Show me the money: the magic of the marketing and finance interface to drive financial performance in hospitality operations

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Chapter 4

Integrating Customer Satisfaction into Cost and Revenue Management: A Two-Stage DEA of Upscale Chain Hotels

"If you build a great experience, customers will pay more for it."

– Tony Hsieh, Zappos

Firms invest resources to produce a quality product that customers value and are willing to pay for. This chapter adopts a customer-centric accounting perspective to evaluate resource utilization in upscale chain hotels by integrating customer satisfaction into cost and revenue management. [18] Using a two-stage efficiency approach, customer satisfaction is treated as an intermediate outcome, linking operating-level accounting data to overall performance. The first stage, Cost-Satisfaction Efficiency, evaluates the hotel's efficiency in converting resources into customer satisfaction, whereas the second stage, Satisfaction-Revenue Efficiency, assesses its ability to generate revenue from the achieved satisfaction level. The two-stage network Data Envelopment Analysis (DEA) was chosen as a tool capable of capturing multiple non-linear effects, especially attributable to the datasets containing behavioral metrics, thus addressing potential limitations of the two previous studies from Chapters 2 and 3. As the last in the series, this study focuses particularly on the integration of accounting and behavioral information for improved management control. Similar cross-level integrated studies are missing in the extant literature due to the substantial workload associated with data collection, the matching of the multiple datasets, and the availability of reliable non-proprietary data needed to conduct such studies. Our main findings indicate consistently high efficiency in generating satisfaction from resources across properties, contrasted with lower and divergent revenue generation outcomes—patterns that traditional accounting systems fail to capture. This makes an important contribution to efficiency research in general, and hotel industry in particular by (a) suggesting that efficiency be measured relative to customer satisfaction, and (b) highlighting that revenue-side inefficiencies signal missed opportunities to capture greater customer spending potential across departments.

[18] This chapter is largerly based on Ng, F., Demydyuk, G., Cui, C. (2025). Maximizing Revenue from Satisfaction: Customer-Centric Perspective on Revenue and Cost Management in Hotels, *Tourism Economics*, *0*(0), 1-22. https://doi.org/10.1177/13548166251372201

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4.1 Introduction

Strategic management accounting (SMA) aims to empower accountants to play a strategic role in enhancing managerial decision-making. Its customer-centric vision challenges the accounting profession to develop a comprehensive understanding of both revenue and cost drivers, to facilitate cross-functional collaboration, and to engage with strategic positioning, customers, and competitors (Bromwich, 1990; Hogreve et al., 2017; Roslender & Hart, 2003). The simultaneous management of costs and revenues in the demanding lodging industry hinges on placing the customer perspective at the center of decision-making (Carlbäck, 2022; Downie, 1997b; McManus, 2013; Nemeschansky, 2020).

The integration of marketing and accounting information is a key feature of SMA, particularly relevant in hospitality research (Downie, 1997b; McManus, 2013). Assaf and Magnini (2012) demonstrated that hotel datasets combining financial and customer-related data produce more insightful information for managerial decision making than accounting-only datasets. Andersson & Carlbäck (2009) and Carlbäck (2022) advocate for a holistic approach to restaurant management that integrates customer values with accounting information, which Nemeschansky (2020) later implemented in a real-life case to demonstrate its benefits. Cugini et al. (2007) show how detailed cost information in a resort helps identify over- and under-investments to better align resource allocation with customer satisfaction. A challenge for such integrated approaches is that customer-level behavioral outcomes occur outside accounting systems, making it difficult to capture and systematize (Ingenbleek, 2014; van der Rest et al., 2018).

The growing mass of Internet customer reviews helps overcome historic limits to accessing reliable satisfaction metrics, enabling the holistic empirical examination of cross-level profitability models, as envisaged by Banker & Johnston (2007) and Carlbäck (2022). The maturity of review platforms and analytical tools now allow for systematic analysis of customer feedback (e.g., Boccali et al., 2022; J. Park & Lee, 2021). Upscale chain hotels are good for studying SMA, as their standardized operations and premium services expose the impact of managerial capabilities on performance efficiency (e.g., Kim & Chung, 2022). Despite these strong foundations, significant room for research remains for integrating customer metrics with accounting data to strengthen the control procedures underlying hotel cost and revenue management (Assaf & Magnini, 2012; Cugini et al., 2007; Demydyuk & Carlbäck, 2024; Downie, 1997b; McManus, 2013; van der Rest et al., 2018). Yin et al. (2020) stress customer centricity in both spending decisions and value

generation (e.g., Kim and Chung 2020; Assaf and Magnini 2012) and identify a clear gap in internal cooperation between operations and marketing. Thus, integrating customer and accounting information is essential for enabling effective cross-functional cooperation.

This study examines how well hotels perform holistically relative to customer satisfaction and competitors by integrating customer satisfaction into the analysis of hotel cost and revenue generation efficiency, the ability to maximize outputs from given inputs or minimize inputs for a given level of output. This study uses a two-stage Network Data Envelopment Analysis (DEA) model (e.g., Kao, 2014). Stage 1 analyzes Cost–Satisfaction (C-S) efficiency; the lower the cost to produce a certain level of customer satisfaction, the higher the C-S efficiency. Stage 2 analyses Satisfaction-Revenue (S-R) efficiency: the greater the revenue a hotel generates from a given level of customer satisfaction, the higher the S-R efficiency.

Our approach is distinct from previous efficiency studies in several ways. First, aligning with the SMA philosophy and recent efforts to broaden firm performance assessment by incorporating accounting measures beyond those used in conventional DEA (Cui et al., 2025), our analysis captures both the cost and revenue sides of hotel operations, in contrast to the single-domain focus on revenue generation seen in earlier studies (Brown & Ragsdale, 2002; Mariani & Visani, 2019; Morey & Dittman, 1995; J. Park & Lee, 2021). Second, we use departmental costs and revenues that hotel managers can control directly, moving beyond structural cost perspectives that incorporate non-manageable fixed assets (e.g., Kim and Chung, 2022). Although informed by Yin et al. (2020) and C. Kim & Chung (2022), our framework is broader in scope and aligns more closely with the approach proposed in Assaf & Magnini (2012). The two-stage DEA approach assesses the operational stages at which inefficiencies emerge (Assaf & Agbola, 2011; Barros, 2005; Barros & Dieke, 2008; Günaydın et al., 2022; Hsieh & Lin, 2010; Lado-Sestayo & Fernández-Castro, 2019). To highlight these distinctions, we conduct a classic one-stage Cost-to-Revenue DEA and compare its results with our main two-stage analysis.

This study contributes to the limited literature on integration of customer satisfaction with accounting controls (Assaf & Magnini, 2012; Demydyuk & Carlbäck, 2024; Nemeschansky, 2020). The integration of internal marketing and accounting information with external competitor data reflects the foundational objectives of the SMA, focusing on positioning a firm's performance in relation to its business environment (Bromwich, 1990; Hogreve et al., 2017; Roslender & Hart, 2003). In designing a two-stage model that assesses C-S and S-R efficiency, our study repositions DEA to be strategically

aligned with SMA, as it integrates both a short-term, internally focused perspective of cost capabilities with a long-term, leading, externally focused perspective of revenue capabilities based on customer satisfaction. This expands the role of DEA beyond the technical measure of productive efficiency to a more comprehensive and holistic evaluation of firm performance (Cui et al., 2024).

Our findings demonstrate stable, high C-S efficiency but an expanding gap in hotels' ability to convert customer satisfaction into revenue. These results reveal shortcomings in current accounting systems, which often fail to incorporate customer feedback into cost and revenue management decisions, thereby limiting firms' ability to optimize performance (e.g., Assaf & Magnini, 2012).

This study promotes customer-centric decision making for management practices by extending beyond the traditional Cost-to-Revenue perspective commonly adopted in accounting DEA research.[19] We propose a 2 × 2 matrix that classifies hotel performance relative to competitors based on C-S and S-R efficiencies and uses specific examples to explain whether a hotel should prioritize improvements in cost or revenue management relative to customer satisfaction.

4.2 Literature Review

Customer satisfaction has often been overlooked in hotel DEA studies despite its recognized importance in long-term hotel success (Demydyuk & Carlbäck, 2024; Ittner & Larcker, 1998a; Srinivasan et al., 2005). Assaf & Magnini (2012) addressed this gap by framing customer satisfaction as the output of a hotel's operational activities and emphasizing the input-to-satisfaction link. They found that integrating customer satisfaction into datasets produces different and more interpretable efficiency scores, acknowledging satisfaction's broader role in driving repeat patronage and attracting new customers. This recognizes satisfaction as both an immediate output and a critical driver of future revenue. Accordingly, hotel performance can be conceptualized as a two-stage process in which operational inputs influence customer satisfaction, which in turn drives financial outcomes – a structure still underexplored in hotel efficiency research.

While Assaf & Magnini (2012) pioneered the integration of customer satisfaction into hotel DEA, subsequent research shifted towards broader financial and brand performance contexts rather than operational efficiency modelling. This provides

[19] Cui et al. (2025) define FinDEA are DEA models which only use accounting and financial measures, distinguished from conventional DEA models that use physical measures.

considerable opportunities to expand their approach. Assaf and Magnini emphasized DEA's ability to track efficiency changes over time and accommodate multiple outputs, features leveraged by later studies, which we review. We address the practical challenges identified in their study, such as incomplete ACSI coverage, and discuss how recent research has overcome this limitation by using customer review data. Building on this foundation, we position customer satisfaction as an intermediate output linked to operational capabilities, advancing the integration of satisfaction into the hotel DEA.

4.2.1 Online satisfaction ratings as a reflection of management capabilities

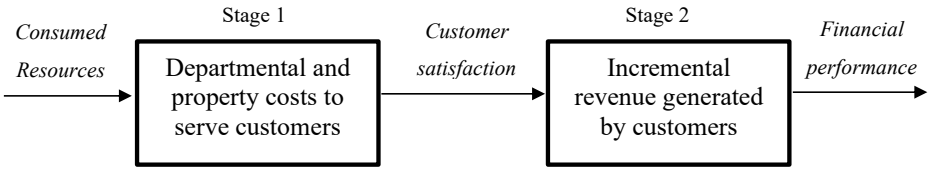
Customer satisfaction is a widely recognized but historically difficult-to-measure indicator in the hotel market. Online reviews on platforms such as Tripadvisor and Booking.com now play a central role in transient customer decision making, with travelers first checking overall satisfaction scores and then details on specific aspects of the stay (Boccali et al., 2022; J. Park & Lee, 2021). These reviews influence price sensitivity and distinguish hotels with similar locations, prices, and facilities (D. H. Park & Kim, 2008; J. Park & Lee, 2021). Lockyer (2005) outlined the typical hotel selection process, in which customers narrow options by location, price, and amenities before using online reviews to make a final choice.

From a revenue management perspective, hotels rely on dynamic pricing strategies that adjust rates based on booking patterns relative to their forecasts (e.g., Chen & Kachani, 2007). This approach does not explicitly consider the current satisfaction ratings posted on websites known to influence booking decisions simultaneously with pricing (Wang, 2012). From a cost management perspective, hotels must allocate resources efficiently to produce customer satisfaction by maintaining the quality of rooms, food, and amenities without overspending (Arbelo et al., 2017; Assaf & Magnini, 2012; Brown & Ragsdale, 2002). While review scores are subject to biases, such as extreme responses and non-representative sampling, they remain highly influential. As Phillips et al. (2015) and Srinivasan et al. (2005) emphasize, customers actively use these ratings to evaluate hotels, making them commercially impactful regardless of their methodological imperfections. From the customer's perspective, the visibility of review scores is more important than their accuracy. Hotels cannot ignore these ratings, because they strongly influence booking decisions. Therefore, our study treats customer reviews as a practical measure of satisfaction, directly linked to pricing and revenue potential.

Therefore, hotels need two critical capabilities: Cost-Satisfaction (C-S) capability – the ability to deliver high satisfaction cost-effectively, and Satisfaction-Revenue (S-R)

capability – the ability to leverage review scores to attract transient customers. We develop a two-stage analytical model to capture how cost management shapes satisfaction, which in turn drives future bookings and revenue, as depicted in Figure 7.

Figure 7: Conceptual model of customer satisfaction efficiency in hotel operations



4.2.2 Hotel efficiency research

A significant body of research has examined hotel performance and capabilities using efficiency methods, such as DEA and stochastic frontier models, with most focusing on overall efficiency in using resources and costs to generate revenues and volumes (Arbelo et al., 2017; Assaf & Agbola, 2011). A smaller stream incorporates customer satisfaction into the efficiency analysis (Assaf & Magnini, 2012; Boccali et al., 2022; Morey & Dittman, 1995). Assaf & Magnini (2012) compared DEA models with and without customer satisfaction and found that average efficiency increased from 81% to 89% when satisfaction was included. Few efficiency studies have explicitly considered hotel capabilities (C. Kim & Chung, 2022; Yin et al., 2020). Recent studies have highlighted the need for holistic views on how activities jointly drive costs, revenues, and satisfaction, including Cugini et al. (2007) for holiday resorts and Nemeschansky (2020) for restaurants, showing frequent misalignment between resources and the satisfaction they generate.

DEA is often used in lodging research because it can accommodate multiple outputs and flexibly set different business priorities (Arbelo et al., 2017; Assaf & Magnini, 2012). Table 29 summarizes prior hotel DEA studies. Early work by Morey & Dittman (1995) examined how room, wage, utility, advertising, and administrative costs drive outcomes, such as revenue, service quality, market share, and growth. Later studies combined accounting measures (assets, payroll, and expenses) and operational measures (property size, labor, rooms, facilities, and location) (Lado-Sestayo & Fernández-Castro, 2019; Yin et al., 2020). Typical outputs are service outcomes, such as revenue, turnover, occupancy rate, RevPAR, and ADR (Günaydın et al., 2022; Karakitsiou et al., 2020; C. Kim & Chung,

2022). Some models focus on specific perspectives, such as investment (Zhang & Ma, 2011) or regional performance (Karakitsiou et al., 2020), reflecting the adaptability of DEA models.

Despite the range of perspectives in prior studies, their approaches have limitations in assessing revenue and cost capabilities that integrate customer satisfaction – gaps this study aims to address when designing its DEA model. First, as Table 29 shows, most existing models adopt a full production perspective, including fixed assets from historical investment decisions. Fixed assets are difficult to adjust, and may not reflect managerial responses to shifts in customer satisfaction. Fixed assets span multiple years, and operating expenses are incurred annually, creating a temporal mismatch (Cui et al., 2025). Cui et al. (2025) caution that firm-level models often include supporting activities that are not directly tied to customer-facing performance, diluting relevance for operational decision-making. Accordingly, this study excludes fixed assets and uses department-level revenues and costs to focus on capabilities that are directly influenced by managers. Additionally, we disaggregated hotel revenue into rooms, food and beverage (F&B), and amenities, allowing an analysis of how hotels align these streams with associated costs based on strategic priorities.

Second, we address the shortcomings of the customer satisfaction data. Prior research uses metrics such as the ACSI (Assaf & Magnini, 2012), J.D. Power's Hotel Guest Satisfaction Index (C. Kim & Chung, 2022), or internal satisfaction measures (Brown & Ragsdale, 2002). These highlight a historic hurdle in SMA research: external metrics may lack property-level precision, whereas internal metrics may lack consistency. For example, ACSI is an aggregate brand index that limits its value for property-specific analysis. We address these gaps using customer satisfaction scores from user-generated online reviews, which are readily available as large datasets. As Boccali et al. (2022) note, DEA can support value-based pricing through online data. Unlike their study, which focused on individual satisfaction attributes, our study uses overall satisfaction ratings from booking websites.

Third, we focus on evaluating distinct capabilities, not just overall efficiency. Network DEA models aim to unpack the 'black box' of production by examining the separate stages. Kao (2014) recommended a two-stage approach to identify where inefficiencies arise, noting that an overall efficient system may still contain inefficient components. Independent models typically estimate efficiencies separately. We designed the selection of inputs and outputs in our network DEA model to capture the different

Table 29: Summary of studies using DEA models on hotel data

Year	Authors	Dataset	Type of DEA model	Input variables	Intermediary variables	Output variables
1995	Morey & Dittman	54 hotels/ observations	Conventional DEA model	(1) room division expenditure; (2) energy costs; (3) salaries; (4) non-salary expenditure for property; (5) salaries and related expenditure for advertising; (6) non-salary expenses for advertising; (7) fixed marked expenditure for administrative work.		(1) total revenue; (2) level of service delivered; (3) market share; (4) rate of growth.
2002	Brown & Ragsdale	46 hotel brands/ observations	DEA CRS model	(1) median price; (2) problems; (3) service; (4) upkeep; (5) hotels; (6) rooms		(1) satisfaction value; (2) value
2005	Barros	42 hotels; 126 observations	Malmquist DEA	(1) labour; (2) physical capital		(1) sales; (2) number of guests; (3) nights spent in the hotel
2008	Barros & Dieke	12 hotels; 84 observations	Two stage DEA model	(1) total costs; (2) investment expenditure.		Revenue per available room
2011	Assaf & Agbola	31 hotels; 124 observations	DEA double bootstrap	(1) total payroll in the room division department; (2) total payroll in other departments; (3) cost of food; (4) cost of beverages; (5) cost of maintaining rooms; (6) number of rooms available		(1) total room revenue; (2) total food & beverage revenue
2011	Zhang & Ma	28 hotels/ observations	Network DEA model	(1) total assets; (2) equity; (3) accrued wages; (4) liquidity	(1) advocate business income; (2) sales expenses; (3) administrative expenses	(1) total assets of growth; (2) profit; (3) current liabilities; (4) cash ratio
2018	Karakitsiou et al.	13 regions/ observations	DEA CRS and VRS model	(1) number of local units; (2) number of employees; (3) investments		Turnover
2019	Lado-Sestayo & Fernández-Castro	400 hotels/ observations	Four stage DEA model	(1) labour costs; (2) depreciation; (3) operational costs		Sales revenue
2020	Yin et al.	68 hotels/ observations	Network DEA model	(1) full-time employees in room department; (2) full-time employees in F&B department; (3) rooms; (4) total floor area of F&B department	(1) occupancy service competence; (2) F&B service competence; (3) marketing expense	(1) rooms department revenue; (2) F&B department revenue
2022	Günaydın et al.	2 hotels; 18 observations	Malmquist DEA	(1) labour cost; (2) food & beverage cost; (3) capital costs		Total revenue
2022	Kim & Chung	17 hotels; 170 observations	Network DEA model	(1) properties; (2) rooms	customer satisfaction	(1) occupancy rate; (2) RevPAR; (3) ADR
2023	El Alaoui et al.	20 hotels/ 40 observations	Two stage DEA model, Malmquist, bootstrapping	(1) total number of hotels; (2) total number of beds		(1) occupancy rate; (2) total number of nights spent

efficiency measures. Relevant to this study are Yin et al. (2020) and C. Kim & Chung (2022), who examined different hotel functions. Yin et al. (2020) conceptualized hotel performance as comprising operations and marketing, with operations using physical measures (e.g., number of employees, rooms, and F&B floor space) to generate occupancy and F&B service scores and marketing using those scores along with marketing expenses to produce room and F&B revenue. C. Kim & Chung (2022) defined performance as service productivity (how resources generate customer satisfaction) and service effectiveness (how satisfaction drives occupancy, ADR, and RevPAR). We follow the overall approach of C. Kim & Chung (2022), whose distinction between service productivity and effectiveness aligns with our focus on cost- and revenue-management capabilities. However, we use department-level revenues and costs, excluding fixed assets and aggregate revenue measures. We also apply a two-stage model that separates customer satisfaction from financial outputs, unlike Assaf & Magnini (2012), who included satisfaction, total revenue, and occupancy as outputs, thus enabling trade-offs between satisfaction and revenue. Our aim is to evaluate distinct capabilities to improve overall firm performance.

4.3 Methodology

4.3.1 Sample and datasets

The initial sample covers 263 corporate-owned hotels from six publicly listed U.S. hotel chains using two datasets matched through unique identification numbers (ID), anonymized, and merged. The list of owned and managed properties was manually collected from the 10-K statements[20] of the SEC Edgar database to guide the data collection. The first dataset comprised of annual STR Host Reports containing detailed operating (e.g., average occupancy rate and room nights sold), cost, revenue, and profitability information, formatted by USALI 11.[21] Anonymization restrictions imposed by the data provider meant that the hotel brand or parent corporation was not identifiable. The accounting data initially consisted of 1549 firm-year data points. Revenue and cost data were organized into three main departments: Rooms, F&B, and Amenities. The second dataset consisted of Internet customer reviews collected from the Tripadvisor website using a PHP 7.4 web crawler. The data included user ratings and comments for overall satisfaction and individual categories rated from one to five. Each entry includes the review

[20] Exhibit 2 to 10-K annual fillings "Properties".
[21] Uniform System of Accounts for the Lodging Industry, 11th edition

date and hotel name, enabling the assignment of a unique hotel ID. The STR removed review texts and titles to ensure hotel anonymity. From 2015 to 2021, the number of individual reviews was 349,869.

Dataset matching was performed by STR via the assignment of SHARE ID to each firm-year's financial data and individual reviews. To match hotel ratings to the accounting data, we aggregated individual review ratings at the reviewer level to the firm-year level by calculating the average ratings of the reviews collected for the given hotel and year. This process resulted in 735 matched data points for six years (2015-2021).

The Appendix provides detailed information on the selection and definition of variables (Remarks A10, A11 and Table A8), respectively). In the period 2015-2022, we defined 2019 as a benchmark pre-COVID-19 year for hotel performance. Moving backward, the 2015-2018 period analyzes performance during a time of stability. Moving forward, 2020 and 2021 analyze the under-demand-shock period.

4.3.2 Preparation of data for DEA modelling

First, we addressed DEA homogeneity requirements by selecting hotels with comparable strategies aligned with the benchmarking logic of the SMA. Cui et al. (2025) warn that heterogeneous accounting data can obscure important contextual differences and risks comparing dissimilar units. All properties were U.S.-based and part of hotel chains in the upscale and upper-upscale segments. Midscale and luxury hotels were excluded because of their small number and distinct pricing. Only hotels offering food, beverages, and amenities were included; those with missing revenues or costs in these areas were excluded.

Second, firm-years with missing or negative values in the variables were excluded, as DEA was designed to analyze only positive values (Dyson et al., 2001; Tone et al., 2020). Specifically, hotel years with missing or negative departmental revenues (total revenue equals zero) together with firms with EBIT below zero were identified and removed manually. This major cleanup of the data reduced the sample size to 586 observations. The critical reasons for adopting this approach are discussed in the Appendix (Remark A12).

Third, we reviewed and removed outliers and potential data entry errors, as they can distort the frontier, making normal, well-performing units appear inefficient compared to the unrealistic standard set by the outlier. Outliers can arise when a hotel's performance in a given year far exceeds industry standards, which we reviewed in two phases. We first examined hotel ratios to identify whether each hotel had plausible data with respect to its own information, identifying cases with unusually high ratios or with results that appear inconsistent across years. We next identified outliers based on the box-whisker method,

defining them as observations that exceeded 1.5 × the interquartile range (IQR)[22] (i.e., Q3 + 1.5 IQR and Q1 – 1.5IQR). See Appendix, Remark A13 for detailed explanations.

Additionally, not all hotels remained under corporate ownership, and the number of owned properties decreased over time, often following the "asset-light" strategy of large hotel corporations. Overall, the sample was narrowed down to 98 hotels after dropping records with incomplete data (ranging from 40 to 76 across the window from 2015 to 2021) and following the natural degradation of the sample over time. The final dataset resulted in a sample size of 455 accounting firm-years, matched with the corresponding average annual review scores, as summarized in Table 30.

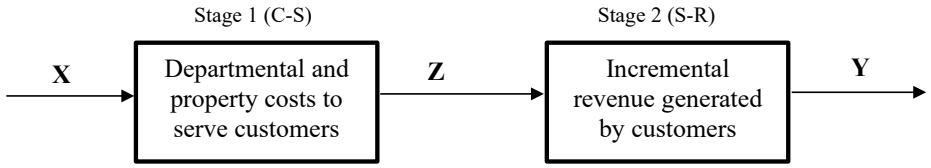
Table 30: Transformation process of Tripadvisor reviews

Individual Tripadvisor reviews, initial sample size	349,869
Reviews converted to annual level scores (firm-years)	735
Annual level review scores matched with non-negative financial data	586
Final number of annual review scores after removing outliers, non-comparable cases, and potential data errors	455

4.3.3 Analytical Model and Variables

To operationalize the conceptual model of this study, as presented in Figure 7, we use a two-stage Network DEA model, as shown in Figure 8, Stage 1 measures how efficiently hotels convert inputs (costs) into an intermediate outcome (satisfaction), termed C-S efficiency. Stage 2 assesses how efficiently satisfaction translates into revenue, which is termed S-R efficiency. The definitions and selection of the variables are provided in Appendix, Table A8 and Remarks A10 and A11.

Figure 8: Two-stage analytical model of customer satisfaction efficiency in hotels



Note: The X, Z, and Y, represent the data matrices of inputs of Stage-1, intermediate product, outputs of Stage-2, respectively.

[22] Interquartile range is the difference between the first and third quartiles

Output factor (**Y**): The revenue generated by the hotel's core operations, room revenue, F&B revenue, and revenue from amenities. Input factor (**X**): To match input to output, we used the costs associated with the core revenue streams, including total room expenses, total F&B expenses, and the total costs of amenities. Intermediate factor (**Z**): Customer satisfaction proxied by the overall satisfaction rating on Tripadvisor. For each hotel, we calculated the annual mean of all the review ratings. These ratings capture the customer perceptions that influence booking decisions. Satisfied customers are more likely to return, pay premium rates, and spend on non-core services such as F&B and amenities, while dissatisfied customers look elsewhere. Thus, customer review ratings serve as an important intermediate variable for evaluating hotels' resource-utilization efficiency.

As Figure 8 shows, we focus on areas where managers can take short-term action exclusively using departmental cost and revenue data. This recognizes that factors such as room count, brand image, and facility quality are largely fixed and not easily adjusted in response to customer satisfaction. Cui et al. (2025) warned that mixing multi-year fixed assets with annual expenses obscures cost-revenue relationships and introduces heterogeneity, especially when firm-level data include broader support activities. Therefore, we also exclude other operating costs such as utilities, support staff wages, insurance, and maintenance, prioritizing core hotel operations (rooms, F&B, amenities). This focus on financial data ensures alignment with our research objectives and allows for a clearer assessment of the operational performance.

It is important to note that customer reviews use a 1-5 ordinal scale, which does not reflect hotel size. To account for this, we scale all expenses and revenues by dividing them by Total Property, Operation, and Maintenance (POM) expenses, which reflect both property scale and investment needs. We also tested alternative approaches by scaling by room nights (Remark A14 in Appendix). Table 31 reports the descriptive statistics, for the annual data set, the number of observations meets the requirement of DEA after the data cleaning process.

Table 31: Descriptive statistics of variables (divided by POM expenses)

	Mean	Standard Deviation	Range	Minimum	Q1	Median	Q3	Maximum
Rooms Expenses	4.70	1.66	8.38	1.37	3.44	4.30	5.83	9.76
F&B Expenses	2.22	2.23	10.50	0.01	0.53	1.15	3.78	10.51
Amenities Expenses	0.27	0.53	7.59	0.00	0.05	0.10	0.25	7.59
Rooms Revenues	17.21	6.98	38.22	2.24	12.15	16.52	21.39	40.46
F&B Revenues	3.04	3.15	13.67	0.07	0.78	1.50	4.99	13.74
Amenities Revenues	0.38	0.45	4.08	0.00	0.10	0.20	0.51	4.08
Review Ratings (stars)	4.03	0.76	4.00	1.00	3.75	4.20	4.52	5.00

N = 455; Q1 – 25th percentile; Median – 50th percentile; Q3 – 75th percentile

To assess the added information from customer reviews, we also examine the cost-to-revenue (C-R) efficiency. C-R efficiency aligns with prior studies that examine how hotels convert costs into revenue, reflecting a traditional financial efficiency approach (Cui et al., 2025). This enables comparisons across three efficiency dimensions: cost-to-satisfaction (C-S), satisfaction-to-revenue (S-R), and cost-to-revenue (C-R). The two-stage model treats satisfaction as both an outcome of resource use and a revenue driver, revealing what a single-stage C-R model may miss. We report these additional C-R findings, along with our main results.

4.4 Findings

This section begins with the baseline year 2019, followed by other years, discussion of the efficiency plots, and further analysis. The efficiency scores on an annual basis are summarized in Table 32 (including descriptive statistics) and Table 33 (mean scores only).

Table 32: Descriptive statistics for efficiency scores

Year	Mean	Standard Deviation	Range of efficiency scores	Minimum	Q1	Median	Q3	99%	100%	*N*
Stage 1: **C-S** Cost to Satisfaction Efficiency:										
2015	0.91	0.11	0.52	0.48	0.87	0.94	1.00	26.67%	26.67%	60
2016	0.88	0.14	0.62	0.38	0.85	0.91	0.98	20.83%	19.44%	72
2017	0.88	0.14	0.73	0.27	0.83	0.92	1.00	28.17%	26.76%	71
2018	0.85	0.15	0.57	0.43	0.78	0.90	1.00	27.50%	27.50%	40
2019	0.83	0.16	0.73	0.27	0.75	0.85	0.93	22.37%	22.37%	76
2020	0.85	0.17	0.80	0.20	0.76	0.89	1.00	29.85%	28.36%	67
2021	0.82	0.20	0.79	0.21	0.75	0.87	0.98	23.19%	20.29%	69
Stage 2: **S-R** Satisfaction to Revenue Efficiency:										
2015	0.76	0.16	0.48	0.52	0.64	0.73	0.88	20.00%	16.67%	60
2016	0.72	0.18	0.62	0.38	0.59	0.71	0.86	13.89%	13.89%	72
2017	0.55	0.18	0.70	0.30	0.43	0.54	0.62	8.45%	8.45%	71
2018	0.67	0.18	0.56	0.44	0.54	0.62	0.79	15.00%	15.00%	40
2019	0.45	0.18	0.73	0.27	0.35	0.38	0.46	6.58%	6.58%	76
2020	0.60	0.25	0.78	0.22	0.39	0.56	0.78	14.93%	14.93%	67
2021	0.49	0.23	0.78	0.22	0.31	0.44	0.59	10.14%	10.14%	69
One-stage: **C-R** Cost to Revenue Efficiency:										
2015	0.91	0.10	0.42	0.58	0.86	0.94	1.00	43.33%	41.67%	60
2016	0.92	0.10	0.34	0.66	0.86	0.97	1.00	47.22%	45.83%	72
2017	0.93	0.09	0.32	0.68	0.87	0.97	1.00	47.89%	46.48%	71
2018	0.95	0.11	0.47	0.53	0.96	1.00	1.00	72.50%	72.50%	40
2019	0.92	0.12	0.50	0.50	0.86	1.00	1.00	52.63%	51.32%	76
2020	0.86	0.16	0.63	0.37	0.75	0.91	1.00	38.24%	38.24%	67
2021	0.91	0.13	0.55	0.45	0.84	0.99	1.00	50.72%	49.28%	69

Q1 – 25th percentile; Median – 50th percentile, Q3 – 75th percentile

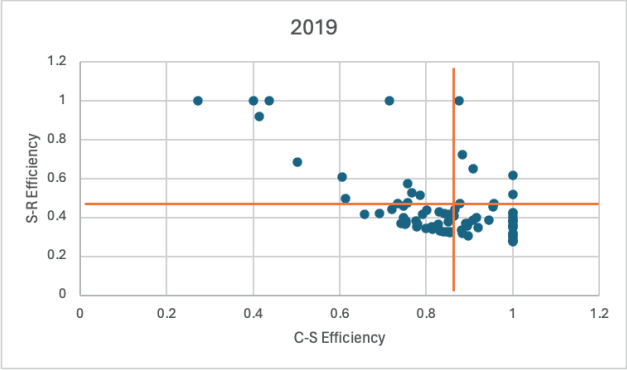
100% - number of efficient decision-making units (DMUs); 99% - number of DMUs efficient at least 99%

Note: All efficiency scores are generated from the VRS output-orientation model as explained in Remark A5 in the Appendix.

4.4.1 Baseline Year 2019

Figure 9 illustrates the analysis for 2019. The x-axis plots the C-S efficiency and the y-axis plots the S-R efficiency. Each point represents a separate hotel. For example, the upper- and left-most hotel achieved an S-R efficiency score of 1 (100%), indicating that this property generated the highest observed revenue relative to their peers with similar satisfaction scores. However, the hotel has a C-S efficiency score of 0.27, meaning it operates at only 27% efficiency compared to its best-performing peers in converting costs into customer satisfaction. This suggests a substantial opportunity for improvement (up to 73%) in how effectively it transforms input costs into guest satisfaction.

Figure 9: C-S and S-R efficiency plot for 2019



To support the interpretation of the mean efficiency scores, we provide C-S and S-R plots, allowing us to observe the relative efficiencies across the sample (Figure 12). The DEA estimates the mean efficiencies based on relative performance. Low mean efficiency indicates that hotels significantly exceed the performance of other hotels, thereby reducing average efficiency. A high mean efficiency for a given year indicates that hotels performed well relative to top performers on average. The orange lines plot the means for C-S (vertical line) and S-R efficiency (horizontal line) for a specific year.

In 2019, mean C-S efficiency was 0.83 (SD 0.15), indicating that hotels in the sample were very efficient in converting cost expenditure into customer satisfaction as compared to top-performing hotels. In contrast, when considering how hotels convert customer satisfaction into revenue, mean S-R efficiency was 0.45 (SD 0.18), identifying that the best-performing hotels did so at a much higher rate compared to the other hotels in the sample. For 2019 we observe a large cluster of hotels in the bottom right of the graph, with high C-

S efficiency (0.83 or higher) but low S-R efficiency (0.45 or lower). This clustering shows that most hotels in the sample achieved similar levels of performance, characterized by high C-S but low S-R efficiency. One implication is that these hotels need to emphasize their revenue capabilities and look at top performers to consider what improvements might be appropriate. In 2019, another observation was that there were hotels that achieved full S-R *or* full C-S efficiency of 100%, but no hotels were fully efficient in both stages. This is because hotels need to outperform competitors in both cost-to-satisfaction and satisfaction-to-revenue to be fully efficient in both. Increased competition places pressure on revenues and costs, meaning that fewer hotels can significantly outperform others in both aspects.

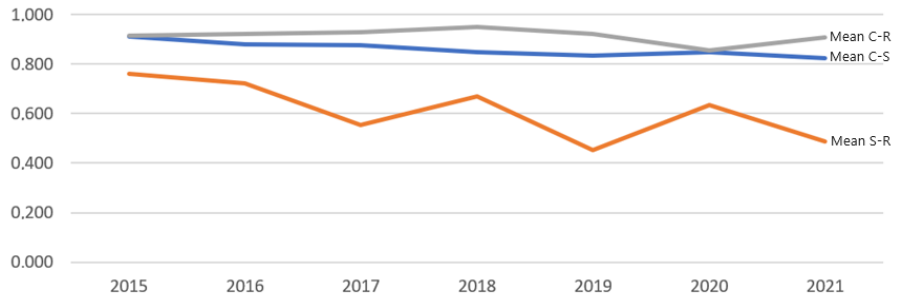
4.4.2 Main Sample (2015-2021)

We now discuss the main results from the overall sample for seven years (2015-2021) providing a trend of average efficiencies, as presented in Table 33, showing means and standard deviations for our main analysis of C-S and S-R scores on an annual basis, along with the C-R analysis for comparison. Figure 10 shows the same numbers in graph format.

Table 33: Mean efficiencies 2015-2021

Year	Mean C-S Efficiency (SD)	Mean S-R Efficiency (SD)	Mean C-R Efficiency (SD)
2015	0.911 (0.11)	0.760 (0.16)	0.915 (0.10)
2016	0.878 (0.14)	0.723 (0.18)	0.920 (0.10)
2017	0.877 (0.14)	0.553 (0.18)	0.927 (0.09)
2018	0.847 (0.15)	0.671 (0.18)	0.950 (0.11)
2019	0.833 (0.16)	0.453 (0.18)	0.920 (0.12)
2020	0.849 (0.17)	0.633 (0.25)	0.855 (0.16)
2021	0.824 (0.20)	0.486 (0.23)	0.907 (0.14)

Figure 10: Graph of mean- cost and revenue efficiencies



We observed a small overall decreasing trend in cost efficiency and a larger decrease in revenue efficiency (from 0.76 in 2015 to 0.49 in 2021). This finding suggests that the hotel industry demonstrates relative consistency in its ability to produce satisfaction from costs. By contrast, the scores vary significantly in terms of efficiency in producing revenue from satisfaction. The way to interpret this decreasing trend in scores is that, on a year-to-year basis, there is an increasing deviation in S-R efficiency between the top-performing hotels and all others. In other words, the best hotels are improving faster (or declining slower) than the industry average.

Figure 12 presents the efficiency plots for 2015-2021, illustrating the year-to-year patterns of hotel efficiency scores. Across all years, a similar triangular pattern was evident, with no hotels exhibiting very low scores for both C-S and S-R efficiency. 2015 and 2016 showed the least dispersion, indicating that the best-performing hotels did not substantially outperform the rest of the industry. From 2017 to 2019, the distribution began to widen, with greater clustering of hotels achieving high C-S efficiency but low S-R efficiency.

During the stability period, this range was greatest in 2019, signifying that the best performers were able to achieve significantly higher efficiency scores. The dispersion was greater in terms of the S-R efficiency than the C-S efficiency. While 2019 was regarded as a benchmark year for the travel and leisure industry, the analysis indicates that selected hotels were able to far exceed performance in terms of leveraging customer satisfaction.

In 2020 and 2021 (crisis years following the COVID-19 demand shock), dispersal across the range of C-S and S-R efficiency increases. This means large variances, where top performers outperform the industry, reinforce declining S-R scores. This could potentially be explained by the fact that all hotels were grappling to simultaneously cut costs, keep customers happy, and compensate for low occupancies at higher prices; however, some of them might have better management skills and/or a more relaxed COVID-related environment. In 2020, the mean S-R score was 0.63, declining to 0.49 in 2021. This shows that, as conditions begin to stabilize, some hotels are once more able to maximize revenue relative to other hotels with the same satisfaction rating.

Our comparison of C-R, C-S, and S-R is important because it reveals that performance differences are primarily driven by revenue, while cost management capabilities relative to review scores appear relatively uniform across the industry. Table 33 and Figure 10 indicate consistently high average efficiency scores for C-R across all years, suggesting that top performers do not substantially outperform the rest of the industry. The lowest score was recorded in 2020, reflecting disruption caused by COVID-

19. The graph of mean efficiencies over time shows that the C-S and C-R efficiencies follow a similar trajectory, with C-R maintaining a slight advantage. In contrast, a more pronounced gap was observed between the average of C-R (one-stage DEA) and S-R.

4.4.3 Additional Analysis – Industry-Plateau Effect

To assess the robustness of our findings and the influence of DEA's mechanical structure, we report an additional analysis that scales cost and revenue data by room nights sold instead of Total POM expenses. This test highlights how the inherent trade-offs in DEA efficiency scores reflect consistent industry markups between cost and revenue per room. The results, detailed in Remark A17 in the Appendix, reveal a systematic pattern: hotels operating near the industry average markup tend to display an inverse relationship between cost-to-satisfaction and satisfaction-to-revenue efficiency. This supports our interpretation that DEA efficiency scores reflect not only performance variation but also structural constraints shaped by pricing strategy and positioning within the market. As Figure 11 shows, some hotels perform above the *industry-average plateau*, indicating that they exceed typical markups. The plateau itself reflects a baseline in which most hotels operate with standard cost–revenue ratios.

When DEA results are clustered along this curve, they reveal limited variations in performance or a greater dispersion beyond the plateau, signalling meaningful performance differences. Thus in 2019, most hotels remained close to the plateau (see Remark A17), suggesting that intensified competition limited their ability to outperform industry markups. This pattern confirms that scaling by Total POM expense (Figure 12) enhances DEA's ability to detect relative performance across hotel size, quality, and condition.

Figure 11: Industry average plateau as seen in 2021 results

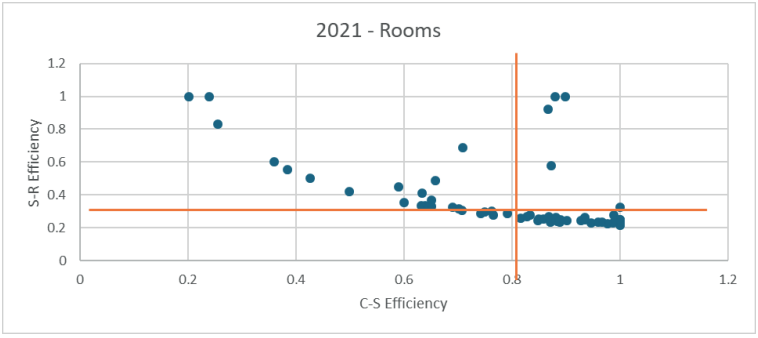
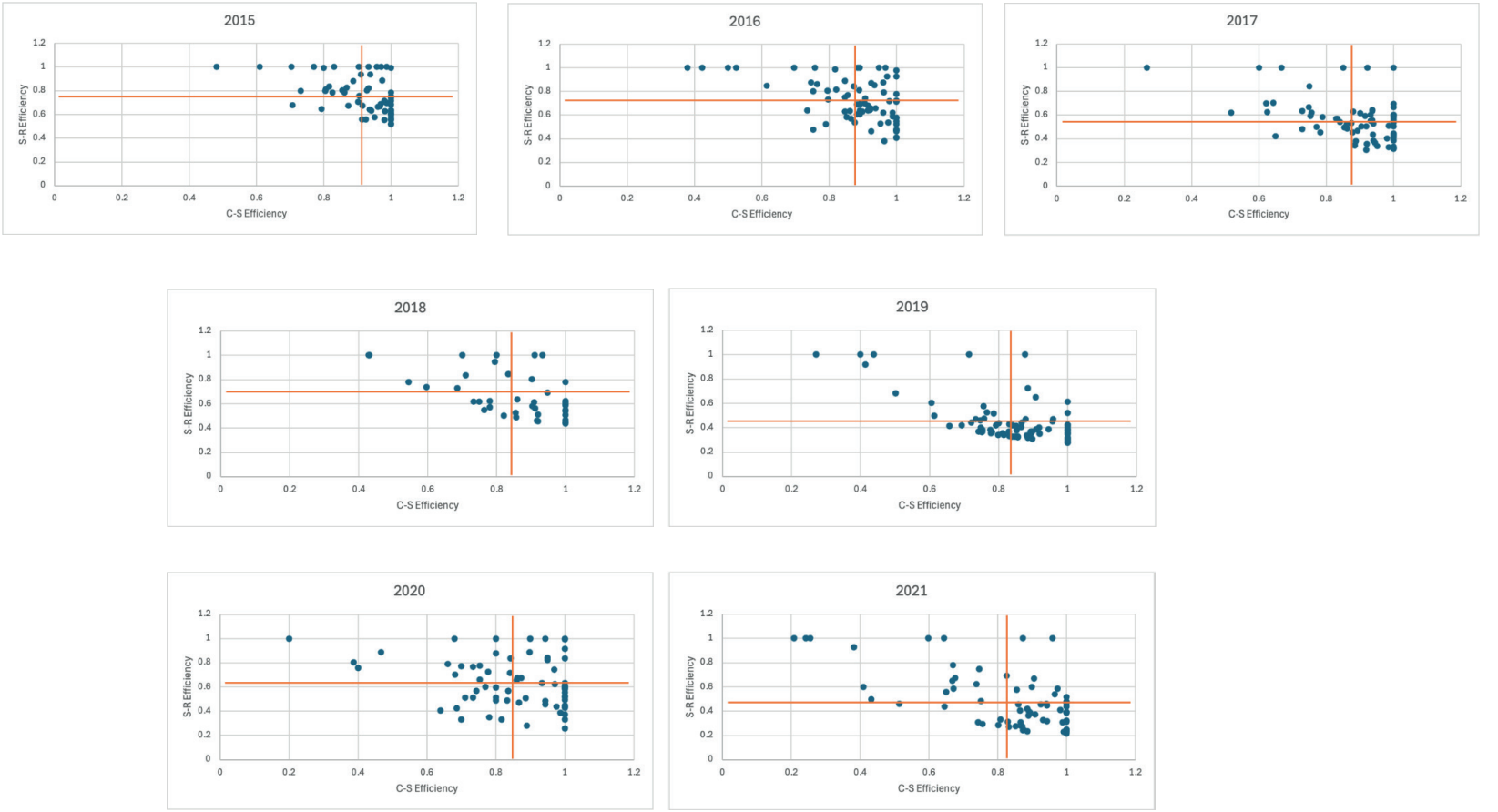


Figure 12: C-S and S-R efficiency plots for 2015 to 2021



4.5 Discussion

Using a two-stage Network DEA model to measure efficiency relative to customer satisfaction, this study focused on evaluating the revenue and cost management capabilities of upscale chain hotels. By combining a two-stage approach with a large property-level dataset, the resulting efficiency scores yielded more nuanced and informative insights. Our results show hotels exhibit high average efficiency in generating customer satisfaction from resources (departmental costs), which remains relatively stable over the study period (Stage 1, C-S efficiency). The same hotels exhibited low average efficiency in generating revenue from customer satisfaction, with a declining trend over the study period (Stage 2, S-R efficiency). In general, inefficiencies can arise from input and output prices as well as productive inefficiencies. Our results demonstrate that the foregone rent is on the revenue side, as hotels are highly efficient on the cost side and exhibit high unrealized revenue potential relative to customer satisfaction levels.

Similar to Assaf and Magnini (2012), our DEA analysis, using integrated marketing and accounting data, produced efficiency scores that differed from those based solely on accounting inputs. Our findings for C-S (ranging from 82% to 91% average efficiency) and higher C-R (from 86% to 95%) are opposite to those of Assaf and Magnini (2012), who report an average efficiency of 89% when including customer satisfaction and 81% without (lower). However, our S-R analysis highlights differences in revenue management capabilities (45% to 76%), suggesting that hotel accounting efficiency is driven by cost capabilities. This divergence in the results compared with prior research indicates the importance of considering capabilities separately.

These results provide evidence for the call by Assaf & Magnini (2012) promoting integration of customer and accounting data for better decision-making. While novel, our results support and extend those of previous studies. Our findings are similar to Yin et al. (2020), who find hotels exhibit greater operational capability than marketing capability. Their study focused only on the number of available rooms; therefore, we extended their findings by focusing on customer satisfaction and widening the analytical perspective. Our findings further extend the results of Kim and Chung (2022), who found that the inclusion of customer satisfaction scores in DEA produces different hotel brand rankings, but does not break down whether it applies to the revenue or cost side of the operations. We further contribute to refinements in how the models are developed to ensure consistency in cross-level analytical models (Banker & Johnston, 2007; Shields & Shields, 2005).

While C-S efficiency remains relatively consistent over the years, S-R efficiency fluctuates yet experiences a declining trend, exacerbated further by the COVID-19 demand shocks. This trend indicates an increasing gap in hotels' ability to recognize and benefit financially from a given level of customer satisfaction. Therefore, our analysis and findings have several important theoretical and practical implications.

4.5.1 Theoretical Implications

The novelty of this study lies in its two-stage network approach, which proposes conceptual refinements to improve the understanding of revenue and cost capabilities, integrating customer and competitor information, thus adding a more strategic dimension to DEA in general, and FinDEA in particular. We build on previous DEA studies that incorporate review scores as model outputs (Boccali et al., 2022; Mariani & Visani, 2019; J. Park & Lee, 2021). Inspired by SMA principals, our analysis uses accounting information that shows incremental revenues generated by customers and associated costs that can be controlled at the hotel manager level. This focus on operating factors that are both controllable in the short term, yet reflected in long-term performance, aligns well with hotels' cost and revenue management capabilities. Moreover, it plays an important role in accounting, going beyond routine transaction recording and cost allocation (Bromwich, 1990; Hogreve et al., 2017; Roslender & Hart, 2003).

This study opens new avenues for accounting and revenue management system design that integrates customer satisfaction and insight gained from a two-stage analysis. Our findings show that hotels exhibit low average satisfaction and revenue efficiency, with a declining trend. Across the competitive lodging landscape, properties generally execute cost management to a strong degree such that the best performers do not significantly outperform the market. By contrast, the best-performing hotels in revenue management outperform the market, and the gap between the best performers and the market is increasing. This increasing gap is possibly due to deficiencies in the current information systems that support pricing decisions, and hotels have the potential to incorporate customer satisfaction information into their analysis and control.

We contribute to the growing literature by integrating nonfinancial customer-level metrics with accounting control (Assaf & Magnini, 2012; Cugini et al., 2007; Demydyuk & Carlbäck, 2024; Ittner & Larcker, 1998a; Srinivasan et al., 2005). Integrating a customer-centric view of accounting and comparing hotels' performance relative to that of competitors provides a practical demonstration of the original aims of SMA (Bromwich,

1990; Hogreve et al., 2017; Roslender & Hart, 2003), which examines how a firm's cost structure is positioned to serve customers relative to competitors. Our approach addresses the longstanding challenges in SMA regarding the historical lack of access to customer and competitor cost data.

Building on Assaf and Magnini (2012), we extend the understanding of how integrating customer satisfaction enhances hotel DEA analysis by disentangling their combined approach into separate C-R and C-S scores, positioning customer satisfaction as a distinct relative performance factor. Our contrasting results arise from this model split: we find that customer satisfaction yields a slightly lower average industry performance compared to revenue, suggesting that hotel performance is only marginally affected when evaluated flexibly using either metric. Our S-R analysis further supports this finding, revealing low average industry performance driven by differences in revenue capabilities between top-performing hotels and the rest of the sector. Therefore, our integrated two-stage approach covers short- and long-term performance horizons – the immediate cost efficiency in the current accounting period and revenue efficiency based on customer satisfaction, leading performance indicator – repositioning DEA as a strategic SMA instrument that supports richer insights into competitive positioning and customer value creation.

Our additional analysis revealed a curve illustrating the trade-off between hotel revenue and cost, which we term the '*industry plateau*', reflecting baseline performance across the sector. The dispersion of performance above this plateau shows how some hotels outperform the baseline by achieving customer satisfaction at lower costs or maximizing revenues from their current level of satisfaction by capturing customers' willingness to spend. This industry plateau provides theoretical insights into DEA information content. Using different scaling methods can risk merely capturing industry markups, rather than true efficiency differences. Examining dispersal above the plateau helps to confirm that the analysis reflects variations in performance.

4.5.2 Practical Implications

The findings of this study provide actionable insights into effective customer-centric management. Our analysis indicates current information systems serve cost management fairly well, yet is lacking in capture of customer perspective; they are not helpful in supporting decisions such as value-informed pricing and product offerings. While this problem is not new (Carlbäck, 2022; Ingenbleek, 2014; van der Rest et al., 2018), our study

provides empirical evidence of the unrealized revenue potential in relation to customer satisfaction.

The conservative approach to revenue management and dynamic pricing is to open and close hotel rate fares, depending on the pattern of actual bookings relative to the forecast. This approach does not explicitly consider customer satisfaction information, and often does not integrate upselling options. By knowing the value of their products and services to customers, hotels can tailor and enhance their offerings beyond standard accounting and competitive market information (Ingenbleek, 2014; van der Rest et al., 2018).

This can be demonstrated by comparing the C-R, C-S, and S-R scores. Table 34 presents several cases from the 2019 analysis.

Table 34: Selected efficiencies from 2019

SHARE ID	C-S Eff	S-R Eff	C-R Eff
2019_82665	0.876	1.000	1.000
2019_83939	0.832	0.331	0.806
2019_95845	1.000	0.306	0.762
2019_99725	0.781	0.366	0.579

Hotel 82665 achieved full C-R efficiency (1.000), showing strong performance when viewed through a single-stage lens. While its current revenue generation appears optimal, given its satisfaction levels (S-R = 1.000), its C-S efficiency score (0.876) reveals that the hotel could incrementally improve its ability to convert costs into customer satisfaction, which may pose long-term risks if guest satisfaction begins to decline. In contrast, Hotel 95845 achieved full C-S efficiency (1.000), but a low S-R score (0.306). While it efficiently creates satisfaction from its costs, it struggles to convert that satisfaction into revenue – a missed opportunity to capitalize on guest goodwill. Other examples are hotels with low C-S but high S-R efficiency, which may be extracting strong short-term revenue from limited satisfaction but risks future customer loss. These contrasting profiles highlight the diagnostic value of separately examining the C-S and S-R stages. Such dynamics were not captured by the C-R score alone.

Therefore, categorizing cost-to-satisfaction and satisfaction-to-revenue efficiency provides valuable insights into whether a hotel should prioritize cost control or revenue optimization. For example, Assaf and Magnini (2012) consider that DEA results can inform

possible changes if managers consider all inputs and outputs included. Our use of two-stage analysis signals to managers where this search can begin. As a practical benchmarking tool, we propose a 2 × 2 matrix that positions hotels relative to competitors in these two dimensions. This framework enables analysts to track performance dynamics both at the individual property level and across the industry (illustrated in Remark A19 Figure 1(A19), in the Appendix). Table 35 presents the matrix classifying hotels based on their cost-to-satisfaction (C–S) and satisfaction-to-revenue (S–R) efficiency scores using mean efficiency values (illustrated by the orange lines in Figure 12). We grouped hotels into four strategic quadrants that highlight value-generation patterns. This matrix helps identify whether hotels effectively convert operational spending into guest satisfaction, and whether that satisfaction translates into revenue.

Quadrant 1 Low C-S, Low S-R: operational and commercial underperformance
Quadrant 2 High C-S, Low S-R: guest satisfaction not monetized effectively
Quadrant 3 Low C-S, High S-R: strong revenue returns relative to low satisfaction
Quadrant 4 High C-S, High S-R: top performers on both dimensions

Table 35: Cost and revenue quadrants

Year	Quadrant 1 Low C-S Low S-R	Quadrant 2 High C-S Low S-R	Quadrant 3 Low C-S High S-R	Quadrant 4 High C-S High S-R
2015	0.083	0.467	0.283	0.167
2016	0.167	0.403	0.222	0.208
2017	0.113	0.437	0.211	0.239
2018	0.150	0.475	0.250	0.125
2019	0.250	0.461	0.184	0.105
2020	0.176	0.368	0.265	0.191
2021	0.101	0.551	0.217	0.130

Our overall results point towards the challenge of generating more revenue for hotels with higher customer satisfaction relative to competitors. Thus, current dynamic pricing tools are not always connected with customer satisfaction and do not cover “the Full House” potential. Industry analytics can explore the potential of incorporating customer satisfaction into dynamic pricing approaches and upselling options, thus enriching in-house sales information with customer feedback. Similar to our approach, these data can be crawled in real time, analyzed, and systemized in an automated process,

thus evolving into an accounting-ready state to refine pricing algorithms and dashboards. Such integration and the two-stage approach can help uncover hidden erosion patterns and support operators in optimizing their costs and improving satisfaction ratings.

4.6 Limitations and Directions for Future Research

This study highlighted DEA's need for deeper sample homogeneity, leaving potential for further research into other aspects of heterogeneity. For example, luxury hotels with older facilities may face different dynamics of customer satisfaction and costs compared with newly built economical hotels. Furthermore, our analysis did not incorporate explanatory contextual or operational factors that may influence efficiency scores. By decomposing the overall performance into C-S and S-R components, our approach provides a framework that can support localized, manager-led investigations into the underlying causes of inefficiency, where other variables can be successfully incorporated. Future research could link efficiency scores to contextual variables, such as staffing, location, or available facilities, to better explain differences in performance and further uncover the strategic or organizational drivers of cost-to-satisfaction and satisfaction-to-revenue efficiency. In addition, we scaled the data by Total POM expenses to control for hotel size, class, and facilities to account for differences in hotel types. Other DEA methods, such as categorical DEA, can directly capture these differences.

Finally, customer reviews are subjective; therefore, they capture customer satisfaction, but not necessarily service quality, which may influence the results. Further analysis of how hotel industry scores change over time would provide further evidence as to whether inefficiency is within or outside a hotel's control, such as the level of market competition.