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An Application of Super Efficiency DEA for Comparative Analysis and Ranking of Regions in the United Kingdom

การประยุกต์ใช้ DEA เพื่อให้ได้ประสิทธิภาพสำหรับการวิเคราะห์เปรียบเทียบและการจัดอันดับเมืองท่องเที่ยวในสหราชอาณาจักร

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Abstract

This study compares and measures the efficiency across the United Kingdom regions as tourism destination, by Data Envelopment Analysis (DEA), a super-efficiency methodology that is based on combining the stochastic frontier. The analysis will present a rank of 21 tourism destination regions in the United Kingdom. Due to the increasing interest in tourism destination competitiveness, there is a need to improve and develop the destinations' standard. This DEA empirical result will show various advantages of each destination. The conclusion of this paper will identify the benefit of DEA super-efficiency as the tool to develop the tourist destinations.

Keywords: Data Envelopment Analysis-Super Efficiency, Effectiveness, United Kingdom

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Section 1: Introduction

Since 1990, there have been many methodologies, frameworks, and models to measure the technical efficiency with a view of the tourism industry for the optimal management. The consequence determines to provide a major economic development for many countries to improve the livelihood of its inhabitant. The United Kingdom, one of the leading countries in Europe, is no exception. They also depend on tourist's arrival and spending.

In 2008, the Economist mentioned that the United Kingdom was the world's sixth major tourist destination, ranked seventh of the highest number of visitors, and were the fifth largest in industry. In 2011, the United Kingdom was ranked number seventh in the international tourist arrivals league which was behind France, USA, China, Spain, Italy, and Turkey. (drop from the sixth place in 2010 and replace by Turkey)

The United Kingdom accounted for 3.0% of global arrivals in 2010 (3.3% in 2010 and 3.5% in 2011). France, Germany, and the USA were the top three markets in term of the number of visitors to the United Kingdom in 2012 while the top three spenders were USA, France, and Germany. For all inbound visitor spending, London accounted for 54% while England was 33%, Scotland was 8%, and Wales was 2% respectively. (VISITBRITAIN, 2011, 12 April).

In 2015, the UNWTO international tourists mentioned that the United Kingdom was ranked number eight in arrivals in Europe, which after France, the USA, and Spain. Hence, the United Kingdom accounted for 2.9% of global arrivals that year. United Kingdom was in the sixth place in the international tourism spending (drop from the fifth place in 2014) which followed the USA, China, and Spain, conferring to UNWTO figures. The United Kingdom reported for 3.4% of international tourism receipts in 2015. Then, the oversea visitors received 36.1 million visited the UK in 2015, spending £22.1 billion. These figures characterise a 5% rise in volume and 1% (nominal) increase in value related with 2014 (VISITBRITAIN, 2015, 12 April).

London has the largest number of tourists and becomes a hotspot for the visitor (VISITBRITAIN, 2011, 12 April). Nevertheless, the number of tourists still far behind other countries like France that shows the strongest image point toward tourist among travellers (Woodside and Lysonski, 1989) with the highest number of tourist arrivals (Blanke, 2007). France was one of the top five popular tourist destination, with 79.3 million visitors in 2008.

Tourism has an important role in the foreign exchange. It is the third highest export earner behind chemical and financial services. International visitors spend around £18 billion a year in this country and earn the income tax more than £3 billion from the Exchequer.

Moreover, domestic tourism earns about £115 billion a year and employs 2.6 million people. The measurements of both accounts make up around 9% of the United Kingdom's economy. From that point, the tourism industry is the fastest growing compared to other economic sectors (VISITBRITAIN, 2011, 13 March).

According to the previous paper, the author had examined 27 countries of the European Union. The result displayed that the United Kingdom was inefficiency in this field and was ranked 19 out of 27 countries (Arnaud and Papangkorn, 2015). Hence, this is the main purpose of this study to identify the needed improvement using Data Envelopment Analysis (DEA) by computerising the facility in each region such as the number of hotels, restaurant, attraction, and others.

However, based on the structure of the directional distance function, the study conducts a methodical analysis on the measurement of super-efficiency to accomplish the main objectives. The reason comprehends the direction to measure by use super-efficiency that entirely resolves the significant infeasibility concern which occurs in the traditional super-efficiency measures. The secondary goal is to demonstrate the indicator such as super-efficiency models, including the conservative ones as special cases. The proposed measurements are valuable because they have circumvented biases in super-efficiency assessment due to input and output projection. This paper will indicate more about tourism destination performance in section 2, **Data Envelopment Analysis** is the methodology procedure to ranking tourism performance in section 3, **Super-efficient DEA Methodology** 4, **Data and variables** 5, results and discussion, and end with the conclusion in section 6.

Section 2: Data Envelopment Analysis

Performance measurements are an important issue in the relation of two reasons. The first one is that, in a group of units, only a limited number of candidates can be selected. The performance of each group must be evaluated in a fair and reliable manner. The other reason is that, as time progresses, better performance are expected. Hence, the units with weak performance must be recognised to make the necessary improvements. The performance of a decision-making unit (DMU) can be evaluated in either a cross-sectional or time-series manner, and DEA is a useful method for both types of evaluation (Kao, 2010).

In general, DEA can be applied to efficiency problems in some public sector agencies such as schools, hospitals, airports, courts, and in some private sector agencies like banks, or hotels. In this study, DEA will be applied to tourist sites and consider them as a generic private touring unit (e.g., museum, historical place, attraction and hotels), using proper inputs to reach multiple outputs. For this reason, an output-oriented CCR model is approved because this paper aims to explore how well the regions in the United Kingdom deploy their input resources for tourism. The aim of a tourist area is to maximise tourist flows to define and be given a stock of tourist resources.

DEA models assess efficiency by using the actual number of each facility to the production frontier giving the maximum possible efficiency. The efficiency measure proposed by Charnes *et al*., (1978) is to maximise the efficiency in term of the ratio of total weighted output to total weight input, subject to the condition that, for every destination, this efficiency measure is smaller than or equal to 1.

In order to guesstimate the efficiency and the productivity change, the researcher assumes that the tourist site production technology possible to be characterised by a production function, providing the maximum possible output as an output target and give proper inputs. (see also, Cracolici, 2004, 2005; Cracolici and Nijkamp, 2006) As the functional form of the production function is not known, while we have to manage multiple inputs and outputs, a non-parametric method like DEA is the most suitable to use.

While the main advantage of the DEA is a parametric approach that does not require any assumption concerning the production technology, DEA can also easily accommodate multiple outputs. As mentioned before, DEA is a non-parametric linear programming method that uses for measuring efficiency to assess a production frontier. The efficiency of all tourist destinations is evaluated against this border. It also means that the effectiveness of a destination is evaluated in comparison with the performance of other destinations.

Section 3: Super-efficient DEA Methodology

The objective of the classic DEA is to provide the basis ranking for the organisations that benefit management, in term of measuring technical efficiency scores. Ttherefore, this is not the potential for the sub-group of organisations that lie on the graph of technology and are 100% technical efficiencies valued. In 1993, Anderson and Petersen purposed the super-efficiency measures of these qualified firms to resolve this problem. An organisation is considered as super-efficient if its DEA efficiency score equal to 100% went beyond when measured against a production possibility set constructed from the input-output data of all other organisation in the sample. While this improved of DEA procedure is quite useful in many cases, for some other linear programming problem for measuring the super-efficiency score might not have any feasible solution in certain situations (Ray, 2008).

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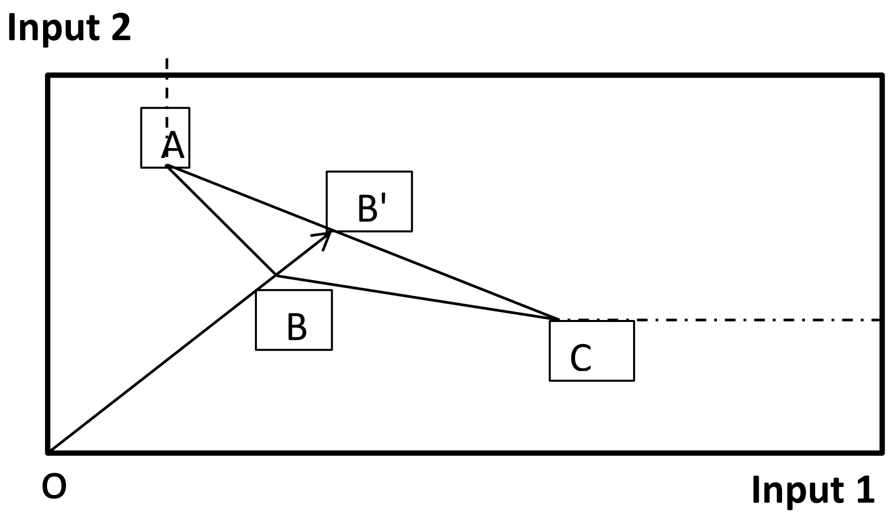
3.1 Super-efficient Input-oriented Models

Ranking of the effective set of DMUs is potential by calculating efficiency scores in excess of unity. Consider unit B in Figure 1. If it was excluded from the frontier, a new frontier would be created comprising only units A and C. The super-efficient score for unit B is attainable by calculating its distance to the new frontier, whereby this ‘extra’ or ‘additional’ efficiency denotes the increase that is allowable in its inputs earlier it would become inefficient.

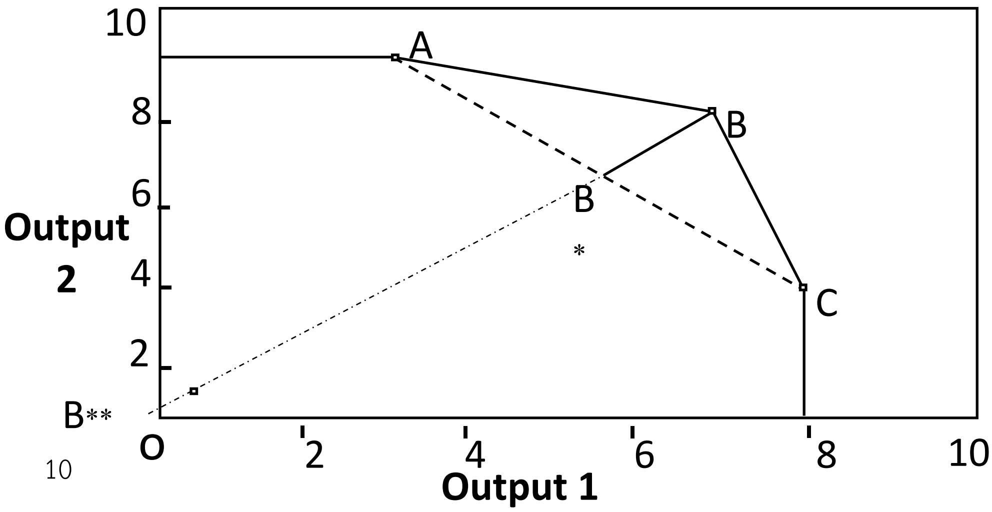


Source: Author’s construction

Figure 1: Standard and Super-efficient DEA Input-oriented Models

The significance of this alteration is to tolerate the scores for efficient units to go above unity. For illustration, a score of 1.15 for unit B would indicate that it increased its inputs by 25% and still stayed efficient (Yawe, 2010). This so-called super-efficient model (Andersen and Petersen, 1993) is applied in the analyses using the method defined in Zhu (2003).

Figure 2 provides visualisation to the revised super-efficiency model, supposing an output orientation. Figure 2 scaled DMU B** which lies one-tenth of the distance along a ray covering from the beginning to DMU B. The straight super-efficiency model excludes DMU B from the reference set, varying the efficient frontier to the broken line segment connecting DMUs A and C, and calculates DMU B opposing to this reduced border. In this example, DMU B obtains a super-efficiency score of 133%. Our modified super-efficiency model scales DMU B to DMU B** and preserves it as part of the reference set. However, as it is now inefficient, it is no longer part of the efficient frontier connecting DMUs A and C. Thus the predictability of the super-efficiency frontier and the revised of super-efficiency frontier correspond. The modification is that scaled DMU B** is inefficient. The radial efficiency of scaled DMU B** is 13.3% (Lovell and Rouse, 2003).



Source: Author's construction

Figure 2: Provides an output-oriented illustration of the super-efficiency model

The method presented by Lovell and Rouse (2003) managed the infeasibility problem. Though, concerns are raised about the desirability of the consequences of this method and the part of the exogenous intervention to the process (Chen et al., 2011; Cook et al., 2009; Ray, 2008). To be more precise, the super-efficiency scores of the efficient DMUs with infeasible solutions are duplicated to the scaling factor. For that reason, these specific results should not be interpreted while the goal levels for inputs and outputs are invented. The results found solely reflected an illogical choice of the scaling factor. In accumulation, Lovell and Rouse's technique unsuccessfully categories the efficient units in that the infeasible DMUs are allocated equal super-efficiency scores.

Chen, (2005) model depends on the replacement of the inefficient units with their efficient projections, beneath the assumption of variable returns to scale (VRS). Chen claims that infeasibility removed whichever in the input- or the output-oriented expression of super-efficiency models, however, not at the same time. As a result, both orientations should be applied to confrontation the infeasibility problem and calculate the whole super-efficiency score of a unit. The complete super-efficiency score develops from the mixture of the two super-efficiency DEA orientations with appropriate weights. Chen's method delivers a partial solution to the infeasibility problem of super-efficiency DEA models for the reason that in some cases it fails to explain a feasible solution in both orientations (Chen et al., 2011; Ray, 2008).

Cook et al. (2009) presented an approach which suggests one-directional input-output movements, define as decreases when input-orientation is applied and increases in case of output-orientation. That is the unit under evaluation with the involvements of infeasibility in super-efficiency models reaches the frontier formed by the rest of DMUs. Lee et al. (2011) introduced a two-stage method to extend Cook et al.'s model as a solution.

Ray (2008) suggested putting a non-oriented super-efficiency model representation on the directional distance function presented by Chambers et al. (1996). Ray's method allowed synchronous proportional output reductions and input extensions by a limitless factor which is resolute by the optimisation technique. Despite this specific method determining the infeasibility problem, it is not an oriented analysis.

Chen et al. (2011) recommended a combinatorial input- and output-oriented method that delivers the targets for the evaluated DMU with radial movements of both inputs and outputs. The aggregated super-efficiency score is interpreted as a ratio of optimal input- and output-oriented super-efficiency modules. Therefore, it is the result of an optimisation procedure without demanding random selections on a factor. Chen et al., the same as Ray, bring together a non-oriented analysis for engaging in the infeasibility problem at VRS super-efficiency DEA models.

Section 4: Data and variables

The DEA model permits the calculation of the relative DMUs efficiency in different RTS assumption (NIRS, CRS, IRS or VRS) and orientation (input, output or input-output). Charnes, Cooper and Rhodes (CCR, 1978) were the firsts to propose a Constance Return to Scale DEA model. Banker et al. (1984) presented the BCC model Variable Retune to Scale DEA model. This paper considered an output-oriented CCR model. For that reason, the BBC model has numerous results that efficient, which the DMUs (efficient score equal to one). Thus it is not possible to rank these DMUs according to their scores. The super-efficiency DEA model permits the discrimination of the performance among efficient DMUs (Andersen and Petersen, 1993; Ray, 2008). To reach this goal, the DMU evaluated is excluded from the reference set, to compute the super-efficiency

The selection of the data will be taken from the 21 regions in the United Kingdom by collecting a number of hotels, museum, historical places, and other attractions as an input and two outputs as the outcome in hospitality spent and nights spent in the United Kingdom in 2008. See figure 3 with a sample size of 21 regions (J = 26), with 4 inputs (N = 4) and 2 outputs (M = 2), conventional rule is respected (J ≥ 2(N+M).

The valuation of technical efficiency needs to carefully select the sample size to include the number of factors, especially the number of inputs plus the number of outputs. These dues to the circumstance of the delivery efficiency are likely to be affected by the classification of outputs. The number of inputs and outputs are included (Magnussen, 1996).

The data selection presents in figure 3;

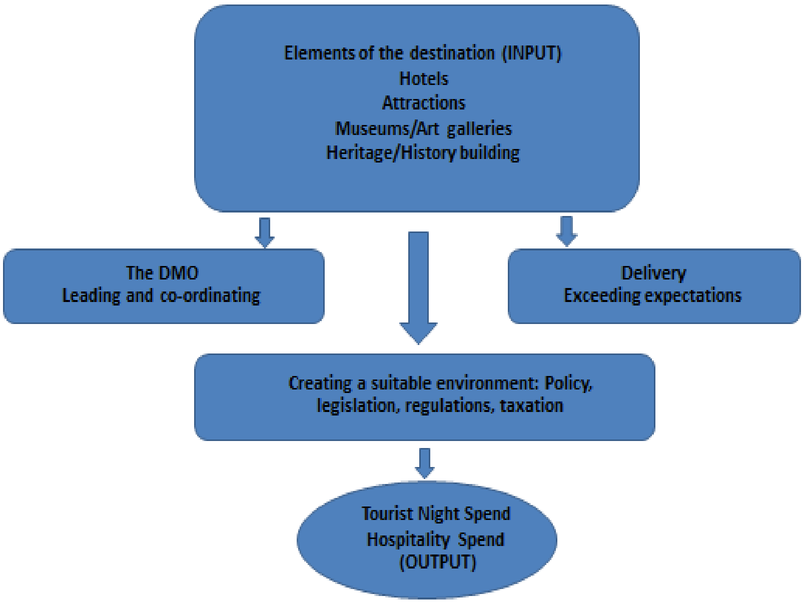


Figure 3: Input and output data correction

Section 5: Results and Discussion

The use of the super efficiency model could contribute and provide details of functional units. The super efficiency name is used in the DEA-modified model whereby the units can have efficiency values larger than one. This paper uses 21 regions in the United Kingdom to estimate the efficiency, which does not have any limitation in term of emerging each input that will not influence other DMU.

This process is obtainable from DEA-solver by Cooper *et al*. (2006), which are fairly new and relevant indicators of destination performance and previously have never been applied to the United Kingdom tourism destination. According to the previous paper about the European Union competitiveness (Abad and Kongmanwatana 2015), the UK ranking was 19th, and, in The Global Competitiveness Index report, was at the 12th place, with 12 pillars. However, in 2008, the United Kingdom was ranked on the seventh place for the number of arrivals. In this case, it means that there must be more room to generate more revenue in the tourism industry.

Table 1: CCR output oriented ranking score

Rank	DMU	Score
1	Lothian	3.49
2	London	1.95
3	Scottish Borders	1.22
4	North Wales	1.14
5	South Wales	0.94
6	Perthshire	0.91
7	Fife	0.77
8	West Midlands	0.74
9	Dumfries & Galloway	0.73
10	Grampian	0.72
11	East	0.64
12	East Midlands	0.59
13	South East	0.59
14	Mid Wales	0.53
15	Dundee & Angus	0.46
16	North West	0.42
17	Noth East	0.40
18	Highlands	0.32
19	South West	0.25
20	Yorkshire and Humber	0.20
21	Ayrshire & Arran	0.13

Table 1 presents the ranking that obtains from the super-efficiency DEA approach, which is (3.49) Lothian, (1.95) London, (1.22) Scottish Borders, and (1.14) North Wales. This result is indeed understandable due to the fact that Lothian, Scottish Borders, and North Wales are considered as history places while London is the place for business shopping, and other means. In total, the four regions are efficiency while twenty-one regions are inefficiency. This could answer the research question about the ranking of the UK was in the 19^{th} place.

Moreover, the super-efficiency DEA provides the projection of input and output which show that London is -41.75% in hotels (input) even while London was scored 1.95. This input is produced by using outputs representing the different components of the hospitality spending and night spent. This could lead to considering to increase the number of the hotels in London, which might increase the revenue. London is considered as an expensive destination, thus if it has more hotels, it will automatically increase the competition capability, and the price of the hotel might be lower.

Then Lothian is -41.76% (output) in hospitality spending. This output is produced by using inputs representing the different components of tourism product, including attractions and supporting services such as transportation, accommodation, and food and beverages. Since Lothian is a historical attraction, the local government should provide more facility such as festival or event for tourist to spend more.

Additionally, each DMU along the frontier is pointed as being efficient, while those falling below the frontiers, such as Ayrshire & Arran, are measured as inefficient. The method of defining the efficiency score for Ayrshire & Arran shows a discrepancy according to the technique engaged from the two classic methods, the input- or output-oriented methods. The efficiency score is determined in effect by influencing the projection directly along the horizontal alignment (outputs) or along the vertical alignment (inputs) (Botti *et al*., 2009).

The method developed in this consequence determines the least-norm projection from an inefficient and efficient DMU to the frontier, in both the input and output. Although the DMU efficient score is equal to, or more than, one, it still has room for development (e.g. London and Lothian). In fact, one progressed the norm projection method (Ortega and Rheinboldt 1970) in which the input, output, and, at least, two-norm projections are identified as special cases. To conserve effort, this paper only describes the norm projection to clarify the advantages of DEA projection.

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Also, by using the oriented methods, the projection onto the frontier is indomitable by reducing (increasing) the inputs (outputs) by a duplicate percentage based on the efficiency score. Hence, if there are four inputs, as shown in Figure 3, then using the input-oriented approach requires not only outputs being held as a constant but also directives that the decrease in inputs along each of the input dimensions is equal and identical to the efficiency score.

Section 6: Conclusion

This paper sought to apply the super-efficiency DEA model introduced by Andersen and Petersen (1993) and Ray (2008). Applying super-efficiency DEA approach, it is perceived that useful for evaluated the performance and efficiency. It is also noted that the ranking of regionals or countries has several tools, such as The Global Competitiveness Index report with 12 pillars (input) and UNWTO. This study also determines how the super-efficiency DEA assist decision maker. A number of alternative input and output measures are possible under the DEA super-efficiency. The implication of alternative specifications is that for any regions considered inefficient or efficient there may exist of the room to develop in each DMU. The ability to test the alternative model is, in fact, an important strength of the DEA approach. It compromises the possibility of methodically evaluating the impact of alternative factors (for both inputs and outputs) on the alternative model.

The driving force of the tourism industry is characterized by the attractions at destination. Visitors have no reason to go to the destinations that have nothing interest to experience. Tourism research has verified that attraction studies are needed in the considerate as the first elements to encourage people to travel. Accomplishing the goal of measuring destination attractiveness necessitates to understand the components and their relationships. There are two ways of examining the supply and demand in this paper using DEA method to measure the efficiency of source. This method assumes the tourism as a system, which is a function of supply interaction. However, the demand also needed to answer the whole picture. The future study needs to accomplish the qualitative method in order the clarified the demand collaboration.

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