Assessing the impact of Information and Communication Technologies on the Portuguese hotel sector: an exploratory analysis with Data Envelopment Analysis

Avaliação do impacto das Tecnologias da Informação e Comunicação no setor hoteleiro português: uma análise exploratória com Data Envelopment Analysis

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Abstract

The overall objective of this paper is to evaluate the impact of Information and Communication Technologies (ICT) on the efficiency of four- and five-star hotels in Portugal and to contribute to the identification of mechanisms that explain the relationship between ICT and efficiency within the hotel sector through Data Envelopment Analysis (DEA). Overall, based on research fundamentals and the results obtained, it can be said that the main research questions were answered and the objectives of the study were achieved. In response to research questions related to the use of ICT in the Portuguese hotel industry, the following uses were determined for hotels in the sample: defining efficient frontiers, identifying efficient and inefficient hotels, ranking hotels according to their efficiency and revealing areas of inefficient hotels that have to be improved to increase effectiveness (improvement targets). Moreover, this study illustrates not only the importance of ICT in achieving higher levels of efficiency but also discusses other specific issues which must be taken into account so that the benefits of ICT can be experienced. Specifically, it was found that the availability of ICT does not alone lead to optimum performance.

Keywords: Data envelopment analysis, information and communication technologies, productivity, hotels.

Resumo

O objetivo global é avaliar o impacto das TIC na eficiência dos hotéis de 4 e 5 estrelas em Portugal e contribuir para a identificação dos mecanismos que explicam a relação entre ambas no sector hoteleiro através da metodologia DEA. Em termos de conclusões, com base nos fundamentos e nos resultados obtidos, pode dizer-se que as principais questões colocadas foram respondidas e os objetivos do estudo foram alcançados. Assim, foi dada resposta às questões de investigação relacionadas com o uso das TIC no sector hoteleiro português, uma vez que foi possível determinar para os hotéis da amostra: a fronteira de eficiência, identificar os eficientes e ineficientes, construir o ranking segundo a sua eficiência e mostrar os aspetos que os hotéis ineficientes têm que melhorar para se tornarem eficientes (metas de melhoria). Por outro lado, este estudo ilustra não só a importância das TIC na obtenção de maiores níveis de eficiência, mas também são abordadas outras questões específicas a ter em conta para que os benefícios das TIC possam ser materializados. Especificamente, verificou-se que a mera disponibilidade de TIC não conduz a um melhor desempenho.

Keywords: Data envelopment analysis, tecnologias da informação e comunicação, produtividade, hotéis.

1. Introduction

The overall objective of this paper is to evaluate the impact of Information and Communication Technologies (ICT) on the efficiency of four- and five-star hotels in Portugal and contribute to the identification of the mechanisms that explain the relationship between ICT and efficiency in the Portuguese hotel sector. ICT enable companies to be, quickly and without geographical limitations, within the reach of many people and can create added value for customers by allowing a quick launch in the market of both new products and services – including web catalogues with descriptions and prices – for a greater availability to end customers. This is also accompanied by an increase in revenue from additional services, as a result of opening new channels of distribution and sales (Bilgihan, Okumus, & Kwun, 2011).

The hospitality industry is no exception to these trends in ICT investments and increasing use over the past two decades (Haro de Rosario, Gálvez Rodrigues & Caba Pérez, 2013; Boaria, Anjos & Raye, 2014; Sirirak, Islam & Khang,

2011; Scholochow, Fuchs, & Höpken, 2010). However, there are several studies on these trends' impact on hotels, and so far the theme in Portugal has not yet been much explored. Thus, the justification for studying the impact of ICT on this sector takes into account the fact that, with the increase of competitiveness in tourism and hospitality, maximising the efficiency of hotels is an important objective. As a result, increased competition has propelled organisations into a search for more effective business strategies, many of them choosing ICT as a way of dealing with economically turbulent environments (Okumus, Altinay & Chathoth, 2010).

However, studies researching the impact of ICT have sometimes led to contradictory results and/or doubts about the benefits of the same (Boaria *et al.,* 2014; Chen, Liang, Yang & Zhu, 2006). With this in mind, the present study was based on the context of the hospitality industry in Portugal, using data collected through a survey on the use of ICT in hotels conducted by the National Institute for Statistics (INE). This survey had the statistical aim of analysing the

presence of ICT in these establishments by coverage, extent and purpose of ICT use. The survey was first conducted in 2008 and later again in 2011, and provided a view over time of data collected. The population covered by the survey consisted of all accommodation establishments in Portugal, within the NACE Rev.3 Group H Group 55.1 classified as of tourist interest by Turismo de Portugal.

2. Literature Review

The first DEA model, proposed by Charnes, Cooper and Rhodes (1978) – named DEA-CCR – had an input orientation and supposed that there were constant returns to scale (CRS). This methodology seeks to establish which firms of a sample determine the envelopment surface or efficient production frontier. The radial distance of a firm from its frontier provides the measurement of its efficiency. The second DEA model proposed presents the hypothesis of variable returns to scales (VRS), known as DEA-BCC (Banker, Charnes & Cooper, 1984). As well as these two important models, there are other DEA models which are less frequently found in the literature. As a result, we can identify at least five basic DEA models: the additive model (Charnes, Cooper, Golany, Seiford & Stutz, 1985), the multiplicative model (Charnes, Cooper, Seiford & Stutz, 1982), the cone-ratio DEA model (Charnes, Cooper, Huang & Sun, 1990), the Assurance Region DEA model (Thompson, Langemeier, Lee, Lee & Thrall, 1990) and the super-efficiency model (Andersen & Petersen, 1993). DEA methodology is applied to the unitary evaluation of homogeneous units or firms, such as hotels. The evaluation unit – which is normally known as the Data Management Unit (DMU) – is what transforms inputs into outputs. This is why its identification in any study is a difficult and crucial aspect. According to DEA, the performance of a firm is evaluated based on an efficient frontier which is built by a linear combination of existing firms. The procedure is based on a complex mathematical model (Annex I). A complete description of these hypotheses is given by Ray (2004) and by Coelli, Rao, O'Donnell & Battese (2005).

Researchers have begun to use DEA as an alternative approach to evaluating the impact of ICT on firm performance because DEA does not have a priori assumptions on the functional form characterising the relationships between ICT investment and firm performance measures (Zhu, 2002). For example Banker, Kauffman, and Morey (1991) use DEA to study operational efficiency gains from ICT. Shafer and Byrd (2000) propose a DEA framework for measuring the efficiency of organisational investments in ICT. Thus, DEA has been used to carry out advanced statistical analysis on the efficiency scores of hotels, which have in turn been evaluated by studying their relationship with various metrics relating to ICT possession, ICT use, Internet access, ICT training and workers with ICT skills.

However, researchers believe that DEA has some limitations (Othman, Foo, Karim & Andaziz, 2010; Deraman, Said & Saman, 2011). DEA does not offer a prediction model of organisation performance. This is due to limitations on its use outside the database employed. As a result, DEA should be considered as specific for the sample used. In other words, DEA analysis is not appropriate to compare with a theoretical maximum efficiency (Othman et al., 2010). Nevertheless, since the DEA model was first introduced, it has been adopted as a research tool to measure operational efficiency and has been frequently applied to measure the performance of organisations in the service sector, as in the case of measuring the efficiency of hotels (Sigala, 2004; Scholochow *et al.*, 2010; Bilgihan *et al.*, 2011; Rebelo, Matias & Carrasco, 2013).

3. Methods

In general terms, this study aims to make a fundamental contribution by answering questions about the use of ICT in the hotel sector and its impact on efficiency, using data envelopment analysis methodology (DEA). The main research questions that fall within the objectives of this study are as follows: 1) Have investment in and use of ICT had some impact on the efficiency of the (four- and five-star) hotel sector in Portugal?, and 2) Have (four- and five-star) hotels in Portugal explored/used ICT to improve their efficiency?.

To achieve these objectives, we collected and analysed data obtained from four-and five-star hotels in Portugal because a focus on a particular sector eliminates contextual factors and operational characteristics of firms that would affect the relationship between ICT, efficiency and productivity. This was done in order to (Sigala, 2003):

- Measure the efficiency of hotels using a robust methodology;

- Distinguish between efficient and inefficient hotels and, at the same time, identify factors that define their efficient frontiers, i.e., factors that affect these;

- Determine potential improvements for the target sector in inputs/outputs;

- Analyse ICT systems used by hotels and the ways in which ICT have been implemented;

- Identify whether hotels with different ICT levels, ICT use, ICT training and workers with ICT skills differ significantly in levels of efficiency.

Specifically, the hypotheses that a) hotels with an Internet presence (stays resulting from Internet bookings and computers with an Internet connection) obtain significantly higher efficiency scores and b) hotels that make a more sophisticated use of their systems and ICT capabilities and possess 1) ICT and ICT departments and 2) ICT training – get significantly higher efficiency scores. When this is found, significant differences are then investigated.

3.1 Variables (inputs and outputs), sample, scale returns and level of analysis

DEA recognises that technical efficiency can be improved and focuses on how this can be done. To use DEA, it is necessary to define the inputs and the outputs of services. Inputs are the resources used and any results which are obtained from the process are called outputs. The characterisation of inputs and outputs implies looking at

the service process as a "black box" (Chen & Zhu, 2004; Färe & Grosskopf, 2000). Indeed, the majority of approaches to productivity adopt this point of view only in the first stages of analysis, with the definition of the process. This can be considered a composite of various business units, each one using the same types of inputs to produce the same types of outputs.

In short, a problem is the accurate definition of what is considered to be input and output in the services sector and their measurement. Production – measured by the comparison of an output with an input – requires both indicators to be quantifiable. The majority the measurement problems come from measuring output: its multidimensional nature (some of the elements or aspects are not quantifiable but are relevant), its intangible nature, the presence of external factors and the difficulty of evaluating quality, among others, are some of the difficulties found when trying to measure output. This is an important inconvenience in measuring this sector's productivity (Grönroos & Ojasalo, 2004).

Another problem in the case of the hotel sector and of the services sector in general is that the definition of productivity/efficiency is complicated given that the traditional concept of efficiency was developed for the manufacturing of physical goods (Assaf, Barros & Josiassen, 2010; Bilgihan *et al.,* 2011). Efficiency measures obtained are quite sensitive to alternative specifications in terms of economies of scale. While recognising this fact, the literature on efficiency does not offer much guidance on the question of how to evaluate the suitability of decisions in this context (Nunes & Machado, 2014).

On the question of the level of analysis, the impact of ICT on efficiency was studied at the organisational level since, as noted by several authors (Chen *et al.,* 2006; Chen & Zhu, 2004), this is considered the best level of analysis. Moreover, to overcome limitations on the measurement of ICT – since it is the deployment of ICT tools and capabilities and not investment per se which can actually lead to increased productivity/efficiency – the construct was operationalised for ICT using four variables that reflect the exploitation of ICT (Chen *et al.*, 2006; Fernández-Menéndez, Sánchez, Duarte & Sandulli, 2009):

- Number of workers who use computers;
- Number of workers who use computers with an Internet connection;
- Total number of workers who attend ICT training courses;
- Total number of workers with ICT skills and with graduate studies.

The use of these measures is justified by the known ability of ICT to promote and support initiatives in business process re-engineering (BPR) (Berezina & Cobanoglu, 2010).

Annex II presents inputs and outputs used in the study of performance in hotels in Portugal from 2008 to 2011. We used a database of 1,935 hotels for 2008 and 1,895 hotels for 2011. This study took into account the reliability and

possible bias of the sample, in order to obtain reliable and consistent responses (Banker *et al.*, 1991; Fernández-Menéndez *et al.,* 2009). To overcome these issues, given that the sample of selected hotels (four- and five-star establishments) comes from the database of the INE on the use of ICT, the data should be examined for non-random selection. However, Sigala (2003) the success of DEA analysis is based on the assumption that the analysed units have the same idiosyncratic characteristics, a fact which is controlled by the use of a number of units within the same sector and the same category, so they must have similar characteristics in types of operations. Therefore, we limited our analysis to a sample of four- and five-star hotels, for 2008. The final number of hotels analysed was 245 (90% of the population and for 2011 was 319 hotels (92% of the population). Thus, the above sample used for both years is almost coincident with the population, which obviates the issues of bias and representativeness.

3.2 Analysis methods applied

The treatment of variables included in the model was carried out in successive steps in a logical order determined by objectives. Thus, the initial step was statistical analysis of variables and, subsequently, an evaluation of ICT using DEA, which is considered the most appropriate method based on a review of the literature (Fernández-Menéndez *et al.,* 2009; Assaf *et al.*, 2010).

The DEA model was applied to assess levels of efficiency and how a finite number of hotels use a set of inputs to produce outputs. Therefore, this step was used to determine frontiers of efficiency, which were identified to serve as a reference of efficient hotels in the benchmarking process of inefficient hotels. With the information obtained, we can formulate improvement plans for inefficient hotels to become more effective, contributing to the measurement of strategic performance and consequently achieving better overall performance. At this stage, to avoid the risks of basing the decision process on one particular model, several DEA models were used initially and, from this, it was determined whether they could lead to more complex models based on data characteristics (Ting & Huang, 2012). To explore causes of inefficiency, operational efficiency is decomposed into the structural components of technical, pure, scale efficiency, and cost efficiency, as suggested in some studies (Barros, 2006; Hu, Shieh, Huanga & Chiua, 2009). Meanwhile, Sigala (2004), Wang, Hung, and Shang (2006) and Wang, Shang and Hung (2006) used multiple DEA models to screen out external effects in efficiency and to compute purely managerial efficiency of hotels. Yu and Lee (2009) and Hsieh and Lin (2010) used a two-stage framework to measure productive efficiency and service effectiveness of tourist hotels. Differences in efficiency between business and leisure hotels have been described in many hotel efficiency researches, such as Sun and Lu (2005) and Wang *et al.*, (2006).

Among the four models applied – BCC and CCR under both input and output orientation – the final model elected was the output-oriented BCC. For this decision we considered the following questions:

1. Does the model show a good relationship between average efficiency and discrimination between variables?

2. Does the model include the variables needed to reach the objectives?

3. Does the application of cluster analysis provide an idea of whether or not companies aggregate into homogeneous groups?

The application of the various models indicated that although both models could be adopted, it seemed more appropriate to consider that there is a tendency for hotels, in an analysis of benefit, to adapt their level of operations to scale but not necessarily to proportionality between inputs consumed and outputs produced. In other words, there is no clear link between efficiency scores and the size of hotels as reflected by the existence of a direct proportionality between inputs used and outputs produced, so it is most appropriate to consider the existence of variable returns to scale. Likewise, we can say that hotels will benefit from fairer comparisons – comparing hotels of equal size to each other – and thereby allow us to assess whether in cases of inefficiency, this is solely due to wrong choices of management policies or because hotels operate on an inadequate scale. This is only possible when using a model with a VRS assumption, as the bottom allows us to assess the existence of economies of scale. Thus, as we also intended to measure the economies of scale, we used the BCC output-oriented model (Hsieh & Lin, 2010).

On the other hand, the DEA group approach also could be applied in this study to identify the effect of particular ICT uses on the productivity/efficiency of hotel groups made up of various hotels level, type and use of ICT. This discrimination of hotels allowed the identification of the impact of different management practices of ICT and thus provides useful guidance on this aspect in particular (Brown & Rasgale, 2002; Sigala, 2003). However, because the number of hotels that could be grouped into clusters with similar ICT configurations would be proportionally small in relation to the inputs and outputs selected, the analysis in this study could not further assess and calculate the impact of different ICT configurations on productivity/efficiency of hotels. Instead, the study utilised DEA under the VRS assumption in order to identify frontiers of productivity and efficiency scores of hotels in the sample and then used statistical inference to investigate whether productivity levels were related to ICT (Barros, 2006; Assaf *et al.*, 2010).

The second question that arises is with respect to what is the best model orientation. Thus, with reference to authors who argue that the best orientation for this kind of industry is input (Barros, 2006), on the basis that hotels may have little control over output variables, we think that this limitation can be overcome by the fact that through new distribution channels hotels can – although they cannot allow reservations on their own website – use third party systems. Today costs are much more blurred than in early, pioneering systems. Moreover, in addition to acting as a reservation channel, ICT also is an important means for marketing and allows hotels to increasingly access a greater number of

potential guests through aggressive pricing policies. Thus hotels may now have more control over output variables. Moreover, since the study did not use traditional input variables but considered others, it would not be an appropriate option to minimise input where assets were acquired as a way to decrease implementation efforts, for example, number of computers and number of training courses, among others. Therefore, in view of the above, it is concluded that analysis carried out with a BCC model (VRS) and output orientation is most suitable to calculating efficiency scores of hotels for each of the years analysed.

4. Discussion

The model results were organised as follows: model fit, table of relative efficiencies and their analysis, variables and weights, and special cases of inefficient hotels. The latter were examined for possibilities for potential improvement (Chen, 2009; Chen, 2011). In addition, the application of DEA allowed us to classify hotels into four different groups depending on their efficiency (Avkiran, 2006):

Efficient hotels in the first group can be considered as an example of good practice in the management of its resources;

Efficient hotels belonging to the second group do not appear in any reference set outside of their own, being likely to show data clearly distinct from other hotels. In this case we need to take a closer look in order to establish if there are no particular characteristics that define them as very different from other hotels so that we can compare them appropriately. This may also be the case for hotels which have different priorities and, as such, should be analysed;

Inefficient hotels belonging to the third group can easily increase their efficiency score;
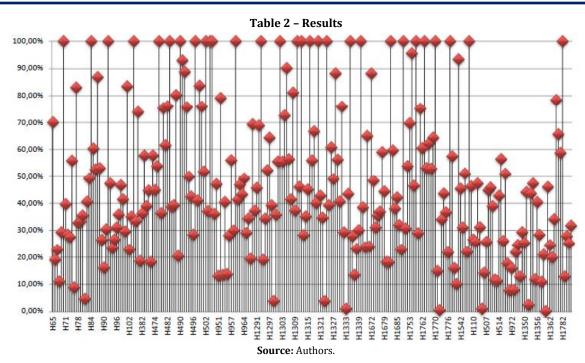
Inefficient hotels belonging to the fourth group are not successful in this area and must be studied to equalise any effect that is not covered by the factors selected. The management of these hotels should be questioned.

In the results (Table 1 and Table 2), an interpretation of the distribution of efficiency scores reveals that analysed hotels are classified as efficient in terms of purely technical efficiency, since we used the BCC model, forming clusters serving as a reference for inefficient hotels. In percentage terms, for the 245 hotels in the study in 2008 and for 319 hotels in 2011 the results are show in the table 1. We concluded, if we compare the results of 2008 and 2011, that the effective number of hotels increased by 2.3%, going from 11.8 to 14.1% and there was also an increase in the minimum efficiency.

Table 1 - Results

Year: 2008	Number Hotels: 245
Efficient Hotels	11,8 % (29 hotels)
Inefficient Hotels	88,2% (216 hotels)
Value of Minimum Efficiency	0,2%
Average Efficiency	47,6%
Median	41,4%
Year: 2011	Number Hotels: 319
Efficient Hotels	14,1% (45 hotels)
Inefficient Hotels	85,9% (274 hotels)
Value of Minimum Efficiency	1,1%
Average Efficiency	47,9%
Median	42,7%

Source: Authors.

Table 2 – Results

Source: Authors.

Moreover, it can be concluded that in 2008, a median of 41.4% means that 50% of hotels had a score of less than or equal to an efficiency of 41.4% to a minimum of 0.2%, and the remaining 50%, of course, have an efficiency score greater or equal to 41.43% up to the maximum. Similarly, for 2011, the median means that 50% of hotels have a score of less than or equal to an efficiency of 42.7% to a minimum of 1.1%, and the remaining 50% obviously have an efficiency score higher than or equal to 42.7% up to the maximum. This value is also present in the second quartile and the fiftieth percentile. In summary, for the efficiency scores of hotels ranging from 1.1% to 100%, 45 hotels are efficient and 274 are inefficient. Therefore, in comparative terms, efficiency in 2011 was higher than efficiency in 2008.

In relation to inefficiency of hotels, one result is the fact that they have all been compared with a set of efficient hotels with identical configuration input/output, which appears in reference sets referred to as global leaders (Avkiran, 2006). The benefit of this information is that we have an efficient hotel that can be emulated to improve the performance of inefficient hotels. Thus, the study of efficiency not only calculates the performance index of each unit but also indicates to what extent and in which areas an inefficient unit needs to improve in order to become efficient. This information allows hotels to set goals that can help inefficient hotels to achieve better performance (Deraman et al., 2011). Therefore, each inefficient hotel has a set of references in efficient hotels that they can imitate to become efficient (Rebelo et al., 2013)

This analysis, either by reducing the inputs and/or increasing outputs, can be carried out on a global level and/or for each input/output. We calculated the relative percentage of potential improvement for each input/output and for 2008, the results indicated that if we make a comprehensive analysis of weights of the output variables of inefficient hotels, we can conclude that of the 216 inefficient hotels, 100 hotels give full weight to the output

variable "total number of stays", meaning that they have a low value for this variable and 18 hotels give full weight to the output variable "total number of stays resulting from Internet bookings". For the remaining 98 hotels weight is mixed. For 2011, it is concluded that for the 274 inefficient hotels, 86 give full weight to the output variable "total number of stays resulting from Internet bookings", as they have a low value for these establishments, and 28 give full weight to the output variable "total number of stays".

The overall result shows that the output variable "total number of stays resulting from Internet bookings" has the highest percentage for potential improvement in the hotels of the 2011 sample (71.7 %) and in 2008 the potential for improvement was 99.6%. Therefore, we concluded that from 2008 to 2011 the value of this variable improved since its rate of improvement declined 27.9%. However, unlike 2008 also, the variable "total number of overnights" needs to improve significantly (16.9%) compared to 0.27% in 2008. In short, inefficient hotels in 2008 and 2011 showed very small values for output variables in relation to average values for the entire sample. However, they showed a heavy structure in terms of input variables obtained at the production level compared to small inputs used. Therefore, we can state that these hotels are not as efficient as those which, despite having a large number of operations, fail to get a total number of overnights that compensates for these inputs in terms of results.

The reliability analysis of weights takes into account that the optimal values calculated by DEA weights are objectively determined, which may not correspond to the relative values that a hotel assign to their inputs and outputs. This is actually a strength and not a weakness of DEA. Therefore, a hotel considered inefficient by DEA is identified as such only after all possible weights have been considered to give this hotel the highest rating possible, consistent with the restriction that no hotel can get more than 100% efficiency. Any set of weights applied would only make a hotel into a hotel which is

becoming inefficient, that is, equally or less efficient. In this way, DEA gives the benefit of doubt to each hotel or service unit in the calculation of efficiency. Furthermore, DEA does not erroneously classify any efficient unit as inefficient (Cooper, Seiford & Tone, 2007).

4.1 Analysis of the implementation and use of ICT (2008-2011)

In terms of ICT inputs variables, data were collected on five aspects: ICT investment; ICT use; Internet usage and connection, ICT training and workers with ICT skills. In terms of outputs, data were collected on a measure that reflects the result of the previous measures: the number of stays resulting from Internet bookings (Annex II).

A descriptive analysis also allowed conclusions in terms of ICT usage in the hotel industry. In summary, we can say that the results (Table 3 - INE survey) for 2008 revealed an almost universal use of these technologies in establishments with 10 or more employees. On the other hand, 70% of hotel establishments accessed the Internet via broadband, with DSL the most used (75%). For 2011, the percentage of establishments that provided accommodation bookings via the Internet was 74%, which represented 30% of total overnight stays. In terms of ICT use, access and presence on the Internet was a widespread practice in establishments with 50 or more employees.

Table 3 – Results

	2008	2011
Hotels used a computer	80%	87%
Hotels Internet access	78%	78%
Hotels Internet present	75%	87%
Hotels establishments accessed the Internet via broadband	70%	
Proportion of hotels that provided accommodation bookings via the Internet	65%	74%
Variation 2008-2011		
Hotels used a computer	7%	
Hotels establishments accessed the Internet via broadband	0%	
Hotels Internet present	12%	
Proportion of hotels that provided accommodation bookings via the Internet	9%	

Source: Authors.

We can conclude that the use of computers, Internet access, broadband, Internet presence and online booking increased between the two years under study.

Taking into account all the above, it is concluded that ICT positively evolved between 2008 and 2011, highlighting the following aspects:

1) The adoption of ICT systems increased in the hospitality industry;

2) ICT was acquired at different rates;

3) Hotels mainly implemented a piecemeal approach to ICT investment, which may affect their ability to improve productivity while automation and synergistic effects materialise.

Therefore, as it is concluded that the use of ICT in the hotel sector increased between the periods considered, we must now evaluate the impact of this event on the efficiency of four- and five-star hotels.

4.2. Analysis of the contribution of ICT variables to the efficiency of hotels – 2008

Since the objective of this study is to evaluate the impact that ICTs have on the efficiency of each hotel in the sample, we calculated the minimum, maximum and average contributions of each variable on efficiency scores. Firstly, an analysis was performed based on input and output variables, individually or in combination with others, to determine which had more influence on the efficiency scores obtained. We gauged which factors affected the

greater or lesser efficiency of sample hotels, opting to divide and distinguish between the variables that contributed to a higher percentage of efficient hotel (100%) and inefficient (less than 100%). The latter we divide into two groups (99.9%-50% and 49.9%-0%).

With respect to the 29 efficient hotels of 2008, the variables that most contributed were the number of workers, the number of computers with Internet connection and number of workers with ICT skills with graduate studies . Regarding the contribution of ICT input variables, the one that contributed most to the scores of efficient hotels was the "number of computers with Internet connection" for 41.38% of the hotels, where this variable contributed to the calculation of their efficiency scores. The low contribution of this variable to 13.11% of inefficient hotels in the first group and 14.19% of inefficient hotels in the second group emphasises the importance of using the Internet and new distribution channels as a success factor. The second ICT input variable that contributed most to efficient hotels was "number of workers with ICT skills with graduate studies", with a contribution of 37.93% to efficient hotels but a higher contribution to inefficient hotels – 52.46% of inefficient hotels in the first group and 48.39% of inefficient hotels in the second group. Since we found that this variable contributes more to the scores of inefficient hotels than to efficient hotels, this has to be analysed for each hotel and management will have to apply reduction measures on a case by case basis, since we cannot forget that this was one of the success factors of efficient hotels. Overall, this variable showed mixed behaviour.

For the remaining ICT input variables, contributions were as follows. The variables relating to the use of ICT and the existence of an ICT department had a higher contribution than the variable that represents ICT investment for efficient hotels. This goes against our hypothesis that it is an appropriate use of ICT which will make the difference in terms of performance and not merely possession. Finally, ICT input variables that made a lower contribution to efficient hotels were related to training. We think that despite the fact that these are important there may be a gap in the results on effects produced in terms of efficiency.

On the other hand, we concluded that the output variable "number of stays resulting from Internet bookings" was the largest contributor, for 89.66% of the efficient hotels, higher than its contribution to the percentages of inefficient hotels, which was 60.66% of inefficient hotels in the first group and 50.97% in the second.

Of particular relevance to the efficiency of hotels in 2008 – with respect to ICT – were the number of computers connected to the Internet and the availability of ICT employees with higher education. The single ICT output variable which contributed to higher efficiency in hotels was the "total number of stays". We can thus conclude once again that the new distribution channels are a fundamental tool for hotels. In relation to inefficient hotels, we can say that of the 61 hotels that were part of the first group, the most influential variables in inefficiency were the number of people who contributed to the inefficiency of 56 hotels and variable total number of training courses that contributed to the inefficiency of 28 hotels. Therefore, a variable number of workers was of particular relevance to the inefficiency of hotels in 2008, which can be both an advantage and a negative factor at the same time. Regarding the single ICT output variable, its contribution to inefficient hotels was less than the total number of stays. With regard to hotels that comprise the second group, the most influential variables were the "number of workers" for 138 hotels and the "total number of training courses" for 62 hotels. Of particular importance to the inefficiency of these hotels in 2008 was the number of workers, which continued to be a negative factor. For the ICT output variable, its contribution to the inefficient hotels was less than the total number of stays. In the latter group of very inefficient hotels, we noted that none of the variables related to ICT were among the top three variables that contributed the most to inefficiency.

4.3 Analysis of the contribution of ICT variables to the efficiency of hotels – 2011

Using the same assumptions we can, in a summarised form, evaluate the percentage of hotels each variable contributed to in 2011. We conclude that the output variable "number of stays resulting from Internet bookings" made the largest contribution to hotels with 100% efficiency, contributing to the efficiency of 82.22% of efficient hotels, higher than its contribution to the percentage of inefficient hotels, which were 80.46% and 67.4% relative to the first and second groups of inefficient hotels respectively. Regarding ICT input variables that contributed most to the scores of these hotels was the "number of workers with ICT skills with

graduate studies" for 53.33% of hotels. On the other hand, the contribution of this variable to inefficient hotels of both groups emphasises that the existence of an ICT department is not by itself a guarantee of success. Thus, this variable also contributed to the scores of inefficient hotels. Each hotel has to be analysed for each variable and management will have to implement reductions in the individual cases it deems relevant, since we cannot forget that this was one of the success factors of efficient hotels. So it seems that this variable may show mixed behaviour, as found for 2008. The second of the ICT input variables that contributed most to efficient hotels was the "number of workers who use computers with Internet connection" with a contribution to 35.56% of hotels, having a lower contribution to inefficient hotels, which goes against the initial hypothesis that the use of ICT and new distribution channels makes the difference. Finally, the ICT input variable that contributed to lowering efficiency of hotels was the one related to training.

In inefficient hotels, in the first group the variables that influenced a greater percentage of hotels were the output variable "total number of stays" (90.80%) and the output variable "total number of stays resulting from Internet bookings" (80.46%). The latter is related to ICT, which in some way indicates that this channel is used effectively. Thus, the hotels of this group should be concerned essentially with these two related factors in an increase of the number of overnight stays. For ICT input variables, we can assert that the input variable "total number of workers with ICT skills with graduate studies" was the second most important in influencing a higher percentage of ineffective hotels in this group (47.13%). This result for the workers may be indicative of a value that can help these hotels reach their efficient frontier.

We conclude that in the second group, the variables that made the largest contribution to the largest percentage of hotels were the output variable "total number of stays", which contributed to 89.3% of inefficient hotels, and the input variable "number of workers" which contributed to 74.3% of inefficient hotels, none of which related to ICT. Thus, the hotels of this group should be concerned essentially with two factors that are, first and foremost, to increase the number of overnight stays and secondly to reduce the number of workers. For ICT variables, we conclude that the output variable "number of stays resulting from Internet bookings" also contributed to a higher percentage of inefficient hotels at 67.4%, a decrease compared to the previous group. We argue that this variable will help these hotels reach their efficient frontiers. Thus, managers should make an effort to increase overnight stays from new distribution channels. In relation to ICT input variables, we conclude that the variable "number of workers with ICT skills with graduate studies" contributed to obtaining inefficiency scores for 35.3% of the hotels in this group, decreasing in relation to the previous group.

5. Conclusions

On the basis of the results obtained, we can affirm that the main issues raised with this study were answered appropriately and that the objectives of the study were achieved. In response to research issues related to the use

of ICT in the Portuguese hotel sector, it was possible to determine the efficient frontier of hotels, to identify efficient and inefficient hotels, to rank hotels according to their efficiency and to show areas where inefficient hotels have to improve to become more efficient (improvement targets). Therefore, for the main practical result of this study, it was possible to identify the most efficient hotels in generating stays within the group analysed for 2008 and 2011, as well as the least efficient hotels, and we can affirm that in 2011 hotels increased their efficiency. We conclude that output variables have to increase at rates much higher than input variables have to decrease. However, it should be noted that calculated efficiency scores are relative to the set of hotels, to inputs/outputs considered and to the model used as well as any amendment to this set of hotels. For example, the exclusion or inclusion of any variables or changing model can interfere with the result, so an extrapolation of its conclusions is not possible. The study results also contributed to the development of an approach to the management of ICT, which in turn raises other issues to consider in future studies and research, while providing empirical evidence on critical issues relating to ICT in order to add organisational value.

Second, by showing the efficiency or inefficiency of hotels, this study may contribute to management, especially that of inefficient hotels, because the degree of efficiency for all hotels analysed can be used as an indicator in the realignment of investment strategies and use of ICT to maximise returns. In addition, the process of generating and interpreting scores on efficiency and potential improvements can assist decision-making about the restructuring of hotels. Hotels where potential for improvement was identified for controllable inputs (i.e., input approved in order to increase output) must be analysed by their managers, not forgetting that certain types of discretionary input would be better left unchanged. In such cases, the main message is that management should not spend additional resources in an attempt to improve these inputs since they do not contribute to an increase in output. On the other hand, outputs identified by DEA as having a potential for improvement should encourage management to explore better ways to operate hotels and can provide valuable information, to be taken into account as inputs are converted into outputs and making hotels which fall within the reference set of inefficient hotels more efficient.

In addition, this study has added value for the hotel and tourism sector both for academics and professionals, and for other sectors in general, by developing and implementing an appropriate methodology, demonstrating that ICTs can improve efficiency. In this sense, the contradictory and inconsistent results from previous studies may be the result of methodological problems that this study was intended to overcome. This study not only illustrates the importance of ICTs in achieving higher levels of efficiency, but also has touched on other specific issues related to ICT that must be taken into account so that the benefits of ICT can experienced. Thus, the ability to identify specific ICT applications and their benefits is of great importance as it allows companies to develop the set of ICT instruments which best correspondence to their strategies

and which comply with the main objectives of these strategies. Hotels are distinguished from each other by creating added value for which clients are willing to pay. As in any sector, a positive distinction is made between more creative and innovative companies. Therefore, there is nothing more important than to take advantage of this innovation to make hotels more attractive, comfortable, functional, and, above all, more profitable. In particular, this study confirmed that the mere availability of ICT does not lead to better performance.

The main limitation of research results regarding the fact that, as have used a source of public data, it has not been possible to collect data on other variables. In the future work to improve the estimation process, other input data could be obtained individually and separately allowing the collection of data from other variables, so that the model is not so restrictive. The investigation was also limited to theoretical background and expertise on which the same could have been constructed and developed. Specifically, although a large number of studies have investigated the impact of ICT on productivity, previous studies have been criticized for its methodology, by the lack of a consolidated theory and widely accepted in the form as ICTs have an impact on productivity, while the productivity measurement and improvement of body knowledge also represent some gaps and limitations.

To this end, after reviewing the existing literature and research, the study had to start by developing a methodology which would examine the paradox of ICT productivity and overcome previous limitations and to strengthen the body of knowledge on how ICT impact productivity and so that they can be better managed for achieving organizational benefits. In this way, as suggestions for possible future work include: suggested the adoption of other variables that complement those used in this study as well as complement DEA with other techniques such as developing a conceptual model for analysing productivity in the hotel sector. This conceptual model can be developed on the basis of, on the one hand, the metaphor of production and, on the other hand, the four perspectives of BSC (Balanced Scorecard) (Nunes & Machado, 2014). In this sense, would be to develop a conceptual model with inputs, intermediate outputs, outputs and contextual variables, which may relate to investment and the use of ICT to productivity in the hotel sector.

References

Andersen, P., & Petersen, N. C. (1993). A Procedure for Ranking Efficient Units in Data Envelopment Analysis. *Management Science*, *39*(10), 1261–1264.

Assaf, A., Barros, C. P. P., & Josiassen, A. (2010). Hotel efficiency: A bootstrapped metafrontier approach. *International Journal of Hospitality Management*, *29*(3), 468–475.

Avkiran, N. (2006). Productivity Analysis in the Services Sector with Data Envelopment Analysis, (3rd ed). Camira: University of Queensland.

Banker, R., Charnes, A. & Cooper, W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30(9), 1078-1092.

Banker, R. D., Kauffman, R., & Morey, R. (1991). Measuring gains in operational efficiency from information technology: a study of the Positran deployment at Hardee's Inc. *Journal of Management Information Systems*, *7*(2), 29–54.

Barros, C. P. (2006). The Measurement of Efficiency in Portuguese Hotels Using Data Envelopment Analysis. *Journal of Hospitality & Tourism Research*, *30*(3), 378–400.

Bilgihan, A., Okumus, F., Kwun, D. D. J.-W., & Nusair, K. Khal. (2011). Information technology applications and competitive advantage in hotel companies. *Journal of Hospitality and Tourism Technology*, *2*(2), 139–153.

Berezina, E. & Cobanoglu, C. (2010). Importance-performance analysis of in-room technology amenities in hotels. In U. Gretzel, R. Law & M. Fuchs, *Information and Communication Technologies in Tourism 2010* (pp. 25-37). Vienna: Springer.

Boaria, F., Anjos, S., & Raye, R. (2014). A aplicação do e-marketing nas redes hoteleiras do Brasil. *Tourism & Management Studies*, 10(2), 116-122.

Brown, J., & Ragsdale, C. (2002). The competitive market efficiency of hotel brands: an application of data envelopment analysis. *Journal of Hospitality & Tourism, 26*(4), 332–360.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European journal of Operational Research, 2*(6), 429–444.

Charnes, A., Cooper W., Seiford L. & Stutz J. (1982). Multiplicative model for efficiency analysis. *Socio-Economic Planning Sciences*, 16, 223-235.

Charnes, A., Cooper W., Golany B., Seiford L. & Stutz J. (1985). Foundations of data envelopment analysis for Pareto-Koopmans efficient empirical production functions*. Journal of Econometrics*, 30(1-2), 91-107.

Charnes, A., Cooper W., Huang M. & Sun D. (1990). Polyhedral Cone-Ratio DEA models with an illustrative application to large commercial banks. *Journal of Econometrics*, 46, 73-91.

Chen, Y., & Zhu, J. (2004). Measuring information technology's indirect impact on firm performance. *Information Technology and Management Journal*, 5, 9–22.

Chen, Y., Liang, L., Yang, F., & Zhu, J. (2006). Evaluation of information technology investment: a data envelopment analysis approach. *Computers & Operations Research*, *33*(5), 1368–1379.

Chen, T.-H. (2009). Performance measurement of an enterprise and business units with an application to a Taiwanese hotel chain. *International Journal of Hospitality Management*, *28*(3), 415–422.

Chen, T.-H. (2011). Performance measurement in a small Taiwanese hotel chain. *Cornell Hospitality Quarterly*, *52*(3), 354–362.

Coelli, T., Rao, D., O'Donnell, C. & Battese, G. (2005). *An introduction to eficiency and productivity analysis*. Berlin: Springer.

Cooper, W., Seiford, L. & Tone, K. (2007). Data envelopment analysis: a comprehensive text with models, applications, references and DEA-solver software. New York: Springer.

Deraman, N., Said, J., & Saman, F. (2011). Data Envelopment Analysis (DEA) evaluation framework of hotel services. *Proceedings of the 2nd International Conference on Business Administration (ICBA '11)*, 154-160.

Färe, R., & Grosskopf, S. (2000). Network DEA. *Socio-economic Planning Sciences*, *34*, 35-49.

Fernández-Menéndez, J., López-Sánchez, J. I., Rodríguez-Duarte, A., & Sandulli, F. D. (2009). Technical efficiency and use of information and communication technology in Spanish firms. *Telecommunications Policy*, *33*(7), 348–359.

Grönroos, C., & Ojasalo, K. (2004). Service productivity. *Journal of Business Research*, *57*(4), 414–423.

Haro de Rosario, A., Gálvez Rodrigues, M., & Caba Pérez, M. (2013). Development of social media and web 2.0 in the top hotel chains. *Tourism & Management Studies*, 9(1), 13-19.

Hsieh, L.-F., & Lin, L. (2010). A performance evaluation model for international tourist hotels in Taiwan: an application of the relational network DEA. *International Journal of Hospitality Management*, *29*(1), 14–24.

Hu, J.-L., Shieh, H.-S., Huang, C.-H., & Chiu, C.-N. (2009). Cost efficiency of international tourist hotels in Taiwan: A Data Envelopment Analysis application. *Asia Pacific Journal of Tourism Research*, *14*(4), 371–384.

Nunes, C., & Machado, M. (2014). Performance evaluation methods in the hotel industry, *Tourism & Management Studies*, 10(1), 24-30.

Okumus, F., Altinay, L. & Chathoth, P. (2010). *Strategic management for hospitality and tourism*. Oxford: Elsevier.

Othman M., Foo L., Karim, M. & Andaziz Y. (2010)- Total Factor Productivity Efficiency Changes In A Malaysian Hotel Chain, Int. J. Revenue Management, 4,. 327-343.

Ray, S. (2004). *Data envelopment analysis: theory and techniques for economics and operations research*. Cambridge: Cambridge University Press.

Rebelo, S., Matias, F., & Carrasco, P. (2013). Application of the DEA methodology in the analysis of efficiency of the Portuguese hotel industry: an analysis applied to the Portuguese geographical regions. *Tourism & Management Studies*, 9(2), 21-28.

Scholochow, C., Fuchs, M. & Höpken, W. (2010). ICT efficiency and effectiveness in the hotel sector: a three stage DEA approach. Proceedings of the International Conference Information and Communication Technologies in Tourism, 1, 642-654.

Shafer, S., & Byrd, T. (2000). A framework for measuring the efficiency of organizational investments in information technology using data envelopment analysis. *Omega*, *28*, 125-141.

Sigala, M. (2003). The information and communication technologies productivity impact on the UK hotel sector. *International Journal of Operations & Production Management*, *23*(10), 1224–1245.

Sigala, M. (2004). ICT paradox lost? A stepwise DEA methodology to evaluate technology investments in tourism settings. *Journal of Travel Research*, *43*(2), 180–192.

Sirirak, S., Islam, N., & Khang, D. B. (2011). Does ICT adoption enhance hotel performance? *Journal of Hospitality and Tourism Technology, 2*(1), 34–49.

Sun, S., & Lu, W. (2005). Evaluating the performance of the Taiwanese hotel industry using a weight slacks-based measure. *Asia-Pacific Journal of Operational Research*, 22(4), 487-512.

Thompson, R.G.; Langemeier, L.N.; Lee, C.; Lee, E. & Thrall, R. (1990). The Role of Multiplier Bounds in Efficiency Analysis with Application to Kansas Farming. Journal of Econometrics, 46(1-2), 93-108.

Ting, C.-T., & Huang, C.-W. (2012). Measuring the effectiveness of mutual learning for Taiwan's tourist hotels with the DEA Approach. *Cornell Hospitality Quarterly*, *53*(1), 65–74.

Zhu, J. (2002). Quantitative models for performance evaluation and benchmarking: data envelopment analysis with spreadsheets. Boston: Kluwer Academic Publishers.

Wang, F., Hung, W. & Shang, J. (2006). Measuring the cost efficiency of international tourist hotels in Taiwan. *Tourism Economics*, 12(1), 65–85.

Wang, F., Shang, J. & Hung, W. (2006). Productivity and service quality changes in international hotels in Taiwan. *Annals of Tourism Research*, 33(2), 571–574.

Yu, M.-M., & Lee, B. C. Y. (2009). Efficiency and effectiveness of service business: evidence from international tourist hotels in Taiwan. *Tourism Management*, *30*(4), 571–580.