IMPACT OF THE COVID-19 PANDEMIC ON UNITED STATES' HOTEL PRODUCTIVITY: A MULTI-PERIOD ANALYSIS

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ABSTRACT

This paper uses the Malmquist Productivity Index to evaluate the impact of the COVID-19 pandemic on hotel productivity. It decomposes total factor productivity change (TFPC) into technical efficiency, pure and scale efficiency, and technical change to conclude on productivity growth before and after the outbreak of the pandemic. 112 hotels in four cities of the United States between 2011–2021 were subject to the analysis, using a multi-input (room, labor, and F&B costs) multi-output (accommodation, F&B, and total revenue) DEA-Malmquist model. The pandemic did not have an adverse effect on hotel productivity change, mainly due to the developments attributed to technological advancements. The paper offers crucial managerial implications. The results of the analysis emphasize the prominence of investment in technology to sustain productivity levels. It supports managers with strategy development and offers decision makers a wider overview of the sector.

KEY WORDS

COVID-19 pandemic, productivity, Malmquist productivity index, technical efficiency change, technical change

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D21, L83, M10

1 INTRODUCTION

The COVID-19 pandemic is among the most impactful events of this century resulting in border closures, lockdowns, and shutdowns of hospitality establishments (Zenker and Kock, 2020). Due to the severe repercussions of the pandemic that hit the prospering US hotel industry, the sector had to respond immediately if hotels were to stand a chance of survival (Škare et al., 2021). High operating costs, high break-even points, and the need to generate revenue typified an industry that was facing new challenges: customers' fear of staying at ho-

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tels, reluctance to use in-house F&B offerings, customer limitations to ensure social distancing, and the need to improve employee training in matters of health and safety (Gursoy et al., 2020). Thus, research that focuses on improving the bottom line is crucial to aid managers counterbalance the new challenges faced by this industry (Gursoy and Chi, 2020). The pandemic led to plummeting sales, diminished occupancy rates, employee redundancies, and lower profit levels, calling for immediate action (American Hotel & Lodging Association, 2022). It is unsurprising that only productive companies can increase their outputs without incurring additional input costs. Increased productivity transforms into higher earnings (Assaf et al., 2011) which aim to counterbalance pandemic-induced effects. Therefore, reaching a superior level of productivity is important in the service sector (Brown and Dev, 2000). However, it is worrisome that the hospitality industry has been characterized by low productivity levels (Martins et al., 2020; McMahon, 1994; Sigala et al., 2005). Hence, this study aims to understand the impact of the global epidemic on productivity levels, an important contributor to hotels' bottom lines (Brown and Dev, 2000).

Productivity, the extent to which inputs can be effectively converted into outputs, is measured as the ratio of a property's output to its inputs (Baker and Riley, 1994). The level of productivity and marginal productivity of a given input determines the rate of survival, implying that productivity is the key to continued existence (Syverson, 2011). Furthermore, the quality of output, which is an important determinant of productivity, is challenging to quantify (Assaf and Agbola, 2011). As a reaction to this widely accepted problem, the United Nations World Tourism Organization (UNWTO) has made productivity issues one of the top priorities to attract researchers' attention (Chatzimichael and Liasidou, 2019).

To determine productivity levels TFPC – which is split into two equally important parts, (technical) efficiency change (EC) and change in (frontier) technology, or technical change (TC) – is computed. The improvement potential in EC designates the possibility of an overall enhanced performance between two time periods and describes the efficiency with which inputs can be converted into outputs and, hence, the capabilities of managers (Färe et al., 1994). Improvement suggested by TC shows the slack portion; that is, it identifies the "under-produced output or over-utilized input" (Avkiran, 2006) in the application of current technologies (Färe et al., 1994), as the model hypothesizes that "businesses do not fully utilize existing technology" (Kim, 2011), and thus identifies the technological progress.

The major determinants for the change in technical efficiency were presumed to be related to human capital, training available to employees, best practices followed by line managers, and the input mix. However, technical progress, was influenced by investment in employed capital, research and development, and improvement of available capital. While this may be true for the manufacturing, construction, or trade industries, Kim (2011) notes that it would be incorrect to assume that the same determinants are valid in the hospitality industry. The application of technological solutions is not only in line with the demands of post-pandemic customers seeking less human contact, but also aids in improving productivity levels through its influence on TC. Technological innovations include self-service kiosks, the application of QR codes, digital room keys, robots that make human interactions redundant, (Gursoy et al., 2020) and artificial intelligence. This study aims to understand the importance of technology on productivity levels in relation to the pandemic.

Hence, this study discusses the following research questions:

- RQ_1: Did the pandemic influence productivity levels?
- RQ_2: Which factors drove TFPC more, EC or TC?

2 THEORETICAL FRAMEWORK

2.1 COVID-19 and the United States' Hotel Industry

The hotel industry was severely hit by the pandemic as border closures made it impossible to travel for 90% of the global population (Gössling et al., 2021). Although the US did not issue unified "shut down" orders, a lack of willingness to travel and country-wide lockdowns led to plummeting occupancy levels, skyrocketing rates of unemployment, tremendous revenue loss (American Hotel & Lodging Association, 2022) and a significant decline of total US exports related to international visitor spending (World Travel & Tourism Council, 2020). Although it is clear that since 2020, a recovery can be observed, a full recovery to pre-pandemic levels is only expected by 2025 (STR, 2021) due to a variety of factors that have appeared during the pandemic: the ongoing presence of hybrid events resulting in lower banqueting spending, the accumulation of debt still not being offset, the elimination of single-day business travel due to enhanced videoconferencing options, and ongoing inflation levels (American Hotel & Lodging Association, 2022). Following the guidelines of PRISMA, this study uses a compilation of pandemic related research using pre-selected keywords, as shown on Tab. 1, similar to the work of Davahli et al. (2020).

The methodology used to compile the table above consisted of three steps: (1) Definition of relevant keywords. (2) Filtering of search results. (3) Removal of non-relevant articles. Three separate searches were conducted using the following keywords: (1) COVID-19 AND hospitality industry (2) COVID-19 AND hotel industry (3) COVID-19 AND tourism industry. As illustrated in Tab. 1, existing papers can be categorized into various groups. First, there are papers that describe and measure the impact and extent of the repercussions experienced by the hotel industry. Second, other papers propose distinct actions, such as strategies to restore hospitality operations to their pre-pandemic levels. Third, some papers take it a step further and employ scenario modelling to suggest different outcomes. Finally, certain papers compare the most recent pandemic with previously experienced health crises. The current paper aims to enrich the first category of literature mentioned above by seeking to understand and measure the impact that the hotel industry experienced due to the pandemic.

2.2 The Impact of Crises on Productivity Growth

The importance of understanding and measuring the impact of the COVID-19 pandemic is highlighted by the fact that the current global epidemic is not the first crisis humankind has faced. Natural disasters, socio-political tensions, and financial and health crises are well-documented phenomena that have been explored in substantial research. Looking back at the impact of previous crises, similar patterns and theories can be recognized that explain the circumstances that the world is facing today (Zenker and Kock, 2020). Considering the fact that the pandemic provoked an economic crisis similar to the global financial crisis in 2008, previous studies analyzing the effects of the economic recession offer basic information about the expected behavior of productivity development during a crisis. Hotels have exhibited incessant resilience against previous financial and health crises and have rebounded quickly, mainly because of their capability to improve TC levels (Peypoch and Sbai, 2011). Slovenian hotels that failed to introduce innovative technologies experienced negative productivity growth during the economic crisis of 2008–2010, even though they showed EC advancements (Frančeškin and Bojnec, 2023). However, crisis-induced organizational modifications have dependably contributed to improving cumulative productivity levels (Meriküll and Paulus, 2024).

Extant studies are not in agreement about the effect of the COVID-19 pandemic, yet they agree on the importance of technological advancements in driving productivity levels. Certain findings demonstrate that the global

Tab. 1: Summary of COVID-19-related research within the hotel industry (extract)

Author(s)	Title	Industry segment	Location	Approach
Ablanedo-Rosas et al. (2023)	COVID-19 impact on the operational efficiency of a downtown hotel	Hotel Industry	United States	Discussing resumption of activities during and after the pandemic
Aigbedo (2021)	Impact of COVID-19 on the hospitality industry: A supply chain resilience perspective	Hospitality Industry	United States	Reporting the impacts of the COVID-19 pandemic
Antonio and Rita (2021)	COVID 19: The catalyst for digital transformation in the hospitality industry?	Hospitality Industry	Portugal	Discussing resumption of activities during and after the pandemic
Bagnera and Stewart (2020)	Navigating hotel operations in times of COVID-19	Hotel industry	Global	Discussing resumption of activities during and after the pandemic
Bakar and Rosbi (2020)	Effect of Coronavirus disease (COVID-19) to the tourism industry	Supply-demand in tourism industry	Global	Developing simulation & scenario modelling
Cajner et al. (2020)	Tracking labor market developments during the COVID-19 pandemic: A preliminary assessment	Hospitality job loss	United States	Measuring the impact of COVID-19
Gerwe (2021)	The Covid-19 pandemic and the accommodation sharing sector: Effects and prospects for recovery	Accommodation sharing sector	Global	Discussing resumption of activities during and after the pandemic
Gössling et al. (2021)	Pandemics, tourism, and global change: A rapid assessment of COVID-19	Airlines, Accommodation, sports events, restaurants, cruises	Global	Comparing COVID-19 with previous public health crises
Hoque et al. (2020)	The effect of Coronavirus (COVID-19) in the tourism industry in China	Inbound and outbound flights, hotel industry, restaurant industry	China	Reporting the impacts of the COVID-19 pandemic
Hu and Lee (2020)	Airbnb, COVID-19 risk and lockdowns: Global Evidence	Hotel industry	China	Reporting the impacts of the COVID-19 pandemic
Kim et al. (2021)	COVID-19 and Hotel Productivity Changes: An Empirical Analysis Using Malmquist Productivity Index	Hotel Industry	United States	Discussing resumption of activities during and after the pandemic
Kim et al. (2022)	What to Sell and How to Sell Matters: Focusing on Luxury Hotel Properties' Business Performance and Efficiency	Hotel Industry	Global	Discussing resumption of activities during and after the pandemic
Ocheni et al. (2020)	Covid-19 and the Tourism Industry: Critical Overview, Lessons, and Policy Options	Aviation, Cruise-shipping, hospitality industry	Global	Discussing resumption of activities during and after the pandemic
Ozdemir et al. (2021)	Quantifying the economic impact of COVID-19 on the U.S. hotel industry: Examination of hotel segments and operational structures	Hotel Industry	United States	Reporting the impacts of the COVID-19 pandemic
Rodríguez-Antón and Alonso-Almeida (2020)	COVID-19 Impacts and Recovery Strategies: The Case of the Hospitality Industry in Spain	Hospitality Industry	Spain	Discussing resumption of activities during and after the pandemic
Rosemberg (2020)	Health and safety considerations for hotel cleaners during COVID-19	Hotel industry	Global	Reporting the impacts of the COVID-19 pandemic
Scholz et al. (2022)	Green management implementation: A case of the Bulgarian hotel market	Hotel industry	Bulgaria	Discussing resumption of activities during and after the pandemic
Štumpf et al. (2021)	Restart of hospitality and tourism	Hospitality Industry	Czech Republic	Developing simulation & scenario modelling
Yang et al. (2020)	Coronavirus pandemic and tourism: Dynamic stochastic general equilibrium modelling of infectious disease outbreak	Tourism demand	Global	Developing simulation & scenario modelling
World Health Organization (2020)	Operational considerations for COVID-19 management in the accommodation sector: Interim guidance 31 March 2020	Hotel industry	Global	Discussing resumption of activities during and after the pandemic

epidemic did not have a negative effect on productivity, mainly driven by TC and optimal efficiency of scale. Investments in service and process improvements drove productivity during the pandemic, supporting its rebound after the outbreak (Tzeremes, 2021). Analysis conducted in the Euro-area has revealed aggregate productivity enhancement due to a proportionally lower decrease in output compared to invested working hours, and the increasing dominance of technologies and remote work stimulating productivity (Criscuolo, 2021). Productivity deteriorated with diminishing technological advancements, while EC improved through effective resource management such as streamlined cleaning processes, lower wages, reduced team size, and partnerships with top hygiene brands. Immediate effects from recommended hygiene innovations like electrostatics and ultraviolet light may not be anticipated (Kim et al., 2021).

2.3 The Importance of Productivity's Components – EC and TC

While authors may not agree about the components driving productivity during the pandemic, it is known that productivity is important during a downturn, and improving it contributes to better profitability, while during an economic upsurge, future success can be preserved. Productivity can be enhanced through higher skilled workers, better equipment, automation, "do-it-yourself" solutions for guests and through making informed strategic decisions, which include ownership structure, management arrangement, hotel categorization, and the size of property (Brown and Dev, 1999). Considering the importance of enhanced productivity and that the hospitality industry is notorious for low levels of productivity (Johns et al., 1997), the potential findings of this study may be crucial to the industry. Especially since it seems that, considering various scenarios, the rebound of tourism demand may be on the pessimistic side, as demonstrated by the scenario modelling undertaken by Štumpf et al. (2021). Notably, there is also a growing body of literature identifying the determining elements of productive operations (Aissa and Goaied, 2016; Peypoch et al., 2021). While EC represents the technical efficiency change due to skillful managers, improved management of the booking channels, and training of employees improving productivity so that hotels can catch up to the production frontier (Kim, 2011), improvement through TC is achieved by the application of revolutionary technical solutions, automation, and digitalization of manual processes, which lead to a shift in production functions (Färe et al., 1994).

Previous research supports the importance of technological advancement in productivity improvement. For example, after analyzing hotels in 30 Chinese provinces between 2005 and 2015, Peypoch et al. (2021) found that the category of a hotel influences its productivity change. Hotels with lower star ratings demonstrated better progress in TC than their higher-rated counterparts, since the initial levels of technological progress were lower than those of higher-category hotels. While the extent of productivity change was different across hotel categories, the importance of TC was confirmed, as this was the main driver of productivity, independent of the hotel category. Similar conclusions were reached by Barros (2005), Chatzimichael and Liasidou (2019), and Kim (2011). Chatzimichael and Liasidou (2019) examined TFP growth in the hotel sector across 25 European countries from 2008 to 2015 and concluded that, despite the fact that TC was driving positive TFPC, it is still considerably superior in other economic sectors compared to the hotel industry. Low levels of improvements in EC lead to plummeting productivity results, while scale efficiency (SE) shows that hotels do not operate at an optimal scale. Notably, low technical efficiency scores may be due to inefficiencies at an operational level and poor managerial decisions. That is, although hotels invest in technology, inputs and outputs fail to exhibit an optimal balance.

Barros (2005) also confirmed the importance of TC after analyzing 42 Portuguese hotel properties during the period 1999–2001. In Kim's (2011) study of 147 hotels operating in the

Malaysian market, the author concluded that although the size of a hotel is an important determinant since the largest hotels demonstrated the best results, TFPC was dominated by technical advancements and worsened by technical efficiency results independent of the size of the respective hotel. Goncalves's (2013) study on French ski resorts found that TFP components had negative impacts on productivity due to inadequate investment in new infrastructure and an aging inventory, resulting in decreasing TC. Additionally, mismanagement of operating costs and high employee turnover contributed to declining EC levels. These studies highlight the pivotal role of technology in long-term productivity. TC, being the primary driver, hinges on hotels' innovation capabilities for future success.

3 METHODOLOGY AND DATA

Productivity growth is analyzed using the data envelopment analysis (DEA)-Malmquist model, which has an advantage over the traditional DEA method in that it engages dynamic time-series data. This linear programming method was used to construct the Malmquist Productivity Index (MPI), which was designed to measure productivity change over time (Assaf et al., 2011) by constructing a non-parametric piecewise production frontier over the data.

Productivity is measured as the ratio of vertical and horizontal distances between two time periods, vertical distance implying an "output expanding orientation," horizontal distance in turn standing for an "input-conserving orientation" (Fried et al., 2008, p. 59). Research notes that, especially within the hotel sector, technical efficiency is a reasonable measure – which is not influenced by underlying costs or prices – to determine a hotel's ability to convert inputs into outputs (Avkiran, 2006; De Jorge and Suárez, 2014). TC describes the need for technological improvement; thus, the extent of development needs to become more competitive and achieve a higher output by shifting the frontier, without changing the number of inputs. TFPC is the multiplication of these two indices, either of the two, or both, being able to explain the improvement in productivity over time (Färe et al., 1994).

The MPI index was generated by calculating the best-fit frontier using DEA technology, since it allows for the "estimation of TFP as a Malmquist index" (Barros and Alves, 2004). When constructing the indices, distance functions were created using both input and output values. Following Färe et al. (1994), the output-oriented Malmquist index was constructed as follows in period t and in time period $t+1$:

$$\begin{aligned} M_o^t &= \frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)} \\ M_o^{t+1} &= \frac{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^t, y^t\right)} \end{aligned} \tag{1}$$

As previously mentioned, the geometric means of the two indices are constructed as follows:

$$\begin{aligned} &M_o\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = \\ &\left[\left(\frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)}\right) \cdot \left(\frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)}\right)\right]^{\frac{1}{2}} \end{aligned} \tag{2}$$

This can be noted as follows: to clearly see EC and TC,

$$M_o\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = a \cdot b,$$

where

$$\begin{aligned} a &= \left(\frac{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)}\right), \\ b &= \left[\left(\frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}\right) \cdot \left(\frac{D_o^t\left(x^t, y^t\right)}{D_o^{t+1}\left(x^t, y^t\right)}\right)\right]^{\frac{1}{2}} \end{aligned}$$

which is equal to the following decomposition, the most common version suggested by Färe et al. (1994):

$$\begin{aligned} &\frac{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)} \cdot \\ &\cdot \left[\left(\frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}\right) \cdot \left(\frac{D_o^t\left(x^t, y^t\right)}{D_o^{t+1}\left(x^t, y^t\right)}\right)\right]^{\frac{1}{2}} \end{aligned} \tag{3}$$

where M_o represents total factor productivity (TFP) indicating output orientation, D are

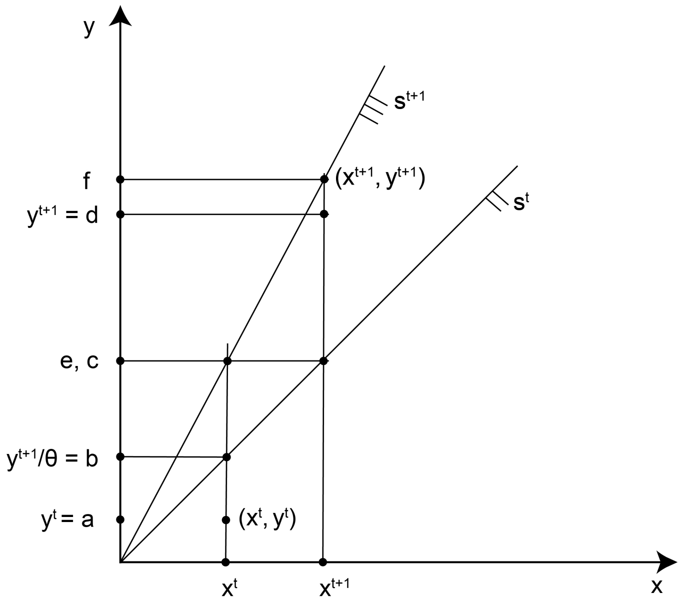

Fig. 1: The Malmquist output-based index of total factor productivity and output distance functions (Färe et al., 1994)

output distance functions, x represents all the inputs, y represents all the outputs for periods t and $t+1$, a stands for the EC between two chosen periods, and b denotes the geometric mean of TC. The EC can be further divided into scale efficiency change (SEC) and pure efficiency change (PEC). The former describes the extent to which the given decision-making unit (DMU) is close to or deviates from its most efficient scale size, and thus can produce at an optimal scale and at constant returns to scale. Hence, this measure considers the optimum size chosen previously to avoid inefficiencies from choosing a company that is either too large or too small. The product of these two change indices amounts to an efficiency change.

Therefore, it can be concluded that maximum productivity is reached when $D_o^t(x^t, y^t) = 1$, for which (x^t, y^t) must be located on the constructed technology frontier. Fig. 1 shows that when (x^t, y^t) are below the efficient production frontier S^t, they are technically inefficient. The frontier can be created by utilizing the "reciprocal of the greatest proportional increase in output(s) given input(s), such that output is still feasible" (Färe et al., 1994), which in the figure below is shown at y^t/θ^*, representing the "best practice" or greatest productivity. It is important to note that when constructing S^t for any time period $t = 1, \ldots, T$, where $x^t \in \mathbb{R}_+^N$, inputs are used to create $y^t \in \mathbb{R}_+^M$; therefore, $S^t = \left\{(x^t, y^t) : x^t \text{ can produce } y^t\right\}$. Two different time periods, t and $t+1$, were observed; thus, the two distance functions are as follows: $D_o^t\left(x^t, y^t\right)$ and $D_o^t\left(x^{t+1}, y^{t+1}\right)$. The values $\left(x^{t+1}, y^{t+1}\right)$ depict the "maximum proportional change in outputs" demonstrated by the distance function still "feasible in relation to the technology at t" (Färe et al., 1994). As illustrated below, S^t shows that a technical change occurred, leading to a shift in the production frontier S.

If $M_o^{t+1}\left(x^{t+1}, y^{t+1}, x^t, y^t\right)$ results in a value higher than 1, productivity growth is confirmed, while a value that equals 1 suggests stagnation, and a value lower than 1 suggests a decline in productivity levels.

3.1 Dataset

Longitudinal data between 2011 and 2021 were collected to analyze productivity levels. The data for the first analysis commences in 2011, the year during which the hotel industry started to rebound from the global financial crisis and ends in 2019, the last full year prior to the

Tab. 2: Structure of the sample (based on data provided by STR)

Variable	Code	Definition	Hotels	Observations
Urban	1	Densely populated location in a large metropolitan area	27	243
Suburban	2	Suburb of metropolitan area	36	324
Airport	3	Proximity to an airport	21	189
Interstate/Motorway	4	Proximity to a highway	0	0
Resort	5	Main source of revenue derives from leisure travel through the hotel's resort location	28	252
Small metro/town	6	Areas with either smaller population or limited services, in remote locations populated with less than 150,000 people	0	0
Size 1	1	< 75 rooms	0	0
Size 2	2	75–149 rooms	35	315
Size 3	3	150–299 rooms	43	387
Size 4	4	300–500 rooms	18	162
Size 5	5	> 500 rooms	16	144
Less than 10	1	Less than 10 years	24	216
Between 11 and 20	2	Between 11 and 20 years	43	387
Between 21 and 30	3	Between 21 and 30 years	35	315
More than 31	4	More than 31 years	10	90
Luxury	1	Top 15% average room rates	17	153
Upper-upscale	2	Next 15% average room rates	31	279
Upscale	3	Next 15% average room rates	36	324
Upper midscale	4	Next 15% average room rates	5	45
Midscale	5	Next 15% average room rates	0	0
Economy	6	Lowest 20% average room rates	23	207
Chain Owned and/or Managed	1	Properties are branded and operated by the chain	90	810
Franchised	2	Third party operator, which in exchange for certain fees is entitled to use the 'brand name, marketing and reservation services, etc.'	18	162
Independent	3	Independent hotel, non-affiliated	4	36

Tab. 3: Descriptive statistics of the variables for the 112 hotels, 2011–2019 (based on data provided by STR)

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Input variables					
Total room related expenses	1,008	4,046,892	4,696,496	203,691	29,041,947
Total labor costs	1,008	7,393,566	9,831,560	266,710	52,419,687
Total F&B costs	1,008	3,258,845	5,533,453	−38	32,448,883
Output variables					
Total sales	1,008	20,489,532	23,942,835	981,646	128,339,827
Accommodation revenue	1,008	14,474,530	15,130,263	967,311	97,404,329
F&B revenue	1,008	4,794,054	8,471,783	−2,368	49,933,329

outbreak of the pandemic. The second analysis compares the first two COVID-19 years with the two years prior to the outbreak. The author is grateful to STR LLC (STR), who provided all data used. Brand names, hotel operators, and property owners were omitted to honor the confidentiality agreement with STR. After the exclusion of STR categories for which no data were received, a sample size of 112 hotels was confirmed, which resulted in 1,008 observations during the first nine years of analysis, whereas for the second analysis, 112 hotels were used annually. Tab. 2 shows the structure of the sample.

Tab. 3 shows the variables used to estimate productivity scores based on data availability, as well as following previous studies. Data are expressed in USD.

4 RESULTS

4.1 Estimation of Productivity – Malmquist Index Prior to the Pandemic

Tab. 4 shows the results of the Malmquist productivity analysis. The index showing TFPC over the years 2011–2019 was decomposed into efficiency change and technical change; the former is further broken down into pure technical efficiency and SE change. Between 2011 and 2019, the cumulative productivity of the 112 hotels increased by 2%. This is partly due to technological development, implying the better use of existing technologies or system-related innovations, leading to a shift in frontier technology. This implies an improvement in efficiency, possibly due to superior investment planning or better organization of hotel operations. For the years during which efficiency change and technical change coincided, the best relative performance was achieved.

The value of technical change amounts to 1.013, which implies the application of advanced digital administrative tools and the accomplishment of technological milestones, such as a shift to self-service check-in processes or the introduction of CRM systems for better retention of customer data. With a mean value of 1.007, efficiency change is the less significant driver for TFP improvement, yet the > 1 result implies that the conversion of inputs into outputs occurred in a more efficient manner compared to the previous year and that the catch-up component is on the decline. This entails the dynamic allocation of employees within the departments based on each subdivision's requirements or a lower number of employees for the productive years, resulting in a better utilization of inputs. However, better results can be attributed to a longer average duration of stay, improved number of guests through better marketing, better overbooking practices, and better management of cancellation policies. In cases where efficiency expansion and technological deterioration coincided (only between 2014/2015 and 2017/2018), organizational advancements were almost certainly not achieved due to the application of new technologies. During these years, delays in adopting new technologies or the lack of employee training may have led to these results. For 2015/2016 and 2018/2019, the change in efficiency was negative, while technological improvements were observed. This may imply that some businesses failed to adopt the latest advances or displayed a lack of technical expertise in these years, possibly due to a shortage of training for the new systems. Furthermore, a principal-agent problem may be observed, implying a mismatch in management empowerment (Dalbor and Andrew, 2000). This may also be attributed to an asymmetric incentive system for employees, or a lack of incentives to improve output levels (Abdullah and Hamdan, 2012).

Considering the building blocks of efficiency change between 2011/2012, 2012/2013, and 2016/2017, an improvement in pure technical efficiency change was detected, implying that in other cases, attainable boundaries were not reached. In two years – 2015/2016 and 2018/2019 – the efficiency of scale pulls down overall efficiency change, implying a possible

Tab. 4: MPI summary of the annual means (based on data provided by STR)

Year	Efficiency change	Technical change (TE)	Pure technical efficiency (PTE)	Scale efficiency (SE)	Total factor productivity change (TFPC)
2011/2012	1.015	1.044	1.005	1.010	1.059
2012/2013	1.050	1.003	1.041	1.009	1.054
2013/2014	1.001	1.016	0.987	1.014	1.018
2014/2015	1.007	0.980	0.977	1.031	0.987
2015/2016	0.984	1.032	0.993	0.991	1.015
2016/2017	1.008	1.009	1.003	1.005	1.017
2017/2018	1.019	0.989	0.998	1.020	1.008
2018/2019	0.976	1.031	0.993	0.982	1.006
Mean	1.007	1.013	1.000	1.008	1.020

deficit in the size of the hotels investigated. This is further supported by the means of both pure and scale efficiency, where it becomes clear that the main contributor to efficiency change is scale efficiency, implying a failure to improve the organization of the inputs by managers related to the production process; hence, a negative learning curve is obtained. This may be due to a lack of marketing activities initiated, failure to demonstrate advancement in the quality of the hotel product offered, or other related improvements in organizational aspects associated with hotel management. For the years during which the value for efficiency related to hotel size is > 1, even smaller hotels could achieve economies of scale by showing an optimal relationship between demand and supply proportionally, or by having scaled down overhead services by sharing this function. It can be reasoned that this was due to the characteristics of the sample, which did not contain the smallest hotel category (0–75 rooms) and may have been the reason for the scale efficiencies showing relatively good results.

4.2 Estimation of Productivity – Malmquist Index During the Pandemic

Tab. 5 displays the results of the productivity analysis between the two pre-COVID years and two years after the outbreak of the pandemic.

Between 2018 and 2021, cumulative productivity of the 112 hotels increased by 9.8%. This growth can be mainly attributed to the performance of the analyzed hotels during the pandemic. There was an irregularly high increase in 2019/2020 (20.9%), which may be attributed to several factors. First, there was a large reduction in headcount in numerous hotels, while the Employee Retention Credit under the CARES Act strongly supported companies and individuals within the sector through a refundable tax credit of 50%, aiding the retention of employees in the sectors highly affected by the pandemic (Internal Revenue Service, 2022). Furthermore, numerous hotels offered limited services (e.g., minimizing non-monetarized services usually performed for regular guests, eliminating stay-over housekeeping services), leading to the complete elimination of costs associated with these labor-intensive services for a certain period of time. However, the large increase in the years 2019/2020 is mainly due to technical change (19%), hence the changes in technology deserve an improved focus. In both 2018/2019 and 2019/2020, TFPC was positive, mainly influenced by the positive technical change. This implies that, in these years, employees managed to use existing technologies in a better way and that innovations may have been introduced. This is in line with the expectation for 2019/2020, since many enterprises, including hotel companies, used the unexpected standstill for employee training and technology upgrades, when the lack of guests allowed for these improvements. In the following year, 2020/2021, only two

Tab. 5: MPI summary per year (based on data provided by STR)

Year	Efficiency change	Technical change (TE)	Pure technical efficiency (PTE)	Scale efficiency (SE)	Total factor productivity change (TFPC)
2018/2019	0.976	1.117	0.993	0.982	1.090
2019/2020	1.016	1.190	1.007	1.009	1.209
2020/2021	1.022	0.982	0.993	1.029	1.004
Mean	1.004	1.093	0.998	1.007	1.098

elements of TFPC were not positive, one of them being technical change, which is probably due to the high increase the year before and new employees hired mid-2021 – when domestic travel started to pick up – lacking the knowledge of operating existing and new technologies.

However, it must be noted that the overall efficiency change is slightly positive with a mean value of 1.004. This improvement is mainly due to the last year of analysis (2020/2021). These results may be due to the lower price sensitivity of guests arriving through domestic travel, as they would have been saving during the pandemic-imposed lockdowns. Furthermore, hotels may have used the time in 2020 to improve operations-related processes. Because of the lower number of hotel staff, it should also be noted that employees had to help out in departments other than their designated placement, leading to a more efficient use of existing resources rather than hiring and training new staff members. Similar to the pre-pandemic analysis, no period was observed in which both efficiency and technical change were positive. The mean value of technical change amounts to 1.093, which is the largest improvement among all the categories. This implies that hotels managed to reach technological milestones, resulting in a shift in the technological frontier. This may have included automating check-in processes, the use of mobile device-based keys, introducing QR codes for orders in hotel restaurants, just to name a few.

5 DISCUSSION AND CONCLUSIONS

This study measured the development of MPI during the pandemic in the US. MPI ensures that not only momentary performance is measured, but also that any change in performance is observed. Prior to the pandemic, a cumulative productivity increase of 2% was observed. By decomposing TFPC, it is concluded that the advancement was mainly due to TC, leading to a shift in the technology frontier. As for the building blocks of EC, the main negative driver was SE, which implies that hotels do not operate at an optimal scale. The first year of the pandemic (2020) drove productivity improvement in the period 2018–2021, as hotels were performing better by 9.8%. The improvement was mainly influenced by the technological innovations that hotels were forced to pursue. Ultimately, the research question is answered: the pandemic did have a positive impact on productivity levels, mainly due to the technological innovations that hotels were forced to adopt, and hence TC is the stronger driver of TFPC.

These findings are in line with previous studies and propose that technological innovations are crucial for rebounding from a crisis. The study's results can serve as a foundation for managers and strategists to enhance profitability by identifying and addressing weaknesses using the MPI. The productivity index is a powerful tool for tracking performance over time and identifying areas of weakness to enhance profitability.

5.1 Practical Implications

Decision-makers within the hotel industry should make it their priority to strive for productivity driven by service innovations, as this is crucial to remain competitive throughout crises that impact industries (Gössling et al., 2021). The requirements of the hotel industry are constantly changing as every competitor strives to achieve larger market share in pursuit of enhanced profitability. This study's findings provide indicators and benchmarks to strive for; however, industry managers who are tasked with implementing changes for better performance will require guidance to achieve these.

The findings clearly demonstrate that technological innovation drives productivity. To achieve revolutionary results in this area, managers should approach tech companies regarding collaboration and exclusive rights to field test pilot projects. Accordingly, hotels can test revolutionary technologies and systems, creating a win-win scenario for both parties. Hotels would save money in applying yet unknown and costly technologies, and actively participate in improving, thus creating new industry-specific technologies. Simultaneously, tech companies would receive first-hand feedback from field experience, speeding up the development process of new technologies.

Furthermore, it is crucial to forecast the future needs of travelers and re-evaluate hotels' current business models, as it is possible that they will no longer be sustainable within the next 10–15 years. Hence, to ensure continuous technological improvement that drives productivity, close collaboration with local and international tourist boards is recommended to receive guidance on market-related changes.

As hospitality is often referred to as a people's business, technological implementation needs to be undertaken carefully, as this may lead to further loss of staff, opening an even wider gap in the lack of a skilled workforce or creating negative guest sentiments leading to lower booking rates; hence, the co-existence of high-tech and a personal touch is crucial (Davari et al., 2022). Nevertheless, with innovative technology such as artificial intelligence (Im and Kim, 2022), even lower skilled staff can be assisted in day-to-day business, and guest satisfaction may be improved.

However, improving technical efficiency should not be neglected, as it can further drive TFP levels. One of these aspects is actively using crisis management tools, which are becoming increasingly important since changing cultural behavior necessitates actively working with these rather than simply ignoring them (Kim et al., 2021). These tools may have existed previously, especially in chain-affiliated hotels, but were mostly ignored as the industry was not facing a crisis to the extent presented by the COVID-19 pandemic. The implementation of such tools may not have an immediate impact; hotels benefit from these in urgent cases whenever a crisis arises and losses appear to a greater extent, thus managing challenges better than competitors. The use of these tools may be crucial to positively influence EC and to avoid the currently prevalent drastic short-term decisions taken to keep hotels financially stable, resulting in pay cuts, reduction of the workforce, and unpaid leave.

Hotels can also implement short-term actions to improve productivity levels. Managers must re-evaluate the allocation of available resources and become smarter to optimize the bottom line. One tool for this could be the tax saving aspect, which could also benefit the notorious post-COVID-19 staff shortage prevalent in the hotel industry. Hotels could work together with governmental organizations to find suitable employees among the government-subsidized group of employees (e.g., apprentices, the elderly, veterans, etc.). Thus, hotels would not only drive productivity levels through tax-saving effects (Kim et al., 2021) but would also contribute positively to improving community-relations. Further immediate actions have included the implementation of new hygiene technologies by large hotel chains (e.g., Hilton and Marriott), which would have otherwise taken years to install due to bureaucracy, such as the use of ultraviolet light and electrostatics. Revolutionary technologies that minimize social contact (e.g., self-service kiosks) have also been implemented in a timely manner. These implementations may not only lead to higher cleanliness and better social distancing practices, and therefore, higher guest satisfaction, but also to better booking rates when marketed and communicated correctly.

5.2 Theoretical Implications

This study makes three important contributions to the literature. First, it offers an up-to-date framework for managers to formulate recommendations aimed at avoiding the loss of customer base, similar to the approach taken by Bakar and Rosbi (2020), who explored strategies to prevent demand deterioration in the hospitality industry. Second, it provides researchers with an overview of how TC impacts hotel productivity over time in various geographic regions in the US. Finally, it offers empirical support for fundamental enhancements achievable through technological innovations.

These results can be used in conjunction with the scenario-based modelling introduced by Štumpf et al. (2021) to develop theoretical strategies. Secondly, this paper contributes to the literature comparing the current pandemic to previous crisis situations. In line with the findings of Gössling et al. (2021), this paper also concludes that the pandemic does not appear to have a long-lasting effect on the industry. Third, the ideas proposed in this study are valuable additions to the literature on productivity development in the hotel sector during the pandemic, emphasizing the significance of technological improvements, similar to the work of Scholz et al. (2022), who introduce technology supporting green initiatives.

5.3 Limitations and Future Research

As with other scientific studies, this study has some limitations. First, the analysis was only conducted in the United States. Despite its undisputed importance, for the sake of generalizability, analysis should be extended to other geographical regions in the scope of future research. Second, only secondary financial data were obtained, which do not reflect the intangible characteristics of the hotels. Hence, the author recommends complementing the use of tangible data by intangible measurements, especially in areas which have severely been affected by the pandemic. In numerous regions, the pandemic has induced socio-economic changes in various fields, e.g. the already vulnerable labor market and thus where the improvement in productivity does not only result from revitalizing guest demand. Finally, due to the cumulative nature of MPI, patterns and sources of productivity change may be concealed, while the non-parametric nature of the DEA method renders this framework vulnerable to sample assumptions (Tzeremes, 2021).

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