rooms	Number of employees	Salary of employees
M_{257}	T_{48}	T_{50}	217	97	190	348,692
M_{96}	T_{01}	T_{44}	144	87	235	3468,440
M_{179}	T_{34}	T_{36}	149	146	72	145,907
M_{222}	T_{42}	T_{55}	187	62	53	58,497
M_{174}	T_{33}	T_{46}	153	23	97	166,505
M_{78}	T_{38}	T_{47}	112	94	30	116,308
M_{272}	T_{51}	T_{57}	0	8	173	389,066
M_{128}	T_{13}	T_{49}	81	80	94	197,755
M_{109}	T_{10}	T_{27}	75	64	41	106,626
M_{192}	T_{35}	T_{45}	73	40	14	10,446
M_{139}	T_{20}	T_{37}	66	42	21	30,242
Gains			1258	745	1020	5038,484
Proportions			47.36%	43.93%	53.99%	64.55%

objective of the proposed methodology is to identify the partners of the post-merger hotels that would ultimately qualify the whole sector, which is hypothetically represented with the selected sample of hotels, to achieve collective maximum performance. Specifically, if we assume that each hotel is willing to merge with another hotel, within the selected sample, all pairwise consolidations among hotels are evaluated through an IDEA model. Based on the optimal gains resulting from the merger, only possibly productive post-merger hotels i.e., those mergers that have potential to generate gains, are further considered. In the next stage, a hybrid procedure that incorporates a DEA model with a greedy heuristic enables the best pairs of productive post-merger hotels to be selected in a way that the collective performance of the ultimate selection is maximized.

To assess the practical scope of the proposed methodology, we considered a case study involving 58 hotels. The IDEA approach was applied to investigate 1653 pairwise consolidations, among which 277 potential post-merger hotels have been identified as productive i.e., likely to generate gains.

One of the most salient results at this stage is undoubtedly the fact that, among the productive post-merger hotels, there are pairs that involve exclusively strongly efficient hotels, which should not require any savings based on the individual hotels' production possibility set. It appears, however, that, after merging with each other, there is still room for savings. Moreover, a thorough analysis of the outcomes of these mergers revealed that the proportions of potential savings per post-merger hotel can reach 82.81%, 82.44%, 87.91%, and 86.75% for number of beds, number of rooms, number of employees and salary of employees, respectively. These proportions, put in the hotel M&A context, can already be considered as strong evidence for the benefits of mergers as potential contributors to enhancing gains.

An important step towards devising the best merger plan is the selection of the best non-overlapping pairs of hotels from the sample of productive post-merger hotels. Each productive post-merger hotel being defined with four cumulative gains, i.e., number of beds, number of rooms, number of employees and salary of employees, the problem is again multi-criteria, which requires primarily a DEA model as a ranking device. Though the ranking pattern that the DEA model produces allows a clear discrimination of the post-merger hotels, developing a greedy heuristic was required for selecting the best non-overlapping pairs of hotels. The selection process unveiled a final list of eleven productive potential post-merger hotels. Accordingly, only 22 of 58 hotels have been paired with the best partner among the existing candidates. The 36 hotels that have been excluded from the list can always merge with each other but all consolidations of two or more hotels among these hotels are likely to be unproductive.

These figures are strategically important for supporting new policies that would promote mergers among hotels as an established option for collective benefits.

Nonetheless, the present methodology may suffer limitations from both methodological as well as practical perspectives. In terms of methodology, the adoption of a standard DEA model for ranking the productive post-merger hotels may not be sufficient to attain full discrimination if there are more inputs and outputs. To overcome such a difficulty, one could resort to developing more advanced ranking techniques, such as DEA cross-efficiency where DM's preferences could be integrated as a key factor in the decision making process.

It is also worth noting that the efficiency estimates computed with both BCC and IDEA models are serially correlated and, hence, are susceptible to potential bias (Simar and Wilson, 1998; Kneip et al., 2008). As a potential research avenue, one could investigate the sensitivity of the merger's results to such a bias by developing appropriate bootstrapping techniques (Simar and Wilson, 2000; Kneip et al., 2011).

On the other hand, it is clear that a comprehensive investigation of all possible pairwise consolidations might be computationally costly if the number of hotels under scrutiny is much higher. Hence, another future research avenue may consider developing models that would duly integrate the merger's evaluation as well as the best partners' selection stages under the same framework.

In practice, the concept of a "merger plan" might not be feasible or even realistic in some business contexts. Therefore, a future study may focus on investigating various contextual settings of horizontal cooperation as well as corporate restructuring strategies where developing a large scale merger plan may be conceptually appropriate and practically relevant. Modeling the problem as a sparse graph (Letchford and Oukil, 2009; Letchford et al., 2014) could be a possible route for the investigations.

While substantial and rapid growth can be created for the post-merger hotels, problematic issues can emerge along the way. A hotel merger is not just about sealing the deal; it is about making it work after it has closed. Through mergers, the hotel boundaries are redrawn and internal work processes are reorganized. Merging management styles and operational processes can transform the scope and nature of jobs, which increases role ambiguity and potential team dysfunction. Common related issues are reduced job satisfaction, higher workloads, lower organizational commitment and subsequent staff turnover (Bolbanabad et al., 2017). The uncertainty, anxiety, and stress caused by such events may have a profound impact on the employees, reflected ultimately in unanticipated costs such as job security and redundancies: psychological contracts are often breached in the process (Young et al., 2018). Indeed, one of the reasons for the high M&A's failure rate is a lack of consideration for the merger's impact on employees (Kenny, 2020). Trust and productivity are frequently sacrificed as a result of conflicts and operational disruptions, which can drain resources and reduce the overall efficiency of the merger, taking the shine off the deal (Duvall-Dickson, 2016). Although the present study provides an explicit quantification of the gains in terms of number of employees, i.e., the number of expected layoffs, it does not address the undesirable effects of such decisions. Future studies may consider an extension of model (IDEA) by introducing as undesirable outputs qualitative variables that enable capturing adequately the subjective aspects that surround the employees' productivity in the hotel post-merger environment.

Expansion of size and area of business are the economic advantages immediately afforded to a newly merged hotel. These advantages are likely to intensify the market influence of the post-merger hotel, possibly eliminate competition and create market monopoly. Under a monopolistic scenario, the prices are likely to increase, resulting in productivity reduction of the hotel merger. In spite of its ability to handle optimally sector-wide performance, the methodology that builds the best merger plan does not refer to possible monopolistic scenarios. As such, it is worthwhile to envisage another research avenue where output and/or input variables that would suitably represent these scenarios can be identified before being integrated in the models and algorithms of the prospective methodology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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