An Evaluation of Efficiency, Productivity and Sustainability of the Hotel Industry in Tunisia using a Two-stage DEA method

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Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Industrial Engineering

Eastern Mediterranean University
January 2020
Gazimağusa, North Cyprus

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ABSTRACT

Hotel industry is a very important domain of the tourism industry that is known for its large presence and growth. This service industry does not only consume a huge amount of resources (water, electricity, fuel…) but also intensifies the environmental problems. There have been very little work directed towards sustainability in the hotel industry. An understanding of the situation of the hotel industry and its relationship to sustainability may help improve the performance of this industry while taking into account the economic, social and environmental concerns of sustainability. To investigate the performance of the hotel industry, first, two-stage data envelopment analysis (DEA) method is used to evaluate the efficiency of the hotel industry in the tourist regions of Tunisia for the period 2014-2015. Next, the impact of a number of independent sustainability variables on the efficiency of hotel industry is tested using Tobit regression model. Finally, the Malmquist productivity index is assessed to examine the level of productivity in hotel industry of the tourist regions in Tunisia. The results reveal that the average efficiency of the hotel industry in Tunisia is 66.83% for 2014 and 61.41% for 2015, and the average productivity is 57.18%. The results conclude that sustainability has a positive impact of the efficiency of the hotel industry. The results of this thesis provide understanding on ways to improve the performance of the hotel industry and the sustainable development.

Keywords: Bootstrapping, DEA, Efficiency, Hotel industry, Malmquist productivity index, Productivity, Sustainability, Tobit regression model.

ÖZ

Otel endüstrisi, büyük varlığı ve büyümesiyle bilinen turizm endüstrisinin çok önemli bir alanıdır. Bu hizmet endüstrisi sadece büyük miktarda kaynak (su, elektrik, yakıt ...) tüketmekle kalmaz, aynı zamanda çevre sorunlarını da yoğunlaştırır. Otel endüstrisinde sürdürülebilirliğe yönelik çok az çalışma yapılmıştır. Otel endüstrisinin durumunu ve sürdürülebilirlikle ilişkisini anlamak, sürdürülebilirliğin ekonomik, sosyal ve çevresel kaygılarını dikkate alarak bu endüstrinin performansını artırmaya yardımcı olabilir. Otel endüstrisinin performansını araştırmak için, 2014-2015 dönemi için Tunus'un turistik bölgelerinde otel endüstrisinin etkinliğini değerlendirmek için ilk önce iki aşamalı veri zarflama analizi (VZA) yöntemi kullanılmıştır. Daha sonra, bir dizi bağımsız sürdürülebilirlik değişkeninin otel endüstrisinin verimliliği üzerindeki etkisi Tobit regresyon modeli kullanılarak test edilmiştir. Son olarak, Malmquist verimlilik endeksi, Tunus'taki turizm bölgelerinin otel endüstrisindeki verimlilik seviyesini incelemek için değerlendirildi. Sonuçlar, Tunus'taki otel endüstrisinin ortalama verimliliğinin 2014 için 66,83 %ve 2015 için 61,41% olduğunu ve ortalama verimliliğin 57,18% olduğunu göstermektedir. Sonuçlar sürdürülebilirliğin otel endüstrisinin verimliliğini olumlu yönde etkilediği sonucuna varıyor. Bu tezin sonuçları, otel endüstrisinin performansını ve sürdürülebilir kalkınmayı iyileştirmenin yolları hakkında bilgi vermektedir.

Anahtar Kelimeler: Malmquist verimlilik endeksi, Otel endüstrisi, Önyükleme, Sürdürülebilirlik, Tobit regresyon modeli, Verimlilik, VZA.

This thesis is dedicated to my beloved parents
For their endless love and constant support

ACKNOWLEDGMENT

I would like to thank my thesis supervisor Asst. Dr. Prof. Sahand Daneshvar of the Department of Industrial Engineering at Eastern Mediterranean University, who very much welcomed and encouraged new ideas and whose door was always open whenever I had questions or needed guidance in my research.

I would like to thank all my instructors during my Master’s degree at Eastern Mediterranean University for sharing valuable knowledge with me: Assoc. Prof. Dr. Gökhan İzbırak, Assoc. Prof. Dr. Adham Makkie, Assoc. Prof. Dr. Hüseyin Güden, Assoc. Prof. Dr. Hasan Ulaş Altiok, Asst. Prof. Dr. Sahand Daneshvar and instructor Faramarz Khosravi.

Finally, I would like to express my deepest thanks and gratitude to my dear parents, family and friends for their continuous support and encouragement throughout my years of study. Without them, this achievement would have never been possible.

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LIST OF ABBREVIATIONS

CRS	Constant Return to Scale
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
EMS	Environmental Management System
EUI	Energy Use Intensifies
F&B	Food and Beverage
GDP	Gross Domestic Product
LCA	Life Cycle Analysis
OCRA	Operational Competitiveness Rating
PPS	Production Probability Set
RTS	Return To Scale
SDEA	Stochastic-DEA
TBL	Triple Bottom Line
TFP	Total Factor Productivity
UAE	United Arab Emirates
UK	United Kingdom
VRS	Variable Return to Scale

Chapter 1

INTRODUCTION

1.1 Problem description

A country's economy is composed of five main economic sectors; primary sector (agriculture, mining, fishing…), secondary sector (manufacturing, processing, construction…), tertiary sector (tourism, transportation and distribution, banking, health care…), quaternary sector (scientific research, education, information technology…) and quinary sector (high level decision makers in government…). Figure 1 summarizes the five sectors and their components.

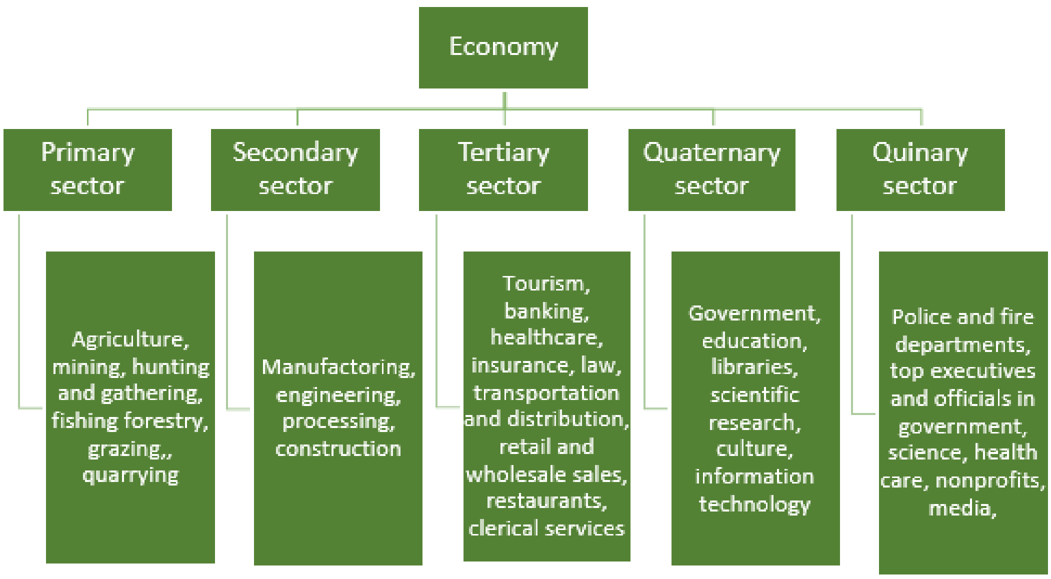

Figure 1: The five sectors of Economy

Tourism is a component of the tertiary economic sector, which itself covers many subcomponents; Hotel industry, adventure and recreation, attractions, events and conferences, food and beverage (F&B), tourism services, transportation and travel trade. The components of the tourism industry are outlined in Figure 2. The focus of this research is the hotel industry.

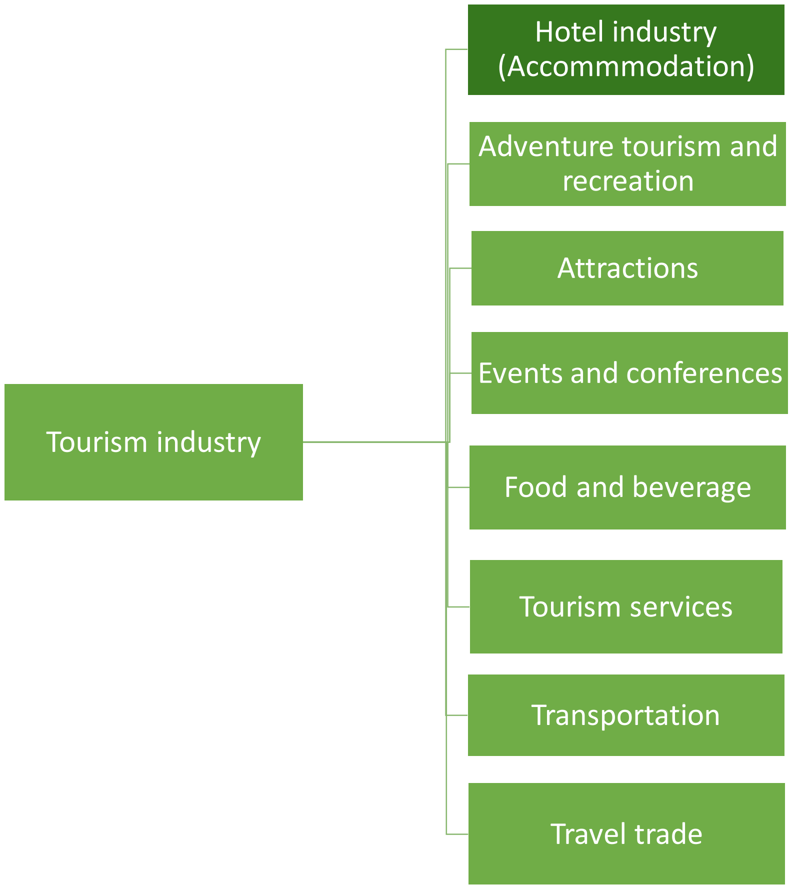

Figure 2: The components of tourism industry

Hotel industry is the service industry concerned with providing accommodation and a variety of related services to its guests (dinning, entertainment...). It is known for its wide presence and rapid growth, which makes it a crucial sector in the tourism industry.

As national and international tourism became more affordable, the demand on hotel industry services increased drastically. In an industry where the quality of services and client satisfaction are very important indices, hotels are not only responsible for the high consumption of resources (water, electricity, fuel...), but also on huge waste and waste-water generation and green-house-gases emission, hence their negative impact on the environment is immense.

In recent years, this issue raised attention, due to the increased intensity of the environmental problems such as climate change, global warming, water and soil pollution, deforestation and the increase of carbon footprint…etc. These problems are threatening the life on planet Earth and the public health, as well as the tourist attractions. Thus, more attention should be directed to this problem. Figure 3 summarizes the main environmental problems threatening the planet Earth.

Many studies suggested green practices that should be implemented in hotels to increase their environmental performance. Other research used methods to assess the impact of hotels on environment, such as Life Cycle Analysis Methodology (LCA). There are works that used Statistical Analysis methods to compare practices in hotels that affect the environment. Other works tried suggesting solution to the issue based on Mathematical Programming Methods.

Figure 3: Main environmental problems

This research was inspired by a research by Hathroubi, Peypoch, and Robinot (2014) which used the standard model of Data Envelopment Analysis Method (DEA) to benchmark 42 Tunisian hotels and determine which environmental practices increase or decrease the hotel efficiency. The purpose of this thesis is to evaluate the efficiency of the hotel industry in the tourist regions in Tunisia from the period 2014-2015 using DEA method. Then, test the relationship of some sustainability factors and the hotel industry efficiency using Tobit regression. As well as evaluate the productivity of the hotel industry in each of the years 2014 and 2015 using Malmaquist productivity index.

DEA is a mathematical programming method that measures the efficiency of different Decision Making Units (DMU)s, and determine which DMUs are efficient and which are not. This method is widespread due to its simplicity and straightforwardness. DEA is a non-parametric method, that is not restricted by a specific number of inputs and outputs and that doesn't require a unified unit for variables. It is also known for analyzing inputs and outputs at the same time and for being strong at detecting inefficiencies of the DMUs. On the other hand, DEA is not very practical when the number of inputs and outputs is high, because it requires the collection of data of a big number of DMUs; the empirical evidence claims the number of DMUs should be three times the total number of variables for DEA to be accurate. Other drawback of DEA is that it fails at recognizing the effect of external variables on the efficiency of DMUs, as well as its tendency to commit statistical bias.

1.2 Structure of the thesis

Chapter 2 of this work contains a literature review of previous researches that took into consideration the environmental sustainability and green management in the hotel industry. In chapter 3, the methodology used in this work is explained in details. Chapter 4 represents a description of the variables and an interpretation of the results achieved. Finally, concluding remarks and future works are provided in chapter 5. Figure 4 summarizes the structure of the thesis.

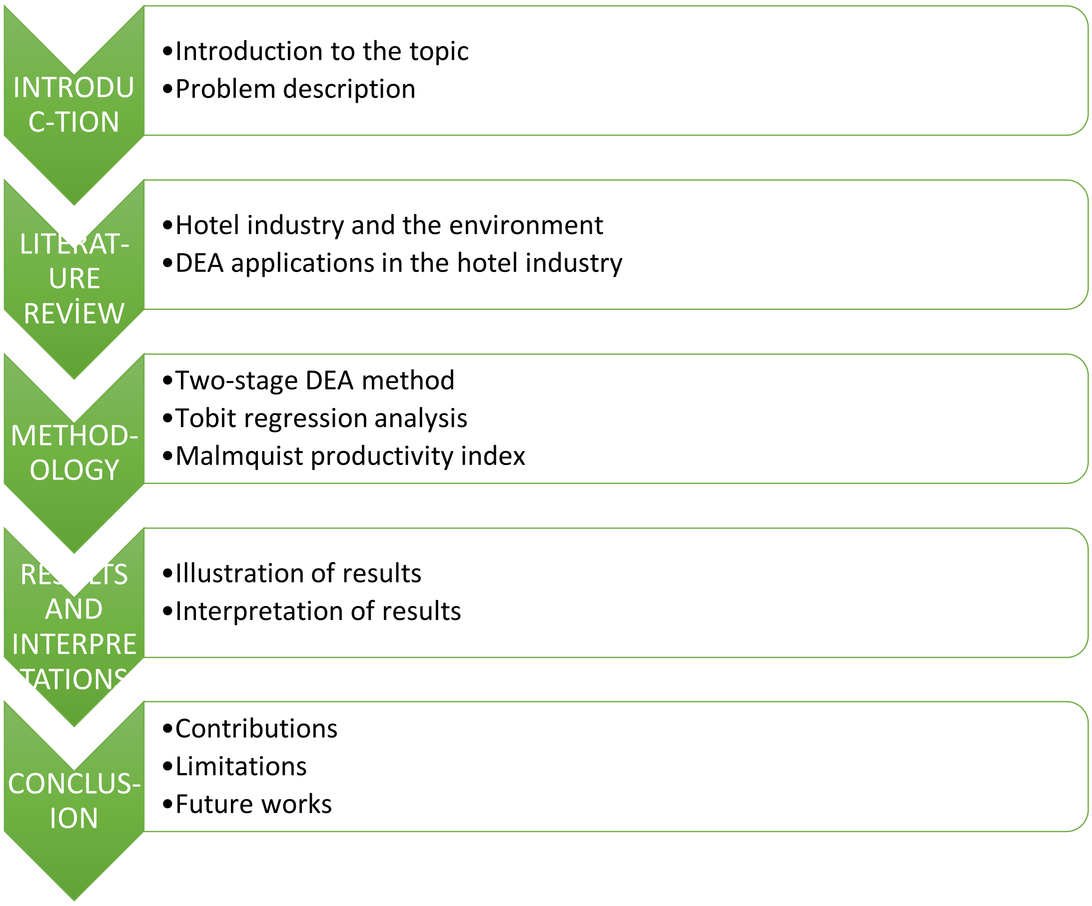

Figure 4: Thesis structure

Chapter 2

LITERATURE REVIEW

2.1 Hotel industry and the environment

In the current century, many conducted researched researches linked between the hotel industry and the environment. There are researches that focused on the impact of hotels on the environment such as, Trung and Kumar (2005) who investigated the use of resources and their management in the hotel industry in Vietnam by conducting surveys in 50 hotels. The surveys enabled gathering information on the water and energy consumption and waste generation in hotels. The average resources consumptions were estimated and compared to other countries and the efficient and inefficient environmental practices in the surveyed hotels were addressed. The research concluded that Vietnamese hotels have a higher water consumption compared the hotels in other countries and suggested practices to improve the environmental efficiency of the hotels. Phu, Hoang, and Fujiwara (2018) collected solid waste samples from 102 hotels in a tourism city in Vietnam to analyze waste characteristics and management practices in Vietnamese hotels. Interviews were conducted in the hotels and statistic analysis were applied to treat the collected data. Findings suggest that the average generated waste and the rate of waste management practices are strongly proportional to internal factors and the size of the hotel, respectively. Tsai, Lin, Hwang, and Huang (2014) investigated CO2 emissions in four types of hotels and determined average CO2 emission of each type. They concluded that the CO2 emission per guest-night is proportional to the service level of the hotel. Xuchao, Priyadarsini, and Eang (2010) established a benchmarking model based on regression analyses to identify energy use intensifies (EUI) of hotels in Singapore. Data were collected from 29 hotels and CO2 emission of each hotel was estimated. The study concluded that industry specific normalized denominator must be used in the determining hotel EUI. Puig et al. (2017) conducted questionnaires in 14 coastland Spanish hotels of star rating from 2 to 5. They evaluated the average carbon footprint of an overnight stay in the hotel using LCA methodology and collected Spanish hotel inventory and impact data to help building environmental solutions for the hotel industry. The research suggests that electricity and fuel consumption, which are proportional to the star rating and occupancy rate of the hotel, are the main contributors to the carbon footprint of the hotel.

Some works investigated if hotels are willing to adopt environmental practices and technologies or not, and what pushes and what stops them from implementing them. Mak and Chang (2019) explored the environmental practices implemented in the hotel industry in Taiwan and determined the forces that encourage and the forces that discourages the implementation of environmental practices in the hotel industry using force field analysis. The research was able to identify 21 environmental strategies from 14 key areas and 8 of these strategies were categorized as low cost. The study identified 26 driving and restraining forces of the adoption of environmental strategies, as well. Another research that investigated the barriers preventing the adoption of environmental technologies in hotel industry was conducted by Chan, Okumus, and Chan (2020) who collected a sample of 102 questionnaires from hotels in Hong Kong. They were able to find 7 barriers, to which they applied ANOVA analysis to determine which barriers are more significant. Chan (2005) used a control cost approach and a pro-rate model to explore the environmental cost resulting from hotel operations. The findings suggest that due to the large capital investment of environmental projects, hotels only invest enough to achieve acceptable environmental conditions.

Other works focused on the assessment of green practices in hotels. For instance, Al-Aomar and Hussain (2017) developed a framework to assess the green practices across hotel supply chain. They selected hotel in United Arab Emirates (UAE) and concluded that hotels in UAE are familiar with green practices and environmental awareness. Alonso- Almeida, Robin, Pedroche, and Astorga (2017) developed a model of green practices adoption and the impact it has on independent hotels. To test the model, 12 hotels were selected from Spain, which is considered a mature tourist destination and 12 others from Chile, an emerging destination. The model shows that both destination are adopting green practices, but each in a different way. Sari and Kazim (2018) developed an evaluation and comparison tool of the environmental performance of hotel supply chain using Fuzzy technique. The tool was implemented in hotels using TOPSIS method. The results revealed that there is no single strategy to improve the environmental performance of a hotel. Hsiao, Chuang, Kuo, and Yu (2014) created a tool to evaluate green hotels in Taiwan by constructing environmental management system (EMS) indicators. The EMS attributes were established by conducting Delphi method on 25 experts. They were able to determine 64 indicators categorized in 10 dimensions. 38 of the 64 indicators are found to be suitable to Taiwan's hotel industry. Furthermore, 18 indicators of those 38 indicators are very important and feasible in the hotel industry of Taiwan.

2.2 DEA applications in hotel industry

2.2.1 Measuring the efficiency of hotel industry using DEA

The first application of DEA method in hotel industry was in a research of Parkan (1996), where a hotel's performance was measured using its monthly operations .The performance was measured using four different methods; Operational competitiveness rating (OCRA), Total factor productivity (TFP), Cost/revenue ratios and DEA. 12 months of operation (May 1992 to April 1993) were used as DMUs with six main cost categories as inputs (Personnel, Supplies, Administration, Marketing, Maintenance and Utilities and taxes) and five revenue categories as outputs (Room sales, Telephone calls, Laundry services, Soft drinks sales and Miscellaneous). The results obtained from OCRA, TFP and Cost/revenue Ratios were similar to each other, unlike DEA's results which were completely different.

Following Parkan (1996), many researches used DEA method in hotel industry. Some of the important works are Johns, Howcroft, and Drake (1997) who collected 12 months data from 15 hotels from the same chain to measure and benchmark hotel productivity in 4 quarters. The 15 hotels were divided into 3 categories; 6 hotels with 180 to 350 rooms, 5 hotels with 150 to 180 rooms and 4 hotels with 90 to 150 rooms. 4 inputs (Number of room nights available, Total labor hours, Total F&B costs, Total utilities costs) and 3 outputs (Number of room nights sold, Total covers served, Total beverage revenue) were selected to be used in the DEA model. The results show a high overall performance between the 3 categories and during 4 quarters and that the difference between hotels performance wasn't related to the size nor the number of employees in the hotel. Reynolds (2003) explains the benefits of using DEA method in hotel and restaurant industry and describes its accuracy in assessing productivity.

Moreover, the research compares DEA's results to Regression analysis result in the case of a small restaurant chain to prove the superiority of DEA method. Barros (2005) used DEA method to benchmark 43 Pousada hotels in Portugal using data from 2001. The selected inputs are Full time workers, Cost labor, Rooms, Surface area of the hotel, Book value of property, Operational costs and External costs. The outputs are Sales, Number of guests and Nights spent. The findings show 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.

Another important work is by Hsieh and Lin (2010) which were the first to use relational network DEA in hotel industry. They collected data from 57 international tourist hotels in Taiwan from the year 2006 and categorized them according to their location and management type. First, they measured the hotel's service production efficiency using Accommodation costs, Employees of the accommodation department, Catering costs, Employees of the catering department as inputs 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, which the overall performance of the hotel. The findings suggest that only few hotels have 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. Studies about the application of DEA in the hotel industry, from the past five years (2015-2019), are summarized in Table 1.

Table 1: Recent studies on DEA applications in hotel industry (2015-2019)

Year	Reference	Applied technique	Object of the analysis (sample size, years)	Inputs	Outputs	Result of analysis
2019	Mariani & Visani	Input oriented BCC DEA model	268 independent hotels in Rome (Italy), 2015	Rooms, Employees, Net operating expenses	Revenues, Online ratings	Online ratings significantly affect hotels' efficiency regardless of the hotel category
	Yin et al.	Improved DEA based two-stage network model	68 Taiwanese international hotels (2011)	Stage 1: Full time employees in room department, FT employees in F&B department, Rooms, Total room area of F&B department Stage 2: Marketing expenses	Stage 1: Occupancy service competence, F&B service competence Stage 2: Revenue of room department, Revenue of F&B department	The proposed model is endorsed by the results
	Lado-Sestayo & Fernandez-Castro	Four-stage CCR DEA model	400 Spanish hotels (2011)	Labor costs, Depreciation, Operational costs	Sales revenue	A positive impact on efficiency is obtained from agglomeration, market concentration and accessibility of the tourist destination
2018	Ang, Chen, & Yang	Group efficiency and group cross efficiency evaluation models	7 hotel chains and their 21 subsidiary hotels (2011-2015)	Total operating costs, Total number of employees , Total number of guest rooms, F&B	Room occupancy percentage, Total hotel revenues	Similar results produced by both models
	Sellers-Rubio & Casado-Diaz	Two-stage double bootstrap model	17 hotel regions (2008-2016)	Number of hotels in the region, Number of available hotel beds in the region, Number of FTE employees of hotels in the region	Average daily rate, Revenue per available room, Average occupancy rate	High overall hotel efficiency

2017	Amado, Santos, & Serra	Input oriented CCR DEA model	26 hotels in Portugal (2001-2010); 2003 is privatization year	Total area, Number of room nights available, FT equivalent workers, Labor and operational costs	Room and other types of revenues, F&B revenues	Productivity growth increase after privatization while total factor productivity and profitability decreased
	Yang, Xia, & Cheng	Output oriented super efficiency SBM DEA method, PCA	31 hotel regions	Regional capacity and attractiveness, Business environment, Image and openness, Hospitality training	Average room rate, Occupancy rate	Regional factors affect the hotel efficiency
2016	Aissa & Goaied	Farrell-Debreu output oriented DEA model, ROA	27 hotels in Tunisia (2000-2010)	Direct expenses, Indirect expenses	Total turnover	Management efficiency of the hotel affects hotel profitability
	Oukil, Channouf, & Al-Zaidi	Output oriented DEA double bootstrapping model	58 hotels in Sultanate of Oman	Number of beds, Salary of employees	Annual revenue, Number of guests, Number of nights, Occupancy rate	Star rating and culture affects the efficiency
	Poldrugovac, Tekavcic, & Jankovic	Output oriented BCC DEA model	100 Croatian hotels	Energy expenses, Room expenses, F&B expenses, Other services expenses, Labor expenses	Total revenue, Occupancy rate	High overall hotel efficiency. Size affects hotel efficiency
2015	Corne	Output oriented DEA model	16 French conurbations in 3 hospitality categories (2013)	Uniform value of 1	Occupancy rate, Revenue per available room	Paris is the benchmark. Budget hotels are the most efficient amongst other categories

2.2.2 Determining the impact of environmental practices on the efficiency of hotel industry using DEA

Few researches used DEA method to investigate the impact of sustainable and environmental practices on hotels. Most of these researches used two-stage bootstrap DEA method for this purpose, such as Shieh (2012) who investigated the relationship between environmental practices and cost efficiency in international tourist hotels in Taiwan using data of a total number of 547 hotels from years between 1997 and 2006. In the first stage DEA model was used to obtain the cost efficiency of the hotels using Rooms, Employees, Floor space of catering division as inputs, Price of room, Price of labor and Price of F&B as input prices and F&B revenue, Room revenue and Other revenues as outputs. In the second stage Tobit regression was used to determine the relationship between cost efficiency and six environmental variables (Type of location, Type of operation, Distance to nearest international airport, Occupancy rate and Level of green). This research suggest that there is a negative relationship between environmental practices and cost efficiency.

The same approach was used by Assaf, Josiassen, and Cvelbar (2012) to determine the impact of Triple Bottom Line (TBL) on hotel performance, using data of Slovenian hotels. In this study the inputs used are Cost of materials, Other operational costs, Number of employees and Number of rooms, as for the outputs, Total rooms sales and Total F&B sales were used. The control variables are Financial reporting, Social reporting, Environmental reporting, Star rating and Hotel age. The findings shows that TBL has a positive impact on hotel performance. Another research that used a similar method is Hathroubi et al (2014) that investigated the impact of a set of green practices on the technical efficiency of hotels using data of 42 Tunisian hotels from the year

2009. The technical efficiency was measured using Number of stars, Cleaning personnel, Service, personnel, Management personnel, Number of rooms and Number of beds as inputs and Arrivals and Nights slept as outputs. Six environmental variable were tested, which are Respect of natural surroundings, Use of clean and renewable energy, Use of economic energy systems, Availability of bottle and paper recycling systems, Implementation of a green labeling program (i.e. ISO 14001) and use of environmental information leaflets. The relationship between these green practices and technical efficiency was tested using two models; Tobit model and the truncated bootstrapped model of Simar and Wilson (2007). The results obtained were similar for both models, which suggested that all the practices have a positive impact of on the technical efficiency, except for using leaflets which was found to decrease the efficiency.

Kularatne, Wilson, Mansson, Hoang, and Lee (2019) used data from 24 hotels in Sri Lanka from 2010 to 2014 to test the effect of environmental variables on the technical efficiency of the hotels. In the first stage, DEA method was used to determine the technical efficiency using Number of employees, Number of rooms and Book value of assets as inputs and Room revenue and Other revenues as outputs. In the second stage truncated regression was used to test the effects of 7 contextual variables; Age, Star, Size and Type of the hotel, as well as, its Energy efficiency, Water consumption and Waste management. Next, bootstrapped Malmquist productivity index was used to determine the productivity of hotels in Sri Lanka. The findings of this research suggest that energy efficiency and waste management affect hotel efficiency positively, while water consumption affects it negatively. Moreover, the majority of hotels in Sri lanka were experiencing a negative productivity growth in the period 2010-2014.

Ramanathan, Ramanathan, and Zhang (2016) investigated the effect of each of marketing capabilities, operations capabilities, environmental capabilities and diversification strategy on hotel performance in the United Kingdom (UK). This research used DEA to measure the marketing capability, operations capabilities, environmental capabilities and hotel performance using different inputs and outputs. Financial performance and diversification were obtained by calculating the relative profitability and the relative diversification of the hotel, respectively. Next, regression analysis was used to find the impact of the aforementioned factors on hotel performance. The results suggest that operations and environmental capabilities have a positive impact on hotels in the UK unlike marketing capabilities, which affect hotel performance negatively. On the other hand, diversification strategy seems to have no effect on hotel performance.

2.2.3 Measuring environmental performance in hotel industry using DEA

Only a small number of studies in the literature measured the environmental performance in hotel industry, this suggests that more researches should be conducted in this field. Chen (2019) tested the hypothesis that hotel chains benefit from higher environmental performance and brand value, when they account for their carbon emission, compared to independent operators. Global Malmquist index was applied to measure the productivity of 45 luxury international hotels in Taiwan from the years 2003, 2005 and 2007. The inputs selected for the model are Number of rooms, Catering area, Number of employees and Annual expenses. Revenue per room, Profit per room and Profit per room measure are used as outputs and Energy equivalent carbon emissions as undesirable output. The findings reveal the tested hypothesis is true.

Peng et al (2017) used SBM DEA model to measure the eco-efficiency of a single tourist destination in China from the period 1981-2014 by considering each year as a separate DMU. The model used Average wage level of employees, New fixed asset investment, Energy consumption, Water consumption and F&B consumption as inputs, Per capita tourism income as output and Emission of garbage, Emission of sewage and Emission of waste gas as undesirable outputs. Tobit regression was used to determine the relationship between the eco-efficiency and the following variables; Per capita tourism revenue, Ratio of a hotel's revenue, Energy consumption, New fixed asset investment and Standard discharge rate of sewage. The research suggests that eco-efficiency in the tourist destination experienced an increasing rate, followed by a constant, then a decreasing rate. Moreover, investment level affected the eco-efficiency negatively, the standard discharger rate had no significant impact on it, as for the rest of the factors, they all had a positive impact on it.

Chapter 3

METHODOLOGY

3.1 DEA efficiency analysis

In this thesis, DEA method will be used. DEA is a mathematical programming method that is used to measure efficiency and benchmark DMUs of the same sector. It was used in different sectors since then (banks, hospitals, hotels, educational institutions…). There exist two Standard DEA models; Standard CCR, introduced by Charnes, Cooper and Rhodes (1978), which is based on a Constant Return to Scale (CRS) assumption and Standard BCC model, developed by Banker, Charnes and Cooper (1984), which is based on a Variable Return to Scale (VRS) assumption.

Figure 5 illustrates the efficiency evaluation of n homogeneous DMU_j with m non-negative inputs x_{ij} for $i = 1,\dots,m$ converted into s non-negative outputs y_{rj} for $r = 1,\dots,s$. 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 $r = 1,\dots,s$

v_i are the weights of input i for $i = 1,\dots,m$

θ_o is the efficiency value of DMU_o

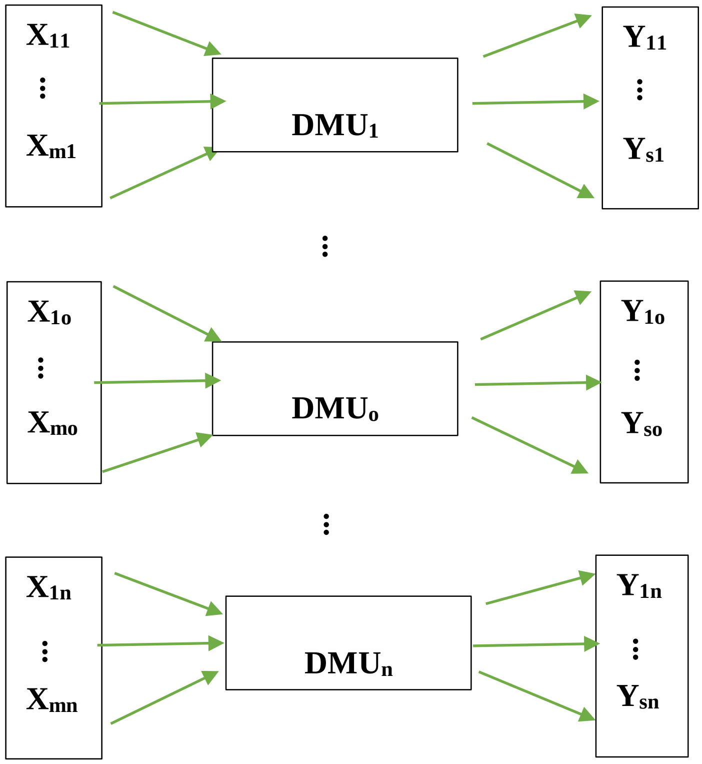

Figure 5: Efficiency structure of n DMUs

3.1.1 Standard CCR model

The Production Probability Set (PPS) of CCR model is defined by the following five assumption:

1. The PPS includes the activities of all the $\boldsymbol{n}$ observed $\boldsymbol{DMU_j}$ for $\boldsymbol{j = 1,\ldots,n}$
2. If the PPS contains the activity $\boldsymbol{(X,Y)}$ then the activity $(\bar{\boldsymbol{X}}, \bar{\boldsymbol{Y}})$ is also contained by PPS, where $\bar{\boldsymbol{X}} \geq \boldsymbol{X}$ and $\bar{\boldsymbol{Y}} \leq \boldsymbol{Y}$
3. The CRS assumption; If the PSS includes the activity $\boldsymbol{(X,Y)}$ then the activity $\boldsymbol{(dX,dY)}$ is also included in the PSS for every scalar $\boldsymbol{d} > \boldsymbol{0}$
4. The linear combination of two activities, say $\boldsymbol{(X,Y)}$ and $(\bar{\boldsymbol{X}}, \bar{\boldsymbol{Y}})$, is also included the the PPS; $\forall \boldsymbol{\lambda} \, \boldsymbol{\epsilon} \, [\boldsymbol{0}, \boldsymbol{1}] \; \boldsymbol{\lambda}(\boldsymbol{X}, \boldsymbol{Y}) + (\boldsymbol{1} - \boldsymbol{\lambda})(\bar{\boldsymbol{X}}, \bar{\boldsymbol{Y}}) \boldsymbol{\epsilon} \; \boldsymbol{PPS}$
5. The interaction of two sets is a smaller set; $\boldsymbol{\lambda}$ is a semi-positive vector in $\boldsymbol{R^n}$ defined as:

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

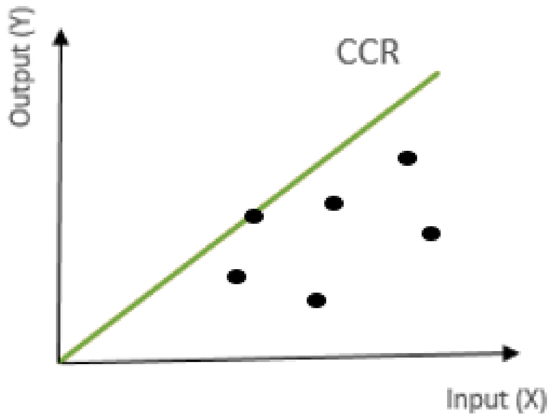

Figure 6: CCR production frontier

In the input-oriented CCR model, the DMU_o is evaluated by finding the efficiency θ_o.

The input-oriented CCR model is written as follows;

$Min \; \theta_o$

$Subject \; to$:

$$(\theta_o X_o, Y_o) \epsilon \; PPS_c$$

$$PPS_c = \{(X, Y) | X \geq \sum_{j=1}^{n} \lambda_j X_j, Y \leq \sum_{j=1}^{n} \lambda_j Y_j \,, \lambda_j \geq 0, j = 1,2, \ldots, n\}$$

The primal form of the input-oriented CCR model is;

$Min \; \theta_o$

$Subject \; to$:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_o x_{io} \quad , i = 1, \ldots, m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \quad , r = 1, \ldots, s$$

$$\lambda_j \geq 0 \quad , j = 1, \ldots, n$$

The dual form of the model is;

$$Max \sum_{r=1}^{s} u_{ro} y_{ro}$$

$Subject\ to$:

$$\sum_{i=1}^{m} v_{io} = 1$$

$$\sum_{r=1}^{s} u_{ro} y_{rj} - \sum_{i=1}^{m} v_{io} x_{ij} \leq 0 \qquad ,j = 1,2,\ldots,n$$

$$u_{ro}, v_{io} \geq 0 \qquad ,r = 1,2,\ldots,s \qquad ,i = 1,,2,\ldots,m$$

In the output-oriented CCR model, the $\boldsymbol{DMU_o}$ is evaluated by finding, $\boldsymbol{\phi_o}$, which is the inverse of the efficiency $\boldsymbol{\theta_o}$. The output-oriented CCR model is written as follows;

$Max\ \phi_o$

$Subject\ to$:

$$(X_o, \phi_o\, Y_o) \epsilon\ PPS_c$$

The primal form of the output-oriented CCR model is;

$Max\ \phi_o$

$Subject\ to$:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} \qquad ,i = 1,\ldots,m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq \phi_o\, y_{ro} \qquad ,r = 1,\ldots,s$$

$$\lambda_j \geq 0 \qquad ,j = 1,\ldots,n$$

The dual form of the model is;

$$Min \sum_{r=1}^{s} p_{io} x_{io}$$

$Subject\ to$:

$$\sum_{i=1}^{m} q_{ro} y_{ro} = 1$$

$$\sum_{r=1}^{s} q_{ro} y_{rj} - \sum_{i=1}^{m} p_{io} x_{ij} \leq 0 \qquad ,j = 1,2,\ldots,n$$

$$p_{io}, q_{ro} \geq 0 \quad For\ p = \frac{v}{\theta}\ and\ q = \frac{u}{\theta} \qquad ,r = 1,2,\ldots,s \qquad ,$$

$$i = 1,,2,\ldots,m$$

Determining efficient and inefficient DMUs is achieved by finding the solution the primal form of the CCR model, hence the efficiency of the DMU under evaluation ($\boldsymbol{\theta o}$). 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;

$$\theta^* = 1, \qquad \lambda_o = 1, \qquad \lambda_j = 0 \; (For \; j \neq o)$$

Finding the weights of the inputs and outputs of each $\boldsymbol{DMU_o}$ ($\boldsymbol{v_{io}}$ and $\boldsymbol{u_{ro}}$ respectively) is achieved by solving the dual form of the CCR model. A weight equal to 0 means the corresponding input or output has no impact on the efficiency of the $\boldsymbol{DMU_o}$. Therefore, a new constraint is added to the model, such that, the weights of the inputs and outputs must be larger than or equal to an extremely small positive value $\boldsymbol{\varepsilon}$ for all inputs and outputs.

3.1.2 Standard BCC model

The difference between CCR and BCC model is their return to scale (RTS) outcomes, which is CRS for the CCR model, expressed as a linear production frontier and variable return to scale (VRS) for the BBC model, expressed as a concave-piecewise production frontier.

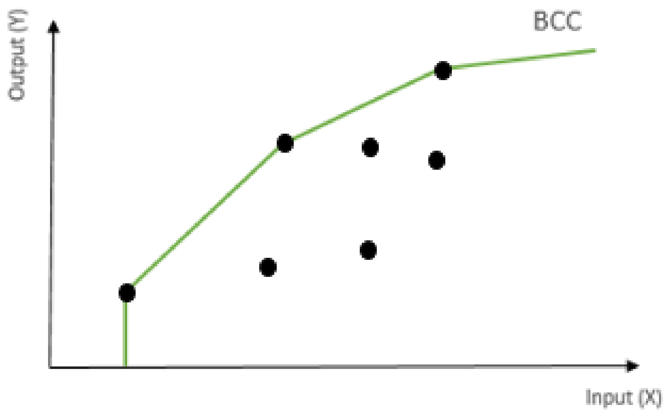

Figure 7: BCC production frontiers

The PPS of the BBC model, is thus defined by the same previous discussed assumptions of the PPS of the CCR model, with the only difference of replacing the CRS assumption (the third assumption) by the VRS assumption expressed as the following; The PPS of the BCC model is a convex combination of the DMUs, such as $\sum \lambda_j = 1$.

The PPS of the BBC model is thus defined as;

$$PPS_B = \left\{(X,Y)\middle| X \geq \sum_{j=1}^{n} \lambda_j X_j, Y \leq \sum_{j=1}^{n} \lambda_j Y_j, \sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0, j = 1,2,\ldots,n\right\}$$

The primal form of the input-oriented BCC model is;

$Min\ \theta_o$

$Subject\ to$:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta_o x_{io} \quad ,i = 1,\ldots,m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \quad ,r = 1,\ldots,s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \quad ,j = 1,\ldots,n$$

The dual form of the model is;

$$Max \sum_{r=1}^{s} u_{ro} y_{ro} + u_0$$

$Subject\ to$:

$$\sum_{i=1}^{m} v_{io} x_{io} = 1$$

$$\sum_{r=1}^{s} u_{ro} y_{rj} - \sum_{i=1}^{m} v_{io} x_{ij} + u_0 \leq 0 \quad ,j = 1,2,\ldots,n$$

$$u_{ro}, v_{io} \geq 0 \quad ,u_0\ unrestricted \quad ,r = 1,2,\ldots,s \quad ,$$

$$i = 1,,2,\ldots,m$$

The primal form of the output-oriented BCC model is;

$Max\ \phi_o$

$Subject\ to$:

$$\sum_{j=1}^{n} \lambda_j x_{ij} \le x_{io} \qquad ,i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \ge \phi_o\, y_{ro} \qquad ,r = 1, \dots, s$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \ge 0 \qquad ,j = 1, \dots, n$$

The dual form of the model is;

$$Min \sum_{r=1}^{s} v_{io} x_{io} - v_0$$

$Subject\ to$:

$$\sum_{i=1}^{m} u_{ro} y_{ro} = 1$$

$$\sum_{r=1}^{s} u_{ro} y_{rj} + v_0 - \sum_{i=1}^{m} v_{io} x_{ij} \le 0 \qquad ,j = 1,2, \dots, n$$

$$v_{io}, u_{ro} \ge 0 \qquad ,u_0\ unrestricted \qquad ,r = 1,2, \dots, s \qquad ,$$

$$i = 1,,2, \dots, m$$

Like the CCR model, solving the primal form of the BCC model provide the efficiency of the DMU under evaluation. As for the solution of the dual form of the BBC model, it provides the weights of the inputs and outputs, as well as the outcomes of the VRS.

There are three outcomes of the VRS;

1. For $\boldsymbol{u_0} \ \ge\ \boldsymbol{0}$, the $\boldsymbol{DMU_o}$ has an increasing RTS.
2. For $\boldsymbol{u_0} \ \le\ \boldsymbol{0}$, the $\boldsymbol{DMU_o}$ has a decreasing RTS.
3. For $\boldsymbol{u_0} = \ \boldsymbol{0}$, the $\boldsymbol{DMU_o}$ has a constant RTS.

3.1.3 Defining inputs and outputs of the DEA model

In this thesis, output-oriented CCR and BCC models are employed and the results obtained from each model are compared. The calculations are performed using a DEA toolbox for Matlab developed by Alvarez, Barbero and Zofio (2016). The version of Matlab used is Matlab R2019a. Matlab is an advanced and powerful software able to perform large number of calculations and run complex algorithms in a short amount of time. The DEA toolbox implemented in Matlab is a very useful and easy-to-use package that is able to perform multiple calculations such as; radial, technical and relative efficiency measurements, productivity measurements and bootstrapping.

There are 11 tourist regions in Tunisia which are; 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. In this research, each tourist region representes a DMU. This thesis aims to measure the total efficiency of the hotel industry in each tourist regions from the period 2014-2015, using data obtained from (Statistics Tunisia, National Institute of Statistics [INS], 2016). Thus, 11 DMUs from each of the two successive years are used in this study.

Therefore, two inputs are used in the study;

1. The total number of hotels in each tourist region.
2. The capacity of each tourist region; measured by the total number of beds.

And two outputs;

1. The occupancy rate of each tourist region.
2. The total number of nights spend in each tourist region.

The choice of inputs and outputs was based on previous studies on DEA applications in the hotel industry and on the data available on the [INS], 2016. For instance, Sellers-Rubio & Casado-Diaz (2018) used Number of hotels in the region, Number of available hotel beds in the region and Number of full-time equivalent employees of hotels in the region as inputs and Average daily rate, Revenue per available room and Average occupancy rate as outputs to evaluate the efficiency of 17 Hotel regions in Spain. In this thesis, the purpose of limiting the total number of inputs and outputs to only four is to respect the empirical evidence (The number of DMUs should be three times the total number of variables for DEA to be accurate).

Using the output-oriented model is a more logical choice, because the resources used in this study requires a huge investment. Thus, the model used in this study should focus on maximizing the outputs rather than minimizing the inputs.

3.2 DEA Bootstrapping

Bootstrapping was, first developed by Efron (1979), which is a method used as a sensivity analysis of efficiency scores to the variations of sampling (Simar & Wilson, 1998). Simar and Wislon, 1998 inroduced DEA bootsrapping, 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 (Assaf & Matawie, 2009). The DEA efficiency boostrapping algorithm of Simar and Wilson (1998) is summarized in the following steps;

1. The effciency $\widehat{\boldsymbol{\theta_k}}$ where ***k= 1,...,n*** is computed by solving the linear program;

$$\widehat{\boldsymbol{\theta_k}} = min\,\{\theta | y_k \leq \sum_{i=1}^{n} \gamma_i y_i; \theta x_k \geq \sum_{i=1}^{n} \gamma_i x_i; \theta > 0;$$

$$\sum_{i=1}^{n} \gamma_i = 1; \gamma_i \geq 0, i = 0, \dots, n\}$$

2. Obtaining $\boldsymbol{\theta}^*_{\mathbf{1b}}, \dots, \boldsymbol{\theta}^*_{\boldsymbol{nb}}$ by generating a random sample of size $\boldsymbol{n}$ from $\widehat{\boldsymbol{\theta}_\iota}$ where $\boldsymbol{i = 1,\dots,n}$

3. The bootsrap sample data $\boldsymbol{\chi}^*_{\boldsymbol{b}} = \{(\boldsymbol{x}^*_{\boldsymbol{ib}}, \boldsymbol{y_i})\ \boldsymbol{i} = \mathbf{1}, \dots, \boldsymbol{n}\}$ is computed where $\boldsymbol{x}^*_{\boldsymbol{ib}} = (\widehat{\boldsymbol{\theta}_{\boldsymbol{k}}}/\boldsymbol{\theta}^*_{\mathbf{1b}})\boldsymbol{x_i}$, $\boldsymbol{i = 1,\dots,n}$

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

$$\widehat{\boldsymbol{\theta}^*_{\boldsymbol{k,b}}} = min\,\{\boldsymbol{\theta}|y_k \leq \sum_{i=1}^{n} \gamma_i y_i; \theta x_k \geq \sum_{i=1}^{n} \gamma_i \boldsymbol{x}^*_{\boldsymbol{k,b}}; \theta > 0;$$

$$\sum_{i=1}^{n} \gamma_i = 1; \gamma_i \geq 0, i = 0, \dots, n\}$$

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

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

According to Hall (1986), a number of replications ($\boldsymbol{B}$) equal to 1000, covers the confidence intervals adequately.

In this research, 200 replications are used in the DEA bootrapping 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.

3.3 Tobit regression analysis

Tobit regression model is a statistical model developed by Tobin (1958) that is based on linear assumption and used when information about the dependent variable are not available for all observations, because they are censored. The point from censoring some of the information is because of the skewness of the continuous dependent variable to one side. Thus, by censoring, the regression is enabled to happen. The standard Tobit regression model for the population is defined as;

$$\boldsymbol{y}^* = \boldsymbol{x\beta} + u, \qquad u|x \sim N(0, \sigma^2)$$

$$\boldsymbol{y} = \max(0, \boldsymbol{y}^*)$$

Where;

$\boldsymbol{y}^*$ is a vector of latent dependent variable

$\boldsymbol{x}$ is a vector of the independent variable

$\boldsymbol{\beta}$ is a vector coefficient estimated by Tobit regression analysis

$\boldsymbol{u}$ is a vector of error terms of normal distribution

Tobit regression model is used to find the relationship between the dependent viable and the independent variables.

In this thesis, the relationship between the efficiency of the hotel industry and some of the selected sustainability factors is measured. Sustainability has three focuses; environmental, social and economic hence, based on the available data, a factor related to each focus was selected and its relationship to the efficiency of the hotel industry was tested. The three selected factors are;

1. Water consumption (in Mm^3); Data about 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).
2. Poverty rate; for Poverty rate ≤ 9.8% a value of 0 is given and for Poverty rate > 9.8% a value of 1 is given. Data were collected from the website of The World Bank (World bank, 2018).
3. Direct contribution of tourism to Gross Domestic Product (GDP) as a share of GDP (%): Information about the GDP for each of the years 2014 and 2015 were collected from an open data platform named Knoema (KNOEMA, 2019).

The calculations are performed using the software STATA 14.2. STATA is an advanced, user-friendly statistical software that provides all the statistical tools needed in research.

3.4 Malmquist productivity analysis

Malmquist productivity index is used to measure the productivity of DMUs over a period of time. It was, first, introduced by Caves, Christensen, and Diewert (1982). Later, it was improved by Fare, Grosskopf, Norris, and Zhang (1994) to be employed in DEA.

The output-oriented Malmquist index is defined as;

$$M_0^t(x^t, y^t, x^{t+1}, y^{t+1}) = \Delta T(x^{t+1}, y^{t+1}).\Delta TE(x^t, y^t, x^{t+1}, y^{t+1}), \quad t = 1, \dots, T-1$$

$$= \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1}}\right] \cdot \left[\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t}\right]$$

The input-oriented Malmquist index is;

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

Information extracted from the Malmquist productivity is that it says if the productivity of DMU increased (value larger than 1), decreased (value less than 1) or remained unchanged (value equal to 1) over a period of time. 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.

Malmquist productivity index is largely applied in the hotel industry, some of the applications are; Barros (2005) that used Malmquist productivity index to measure the efficiency of small public owned hotel chain in Portugal for the period 1991-2001. The findings of the research show that during the period of the study there was no growth achieved except for a small number of hotels. Moreover, it was observed that many hotels achieved a technical change but no technological change. Assaf and Barros (2011) used Malmquist productivity index to evaluate the productivity of the hotel industry in Gulf. The results show that the highest productivity growth is achieved by the hotel chains of Saudi Arabia, followed by UAE and Oman. Luo, Yang and Law (2014) used Malmquist productivity index to evaluate the efficiency change of the hotel industry in some major cities in China for the period 2001-2011. The study shows a significant improvement in productivity growth, during that period, due to an increase in the technical change. As mentioned in the previous chapter, Malmquist productivity index was also used in a research of Kuraltne et.al. (2019) to measure the productivity of 24 hotels in Sri Lanka for the period 2010-2014. The findings suggested a decreasing growth in the productivity of most of the hotels during the studied period.

In this thesis, Malmquist index will be employed to measure the productivity of the hotel industry in each tourist region in Tunisia for the years 2014 and 2015 and a comparison will be made in the next chapter (Chapter 4). The computations are made on Matlab.

3.5 Method description

This thesis has three main focuses, the first one is to the determine the efficiency of the hotel industry in each of the tourist regions in Tunisia for the years 2014 and 2015, using two inputs; Total number of hotels and Total number of beds, and two outputs; Occupancy rate and Total number of nights spent. The efficiency is measured using output-oriented CCR and BCC model. Next, the bias of the obtained efficiency scores was corrected by following Simar and Wilson’s (1998) DEA bootstrapping approach. The bootstrapping of the efficiency was performed using the DEA package for Matlbab (Alvarez et.al., 2016) with the standard number of replications, which is 200 replications.

The second focus of this thesis, is the measure the relationship between the hotel industry and sustainability in Tunisia. Three factors were selected based on the availability of data, each factor is related to one of the pillars of sustainability; water consumption is related to the environmental pillar, poverty rate is related 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. Tobit regression model is used in this study to determine the relationship between hotel industry efficiency and each of the aforementioned factors, using 1000 replications.

The third focus of this study is to measure the productivity of the hotel industry in each tourist regions of Tunisia in the period of 2014 and 2015. This is achieved by using Malmquist productivity index. In the next chapter of this thesis (Chapter 4), all the obtained results will be described and interpreted in a detailed way.

Chapter 4

RESULTS AND INTERPRETATIONS

This chapter is divided into two main parts; in the first part, the description of the results obtained using the DEA package for Matlab (Alvarez et.al.,2016) and Stata is made. Next, a detailed interpretation of the obtained results is done in the second part.

4.1 Description of results

4.1.1 Efficiency and Bootstrapped efficiency results

The output-oriented dual form of CCR and BCC models are used to estimate the efficiency scores of the DMUs for the years 2014 and 2015. Next, the bias-corrected efficiency scores are estimated using the bootstrapped DEA method (Simar & Wilson, 1998).

As mentioned previously, the outputs used for the estimation of the efficiency of the DMUs are the occupancy rate and the nights spent. As for the inputs, the number of hotels and the number of beds are used. Table 2 gives a statistical summary of the used variables for the year 2014.

Table 2: Descriptive data of the data in 2014

Variable	Description	Minimum	Maximum	Mean	Standard deviation
Output 1	Occupancy rate	17.1	59.9	37.15	15.22
Output 2	Nights spent	5700	6794400	2253427	2289058
Input 1	Number of hotels	14	172	77.09	50.12
Input 2	Number of beds	616	56349	21828.45	17585.02

The dual output-oriented aims to maximize ϕ_o which has a value larger than or equal to 1. An efficient DMU will have an efficiency score of 1, while an inefficient DMU will have a larger than 1. When a DMU obtains a value larger than 1, this signifies that the DMU is supposed to produce a larger amount of output using the amount of input it consumes. Radial efficiency that is based on the CRS assumption, technical efficiency that is based on VRS assumption, and relative efficiency, which obtained by dividing the radial efficiency by technical efficiency, are obtained for each DMU. Table 3 summarizes the ϕ_o efficiency scores for the year 2014.

The results of the year 2014 show that, out of the 11 DMUs, there are 3 efficient DMUs in the CCR model, which are DMU 3, DMU 5 and DMU 9. As for the BCC model, there are 5 efficient DMUs: DMU 3, DMU 5, DMU 6, DMU 7 and DMU 9.

Table 3: The generated ϕ_o scores for 2014

DMU	Tourist Region	Radial efficiency (CRS)	Technical efficiency (VRS)	Relative efficiency
1	Tunis-Zeghouan	1.8597	1.7532	1.0607
2	Nabeul-Hammamet	1.3545	1.3140	1.0308
3	Sousse-Kairouan	1.0000	1.0000	1.0000
4	Yassmine Hammamet	1.1129	1.1107	1.0020
5	Mounastir-Skanes	1.0000	1.0000	1.0000
6	Mahdia-Sfax	1.0547	1.0000	1.0547
7	Jerba-Zarzis-Gabes	1.0947	1.0000	1.0947
8	Gafsa-Tozeur	4.6000	2.2275	2.0651
9	Sbeitla-Kasserine	1.0000	1.0000	1.0000
10	Bizerte-Beja	1.5978	1.2178	1.3120
11	Tabarka-Ain Draham	1.6112	1.1651	1.3829
	Mean	1.5714	1.2535	1.1821
	Standard deviation	1.0483	0.3941	0.3210

As mentioned in the previous chapter, $\boldsymbol{\theta_o}$ ranges between 0 and 1 and $\boldsymbol{\phi_o}$ is the inverse of the efficiency $\boldsymbol{\theta_o}$. Thus, for the sake of simplicity and to be able to compare the efficiency of the DMUs in a smaller range, $\boldsymbol{\theta_o}$ of the DMUs has been computed (Table 4).

Table 4: CRS, VRS and relative efficiency scores (θ_o) for 2014

DMU	Tourist Region	Radial efficiency (CRS)	Technical efficiency (VRS)	Relative efficiency
1	Tunis-Zeghouan	0.5377	0.5704	0.9428
2	Nabeul-Hammamet	0.7383	0.7610	0.9701
3	Sousse-Kairouan	1.0000	1.0000	1.0000
4	Yassmine Hammamet	0.8986	0.9003	0.9980
5	Mounastir-Skanes	1.0000	1.0000	1.0000
6	Mahdia-Sfax	0.9481	1.0000	0.9481
7	Jerba-Zarzis-Gabes	0.9135	1.0000	0.9135
8	Gafsa-Tozeur	0.2174	0.4489	0.4842
9	Sbeitla-Kasserine	1.0000	1.0000	1.0000
10	Bizerte-Beja	0.6259	0.8211	0.7622
11	Tabarka-Ain Draham	0.6207	0.8583	0.7231
	Mean	0.7727	0.8509	0.8856
	Standard deviation	0.2512	0.1905	0.1642

In the CCR model, there are 2 DMUs with an efficiency $90 \leq \theta_o < 100\%$; DMU 6 and DMU 7, 1 DMU with $80 \leq \theta_o < 90\%$; DMU 4, 1 DMU with $70 \leq \theta_o < 80\%$; DMU 2, 2 DMUs with $60 \leq \theta_o < 70\%$; DMU 10 and DMU 11, 1 DMU with $50 \leq \theta_o < 60\%$; DMU 1, and 1 DMU with $\theta_o < 50\%$ which is the least efficient DMU; DMU8. The mean value of the CCR model is 0.7727.

For the BCC model, there is 1 DMU with an efficiency $90 \leq \theta_o < 100\%$; DMU 4, 2 DMUs with $80 \leq \theta_o < 90\%$; DMU 10 and DMU 11, 1 DMU with $70 \leq \theta_o < 80\%$; DMU 2, 1 DMU with $50 \leq \theta_o < 60\%$; DMU 1, and 1 DMU with $\theta_o < 50\%$ which is the least efficient DMU; DMU 8. The average efficiency of the BCC model is 0.8509. Therefore, it seems that DMUs have a better overall efficiency with the BCC model.

The relative efficiency gives an efficiency score to the DMUs relative to the reference set, which is the closest DMU on the efficient frontier to an inefficient DMU. Thus, relative efficiency shows by how much a DMU is less inefficient compared to its reference set. From the 11 DMUs, there are 3 DMUs on the efficiency frontier; which are DMU 3, DMU 5 and DMU 9, these DMUs represent reference sets to the inefficient DMUs. There are 5 DMUs with a relative efficiency ranging between 90% and 100%; DMU 1, DMU 2, DMU 4, DMU 6 and DMU 7 and 2 DMUs with relative efficiency ranging between 70% and 80%; DMU 10 and DMU 11. Only one DMU has a relative efficiency less than 50% which is DMU 8.

Table 5: Descriptive data of the data in 2015

Variable	**Description**	**Minimum**	**Maximum**	**Mean**	**Standard deviation**
Output 1	Occupancy rate	7.1	30.2	19.98	5.97
Output 2	Nights spent	3800	3108900	1015391	1039697
Input 1	Number of hotels	13	167	78.36	50.02
Input 2	Number of beds	570	57125	21944.73	17811.18

Table 5 gives a statistical summary of the inputs and output used for the estimation of the efficiencies of the DMUs for the year 2015.

Table 6: The generated ϕ_o scores for 2015

DMU	Tourist Region	Radial efficiency (CRS)	Technical efficiency (VRS)	Relative efficiency
1	Tunis-Zeghouan	1.3088	1.2942	1.0112
2	Nabeul-Hammamet	1.5977	1.1661	1.3701
3	Sousse-Kairouan	1.0000	1.0000	1.0000
4	Yassmine Hammamet	1.0000	1.0000	1.0000
5	Mounastir-Skanes	1.3003	1.2519	1.0387
6	Mahdia-Sfax	1.4666	1.4666	1.0813
7	Jerba-Zarzis-Gabes	1.1399	1.0000	1.1399
8	Gafsa-Tozeur	8.3119	3.6694	2.2652
9	Sbeitla-Kasserine	1.0000	1.0000	1.0000
10	Bizerte-Beja	1.6811	1.1486	1.4637
11	Tabarka-Ain Draham	1.4637	1.0000	1.7621
	Mean	1.9337	1.3633	1.2847
	Standard deviation	2.1292	0.7804	0.4086

Table 6 summarizes the ϕ_o scores for 2015.The results show that, out of the 11 DMUs, there are 3 efficient DMUs in the CCR model, which are DMU 3, DMU 4 and DMU 9. . As for the BCC model, there are 5 efficient DMUs: DMU 3, DMU 4, DMU 7, DMU 9 and DMU 11. Similarly to 2014, the number of efficient DMUs in BCC model is more compared to CCR model.

Table 7: CRS, VRS and relative efficiency scores ($\boldsymbol{\theta_o}$) for 2015

DMU	Tourist Region	Radial efficiency (CRS)	Technical efficiency (VRS)	Relative efficiency
1	Tunis-Zeghouan	0.7641	0.7727	0.9889
2	Nabeul-Hammamet	0.6259	0.8576	0.7299
3	Sousse-Kairouan	1.0000	1.0000	1.0000
4	Yassmine Hammamet	1.0000	1.0000	1.0000
5	Mounastir-Skanes	0.7691	0.7988	0.9627
6	Mahdia-Sfax	0.6819	0.6818	0.9248
7	Jerba-Zarzis-Gabes	0.8773	1.0000	0.8773
8	Gafsa-Tozeur	0.1203	0.2725	0.4415
9	Sbeitla-Kasserine	1.0000	1.0000	1.0000
10	Bizerte-Beja	0.5948	0.8706	0.6832
11	Tabarka-Ain Draham	0.6832	1.0000	0.5675
	Mean	0.7379	0.8413	0.8342
	Standard deviation	0.2545	0.2197	0.1980

Table 7 summarizes $\boldsymbol{\theta_o}$ efficiency scores for the year 2015. The results show that in the CCR model, there is 1 DMU with an efficiency 80 ≤ $\boldsymbol{\theta_o}$ < 90%; DMU 7, 2 DMUs with 70 ≤ $\boldsymbol{\theta_o}$ < 80%; DMU 1 and DMU 5, 3 DMUs with 60 ≤ $\boldsymbol{\theta_o}$ < 70%; DMU 2, DMU 6 and DMU 11, 1 DMU with 50 ≤ $\boldsymbol{\theta_o}$ < 60%; DMU 10, and 1 DMU with $\boldsymbol{\theta_o}$ < 50% which is the least efficient DMU; DMU 8. The mean value of the CCR model is 0.7379.

For the BCC model, there are 2 DMUs with an efficiency 80 ≤ $\boldsymbol{\theta_o}$ < 90%; DMU 2 and DMU 10, 2 DMUs with 70 ≤ $\boldsymbol{\theta_o}$ < 80%; DMU 1 and DMU 5, 1 DMU with 70 ≤ $\boldsymbol{\theta_o}$ < 80%; DMU 2, 1 DMU with a 60 ≤ $\boldsymbol{\theta_o}$ < 70%; DMU 6, and 1 DMU with $\boldsymbol{\theta_o}$ < 50% which is the least efficient DMU; DMU 8. The average efficiency of the BCC model is 0.8413. Thus, it seems that in the BCC model, DMUs have a better overall efficiency.

3 DMUs out of 11 DMUs are on the efficiency frontier; which are DMU 3, DMU 4 and DMU 9. There are 3 DMUs with a relative efficiency ranging between 90% and 100%; DMU 1, DMU 5 and DMU 6, 1 DMU with relative efficiency ranging between 70% and 80%; DMU 7, 1 DMUs with relative efficiency ranging between 60% and 70%; DMU 2, 1 DMUs with relative efficiency ranging between 50% and 60%; DMU 11. DMU 8 has a relative efficiency less than 50%.

By comparing the means of the efficiency scores of CCR model, BCC model and relative efficiency for the year 2014 with the year 2015, it is noticed that there is a decline in the efficiency scores from 2014 to 2015. It was also noticed that the least efficient DMU in both years is DMU 8. Some DMUs remained efficient in both years, which are DMU 3 and DMU 9 for the CCR model, and DMU 3, DMU 7 and DMU 9 for the BCC model.

As mentioned earlier in this thesis, bootstrapping the efficiency scores enables obtaining bias-corrected efficiency results. Bootstrapped efficiency scores for 2014 are summarized in Table 8 (for the CCR model) and Table 9 (for the BCC model).

Table 8: CRS bootstrapped efficiency and 95% confidence intervals for 2014

DMU	Efficiency (ϕ_o)	Bootstrapped efficiency	Lower bound	Upper bound	Efficiency (θ_o)	Bootstrapped efficiency	Lower bound	Upper bound
1	1.8597	2.0266	1.8743	2.2764	0.5377	0.4934	0.4393	0.5335
2	1.3545	1.5180	1.3613	1.7300	0.7383	0.6588	0.5780	0.7346
3	1.0000	1.1298	1.0147	1.2806	1.0000	0.8851	0.7809	0.9855
4	1.1129	1.299	1.1207	1.5842	0.8986	0.7698	0.6312	0.8923
5	1.0000	1.2092	1.0104	1.4737	1.0000	0.8270	0.6786	0.9897
6	1.0547	1.1629	1.0712	1.3038	0.9481	0.8599	0.7670	0.9335
7	1.0947	1.2153	1.1008	1.4016	0.9135	0.8228	0.7135	0.9084
8	4.6000	5.233	4.6699	6.0898	0.2174	0.1911	0.1642	0.2141
9	1.0000	1.3188	1.0132	1.7726	1.0000	0.7583	0.5641	0.9870
10	1.5978	1.8526	1.6148	2.1698	0.6259	0.5398	0.4609	0.6193
11	1.6112	1.8357	1.6223	2.1582	0.6207	0.5448	0.4633	0.6164
Mean	1.5714	1.8000	-	-	0.7727	0.6683	-	-

Comparing the previously obtained θ_o efficiencies to the bias-corrected θ_o efficiencies shows that the bootstrapped efficiency scores are smaller than the originally obtained scores. The efficient DMUs; DMU 3, DMU 5 and DMU 9 in the CCR model, do no longer have an efficiency equal to 100%, but efficiencies ranging between 75% and 88%. The bootstrapped efficiency mean is 0.6683, which is less than the originally obtained mean.

Similarly to the bootstrapped efficiencies of CCR model, the bootstrapped efficiencies of the BCC model are also smaller than the originally obtained scores and the efficient DMUs; DMU 3, DMU 5, DMU 6, DMU 7 and DMU 9 do no longer have an efficiency equal to 100%, but efficiencies ranging between 84% and 91%. The bootstrapped efficiency mean is 0.7634, which is smaller than the originally obtained mean, but bigger than the mean of the bootstrapped CCR model.

Table 9: VRS bootstrapped efficiency and 95% confidence intervals for 2014

DMU	Efficiency (ϕ_o)	Bootstrapped efficiency	Lower bound	Upper bound	Efficiency (θ_o)	Bootstrapped efficiency	Lower bound	Upper bound
1	1.7532	1.9121	1.7628	2.1525	0.5704	0.5230	0.4646	0.5673
2	1.314	1.4301	1.3238	1.6132	0.7610	0.6993	0.6199	0.7554
3	1.0000	1.1098	1.0061	1.2556	1.0000	0.9011	0.7964	0.9940
4	1.1107	1.2152	1.1183	1.4571	0.9003	0.8229	0.6863	0.8942
5	1.0000	1.1342	1.0074	1.3707	1.0000	0.8817	0.7296	0.9927
6	1.0000	1.1105	1.0054	1.2254	1.0000	0.9005	0.8161	0.9946
7	1.0000	1.156	1.0100	1.3722	1.0000	0.8651	0.7288	0.9901
8	2.2275	2.4146	2.2389	2.627	0.4489	0.4141	0.3807	0.4466
9	1.0000	1.1866	1.0042	1.5542	1.0000	0.8427	0.6434	0.9958
10	1.2178	1.3287	1.2273	1.5191	0.8212	0.7526	0.6583	0.8148
11	1.1651	1.2589	1.1749	1.3754	0.8583	0.7943	0.7271	0.8511
Mean	1.2535	1.3870	-	-	0.8510	0.7634	-	-

Table 10 and Table 11 summarize the bias-corrected efficiencies for 2015, of the CCR model and BCC model, respectively.

Table 10: CRS bootstrapped efficiency and 95% confidence intervals for 2015

DMU	Efficiency (ϕ_o)	Bootstrapped efficiency	Lower bound	Upper bound	Efficiency (θ_o)	Bootstrapped efficiency	Lower bound	Upper bound
1	1.3088	1.4536	1.3174	1.6445	0.7641	0.6879	0.6081	0.7591
2	1.5977	1.8505	1.639	2.1589	0.6259	0.5404	0.4632	0.6101
3	1.0000	1.1694	1.0142	1.3665	1.0000	0.8551	0.7318	0.9860
4	1.0000	1.217	1.0182	1.4406	1.0000	0.8217	0.6942	0.9821
5	1.3003	1.5543	1.3189	1.8717	0.7691	0.6434	0.5343	0.7582
6	1.4666	1.6364	1.4921	1.8238	0.6818	0.6111	0.5483	0.6702
7	1.1399	1.302	1.1483	1.5205	0.8773	0.7680	0.6577	0.8709
8	8.3119	9.4567	8.4826	10.7752	0.1203	0.1057	0.0928	0.1179
9	1.0000	1.3519	1.0173	1.8207	1.0000	0.7397	0.5492	0.9830
10	1.6811	2.0076	1.721	2.4014	0.5948	0.4981	0.4164	0.5811
11	1.4637	2.0657	1.7988	2.4607	0.6832	0.4841	0.4064	0.5559
Mean	1.9336	2.2786	-	-	0.7379	0.6141	-	-

For 2015, the efficient DMUs in the CCR model; DMU 3, DMU 4 and DMU 9 have bootstrapped efficiencies ranging between 73% and 86%. As for the bootstrapped efficiency mean, it is equal to 0.6141, which is less than the bootstrapped mean for 2014.

In the BCC model, the efficient DMUs; DMU 3, DMU 4, DMU 7, DMU 9 and DMU 11 have bootstrapped efficiencies ranging between 83% and 89%. It can be noticed that the bootstrapped efficiency scores of the efficient DMUs for 2015 are not significantly different. The bootstrapped efficiency mean for 2015 is equal to 0.7524, which is very close to the bootstrapped mean for 2014 equal to 0.7634.

Table 11: VRS bootstrapped efficiency and 95% confidence intervals for 2015

DMU	Efficiency (ϕ_o)	Bootstrapped efficiency	Lower bound	Upper bound	Efficiency (θ_o)	Bootstrapped efficiency	Lower bound	Upper bound
1	1.2942	1.4179	1.3016	1.5769	0.7727	0.7053	0.6342	0.7683
2	1.1661	1.2629	1.1692	1.3888	0.8576	0.7918	0.7200	0.8553
3	1.0000	1.1485	1.0052	1.3124	1.0000	0.8707	0.7620	0.9948
4	1.0000	1.1294	1.0086	1.319	1.0000	0.8854	0.7582	0.9915
5	1.2519	1.3763	1.2585	1.639	0.7988	0.7266	0.6101	0.7946
6	1.4666	1.4796	1.3638	1.6459	0.6818	0.6759	0.6076	0.7332
7	1.0000	1.1583	1.0117	1.376	1.0000	0.8633	0.7267	0.9884
8	3.6694	4.0026	3.7068	4.3645	0.2725	0.2498	0.2291	0.2698
9	1.0000	1.199	1.0028	1.7297	1.0000	0.8340	0.5781	0.9972
10	1.1486	1.2703	1.1637	1.4371	0.8706	0.7872	0.6958	0.8593
11	1.0000	1.1282	1.0051	1.2379	1.0000	0.8864	0.8078	0.9949
Mean	1.3633	1.5066	-	-	0.8413	0.7524	-	-

By comparing the original efficiency means and the bootstrapped efficiency means, it can be said that the original efficiency mean for 2014 is largely better than 2015, while the difference between the bootstrapped means for each year is not very large 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 a DMU can never be 100% efficient, because there are many other variables that affect its efficiency that were not considered by the study.

4.1.2 Tobit regression results

As mentioned in Chapter 3, Tobit regression is used to determine the relationship between a dependent variable skewed to one direction, and other independent variables. The bootstrapped efficiency is used as the dependent variable in this study.

Figure 8 and Figure 9 illustrate the normal-density plot of the CCR model and BCC model respectively. The figures show that normal-density plots are skewed to the left.

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 in each tourist region (Var 1), poverty rate (Var 2) that will have a value of 0 if the poverty rate is less than or equal 9.8% and a value of 1 is poverty rate is larger than 9.8%, and the direct contribution of tourism to GDP (Var 3). The direct contribution of the tourism of each tourist region to the GDP was estimated by giving a weight to each region based on its efficiency, which means that the regions that have a better efficiency obtain a better weight, hence have a larger contribution to the tourism GDP.

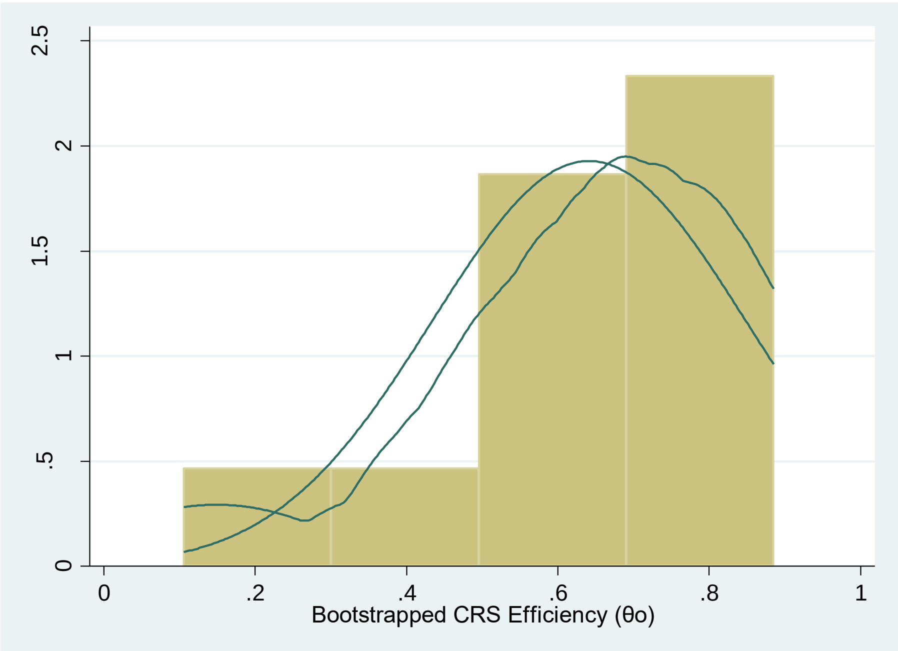

Figure 8: Histogram, Normal-density and Kernel-density plots of CRS efficiencies (θ_o)

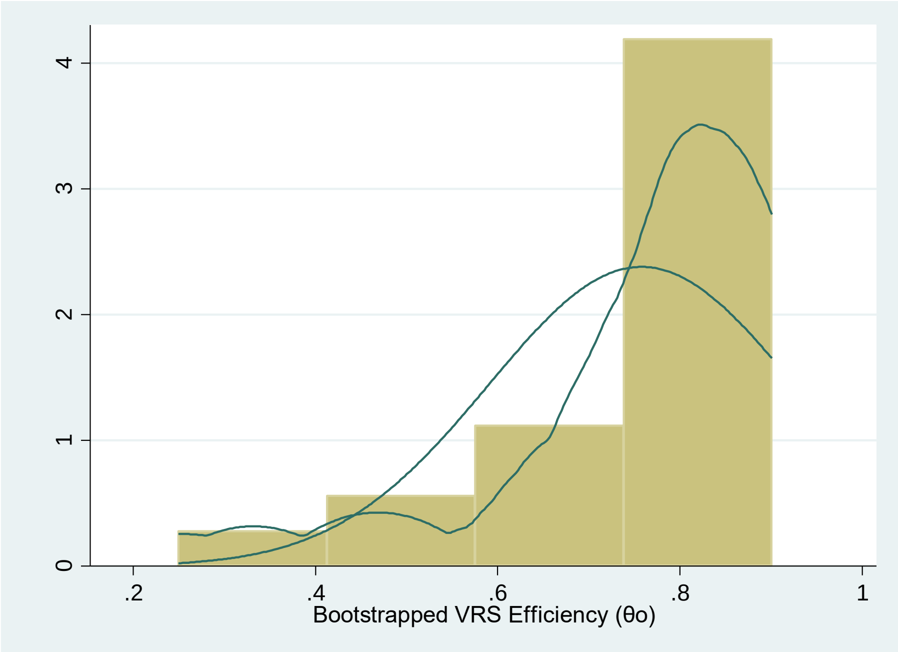

Figure 9: Histogram, Normal-density and Kernel-density plots of VRS efficiencies (θ_o)

The Tobit regression model used in this study is expressed as follows:

$$B.E_i = \beta_0 + \beta_1 Var1_i + \beta_2 Var2_i + \beta_3 Var3_i + u_i$$

Where;

$\boldsymbol{B.E_i}$ is the bootstrapped efficiency for each DMU

$\boldsymbol{\beta_0}$ is a constant

$\boldsymbol{\beta_1}$, $\boldsymbol{\beta_2}$ and $\boldsymbol{\beta_3}$ are the coefficients measured by the Tobit regression

$\boldsymbol{Var1_i}$ is the water consumption variable for each DMU

$\boldsymbol{Var2_i}$ is the poverty rate variable for each DMU

$\boldsymbol{Var3_i}$ is the direct contribution of tourism to GDP variable for each DMU

$\boldsymbol{u_i}$ is the error term of normal distribution for each DMU

Table 12 represent the correlation matrix of the independent variables that will be tested using the Tobit analysis. The results show that there are no strong correlations between the independent variables.

Table 12: Correlation matrix

	Var1	Var2	Var3
Var1	1.0000		
Var2	-0.3310	1.0000	
Var3	0.1879	-0.1261	1.0000

Table 13 and Table 14 summarize the results obtained from STATA of the Tobit regression analysis for the CCR model and the BCC model, respectively. The number of replication used in this study is 1000 replications.

Table 13: Tobit regression analysis (CRS efficiency)

	Observed Bootsrap		**Normal-Based (0.05 significance)**			
Variables	**Coefficient**	**Standard error**	**Z-statistic**	**P-value**	**Lower bound**	**Upper bound**
Var1	0.0252161	0.0241865	1.04	0.297	-0.0221886	0.0726208
Var2	-0.0572965	0.0572573	-1.00	0.317	-0.1695188	0.0549257
Var3	0.8161004	0.1312162	6.22	0.000	0.5589214	1.073279
Constant	0.0559671	0.118555	0.47	0.637	-0.1763965	0.2883307
Sigma	0.1079115	0.0138972	-	-	0.0806735	0.1351495

The Tobit analysis for the CCR model shows that Var 1 has a positive impact on the efficiency while Var 2 has a negative impact on the efficiency. As for Var 3, it has a significant positive impact on the efficiency.

Table 14: Tobit regression analysis (VRS efficiency)

	Observed Bootsrap		**Normal-Based (0.05 significance)**			
Variables	**Coefficient**	**Standard error**	**Z-statistic**	**P-value**	**Lower bound**	**Upper bound**
Var1	-0.0041399	0.0194588	-0.21	0.832	-0.0422784	0.0339986
Var2	-0.0295662	0.0381214	-0.78	0.438	-0.1042828	0.0451505
Var3	0.7358112	0.1381882	5.32	0.000	0.4649672	1.006655
Constant	0.2501525	0.111709	2.24	0.025	0.0312069	0.4690981
Sigma	0.081845	0.0097967	-	-	0.0626438	0.1010461

On the other hand, the Tobit analysis of BCC model shows that Var 1 and Var 2 have a negative impact on the efficiency, while Var 3 has a significant positive impact on the efficiency.

It is noticed that the Tobit analysis of CCR and BCC model provide similar results on Var 2 and Var 3, but different results on Var 1.

4.1.3 Malmquist productivity index results

In this section, Malmquist productivity index is used to measure the productivity of the DMUs over the period 2014-2015 using CCR model. The output-oriented model was used in measuring the productivity of the DMUs. This means that output-oriented Malmquist productivity index is measuring the ability of the DMUs to increase their outputs amounts using the same amount of inputs over the studied period. The computations of the productivity were run through Matlab.

By running a DEA test of RTS on Matlab, where the null hypothesis (H_0) is that the set of DMUs used in this study has an overall CRS and the alternative hypothesis (H_1) is that the set of DMUs has an overall VRS, it was found that CRS assumption is more appropriate to use to determine the productivity of the DMUs. The results of the test, for the years 2014 and 2015, are summarized in Table 15.

Table 15: 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

The P-value is 0.3150 for the 2014 and 0.2150 for 2015, while the significance lever is 0.05. Therefore, the test fails to reject the null hypothesis (***H_0***). This means that the CCR model is more appropriate for the set of DMUs of this study.

Table 16 summarizes the results of the Malmquist productivity, efficiency change and technical change over the period 2014-2015.

Table 16: Malmquist productivity, efficiency change and technical change of the period 2014-2015

DMU	Tourist Region	Malmquist productivity	Efficiency change	Technical change
1	Tunis-Zeghouan	0.6815	1.4209	0.4796
2	Nabeul-Hammamet	0.4021	0.8478	0.4743
3	Sousse-Kairouan	0.4721	1.0000	0.4721
4	Yassmine Hammamet	0.5584	1.1129	0.5017
5	Mounastir-Skanes	0.3635	0.7690	0.4726
6	Mahdia-Sfax	0.3557	0.7192	0.4946
7	Jerba-Zarzis-Gabes	0.4514	0.9603	0.4700
8	Gafsa-Tozeur	0.3051	1.0000	0.5513
9	Sbeitla-Kasserine	0.9903	0.9504	0.9903
10	Bizerte-Beja	0.8830	0.9144	0.9290
11	Tabarka-Ain Draham	0.8263	1.0000	0.9037
	Mean	0.5718	0.9723	0.6127

From table 16, it is noticed that the Malmquist productivity of all the 11 DMUs is less than 1, with only one DMU with a score very close to 1, which is DMU 9 with a score equal to 0.9903. As for the efficiency change, 2 DMUs have efficiency score larger than 1; DMU 1 and DMU 4, 3 DMUs have efficiency scores equal to 1; DMU 3, DMU 8 and DMU 11, while the rest of DMUs have efficiency scores less than 1. On the other hand, the technical change scores are strictly less than one for all DMUs, with only 3 DMUs scoring more than 90% technical efficiency change; DMU 9, DMU 10 and DMU 11.

The mean values of the Malmquist productivity is equal to 0.5718, which is a very low value. The mean value of the efficiency change and the technical change are 0.9723 and 0.6127, respectively.

4.2 Interpretation of results

In this section of Chapter 4, an interpretation is made on the situation of the hotel industry in the tourist regions of Tunisia during the period 2014-2015, based on the performed computation and the obtained results.

First, the efficiency of the hotel industry in tourist regions is discussed based on the CCR model, BCC model and bootstrapped efficiency results. Next, the Tobit regression analysis are interpreted to determine the relationship between the hotel industry and sustainability, based on the selected three factors. Finally, the productivity of the hotel industry in each tourist region on the period 2014-2015 will be discussed, based on the Malmquist productivity index results.

4.2.1 The efficiency of the hotel industry in the tourist regions of Tunisia

As a county that is ranked amongst the world's top thirty tourist destinations (The Tourism Real Estate Agency [AFT], n.d.), the hotel industry must play a very important role in the tourism sector of Tunisia. As previously mentioned, there are 11 tourist regions in Tunisia, which are; 1- Tunis-Zeghouan, 2- Nabeul-Hammamet, 3- Sousse-Kairouan, 4- Yassmine Hammamet, 5- Mounastir-Skanes, 6- Mahdia-Sfax, 7- Jerba-Zarzis-Gabes, 8- Gafsa-Tozeur, 9- Sbeitla-Kasserine, 10- Bizerte-Beja and 11- Tabarka-Ain Draham.

With the CRS assumption, the tourist regions with the most efficient hotel industries, in 2014, were; Sousse-Kairouan with a bias-corrected efficiency of 88.51%, Mounastir-Skanes with 82.70% and Sbeitla-Kasserine with 75.83%. 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 dropped to 85.51%, Yassmine Hammamet which improved from 76.98% to 82.17% and Sbeita-Kasserine which dropped to 77.97%. Monastir-Skanes, which was a tourist region with an efficient hotel industry, dropped to 64.34%. As for Gafsa-Tozeur, it didn't just remain as the region with the least efficient hotel industry, but also dropped to and very low efficiency score of 10.57%.

With the VRS assumption, the results were quite different, the BCC model generated higher efficiency scores, hence more efficient hotel industry regions. In 2014, the tourist regions with the most efficient hotel industries were; Sousse-Kairouan with a bias corrected efficiency equal to 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 tourist region with the least efficient hotel industry was Gafsa-Tozeur with 41.41%. In 2015, the efficient hotel industry regions were; Tabarka-Ain Draham which increased from 79.43% to 88.64%, Yassmine Hammamet which increased from 82.29% to 88.54%, Sousse-Kairouan which dropped to 87.07%, Jerba-Zarzis-Gabes which remained almost constant (86.33%) and Sbeitla-Kasserine which dropped to 83.40%. 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 overall drop in efficiency in 2015 is probably affected by the terrorist attacks that were targeting tourists and that happened during 2015 in the region of Tunis and the region of Sousse, as well as the Arab spring events (The National, 2018). It can be said the, the political instability and the safety concerns of the country affected the tourism during the period 2014-2015.

The very low efficiency of the hotel industry in the tourist region of Gafsa-Tozeur, is possibly because of the geographic location of the region. Gafsa-Tozeur is located in the Sahara desert, which is known for its difficult weather conditions, water scarcity and undeveloped and isolated conditions.

Contrarily to the tourist region of Gafsa-Tozeur, most of the hotel industries in Tunisia that were found efficient are located in coastal areas. Therefore, tourists are probably more attracted to coastal destinations, because of their moderate weather, which is less harsh than the desert weather. Figure 10 represents a map of Tunisia to help locate the tourist regions.

Figure 10: Map of Tunisia (World Atlas, 2017)

4.2.2 The hotel industry and sustainability in Tunisia

This thesis attempted to measure the relationship between the hotel industry and sustainability in Tunisia based on three selected factors which data were available. Each factor was used to represent one of the pillars of sustainability; the environmental pillar was represented by the water consumption of the tourism sector in the tourist region, the social pillar was represented by the poverty rate in the tourist region and the economic pillar was represented by the direct contribution of tourism to the country's GDP by each tourist region.

Two different results were obtained based on RTS assumptions. The CRS assumption results showed that water consumption has a positive impact on the efficiency of the hotel industry, poverty rate has a negative impact on the hotel industry efficiency and tourism GDP has a significant positive impact on the hotel industry efficiency. Meanwhile, the VRS assumption results, gave similar results on social and economic variables, but a different result concerning the environmental variable; water consumption affects the efficiency of the hotel industry negatively.

Since the DEA test for RTS assumption, was in favor of CRS assumption, then the Tobit regression analysis results for the CRS will be interpreted. Moreover, it makes more sense that a tourist region that has access to more water can achieve better hotel industry efficiency.

Although it has been shown that water consumption has a positive impact on the hotel industry, water has to be consumed in a moderate and sustainable manner. Tunisia in one of the countries suffering from water scarcity, it is ranked as number thirty of the most water-stressed counties in the world (World Resources Institute, 2019).

Thus, Tunisia has to consider sustainable ways in using water resources, such as water recycling, seawater desalination...etc. Moreover, the hotel industry should be responsible in using water resources, by investing in better technologies. As the results of the study of Hathroubi et.al. (2014) on the Tunisian hotel industry have shown, using clean and renewable energies and economic energy systems have a positive impact on the efficiency of hotel industry in Tunisia.

The Tobit analysis shows that less poverty rate has a positive impact on the efficiency industry. This should push hotel industry to alleviate poverty through Corporate Social Responsibility (CSR) projects, hence this will offer a win-win solution to both, the hotel industry and the society of Tunisia.

The poverty rates in Tunisia have seen a continuous decrease between from 2000 to 2015, as Figure 11 shows, but more efforts have to be done in the future.

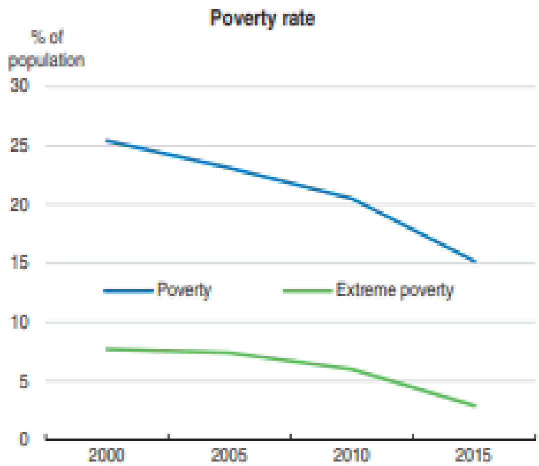

Figure 11: Poverty and Extreme poverty rates in Tunisia 2000-2015 (INS, 2016)

Another inference that was achieved through the Tobit analysis, is that the direct contribution of tourism to the GDP affects the efficiency of the hotel industry in a significant positive way. This means that the more tourists a tourist region attracts, the higher the contribution of the region to tourism GDP of the country and the more tourist are hosted by the hotel industry in the region. Therefore, more investment in the tourism industry should be made to attract more tourists. More focus could be given the less efficient tourist region to improve the efficiency of their hotel industry.

4.2.3 The productivity of the hotel industry in Tunisia in the period 2014-2015

The results of the Malmquist productivity index show an overall negative productivity growth of the hotel industry in all tourist regions of Tunisia, in the period 2014-2015. The hotel industry in the tourist region Sbeitla-Kasserine is the only one to show a better productivity growth compared to the other tourist regions. The Malmquist productivity shows that the hotel industry in Gafsa-Tozeur is the least productive and this emphasizes the efficiency results previously obtained.

The decomposition of the Malmquist index into efficiency change and technical change provide more information on the situation of the hotel industry. It seems like in service industries, such as the hotel industry, the technical change cannot increase in the same pace as the efficiency change, unlike manufacturing industries. The mean value of efficiency change is equal to 0.9723, which shows an overall good efficiency change in the hotel industry, for the period 2014-2015. The mean value of the technical change is 0.6127, is significantly smaller than efficiency change.

The efficiency change shows that the tourist regions Tunis-Zeghouan and Yassmine Hammamet have seen an efficiency increase over the studied period. The regions Sousse-Kairouan and Gafsa-Tozeur and Tabarka-Ain Darham had an unchanged efficiency over the period. Meanwhile, the efficiency change of the hotel industry in all the other tourist regions decreased. As for the technical change of the tourist industry, it decreased in all the tourist regions, in the period 2014-2015, but the regions; Sbeitla-Kasserine, Bizerte-Beja and Tabarka-Ain Draham show better results, compared to the other regions.

Although the tourist regions Tunis-Zghouan and Yassmine Hammamet made some positive progress in their efficiency over the period 2014-2015, their productivity was pulled down because of their decreasing technical change. This means that the hotel industry in Tunisia is in need to new technologies to improve their productivity in the future.

One way to improve the technological change in hotel industry is through implementation of the green and sustainable technologies which have been proven by Kuraltne et.al. (2019), as well, to improve the efficiency of the hotel industry. Furthermore, Kang, Stein, Heo and Lee (2012), have found that customers are willing to pay more for hotels adopting sustainable practices.

Chapter 5

CONCLUSION

In the conclusion of this thesis, the contributions of this work to the literature is briefly summarized. Finally, the limitation of this study and the possible future works are discussed.

5.1 The contributions of this thesis

In this thesis, the efficiency of the hotel industry of the eleven tourist regions of Tunisia was evaluated for the years 2014 and 2015, using the output-oriented CCR and BCC model. Two outputs, which are the occupancy rate and the nights spent, and two inputs, which are the number of hotels and the number of beds, were used. The bias of the efficiency scores was corrected using DEA bootstrapping method. Next, Tobit regression analysis was used to find the relationship between the efficiency of the hotel industry and three sustainability factors (independent factors), which are water consumption, poverty rate and the direct contribution of tourism to GDP. Finally, Malmquist productivity index was used to evaluate the productivity of the hotel industry over the period 2014-2015.

The findings of this research showed a decrease in the average efficiency of the hotel industry for the period 2014-2015, from 66.83% to 61.41%, linked to the political situation of the country. Furthermore, the efficiency of the hotel industry in the coastal regions is found to be higher than the efficiency of the hotel industry in the Sahara region. The results, also showed that water consumption and the tourism contribution to GDP have a positive impact on the efficiency of hotel industry. Contrarily to the poverty rate which affect the hotel industry efficiency in a negative way. Moreover, the evaluation of the productivity of the hotel industry over the period 2014-2015 showed an overall decreasing productivity growth in the hotel industry of all regions and average productivity equal to 57.18%. That is due to the lack of implementation of new technologies in the hotel industry of Tunisia. The results of the thesis conclude that sustainability have positive effect on the efficiency of the hotel industry.

5.2 The limitations and the future works

Many difficulties were faced during the data collection process of this research, due to the lack or unavailability of data on the tourism and hotel industry of Tunisia. A better understanding of the situation of the hotel industry could have been achieved by evaluating the efficiency and performance over a longer period of years. Moreover, to be able to measure the relationship between the hotel industry and sustainability accurately, more factors have to be used. For this purpose, this thesis encourages the voluntary data collection on tourism sector, hotel industry, and sustainability, to help future works find more precise results and suggest more accurate solutions to the environmental and sustainability problems in the hotel industry.

As suggestions, the efficiency of the hotel industry could be evaluated using other inputs, such as the total number of hotel employees in each tourist region, total costs of the hotel industry in each tourist region… and outputs, such as the total revenues of the hotel industry in each tourist region…. The impact of other characteristics of tourist regions (weather type, area, urban/rural, coastal/inland…etc) on the efficiency of the hotel industry could be tested. Other sustainability factors for each pillar could be tested, for the environmental pillar; total electricity consumption, total carbon emission… For the social factor; unemployment rate, education rate… For the economic factor; Capital costs, operating costs…. A bias-corrected productivity could be evaluated using bootstrapped productivity index.

Some other future studies could discuss the ranking of the hotel industry in the tourist regions of Tunisia using DEA ranking models. An evaluation of the efficiency of the hotel industry in each regions of Tunisia using Stochastic DEA (SDEA), can also be discussed, since the inputs and outputs of the hotel industry are stochastic variables.

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APPENDICES

Appendix A: Inputs and outputs data of tourist regions for 2014-2015

Year	Tourist region		Inputs		Outputs	
	DMU	Tourist region name	Number of hotels	Number of beds	Occupancy rate	Nights spent
2014	1	Tunis-Zeghouan	131	24437	34.1	1652100
	2	Nabeul-Hammamet	113	39894	40.1	3870800
	3	Sousse-Kairouan	112	40789	50.6	5383900
	4	Yassmine Hammamet	45	19602	46.9	2140700
	5	Mounastir-Skanes	48	23422	59.9	2848000
	6	Mahdia-Sfax	68	14030	46.9	1615100
	7	Jerba-Zarzis-Gabes	172	56349	50.6	6794400
	8	Gafsa-Tozeur	87	11067	18.1	247600
	9	Sbeitla-Kasserine	14	616	17.1	5700
	10	Bizerte-Beja	25	3475	19.2	79700
	11	Tabarka-Ain Draham	33	6396	25.2	149700
2015	1	Tunis-Zeghouan	141	25549	18.1	1197600
	2	Nabeul-Hammamet	115	41078	22.9	1571500
	3	Sousse-Kairouan	107	40138	23.5	2490000
	4	Yassmine Hammamet	45	19724	30.2	1115500
	5	Mounastir-Skanes	47	22222	24.1	896000
	6	Mahdia-Sfax	75	13968	19.3	563200
	7	Jerba-Zarzis-Gabes	167	57125	17.7	3108900
	8	Gafsa-Tozeur	90	11111	7.1	70200
	9	Sbeitla-Kasserine	13	570	16	3800
	10	Bizerte-Beja	25	3475	17.1	57000
	11	Tabarka-Ain Draham	37	6432	23.8	95600

Appendix B: Independent factors data of tourist regions for 2014-2015

Year	Tourist region		Independent factors		
	DMU	Tourist region name	Water consumption (Mm^3)	Poverty Rate (dummy variable)	Direct contribution of tourism to GDP (%)
2014	1	Tunis-Zeghouan	2.2	1	0.5497
	2	Nabeul-Hammamet	3.7	0	0.7334
	3	Sousse-Kairouan	1.1	1	0.9637
	4	Yassmine Hammamet	1.3	0	0.8676
	5	Mounastir-Skanes	1.9	0	0.9637
	6	Mahdia-Sfax	1.1	0	0.9637
	7	Jerba-Zarzis-Gabes	3.8	1	0.9637
	8	Gafsa-Tozeur	0.1	1	0.4326
	9	Sbeitla-Kasserine	0.1	1	0.9637
	10	Bizerte-Beja	0.1	1	0.7913
	11	Tabarka-Ain Draham	0.3	1	0.8271
2015	1	Tunis-Zeghouan	1.8	1	0.5710
	2	Nabeul-Hammamet	3.1	0	0.6338
	3	Sousse-Kairouan	0.9	1	0.7390
	4	Yassmine Hammamet	0.9	0	0.7390
	5	Mounastir-Skanes	1.3	0	0.5903
	6	Mahdia-Sfax	0.9	0	0.5449
	7	Jerba-Zarzis-Gabes	2.7	1	0.7390
	8	Gafsa-Tozeur	0.1	1	0.2014
	9	Sbeitla-Kasserine	0.1	1	0.7390
	10	Bizerte-Beja	0.1	1	0.6434
	11	Tabarka-Ain Draham	0.2	1	0.7390