The efficiency of the continental European transportation cruise ship companies. A slack based DEA application

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The cruise sector grew by 200% in the decade 2007-2017, especially in North America and Europe.
The European cruise market is one of the largest cruise markets in the world, ranking only behind North America for market revenue. Around 6.7 million passengers were carried on cruises in Europe in 2016. In the wider European economy, the cruise industry has a major economic impact; for the manufacturing industry alone, the cruise sector directly contributed 6.1 billion euros in durable goods and 1.9 billion euros in non-durable goods in 2015.
The research aims to investigate the relative efficiency of the 148 continental European transportation cruise ship companies via DEA (Data Envelopment Analysis) Slack Based model.
Our findings suggested that the management of transportation cruise ship companies does have to benefit from the understanding on how to direct their actions by allowing companies to the right proportions and size. Limitations and, therefore, future research will focus on the size dimension.

Keywords: Data Envelopment Analysis, DEA, Slack Based Model, Cruise Ship Companies, Managerial, Scale Efficiency.
JEL Classification: C61, G14, R42

1 Introduction

The world cruise market is experiencing an extremely positive period as evidenced by the data provided by the *Cruise Lines International Association* (CLIA) in its *2017 Cruise Industry Outlook*, the world's largest trade association in the sector that analyses 458 cruise ships. The year 2016 closed with 24.7 million passengers aboard ships around the world and it is expected to reach 25.8 million by the end of 2017.

In particular, CLIA confirms a 3.4% growth in European passengers in 2016 compared to the previous year. The growth in 2016 was driven by Germany, UK and Ireland, as documented by the CLIA *2016 Annual Report*. The European market has grown steadily over the last 10 years, successfully reaching 6.7 million travelers. The trend of the last 5 years has been increasing in all the European markets, in particular in Germany with a + 11.3% that has allowed to reach the record of over 2 million passengers. In the United Kingdom and Ireland, there was an increase of + 5.6% with almost 1.9 million passengers, while Spain continues the recovery with an increase of 4.2% after the decline recorded in 2014.

Efficiency in the service sector is a significant issue as the world became globally connected. As one of the auxiliary service businesses in the tourism sector, the transportation cruise ship companies went under pressure as European touristic destination, from North to South Europe, became open to diverse kind of tourists, from young to old, from cheap expenditure power to well-off people.

The research aims to investigate the relative efficiency of the 148 continental European transportation cruise ship companies via DEA (Data Envelopment Analysis) Slack Based model.

2 Theoretical Background

The tourism literature analysed a variety of field sectors to determine whether operations are efficient: hotels (Barros, 2005; Hwang and Chang, 2003), resorts (Goncalves, 2013), travel agencies (Fuentes, 2011) and cruise lines (Chang et al., 2017; Gregoriou et al., 2017; Peisley, 1995, 1998, 1999).

About hotels, Barros (2005) in his study discusses, by means of data envelopment analysis, the efficiency of individual hotels belonging to the Portuguese state-owned chain, Pousadas de Portugal, and he points how the DEA stands out as one of the most promising techniques to aid the improvement of efficiency. Instead, Hwang and Chang (2003) use the DEA and the Malmquist productivity index expressed by Färe et al. (1992) to measure the managerial performance of 45 hotels in 1998 and the efficiency change of 45 Hotels from 1994 to 1998.

Relating to resorts, Goncalves (2013) analyses French ski resorts productivity using LPI (Luenberger Productivity Indicator) based on the directional distance function, that allows the calculation of a productivity indicator divided into technical efficiency change and technological change.

Fuentes (2011) explores the relative efficiency of 22 travel agencies of similar characteristics based in Alicante (Spain) using the DEA technique and smoothed bootstrap.

Focusing on cruise lines, Chang et al. (2017) measure the efficiency of the top three cruise lines to develop a network DEA model to analyze the cruise operations at two stages, namely operating and non-operating stages and, furthermore, the determinants of the efficiencies are examined using a bootstrapped-truncated regression model. Gregoriou et al. (2017) use the DEA to examine the efficiency of cruise ships adopting basic and super efficiency models. Using DEA allows to observe which ships are constructed as the most efficient, suggesting that a cruise ship does not have to be big to be efficient, rather, it needs to have the right proportions and size.

Peisley (1995) looks at the strategies being adopted by the major cruise lines and the behaviour patterns of the main cruise markets in North America and Europe, as well as other newly emerging markets. In 1998, he focuses on the North American market and in 1999 on the Asian Pacific cruise industry.

The most investigated side refers mainly to the cruise industry (Brida and Zapata, 2010; Castillo-Manzano et al., 2015; Chase and Alon, 2002; Dowling, 2006) funding that, generally, the international nature of the cruise industry has significant impacts on many emerging and less on developed economies (Belal et al., 2013).

In particular, Brida and Zapata (2010) provide an overview of the different impacts of cruise tourism in Costa Rica, in order to collect information (passenger demographic characteristics, preferences and expenditure behaviors) to help the decision making process and the establishment of policies and strategies for cruise ship tourism. Castillo-Manzano et al. (2015) focus on analysing the perception that the tourism sector itself has of its impact in cities representing the cruise's stages.

The research by Chase and Alon (2002) develops a model to evaluate the impact of cruise tourism on a destination and tests the model on the economy of Barbados.

Dowling (2006) explores the evolution of the cruise industry that is still growing rapidly and is one of the major areas of tourism growth nowadays.

Researches on the major cruise *"floating resort spaces"* are largely confined to economic analyses (Dwyer and Forsyth, 1996, 1998; Dwyer et al., 2004; McKee and Chase, 2003; Mescon and Vozikis, 1985; Petrick, 2004a, 2004b, 2004c) and environmental impact studies (Brida and Zapata, 2009; Butt, 2007; Klein, 2003; Ritter and Schaffer 1998; Wood, 2000).

Applying a framework of analysis of their own, Dwyer and Forsyth (1996) provide some tentative to estimate the economic impact of cruise tourism in Australia. Afterwards, they (1998) develop their framework for assessing the economic impacts of cruise tourism for a nation and its subregions and estimating the relevant benefits and costs. Finally, Dwyer et al. (2004) setup a model to evaluate the economic impacts of cruise tourism in any port of call. McKee and Chase (2003) and Mescon and Vozikis (1985) also focus on the same aspect, but they take into consideration different case studies, respectively, Jamaica and the Port of Miami.

From a different point of view, Petrick (2004a) examines the roles of quality, perceived value and satisfaction in predicting cruise passengers' behavioural intentions. Besides, he also (2004b) tries to determine if loyal cruise passengers are more desirable than both first time visitors and less loyal visitors. At last (2004c), he combines the topics of the previous two researches, testing the relationships between reputation, emotional response, monetary price, behavioural price, quality, perceived value, and repurchase intentions for first-time visitors and repeat visitors.

Regarding the environmental impacts, Brida and Zapata (2009) also describe different activities associated to the cruise ship industry to identify costs and benefits for the actors of the local economies. Butt (2007) investigates current waste management and disposal options for cruise ship generated waste and the associated impacts of this waste for ports. Klein (2003) discusses the positive and negative features of the cruise industry, particularly as they apply to port cities, and addresses economic, environmental and social issues related to the sector. Ritter and Schafer (1998) debate on the sustainability factors in cruise tourism. Wood (2000) explores the central manifestations of globalization at work in the Caribbean cruise industry.

Despite the importance of assessing the performance, researchers have yet not focused on operational and economic performance of the transportation cruise lines companies. Indeed, they needs to be even more efficient because many of them belongs, directly or indirectly, to state owned companies, nowadays under fully commercial pressures of competitors.

Cruise ship transportation companies themselves (Business Research and Economic Advisors - BREA, 2005) are one of the three sources of port income generator alongside with cruise passengers (Vina and Ford, 1998) and vessels crews (Peisley, 2003).

The first two points of the *Capetown Declaration on Responsible Tourism* (2002) defined, incidentally, it as:

1. *minimising* negative economic, environmental, and social impacts (alias, efficiency);
2. generating *greater economic benefits for local people* and enhancing the wellbeing of host communities.

Efficiency is significant and an implicitly considered issue, even when talking about sustainability.

This research contributes to tourism literature in two ways. First, the efficiency of continental transportation cruise ship lines companies is measured for 2015, and second because, except Sun et al. (2013) which dealt with environmental operational efficiency impact of Chinese inland cruises, it deals with also some inland companies.

All considered, there is a lack of comprehensive research on this specific issue.

3 Methodology and Sample

3.1 Methodology

The DEA developed by Charnes, Cooper and Rhodes (1978) with the model Constant Return to Scale (CCR or CRS) was enhanced by Banker, Charnes and Cooper (1984) with the Variable Return to Scale model (BCC or VRS). DEA is designed to estimate the efficiency frontier by measuring the efficiency level of single units named DMUs (decision making units).

It identifies the DMUs that lies on the frontier of production possibilities by defining them efficient and inefficient the DMUs located at a distance from the identified relative efficiency frontier best practice frontier. The higher the distance from the frontier and the higher the inefficiency relative to the DMUs classified as efficient.

The main advantages are the ability to accommodate a multiplicity of inputs and outputs, the no a priori weights assumption (Sexton, 1986).

Multiple inputs and outputs are converted into measurable units (Thanassoulis et al., 1996) and after in efficiency score for every single (Coelli et al., 2005). Thanassoulis (1993) found that DEA outperforms regression analysis while the *"black box"* (Färe and Grosskopf, 2000) simply considers the inputs consumed and the outputs produced.

With reference to the objective function to maximize or minimize and the different projections of DMUs that are inefficient compared to efficient ones, two possible starting models can be identified:

- The *input-oriented model*, which projects the DMUs on the efficient frontier by reducing all inputs and at the same time maintaining the output level constant.
- The *output-oriented model*, which underlies an inverse logic and keeps the inputs level constant by trying to increase outputs proportionally in order to reach the efficient frontier.

The information provided is more relevant, through the input-oriented model, for the operational and managerial side while the output-oriented model seeks for more strategic information.

An efficient DMUs, under DEA methodology, receive an efficiency scores of $\theta = 1$, the maximum of 100% (the fully efficient), while the DMUs scoring less than 1 are, in different degrees, inefficient.

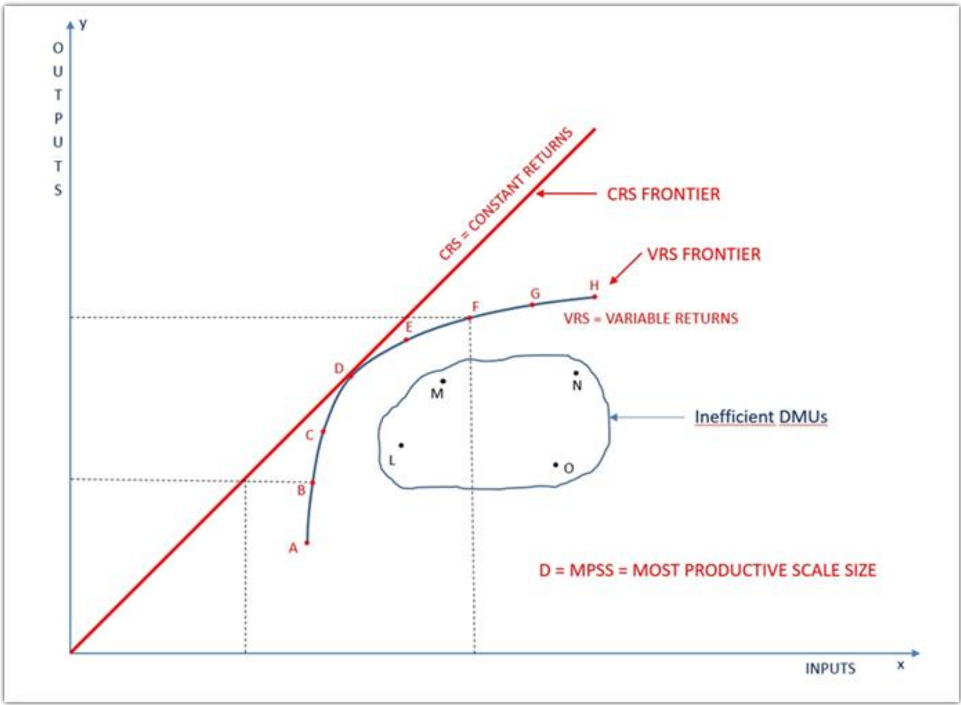

Figure 1 The DEA efficiency frontiers for the CRS and VRS input oriented models.
Source: own elaboration.

The underlying logic is, where possible try to expand the outputs without any inputs decrease *(output-oriented)*, or reducing inputs without a decreasing any outputs *(input-oriented)*.

The table 1 presents the *CCR - Constant Return to Scale (CRS)* and *BCC - Variable Return to Scale (VRS)* linear models.

Table 1 The CCR and BCC linear models.

(1) CCR Model (Constant Return to Scale) Input oriented $\min \theta$ $s.t.\quad \theta\, xj - X\lambda \geq 0,$ $Y\lambda \geq yj$ $\lambda \geq 0$	(2) BCC Model (Variable Return to Scale) Input oriented $\min \theta$ $s.t.\quad \theta\, xj - X\lambda \geq 0,$ $Y\lambda \geq yj$ $e\lambda = 1$ $\lambda \geq 0$

Source: own elaboration.

The efficiency measure is associate to the use of a minimum number of inputs in order to produce a certain number of outputs or the maximum production of outputs using a certain number of inputs (Fethi and Pasiouras, 2010). The measure of the scale efficiency is the ratio of CRS efficiency scores to VRS efficiency scores meaning that is equal to $CRS\ score/\ VRS\ score$. The lower the scale efficiency is, the higher the impact of scale size (Thanassoulis, 2001).

The VRS model means that it scores the pure technical efficiency (also called managerial efficiency) and includes the so-called convexity constraints by changing the specification of the problem and providing the measure of Managerial Efficiency θ VRS adding eλ = 1 to the program (where θ is a scalar and λ is a vector of constants).

The table 2 presents the Slack Based Model (CRS) methodology used for computations.

Table 2 The Slack Based Model.

SBM Model (Constant Return to Scale) Input oriented

$$\rho = \min_{\lambda,\ s,\ s} \frac{1-\frac{1}{m}\sum_{i=1}^{m}\left(\frac{s_i}{x_{i0}}\right)}{1+\frac{1}{s}\sum_{r=1}^{s}\left(\frac{s_r}{y_{r0}}\right)}$$

$$
\begin{aligned}
s.t.\quad & x_0 - s = X\lambda \\
& y_0 + s = Y\lambda \\
& \lambda \geq 0, s \geq 0, s \geq 0
\end{aligned}
$$

Source: own elaboration.

In order to account for the SBM Variable Returns to Scale, the condition e^Tλ = 1 needs to be added to the formula. The gap to fill between a single DMU and its “peer” DMUs is named “slack”. The apex signs s^+ e s^- denote, respectively, the output slacks to be augmented and the input slacks to be reduced. In fact, there is a need for a further proportional reduction of excesses of slacks (input slacks) and/or a proportional augmentation of outputs shortage (output slacks).

In order to account for scale dimension, the measure of the Scale Efficiency is evaluated by the ratio of SBM-CRS efficiency scores to SBM-VRS efficiency scores. The lower the scale efficiency is, the higher the impact of scale size (Thanassoulis, 2001).

3.2 Sample

The survey population frame of this study consisted of 148 transportation cruise ship companies located in 21 continental Europe countries and operating at local and international level as per their 2015 financial statements sourced from Amadeus (activity code 5010).

The companies were selected on the base of their Total Assets ranging between 2 and 500 million of euros. These values have been transformed into a logarithmic function.

Companies presenting missing data were eliminated. To eliminate the outliers we relied on the Median Absolute Deviation (MAD) setting the z critical score to 3.5.

Consequently, the final sample consists of 148 companies.

Table 3 reveals the composition of sample for different European countries. Norway is European country with more companies, in the sample, in fact, there are 24 enterprises (16.23%). The second country is Italy with 18 companies and the third is Russia with 17.

Table 3 Sample composition.

Countries	DMUs	Percentage %
Bulgaria	1	0.68
Denmark	7	4.73
Finland	4	2.70
France	7	4.73
Germany	3	2.03
Great Britain	14	9.46
Greece	6	4.05
Hungary	2	1.35
Italy	18	12,16
Latvia	2	1,35
Macedonia	1	0.67
Malta	4	2.70
Montenegro	1	0.67
Netherland	1	0.67
Norway	24	16.23
Portugal	7	4.73
Romania	2	1.35
Russia	17	11.49
Spain	10	6.76
Sweden	15	10.14
Ukraine	2	1.35
Total	**148**	**100**

Source: own elaboration.

3.3 Selected inputs and outputs

Table 4 shows the mean, standard deviation, minimum-maximum values, measures of skewness, and kurtosis of the numerical variables of all companies.

According to Table 4, the number of employees ranges between 7 and 899 with an average of approximately 52 workers. The average costs are approximately 6,704 euros.

From the sample data, it immediately emerged that the average number of employees is significantly different in the three European countries with more companies. In Norwegian companies, the average number of employees is 98, 140 in those Italians, and about 180 employees in the Russian companies.

The Italian companies, most off capital companies, have an operating revenue and a total asset on average higher (about 30,000 euros) than the Norwegian and Russian companies, which is about 15,000 euros.

The average costs incurred by the Russian transportation cruise ship companies (7,303) are in line with the average for the entire sample (6,704) while those of Italian companies are much higher (24,568).

Table 4 Descriptive statistics.

Variables	I/O	Min	Max	Average	St. Dev.	Kurtosis	Skewness
Ln Total assets	X_1	7.60	12.52	8.97	1.23	2.57	0.70
Number of employees	X_2	7	899	52	180.47	8.57	2.36
Costs	X_3	1076.69	141797.50	6704.32	34875.24	6.32	2.07
Operating revenue	Y_1	472.25	159762.60	7487.03	37806.39	6.27	2.04
Profit before taxes	Y_2	-13329.26	24484.63	291.75	4460.90	10.50	2.04

Source: own elaboration.

Table 5 presents the Pearson correlations matrix between the variables analysed. The results of the Pearson correlation indicate that all the variables are significant at level 0.01. The greatest correlation is that between Costs and Operating revenue (0.79). Thus indicating no apparent evidence of the presence of severe multicollinearity amongst the variables (Berry and Feldman, 1985).

Table 5 Bivariate correlations.

Bivariate correlation	Number of employees	Ln Total assets	Costs	Profit before taxes	Operating revenue
Number of employees	1				
Ln Total assets	0.4388*	1			
Costs	0.5871*	0.7375*	1		
Profit before taxes	0.4200*	0.4845*	0.4952*	1	
Operating revenue	0.6034*	0.7552*	0.7943*	0.5803*	1

* Correlation is significant at level 0.01 (two code).

Source: own elaboration.

4 Results

Table 6 displays the efficiency level results for 2015 and indicates that only 36 companies out of 148 (24.32%) were fully efficient, either on CRS and VRS, while 16 out 148 operates at the maximum Scale Efficiency (10.81%).

Single efficiencies range from 0.0641 to 1 under CRS and from 0.6555 to 1 under VRS.

Table 6 The average efficiency level for the 148 cruise ship companies on 2015.

MODEL	Average	Min	Max	St. Dev.
SBM CRS	0.4245	0.0641	1	0.2598
SBM VRS	0.8479	0.6555	1	0.1135
Scale Eff.	0.4934	0,0641	1	0.2577

Source: own elaboration.

Figure 2 shows the average of efficiency score for the countries with more of 10 DMUs.

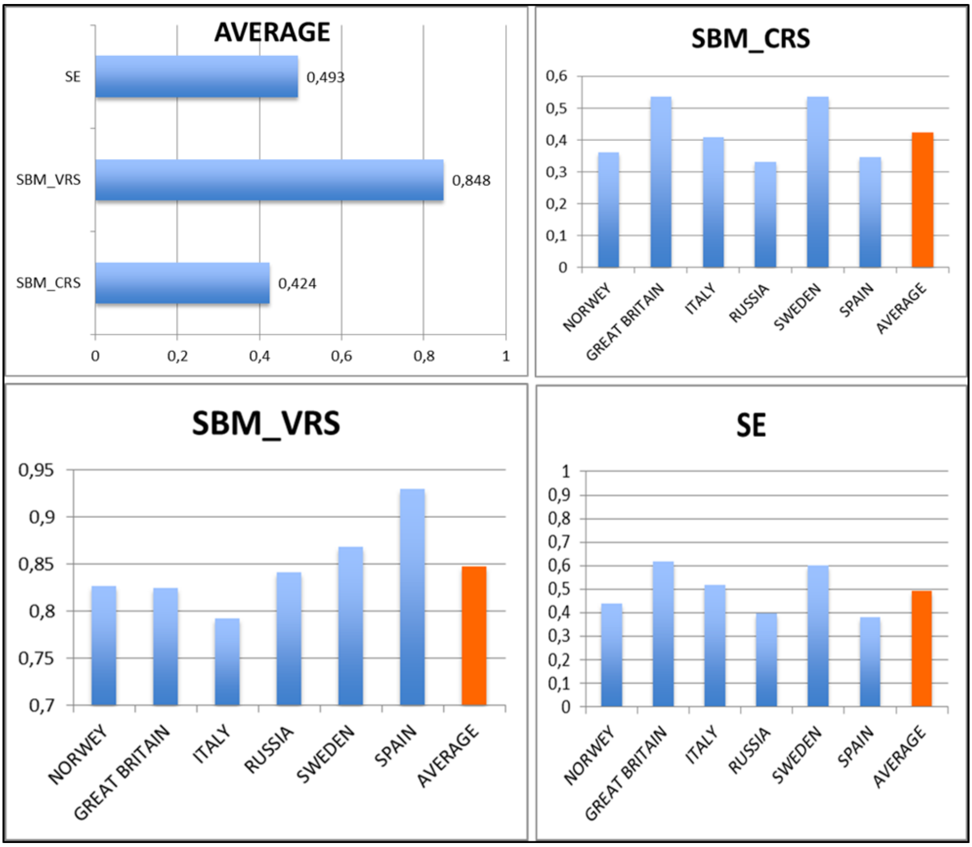

Figure 2 General efficiency level.

Source: own elaboration.

Sweden and Great Britain are the countries in which the companies reach an efficiency score higher of the average, in CRS version, while Spain and Sweden are outperformance in VRS model.

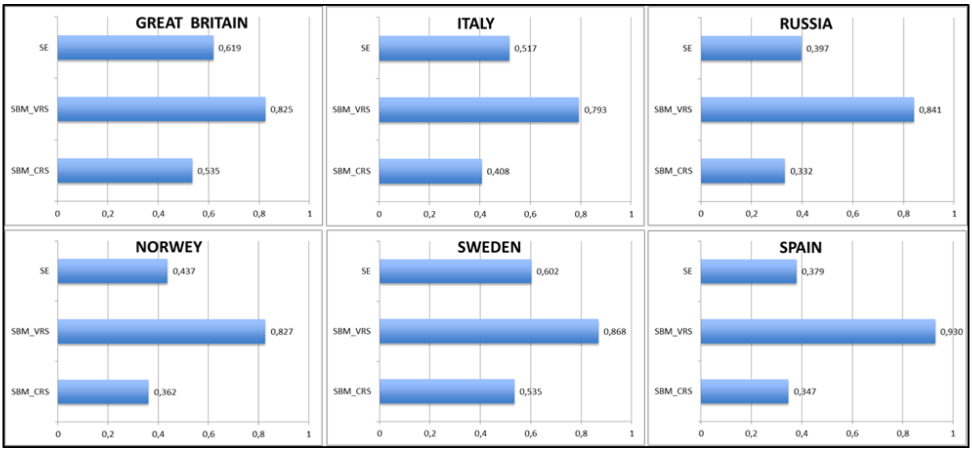

Figure 3 Efficiency level aggregated per countries with DMUs > 10.

Source: own elaboration.

Analysing the slacks, the authors also calculated the potential for improvement for each inefficient unit in order to become 100 per cent efficient. It can have positive or negative value due the inputs or outputs are too large or too small to reach the optimal score. Figure 4 shows the average potential improvements (average increases or decreases) for all sample and for that countries with more 10 DMUs.

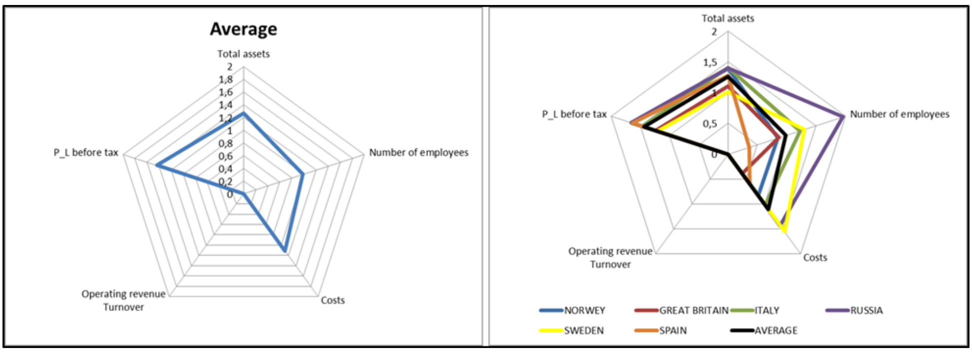

Figure 4 Slacks – further efficiencies improvements.

Source: own elaboration.

5 Conclusions

This study employed the DEA, which is a popular modelling tool for measuring the relative efficiency of a Decision-Making Unit. The DEA is most useful when a comparison is sought against ‘‘best-practice’’ DMUs (Avkiran, 2000). For this motive, the study primarily attempted to find out the efficiency scores of transportation cruise ship companies and compare them on the basis of number employees and total assets. The study has been able to identify some highly efficient as well as inefficient companies and concluded that the majority of enterprises operated inefficiently.

On CRS, 34 out of 148 (23%) companies reached an efficiency level over the average score. On VRS, 65 companies scored over the average level.

On CRS 20 companies scored over 90% while 53 on VRS, implying that few companies are close to being on the best practices frontier.

The study shows that the most efficient companies are the largest ones. The 16 companies that obtained the maximum efficiency score have an average value of total assets equal to 87,524 while for the other companies the value is equal to 17,807.

An increase of total assets and a decrease of the number of the employees are the suggestions to improve the efficiency performance.

Our findings suggested that the management of transportation cruise ship companies does have to benefit from the understanding on how to direct their actions by allowing companies to the right proportions and size. Limitations and, therefore, future research will focus on the size dimension.

According to us, despite these limitations, the DEA seems still one of the most commonly accepted tools for efficiency evaluation both in the service and the production sectors.

Summary

The research aims to investigate the relative efficiency of the 148 continental European transportation cruise ship companies via DEA (Data Envelopment Analysis) Slack Based model.

The study has been able to identify some highly efficient as well as inefficient companies and concluded that the majority of enterprises operated inefficiently. The analysis shows that the most efficient companies are the largest ones.

Our findings suggested that the management of transportation cruise ship companies does have to benefit from the understanding on how to direct their actions by allowing companies to the right proportions and size.

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