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A two-stage data envelopment analysis approach to productivity, efficiency and their sustainability in the hotel industry of Tunisia

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Abstract
Integrating sustainable practices to hotel industry is crucial to overall business and environmental sustainability. The productivity, efficiency, and their sustainability in hotel industry of Tunisia (years: 2014–2015) is analyzed using two-stage Data Envelopment Analysis. The study employed a bootstrapping method to correct possible bias associated with the efficiency scores. Tobit regression analysis was used to find the relationship between efficiency and sustainability indicators. In addition, Malmquist productivity index was adopted to estimate productivity. A comparison is done on the efficiency and productivity of touristic regions of Tunisia and the effect of the sustainability indicators like water consumption, tourism gross domestic product and poverty rate. Results show that Tunisian hotel industry has experienced decline in efficiency from 2014 to 2015. Further analysis shows that operational inefficiency is the root-cause of the underperformance rather than scale inadequacy. Water consumption and direct contribution of tourism to gross domestic product has a positive impact on the efficiency of the country's hotel industry. Poverty rate negatively affects the efficiency of the country's hotel industry. Integrated practices with operational improvement and sustainability practices are recommended as policy mechanism. To support required water and sustainability, water-recycling plants are also suggested, coupled with Corporate Social Responsibility projects.

Keywords Productivity · Efficiency · Sustainability · Data envelopment analysis (DEA) · Tobit regression · Tunisia

1 Introduction

The major macroeconomic goal of every state is to achieve stable economic growth with the complementary factor of full employment, exchange rate and price stability along with a favourable balance of payment amidst strong investment and drives (Jhingan 2012; Iheonu et al. 2020). In recent time, the Tunisian economy has been largely dependent on oil

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and agriculture over the years, thus adversely affecting the performance of other sectors of the economy (Djebali and Zaghdoudi 2020). The susceptibility of oil prices to global fluctuation has hampered economic development globally. The quest for global economic prosperity has consequently inform the diversification policy especially in the tourism industry of most economies (where hotel services has been a major part) as well as other sectors of the economy (WTTC 2018). The hotel industry is the foremost and paramount part of the tourism service industry, providing lodging and accommodation for a relatively short period at a particular price (Chan 2005). Most often, hotels make available diverse services to its guests to ensure that the satisfaction of its customers is guaranteed. Such services ranges from restaurants to entertainment and relaxation. Hotel businesses are known for their rapid growth and ubiquity and thus constitutes an indispensable sector to the tourism industry (Chan 2005).

In the case of Tunisia, the tragic events of the 2015 Tunis museum and Sousse resort terror attacks that claimed the life of several people hampered the country's tourism sector. The country's tourism economy was devastated and thus created a daunting challenge for the Tunisian government, especially in terms of revenue generation. It was reported that the resultant effect caused a significant decline in Revenue Per Available Room (RevPAR) following the March 2015 Tunis Museum attack (Jeffrey and Bleasdale 2017) which worsened after the Sousse attack that June. In 2017, business tourism accounted for 41% of tourism activity in Tunisia (WTTC Report 2018), an activity that is being developed and perpetuated with the rise of the hotel industry and increase in demand for medical tourism, which makes use of the same hotel infrastructures. To achieve the goal of economic growth and stability from the perspectives of the hotel industry, the question of productivity, efficiency and sustainability becomes crucial. Quality of service and customer satisfaction is key in the hotel industry. They are not only responsible for the high consumption of resources such as water, electricity, and fuel, but are also huge producers of waste such as waste-water, solid waste, and greenhouse gases with negative impact on the environment.

Measuring efficiency and productivity is a standard practice in the hotel industry (Kirillova et al. 2020; Ponting 2020). Efficiency connotes the relationship between inputs and outputs during operation. Reliable efficiency assessment is a prerequisite for effective strategic decision-making and sustainable planning (Hsieh and Lin 2010). An accurate measure of efficiency highlights potential optimal resource allocation, thus providing improvement targets for management and strengthen competitive advantages. Moreover, benchmarking has been regarded as a useful tool for identifying the best management practices geared towards effective practices (Hsieh and Lin 2010). The activities of the hotel industry have been critical, given the growing environmental challenges such as resource (water and energy) depletion, global warming, soil pollution, deforestation, and increase of carbon emission (Shieh 2012; Cop et al. 2020). Therefore, assessing the sustainability of the hotel industry, given its productivity as reflected by revenue generation and efficiency in the use of resources is a focal point of this study. Li et al. (2019) and Çop et al. (2020) suggested green practices that should be implemented in hotels to increase their environmental performance.

Based on these aforementioned motivations, this study utilize the robust data envelopment analysis (DEA) method in two stages (Two-stage DEA) to evaluate the efficiency, productivity and sustainability of the hotel industry in Tunisia. Although Aissa and Goaied (2016) employed the DEA to examine the role of managerial efficiency in the profitability of hotel industry in Tunisia, the current study is an improvement on Aissa and Goaied (2016), thus making a more profound contribution to the existing literature. Importantly, the Tobit regression analysis and Malmquist productivity index analysis were further

employed in addition to the DEA approach, thus providing a robust result. In specific, while the Tobit regression analysis was utilized to establish the relationship between efficiency and sustainability indicators, the Malmquist productivity index was adopted to estimate productivity of the tourism industry in Tunisia. The case of Tunisia is considered in this study because of the challenges associated with the country's tourism industry in recent years despite the stakeholders' desire to pursue growth of the industry (Aissa and Goaied 2016). Thus, in a rare approach, the current study seek to provide relevant information and policy guide on the productivity, efficiency, and sustainability of the hotel industry in Tunisia.

The remainder of this paper is sequentially arranged: Sect. 2 contains a brief literature review on efficiency, environmental sustainability, and green management practices in the hotel industry. Section 3 highlights the adopted data and research methodology. The results and discussions are presented in Sect. 4, with conclusions in Sect. 5.

2 Literature review

This section presents literature on hotel industry efficiency, productivity and sustainability, which are divided into three major categories: (1) hotel industry and sustainable environment; (2) measuring the productivity and efficiency of hotel industry using DEA; and (3) measuring environmental performance in hotel industry using DEA.

2.1 Hotel industry and the sustainable environment

Various studies have been carried out to analyse the existing relationship between the hotel industry and the environment, this relationship relay the impact and contributions of the industry to the environment. Trung and Kumar (2005) analysed resources, usage, and their management in the hotel industry in Vietnam, adopting the surveys design where 50 hotels were studied. Water and energy consumption and waste generation in hotels information were obtained by the surveys. Country based comparison of resources consumption were analysed, whilst different efficient and inefficient environmental practices in the surveyed hotels were addressed. The findings of their study showed that the hotels in Vietnam engages in activities with higher consumption of water resources compared to the hotels in other countries.

Phu et al. (2018) studied 102 hotels in Vietnam tourism city, and thus collected solid waste samples to analyse waste attributes and different management practices set in place in the Vietnamese hotel industry. The data collection was employed using interview method and the collected data were treated using statistical analysis. Result show that the average generated waste and the rate of waste management practices are relatively proportional to the hotel size and internal factors, respectively. Carbon footprint of different types of hotels is considered to be proportional to the service level of the hotel. It is further opined that on the average, electricity and fuel consumption are proportional to the star rating and occupancy rate of the hotel.

Various studies were undertaken to assess the willingness of the hotel industry to adopt practices and technologies that are considered to be environmentally friendly. Mak and Chang (2019) investigated environmental practices in Taiwan to ascertain the factors that promote or deter the efficient implementation of sustainable programs in the hotel industry. 21 environmental strategies were identified from 14 key dimensions and 8 of these

strategies were asserted to be low cost. Chan et al. (2020) also investigated the barriers preventing the adoption of environmental technologies in hotel industry in Hong Kong. They found that 7 barriers are hindering effective implementation of environmental friendly practices.

The question of sustainable environment through the activities of the hotel industry has been analysed by various researches especially in the aspect of green practices in hotels. Al-Aomar and Hussain (2017) ascertain green practices across hotel supply chain in United Arab Emirates (UAE). Hotels were randomly selected and it was concluded that green practices and environmental consciousness is a common practice in in UAE hotel industry. Also, various models of green practice adoption were developed with the aim of identifying the impact it has on independent hotels. To test one of the model a study was carried out in Spain and Chile, 12 hotels were selected from both countries, which were considered as mature tourist destination in Spain and 12 as an emerging destination in Chile. The study showed that both destinations are adopting green practices, but each in a unique way (Alonso-Almeida et al. 2017).

An evaluation and comparison tool of the environmental performance of hotel supply chain using Fuzzy technique was developed using TOPSIS method. The findings showed that there is no single strategy to improve the environmental performance of a hotel (Sari and Suslu 2018). In the same vein, Hsiao et al. (2014) developed a tool to evaluate green hotels in Taiwan by constructing environmental management system (EMS) indicators. The EMS characteristics were underpinned by conducting Delphi method on 25 experts. They found 64 indicators categorized in 10 dimensions, of which 38 indicators were found to be suitable for Taiwan's hotel industry.

2.2 Measuring productivity and efficiency of hotel industry using DEA

The productivity and efficiency in the hotel industry using DEA method was first employed by Parkan (1996) using its monthly activities. The hotel industry performance was measured by Total Factor Productivity (TFP), Operational Competitiveness Rating (OCRA), Cost/Revenue Ratios, and DEA method. The inputs and outputs used were: Personnel, Supplies, Administration, Marketing, Maintenance and Utilities and taxes, Room sales, Telephone calls, Laundry services, Soft drinks sales and Miscellaneous. The findings of the study from the OCRA method, TFP method and Cost/revenue Ratios method are homogeneous in relation to one another, whereas DEA's results are considered different from the other methods. Johns et al. (1997) benchmark hotel productivity in 4 quarters by using the annual available data of 15 hotels from the same chain. Four inputs (Number of room night's available, total labour hours, total F&B costs, total utilities costs) and three outputs (Number of room nights sold, Total covers served, Total beverage revenue) were selected for the study. Barros (2005) used DEA to benchmark 43 hotels in Portugal using data from 2001. The selected inputs are Full time workers, Cost labour, Rooms, Surface area of the hotel, Book value of property, Operational costs and External costs while outputs are Sales, Number of guests and Nights spent. The study reveals a high overall efficiency of the hotels, as for the less efficient ones, references were identified to improve their efficiency. The study also suggests that economy of scales and location have a crucial impact on the efficiency of hotels.

Hsieh and Lin (2010) used relational network DEA in hotel industry to ascertain the efficiency and productivity in the industry. Data was obtained from 57 international tourist hotels in Taiwan from the year 2006 and were grouped according to their management type

and location. Hotel industry service production efficiency was measured using inputs such as Accommodation costs, Employees of the accommodation department, catering costs, Employees of the catering department and Rooms and Catering floors as intermediate outputs. Next, they measured the service consumption effectiveness using Rooms and Catering floors as inputs and Revenue of accommodation and Revenue of catering as outputs. Finally, they measured the hotel's service production effectiveness, with the overall performance of the hotel. The findings of their study reveals that only few hotels have had high service production efficiency and that the location and the type of management of the hotel affect the service production efficiency and overall performance, respectively.

2.3 Impact of environmental practices on the efficiency of hotel industry using DEA

In recent times, there has been continuous clamour for a favourable and sustainable environment given the increase in environmental pollution. Studies have been conducted using DEA to analyse the impact of sustainable and environmental practices on the global hotel industry. Shieh (2012) investigated the relationship between environmental practices and cost efficiency in international tourist hotels in Taiwan. In the first stage, DEA was used to obtain the cost efficiency of the hotels, inputs include: Rooms, Employees, Floor space of catering division, Price of room, Price of labour and Price of Food & Beverage, while outputs are Food &Beverage revenue, Room revenue and other revenues. To ascertain the relationship between cost efficiency and six environmental variables which are; location type, operation type, nearest distance to international airport, occupancy rate and the degree of green practices, the Tobit regression was adopted in the second stage of analysis. The result of the study reveals the presence of negative relationship between environmental practices and cost efficiency.

Kularatne et al. (2019) test for the effect of environmental variables on the technical efficiency of the hotels in Sri Lanka. They adopted the DEA method in the first stage to ascertain the technical efficiency using Number of employees, Number of rooms, and Book value of assets as inputs, with Room revenue and other revenues as outputs. Truncated regression was used in the second stage to test for the effects of 7 contextual variables; Age, Star, Size and Type of hotel, as well as Energy efficiency, Water consumption. The result of the study shows that the majority of hotels in Sri Lanka were experiencing a negative productivity growth from 2010 to 2014. The study further suggest that hotel efficiency is positively affected by energy efficiency and waste management. Whereas, water consumption negatively affects hotel efficiency. Ramanathan et al. (2016) employed the DEA to investigate the effect of marketing capabilities, operations capabilities, environmental capabilities, and diversification strategy on hotel performance in the United Kingdom (UK). The result of the regression analysis showed that hotels performance in the UK were positively impacted by operations and environmental capabilities. Hotels were negatively impacted by marketing capabilities, while diversification strategy seems to have no effect on hotel performance.

Few studies in the literature have analysed environmental productivity in hotel industry. Chen (2019) adopted the Malmquist index to measure the productivity of 45 luxury international hotels in Taiwan from 2003 to 2007. Number of rooms, catering area, Number of employees and Annual expenses were considered as inputs, while output include revenue per room, profit per room, and energy equivalent carbon emissions as undesirable output. The result of Chen study reveal that hotel chains benefit from higher environmental performance and brand value, when they account for their carbon emission, compared

to independent operators. Peng et al. (2017) found out that there is an increasing rate of eco-efficiency in the tourist destination. It was further revealed that the eco-efficiency was negatively impacted by investment levels, and the standard discharger rate had no significant impact on it, as for the rest of the factors, they all had a positive impact on the hotel efficiency.

3 Data and methodology

3.1 Data

The Tunisian hotel industry had brilliant experiences in the years leading up to the political tensions of 2010. This was because of its cultural and historical richness and having both of the Mediterranean and desert climates. In 2013–14 new structural reforms were introduced to improve the hotel industry of Tunisia such as investment agreements with famous hotel chains in the hotel industry and paying attention to regional and natural infrastructures and environmental issues. Effects of the changes emerged at the beginning of 2014. Therefore, to determine the efficiency and productivity in each tourist region in Tunisia the data used are in line with previous studies mentioned in the literature for 2014–2015. To ensure robustness of DEA efficiency models, the rule of thumb for number of DMUs should be two times the products of inputs and outputs. Therefore, the minimum acceptable number of DMUs is 8. The study utilizes a meta-frontier of twenty DMUs in 2014–2015.

The data used are in line with previous studies mentioned in the literature. Two inputs; Total number of hotels and Total number of beds, and two outputs; Occupancy rate and Total number of nights spent are used to estimate efficiency and productivity (Hsieh and Lin 2010; Tarim et al. 2000; Yin et al. 2020). Subsequently, possible bias of efficiency score was corrected using bootstrapping method of Simar and Wilson's (1998). Relationship between the hotel industry and sustainability in Tunisia was analysed using three factors related to the pillars of sustainability; water consumption is related to the environmental pillar, poverty rate is related to the social pillar, and the direct contribution of tourism to GDP to the economic pillar. The contribution of tourism to GDP in each tourist region was estimated by giving weights to each region based on its hotel industry efficiency. The direct contribution of tourism to Gross Domestic Product (GDP) is measured as a share of GDP..Data were collected from the website of The World Bank (World Bank 2018). Information about the GDP for each of the years 2014 and 2015 were collected from an open data platform named Knoema (KNOEMA 2019). For the data on the water consumption by tourism sector in each tourist region per year were obtained from website of the national company of water exploitation and distribution in Tunisia (SONEDE 2015). Tobit regression model is used to determine the relationship between hotel industry efficiency and each of the aforementioned factors, using 1000 replications.

3.2 Methodologies

In this section, the procedures employed for the investigation is provided in a particular order. The first DEA bootstrapping method is considered in the first approach. This method is followed by Tobit regression analysis and later by the use of Malmquist productivity index.

3.2.1 Data envelopment analysis bootstrapping

Data Envelopment Analysis (DEA) is a nonparametric linear programming method for evaluating efficiency of systems known as decision making units (DMUs). DEA was introduced by Charnes et al. (1978) through the CCR model under constant return to scale (CRS). Banker et al. (1984) modified the model to include variable return to scale (VRS). DEA has been applied in various sectors including healthcare (Ibrahim and Daneshvar 2018), resource and sustainability (Ibrahim et al. 2019b) among others. The CCR and BCC models are adopted in this study to capture both CRS and VRS characteristics of the industry. The mathematical model is developed as follows:

Assume n homogeneous DMU_j in a production possibility set (PPS) with m nonnegative inputs x_{ij} for $i=1,\ldots,m$ converted into s non-negative outputs y_{rj} for $r=1,\ldots,s$. DMU_o is the DMU under evaluation where; y_{ro} is the amount of output r produced by DMU_o x_{io} is the amount of input i consumed by DMU_o y_{rj} is the amount of output r produced by DMU_j x_{ij} is the amount of input i consumed by DMU_j u_r are the weights of output r for $r=1,\ldots,s$. v_i are the weights of input i for $i=1,\ldots,m$. θ_o is the efficiency value of DMU_o λ is a semi-positive vector in R^n. The set of DMUs in PPS is represented in output oriented CCR model as follows:

$$PPS_C = \left\{ (X,Y) | X \geq \sum_{j=1}^{n} \lambda_j Y_j, \lambda_j \geq 0, j = 1, \ldots, n \right\}$$

and PPS for the BCC output oriented models is:

$$PPS_B = \left\{ (X,Y) | X \geq \sum_{j=1}^{n} \lambda_j X_j, Y \leq \sum_{j=1}^{n} \lambda_j Y_j, \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0 j = 1, \ldots, n \right\}$$

Model (1) and (2) presents the linear programming CCR and BCC model respectively.

$$Max\, \theta_0$$

$$Subject\ to:$$

$$\begin{aligned} &\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io}, \quad i = 1, \ldots, m \\ &\sum_{j=1}^{n} \lambda_j y_{rj} \leq \theta_0 y_{ro}, \quad r = 1, \ldots, s \\ &\lambda_j \geq 0 \qquad\qquad j = 1, \ldots, n \end{aligned} \tag{1}$$

$$Max\, \theta_0$$

$$Subject\ to:$$

$$\begin{aligned}
&\sum_{j=1}^{n} \lambda_j x_{ij} \le x_{io}, \qquad i = 1, \ldots, m \\
&\sum_{j=1}^{n} \lambda_j y_{rj} \le \theta_0 y_{ro}, \quad r = 1, \ldots, s \\
&\sum_{j=1}^{n} \lambda_j = 1 \qquad\qquad j = 1, \ldots, n \\
&\lambda_j \ge 0 \qquad\qquad\quad j = 1, \ldots, n
\end{aligned} \tag{2}$$

Each ***DMUo*** is evaluated individually and obtains an efficiency value $\boldsymbol{\theta o}$ ranging between 0 and 1. A DMU is said to be efficient when; $\theta^* = 1$, $\lambda_o = 1$, $\lambda_j = 0$ (*For* $j \neq o$).

Simar and Wislon (1998) introduced DEA bootstrapping, which does not only correct the efficiency scores bias, but also solves the correlation problems of the efficiency and provides accurate conclusions in explaining the determinants of the DEA efficiency. The DEA efficiency bootstrapping algorithm of Simar and Wilson (1998) is summarized in the following steps;

1. The efficiency $\widehat{\boldsymbol{\theta}_{\boldsymbol{k}}}$ where $\boldsymbol{k = 1,\ldots,n}$ is computed by solving the linear program;

$$\widehat{\boldsymbol{\theta}_{\boldsymbol{k}}} = \min \left\{ \theta \middle| y_k \le \sum_{i=1}^{n} \gamma_i y_i;\ \theta x_k \ge \sum_{i=1}^{n} \gamma_i x_i;\ \theta > 0; \right.$$
$$\left. \sum_{i=1}^{n} \gamma_i = 1;\ \gamma_i \ge 0;\ i = 0, \ldots, n \right\}$$

2. Obtaining $\theta_{1\boldsymbol{b}}{}^*, \ldots, \theta^*{}_{\boldsymbol{nb}}$ by generating a random sample of size $\boldsymbol{n}$ from $\widehat{\boldsymbol{\theta}_{\boldsymbol{i}}}$ where $\boldsymbol{i = 1,\ldots,n}$
3. The bootstrap sample data $\boldsymbol{x_b^*} = \left\{ (\boldsymbol{x_{ib}^*},\ \boldsymbol{y_i}) \boldsymbol{i} = \mathbf{1}, \ldots, \boldsymbol{n} \right\}$ is computed where

$$\boldsymbol{x_{ib}^*} = \left(\widehat{\boldsymbol{\theta}_{\boldsymbol{k}}} \Big/ \boldsymbol{\theta_{1b}^*} \right) \boldsymbol{x_i},\ \boldsymbol{i} = \mathbf{1}, \ldots, \boldsymbol{n}$$

4. The bootstrap estimate $\widehat{\boldsymbol{\theta}_{\boldsymbol{k,b}}^*}$ of $\widehat{\boldsymbol{\theta}_{\boldsymbol{k}}}$ for $\boldsymbol{k = 1,\ldots,n}$ is computed by solving;

$$\widehat{\boldsymbol{\theta}_{\boldsymbol{k,b}}^*} = \min \left\{ \boldsymbol{\theta} \middle| y_k \le \sum_{i=1}^{n} \gamma_i y_i;\ \theta x_k \ge \sum_{i=1}^{n} \gamma_i \boldsymbol{x_{k,b}^*} x_i;\ \theta > 0; \right.$$
$$\left. \sum_{i=1}^{n} \gamma_i = 1;\ \gamma_i \ge 0;\ i = 0, \ldots, n \right\}$$

5. The steps 2 to 4 are repeated $\boldsymbol{B}$ times to obtain for $\boldsymbol{k = 1,\ldots,n}$ a set of estimates

$$\widehat{\boldsymbol{\theta}_{\boldsymbol{k,b}}^*}, \boldsymbol{b} = \mathbf{1}, \ldots, \boldsymbol{B}$$

According to previous studies, a number of replications ($\boldsymbol{B}$) equal to 1000, covers the confidence intervals adequately. In this study, 200 replications are used in the DEA bootstrapping algorithm, which is the standard number of replications for the DEA package for Matlab (Alvarez et al. 2016). The bias-corrected efficiency scores and 95% confidence intervals are computed on Matlab.

3.2.2 Tobit regression analysis

Tobit regression model is used to find the relationship between the dependent viable and the independent variables. The relationship between the efficiency of the hotel industry and some of the selected sustainability factors is measured. The three selected factors are:

Water consumption (in Mm^3), Poverty rate (for Poverty rate $\leq 9.8\%$ a value of 0 is given and for Poverty rate $> 9.8\%$ a value of 1 is given) and the share of tourism in GDP.

The regression model used in this study is expressed as:

$$\beta.E_I = \beta_0 + \beta_1 Var1_i + \beta_2 Var2_i + \beta_3 Var3_i + \mu_i \tag{3}$$

where;

$\beta.E_I$: bootstrapped efficiency for each DMU.
β_0: constant.
β_1, β_2 and β_3: coefficients measured by the Tobit regression.
$Var1_i$: water consumption variable for each DMU.
$Var2_i$: poverty rate variable for each DMU.
$Var3_i$: direct contribution of tourism to GDP variable for each DMU and.
μ_i represent the stochastic or random term that are not captured by the model.

3.2.3 Malmquist productivity index

Malmquist Productivity index (MPI) is employed to measure the productivity of the hotel industry. MPI is largely applied in the hotel industry; (Tzeremes 2020) and Healthcare industry (Ibrahim et al. 2019a). It was, first, introduced by Caves et al. (1982). It was later improved by Färe et al. (1994) to be employed in DEA. To compute MPI, two periods (2014–2015) required to compare productivity change.

The output-oriented Malmquist index is defined as;

$$\begin{aligned} M_0^t(x^t,\ y^t,\ x^{t+1},\ y^{t+1}) &= \Delta T(x^{t+1},\ y^{t+1}) \cdot \Delta TE(x^t,\ y^t,\ x^{t+1},\ y^{t+1}), \quad t = 1, \ldots, T-1 \\ &= \left[\frac{D_0^t(x^{t+1},\ y^{t+1})}{D_0^{t+1}(x^{t+1},\ y^{t+1})}\right] \cdot \left[\frac{D_0^{t+1}(x^{t+1},\ y^{t+1})}{D_0^{t+1}(x^t,\ y^t)}\right] \end{aligned} \tag{4}$$

The input-oriented Malmquist index is;

$$M^{t,\,t+1} = \left[\frac{D^t(x^{t+1},\ y^{t+1})}{D^t(x^t,\ y^t)} \cdot \frac{D^{t+1}(x^{t+1},\ y^{t+1})}{D^{t+1}(x^t,\ y^t)}\right]^{1/2} \tag{5}$$

MPI estimates change in productivity over two periods. MPI = 1 signifies increase in productivity, MPI < 1 shows a regress in productivity, and MPI = 1 indicates constant productivity between the periods.

Malmquist productivity is the product of efficiency change and technical change. Efficiency change demonstrate how close did the DMU move to the production frontier. As for the technical change, it shows the change of the PPS.

4 Result and discussion

4.1 DEA efficiency analysis

Table 1 shows the descriptive statistics of inputs and outputs used in the efficiency analysis. Figure 1 illustrates the average efficiency for 2014 and 2015 for Tunisian hotel industry. The overall Tunisian hotel industry showed a decrease in all forms of

Table 1 Descriptive statistics of inputs/outputs

Variable	Min		Max		Mean		Std. Dev	
	2014	2015	2014	2015	2014	2015	2014	2015
Occupancy rate	17.1	7.1	59.9	30.2	37.15	19.98	15.22	5.97
Nights spent	5700	3800	6,794,400	3,108,900	2,253,427	1,015,391	2,289,058	1,039,697
Number of hotels	14	13	172	167	77.09	78.36	50.12	50.02
Number of beds	616	570	56,349	57,125	21,828.5	21,944.7	17,585.02	17,811.2

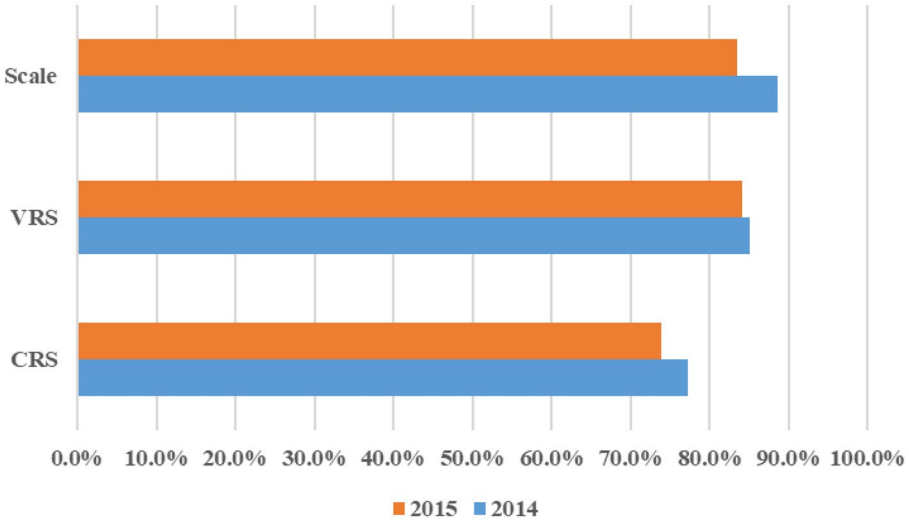

Fig. 1 Average efficiency of Tunisian hotel industry (2014 and 2015)

efficiency. However, average scale efficiency infers that, the cause of inefficiency is operational inefficiency rather than scale inefficiency.

Table 2 presents the conventional DEA efficiency score for individual tourist regions (Tunis-Zeghouan, Nabeul-Hammamet, Sousse-Kairouan, Yassmine Hammamet, Mounastir-Skanes, Mahdia-Sfax, Jerba-Zarzis-Gabes, Gafsa-Tozeur, Sbeitla-Kasserine, Bizerte-Beja, and Tabarka-Ain Draham.), while Table 3 shows the DEA-bootstrap efficiency with 95% confidence interval. The bias-corrected efficiencies shows bootstrapped efficiency scores are smaller when compared to the ordinary efficiency scores. This therefore connotes that the result of CCR model which shows 100% efficient DMUs has lower efficiencies ranging from 75 to 88% when the bootstrapped efficiency was used. It is imperative to note that by comparing the average original efficiency and the average bootstrapped efficiency, the result reveals that original efficiency mean for 2014 seems better than 2015, as the difference of bootstrapped means for each year is small and the mean of 2014 is slightly better than 2015. As for the models, BCC model showed a better overall efficiency of the DMUs compared to CCR in both 2014 and 2015. Moreover, the upper bound of 95% confidence intervals is strictly smaller than 1, which means that

Table 2 DEA efficiency score for Tourist regions

	CCR		BCC		Scale	
Tourist regions	2014 (%)	2015 (%)	2014 (%)	2015 (%)	2014 (%)	2015 (%)
Tunis-Zeghouan	53.8	76.4	57.0	77.3	94.3	98.9
Nabeul-Hammamet	73.8	62.6	76.1	85.8	97.0	73.0
Sousse-Kairouan	100.0	100.0	100.0	100.0	100.0	100.0
Yassmine Hammamet	89.9	100.0	90.0	100.0	99.8	100.0
Mounastir Skanes	100.0	76.9	100.0	79.9	100.0	96.3
Mahdia-Sfax	94.8	68.2	100.0	68.2	94.8	92.5
Jerba-ZarzisGabes	91.4	87.7	100.0	100.0	91.4	87.7
Gafsa-Tozeur	21.7	12.0	44.9	27.3	48.4	44.2
Sbeitla-Kasserine	100.0	100.0	100.0	100.0	100.0	100.0
Bizerte-Beja	62.6	59.5	82.1	87.1	76.2	68.3
Tabarka-Ain Draham	62.1	68.3	85.8	100.0	72.3	56.8

Table 3 DEA-bootstrap efficiency with 95% confidence interval

	CRS		VRS	
Tourist regions	2014 (%)	2015 (%)	2014 (%)	2015 (%)
Tunis-Zeghouan	49.3	68.8	52.3	70.5
Nabeul-Hammamet	65.9	54.0	69.9	79.2
Sousse-Kairouan	88.5	85.5	90.1	87.1
Yassmine Hammamet	77.0	82.2	82.3	88.5
Mounastir Skanes	82.7	64.3	88.2	72.7
Mahdia-Sfax	86.0	61.1	90.1	67.6
Jerba-ZarzisGabes	82.3	76.8	86.5	86.3
Gafsa-Tozeur	19.1	10.6	41.4	25.0
Sbeitla-Kasserine	75.8	74.0	84.3	83.4
Bizerte-Beja	54.0	49.8	75.3	78.7
Tabarka-Ain Draham	54.5	48.4	79.4	88.6

a DMU cannot be 100% efficient, because there are many other variables that affect its efficiency that were not considered by the study.

In the quest for more income generation in the Tunisian economy, the tourism industry has been a significant contributor to its GDP. It is vital to note that tourist activities are affected by socioeconomic and security conditions, and thus fluctuates with the state of security and social stability of the regions. In 2014, the tourist regions with the most efficient hotel industries based on the CRS assumption with a bias-corrected efficiency are; Sousse-Kairouan with 88.51%, Mounastir-Skanes with 82.70% and Sbeitla-Kasserine with 75.83%. On the other hand, the least efficient hotel industry was in the region Gafsa-Tozeur with 19.11%. In 2015, the most efficient hotel industries were in the regions; Sousse-Kairouan which decline to 85.51%, Yassmine Hammamet had a 5% increase and Sbeita-Kasserine declined. Monastir-Skanes, was a tourist region with an efficient hotel industry, dropped to 64.34%. The best performing tourist regions based on VRS bootstrap DEA

were; Sousse-Kairouan with 90.11%, Mahdia-Sfax with 90.05%, Mounastir-Skanes with 88.17%, Jerba-Zarzis-Gabes with 86.51% and Sbeitla-Kasserine with 84.17%. The region with the least efficient hotel industry was Gafsa-Tozeur with 41.41%. For the year 2015, the most efficient hotel industry regions were; Tabarka-Ain Draham which rose from 79.43 to 88.64%, Yassmine Hammamet which rose from 82.29 to 88.54%, Sousse-Kairouan which declined to 87.07%, Jerba-Zarzis-Gabes which was almost constant (86.33%) and Sbeitla-Kasserine which declined to 83.4%. Gafsa-Tozeur, remained as the tourist region with the least efficient hotel industry, with a drop of efficiency to 24.98%. Monastir-Skanes and Mahdia-Sfax, which were efficient in 2014, experienced a decrease in efficiency to 72.66% and 65.59%, respectively.

The political instability and the safety concerns affected the tourism sector during the period of study. This explains why Tunis and the Sousse region hotel industry experienced inefficiency due to the terror attack of 2015 (Financial Times, 2018). The Gafsa-Tozeur tourist region which is located in the Sahara Desert, which is known for its difficult weather conditions, water scarcity and undeveloped and isolated condition experience a very low efficiency of the hotel industry which is attributed to it geographic characteristics. However, the coastal areas were found to be most efficient because of their moderate weather, which is less harsh than the desert weather and are thus the regions with the most efficient hotel industry.

4.2 Tobit regression analysis

The Tobit regression model is used in this study to measure the relationship between the bootstrapped efficiency and three variables, which are the water consumption by the tourism sector (Var1), poverty rate (Var2), and the direct contribution of tourism to GDP(Var3). Tobit regression for the CCR model shows that water consumption by the tourism sector and direct contribution of tourism to GDP has a positive impact on the efficiency, while poverty rate has a negative impact on the efficiency.

It can be deduced that the results on the Var2 and Var3 of CCR and BCC models are similar. The result of Var1 in Table 4 for CCR model shows a positive impact but in Table 5 this impact for BCC model is negative with very small negative coefficient and relatively small Z-statistic (in comparison with other Z values). This may occurred because of the convexity restriction of BCC model and statistically nonsignificant coefficients. So it can be concluded that under both CRS and VRS assumptions, tourism GDP has (significantly) positive impact, poverty rate has (significantly) negative impact and water consumption (almost significantly) has positive impact on the efficiency of the hotel industry.

Table 4 Tobit regression for CRS efficiency

	Observed Bootstrap		Normal-Based (0.05 significance)			
Variables	Coefficient	Standard error	Z-statistic	*P*-value	Lower bound	Upper bound
Var1	0.0252	0.0242	1.04	0.297	−0.0222	0.0726
Var2	−0.0573	0.0573	−1	0.317	−0.1695	0.0549
Var3	0.8161	0.1312	6.22	0	0.5589	1.0733
Constant	0.0560	0.1186	0.47	0.637	−0.1764	0.2883
Sigma	0.1079	0.0139	–	–	0.0807	0.1351

Table 5 Tobit regression for VRS efficiency

	Observed Bootstrap		Normal-Based (0.05 significance)			
Variables	Coefficient	Standard error	Z-statistic	*P*-value	Lower bound	Upper bound
Var1	−0.0041	0.0195	−0.21	0.832	−0.0423	0.0340
Var2	−0.0296	0.0381	−0.78	0.438	−0.1043	0.0452
Var3	0.7358	0.1382	5.32	0	0.4650	1.0067
Constant	0.2502	0.1117	2.24	0.025	0.0312	0.4691
Sigma	0.0818	0.0098	–	–	0.0626	0.1010

Although the result of the study based on the CRS assumption revealed that water consumption has a positive impact on the hotel industry efficiency, water consumption should be moderated in order to ensure a sustainable utilization. Importantly, Tunisia has been ranked as the 30th country with the most water-stressed in the world (World Resources Institute 2019). Thus, water resources are considered essential for survival, since Tunisia faces a certain degree of its scarcity, and sustainability matters in the use of these resources. Practices such as water recycling, seawater desalination among others coupled with increased investing in better technologies that ensures responsible approach in the use of water resources in the country's hotel industry should be implemented. It has also been shown that using clean and renewable energies, and economic energy systems has a positive impact on the efficiency of the hotel industry in Tunisia (Hathroubi et al. 2014).

Based on the Tobit analysis, lower poverty rate has shown to have a positive impact on the efficiency of the hotel industry in Tunisia. This means that when the hotel industry implements Corporate Social Responsibility projects, there is bound to create jobs opportunities which reduces the poverty rate and thus have a positive impact on both the hotel industry and the society in general. Furthermore, Tobit analysis has equally revealed that tourism have a direct and proportional contribution to the Tunisian GDP which have a positive impact on the efficiency of the hotel industry. Therefore, the higher the number of tourists to a particular region, the higher the contribution of the region to tourism GDP of the country.

4.3 Malmquist productivity index analysis

The productivity of the DMUs was measured using the Malmquist productivity index between 2014 and 2015. The output-oriented Malmquist productivity index measures DMUs ability to increase their outputs amounts using the same amount of inputs over the studied period.

The Table 6 shows that the P-value is 0.3150 for the 2014 and 0.2150 for 2015, while the level of significance is 0.05. Therefore, the results fail to reject the null hypothesis (H_0), which connotes that the most appropriate set of DMUs for this analysis is the CCR model.

Figure 2 summarizes the results of the Malmquist productivity, efficiency change and technical change over the period 2014–2015. The result showed that productivity growth of the hotel industry in the 11 tourist region of Tunisia for the time being of 2014 and 2015 was negative. Sbeitla-Kasserine region hotel industry was the only one that experience improved productivity relative to the other tourist regions, whereas the

Table 6 DEA test of RTS

Hypotheses	H_0 = Globally CRS, H_1 = VRS	
Bootstrap replications	1000	
Significance level	0.05	
Year	2014	2015
S-statistic	0.9081	0.8594
Critical value	0.7175	0.6791
P-value	0.3150	0.2150

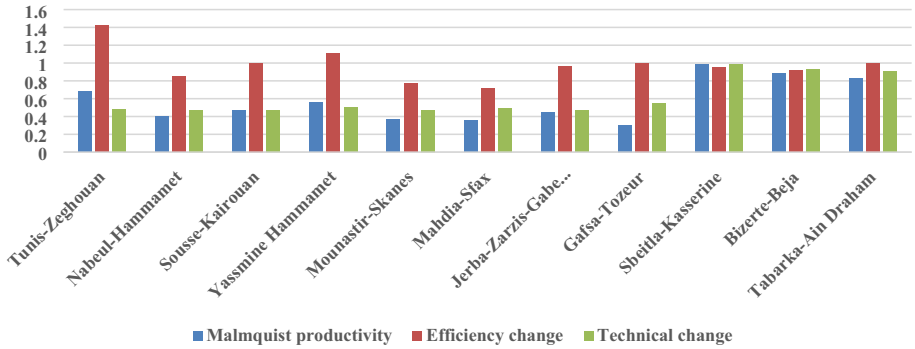

Fig. 2 Malmquist productivity index analysis

hotel industry in Gafsa-Tozeur region experience the least productivity given by the Malmquist productivity measure.

Result of the technical efficiency depicts that Tunis-Zeghouan and Yassmine Hammamet tourist regions experience increase efficiency over the period of study, while the region of Sousse-Kairouan and Gafsa-Tozeur and Tabarka-Ain Darham efficiency level remain unchanged over the period of study while the hotel industry efficiency in the other tourist regions significantly decline. With regards to the technical change of the tourist industry, there was a total decline in all the tourist regions for the period of the study, with the exception of Sbeitla-Kasserine, Bizerte-Beja and Tabarka-Ain Draham whose results shows an improved efficiency in relation to the other regions. A positive progress in regards to technical efficiency was achieved in the regions of Tunis-Zeghouan and Yassmine Hammamet over the period of the study, however their overall productivity declined arising from their decreasing technical change. Therefore, new technologies to improve their productivity need to be introduced in the Tunisian hotel industry in the near future to achieve significant improvement in productivity. This therefore connote that implementation of green and sustainable technologies have the capacity to improve the technological change and the efficiency in the Tunisian hotel industry since studies have shown that customers are willing to pay better for hotels adopting sustainable practices. (Kuraltne et al. 2019; Kang et al. 2012).

5 Conclusion

This study examined the efficiency, productivity, and sustainability of the hotel Industry in Tunisia by using the combination of a two-stage DEA Analysis, Tobit regression analysis, and the Malmquist Productivity Index analysis. The key findings of this study revealed that the efficiency in the Tunisian hotel industry has significantly declined, possibly due to the socio-political instability over the period of study. In addition, it was ascertained that the geographical location of the hotel industry in Tunisia significantly affects its efficiency. These findings are backed by the fact that hotel industry in the coastal regions experience higher degree of efficiency in relation to the hotel industry in the Sahara region. It was further revealed that there exists a positive relationship between hotel industry efficiency and water consumption and tourism GDP, while poverty rate is discovered to have a negative relationship on the hotel industry efficiency. Finally, the productivity level of the Tunisian hotel industry in all regions over the period of study has shown a total decline in productivity, which could be attributed to the absence of efficient and effective implementation of new green and sustainable technologies.

Concerning policy direction, Tunisia should further focus on ensuring adequate security across the entire country in order to achieve a trajectory development of the country's tourism industry (Oxford Business Group 2017). Summarily, to increase the Tunisia's hotel industry efficiency, there is a pressing need to increase investment in the country's tourism industry which will, in turn increase the number of tourist attractions such as parks, museums, art galleries, concerts, sport events, zoos, botanical gardens and also restore the country historic monuments and structures coupled with aggressive tourism marketing(operational upscaling). It is important to note that the provision of social amenities such as sufficient water and electricity supply and distribution in rural areas of Tunisia with the adoption of green and sustainable technologies and practices that can significantly improve the efficiency and sustainability of the hotel industry in the country.

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Declarations

Conflict of interest Authors declare that there is no known competing financial interests or personal relationship that could have influenced the study.

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