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機場私有化政策對營運效率之影響 — 以英國為例

The Impact of Airport Privatisation on Airport Operational Efficiency: Evidence from the UK

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摘要

國營或國有公司一直以來被人討論無法提供良好的公司營運效率，也無法有效地節省成本。本研究將以機場私有化政策作為研究主軸並以英國的機場作為例子。機場私有化政策首先始於英國從 1997 年至今已實行大約 20 年的時間。過去有許多研究已採用資料包絡分析 (Data Envelopment Analysis) 進行分析並提出相關結論指出，私有化並無法有效提升營運效率。因此本研究將採用相同的分析方法與指標但延長資料期間，來探討是否如前人研究所言私有化並無法有效提升營運效率，亦或是綜效尚未顯現。本研究結果顯示在經過多年營運後，私有機場確實能有效提升營運效率。其內容也可作為目前國內港務公司或其他國營公司私有化的借鏡。

關鍵字：英國機場管理局、資料包絡分析法、機場營運效率、機場私有化政策

Abstract

A shift of ownership of public transportation to private sectors has been taking place for over two decades. Under this trend in the UK, the British Airports

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Authority (BAA) has become a publicly listed company and regional airports were sold to the private sector in 1980s. Since then, there has been an opportunity to assess the impact of these changes on the privatised airports' performance. A previous study in 1997 applied a Data Envelopment Analysis (DEA) approach to evaluate UK airports efficiency and the research concluded that airport privatisation policy had not benefited the operational efficiency of BAA. The aim of this study is to apply the same method and indicators but with an extended data period (1997/98 ~ 2008/09) to investigate if the impacts of privatisation are more long term in nature. The results of this study show that the improvement of BAA airports' operational efficiency resulted from British airport privatisation policy is greater between 1997/98 ~ 2008/09 than the period between 1987/88 ~ 1995/96.

Keywords: British Airports Authority (BAA), Data Envelopment Analysis (DEA), Airport efficiency, Airport privatisation policy

1. INTRODUCTION

Since 1987, there has been a trend towards airport privatisation in the UK. In the 1986 Airports Act, the UK government privatised the airports of the British Airports Authority (BAA) and transformed UK municipal airports into commercial companies. Since then, the pattern of airport ownership has evolved unevenly over time as airports have been commercialised and privatised in a variety of forms (Humphreys, 1999). A number have experienced several changes in ownership.

In 1990s, it was widely believed that airport privatisation could help to improve airport operational efficiency and reduce subsidy from the governments (Oum et al., 2006). Furthermore, deregulation of the aviation market has stimulated the development of reliable efficiency measurement, since airlines operate in a highly competitive market and cannot pass the higher operating costs at inefficient airports onto their passengers (Pels et al., 2001).

Lai et al. (2012) pointed out that of the 66 papers were conducted to assess airport operational efficiency or performance since 1997. Few of them tried to compare the operational efficiency between different airport ownerships. In addition, Oum et

al. (2006 and 2008) attempted to adopt different evaluation methods and selected sample airports worldwide to find out "Does different ownership affect airport efficiency?" The result of above research showed that ownership does affect airport performance. However, Lin and Hong (2006) also evaluated 20 major airports around the world, but the result showed there was no relationship between ownership and operational efficiency by applying a DEA method.

Unlike those studies, Parker (1999) was the first paper attempted to compare the airport efficiency in the UK before (1979 ~ 1987) and after (1988 ~ 1996) privatisation. From this kind of comparison, the evolution of privatisation on the specific firm can be clearly presented. However, by using employment, capital stock, non-labour and capital costs as inputs and numbers of passengers and cargo and mail handled as outputs. In addition, the result reveals that economies of scale at airports exist, thus encouraging the use of variable-returns-to-scale DEA model. However, the study stated that privatisation had no noticeable impact on technical efficiency. Generally speaking, in 1990s, it was widely believed that airport privatisation could help to improve operational efficiency and reduce subsidy from the governments. By means of this concept, the UK government not only privatised airports but also water companies, railway companies, airline companies, etc. But the results revealed that privatisation had no noticeable impact on the operational efficiency of BAA or the other privatised UK airports. The result brought us a huge impact for the privatisation. In the authors' view, Parker's research was undertaken too early in the privatisation cycle to establish whether airport privatisation and changing of the ownership could improve efficiency.

In case, this study tried to replicate and extend the work of Parker (1999) with the same methodology and variables but extended period of data (1997 ~ 2008) to observe if airport privatisation actually can improve the operational of efficiency. The reason for only applying the yearly data to 2008/09 is discussed in the following sections. The rest of this study is arranged as follows. Firstly, a brief review of the ownership evolution of BAA and UK airports is provided. Then, the method, which is used in this study, DEA is discussed. Finally, the results are compared with Parker's original findings and the main differences between these two studies are highlighted.

2. AIRPORT EFFICIENCY EVALUATION

In the mid-1990s, the literature on efficiency evaluation, which had already been applied to numerous industries, was introduced to the airport sector (Gillen and Lall, 1997). Since then, a number of papers have been published on airport efficiency, although the depth of coverage is perhaps less than in other transport industries such as seaports (Woo et al., 2011). One approach adopted is the use of partial measures, which calculate the ratios of one input to one output to assess efficiency in relation to a specific dimension. Francis et al. (2002) highlighted that the denominator is often a Work Load Unit, defined as one passenger processed or 100 kg of freight handled. A further discussion of partial measures can be found in Graham (2005), while an application of this approach can be found in the UK Competition Commission's investigation into BAA plc (Competition Commission, 2008).

Another set of approaches is associated with MCDM, which establishes preferences between options against a specific set of objectives. The use of these approaches within airport efficiency literature is limited. For example, Wang et al. (2004) used Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to evaluate the operational efficiency of Taiwanese airports. While AHP is a popular MCDM approach, its use has been limited to other areas of airport management, including airport development (Vreeker et al., 2002; Zietsman and Vanderschuren, 2014), customer service (Correia et al., 2008; Tsai et al., 2011) and airport security (Yoo and Choi, 2006).

By far the most popular approach for efficiency evaluation has been the use of frontier analysis methods. These methods identify an efficient frontier and then evaluate inefficiency against this. DEA is the most prevalent of the associated methods; Lai et al. (2012) identified 23 papers using DEA between 1997 and 2011, including variants of DEA. Other frontier methods used to evaluate airport efficiency include the Total Factor Productivity index method (Hooper and Hensher, 1997), Stochastic Frontier Analysis (Oum et al., 2008; Barros, 2008), Variable Factor Productivity (Oum et al., 2012) and a Bayesian dynamic frontier model (Assaf et al., 2012).

Finally, combinations of approaches have been used in a limited number of papers (Pels et al., 2001; Martin and Roman, 2006; Yang, 2010; Assaf and Gillen, 2012). These combinations have focused on bringing

together different (objective) frontier analysis approaches. Papers that combine MCDM and efficiency evaluation have not yet been used in airport efficiency analysis, although they have been used in other transport and logistics applications. For example, Azadeh et al. (2008) combined AHP and DEA to find the optimal solution to improve railway timetable reliability and efficiency; Korpela et al. (2007) used the same combination of approaches in the context of warehouse management. From the literature review, airport efficiency evaluation is a widely applied research topic.

3. THE CHANGING NATURE OF UK AIRPORTS

In most developed countries around the world, airport ownership and governance have seen considerable change including in the EU and US. As governments began to deregulate airline services and subsequently pursue airport expansion policies, there has been an emergence of the low-cost airline company and new terminal construction in several EU airports (Graham, 2008). The shift that occurred across many countries had several common sources. Air traffic was growing at a rapid rate and airports needed to invest in capacity and there was a general rethinking of the role government should play in the economy and airports were considered a place where the private sector could legitimately provide much needed service improvement and investment funds. This was driven by successes in the deregulated airline sector, which was showing significant improvements in productivity, and product innovation, which many argued, could be extended to the airport sector (Evans and Kessides, 1993; Assaf and Josiassen, 2011; Barros and Cuoto, 2013). Accordingly, there was a newfound recognition of the relationship between ownership structure, governance and performance.

Airport privatisation can occur in a number of different ways. The types of privatisation models fall broadly into five categories (Carney and Mew, 2003):

(a) Share flotation:

In a share flotation, the government will give up total or partial ownership, while transferring the economic risk and effective control to new shareholders. To date, the only 100% share flotation, which has taken place, was with BAA in 1987 in the UK.

(b) Trade sale:

In a trade sale, some or all of an airport will be sold to a trade partner or consortium of investors, usually through a public tender. The first significant trade sale took place in

1990 when 76% of Liverpool airport was sold to British Aerospace. Subsequently a number of other UK airports, such as East Midlands, Cardiff, and Bournemouth have been sold off to a trade partner (Graham, 2008).

(c) Concession:

Here an airport management company or consortium will purchase a concession or lease to operate the privatised airport for a defined period of time, usually between 20 ~ 30 years. Luton airport provides an example where a consortium originally consisting of Barclays Investment, Bechtel Enterprises, and Airport Group International (AGI) was given a 30 years concession to run the airport in 1998.

(d) Project finance privatisation:

A company usually builds or develops and then operates an airport or specific facility, such as a terminal, for a certain length of time, typically around 20 ~ 30 years. Build-Operate-Transfer (BOT) is also based on this kind of privatisation. The Eurohub, the second largest passenger terminal of Birmingham airport, was built under a BOT-type arrangement in 1991 (Lambert and Hartley, 1993).

(e) Management contract:

When ownership of an airport remains with the government but contractors take responsibility for the day-to-day operation of the airport, usually for a period of 5 ~ 10 years. This kind of model has not been adopted in the UK.

Table 1 shows the trend of ownership in the UK, and for some airports there have been several changes in ownership in the past 20 years. Both East Midlands and Bournemouth have moved from the private sector back into full public ownership (i.e. Manchester Airport Group: MAG). Humberside has remained in public ownership, but a majority of its shares are held by MAG. Birmingham has stayed partly privatised and Liverpool has stayed fully privatised, but the private owners have changed. Exeter and Blackpool have moved from the public sector to the private sector. Meanwhile, Norwich, Leeds Bradford, Durham Tees Valley, Newcastle and Luton have gone from being publicly owned to being partly privately owned. Since 1987, only Manchester airport has retained the same ownership.

Privatisation was introduced in the UK to control the Public Sector Borrowing Requirement (PSBR) by addressing the inefficiencies of loss-making public sector industries. As a result, the amount of public money required to subsidise nationalised industries has been drastically reduced; the strain on public sector borrowing has been removed; access to private finance has been

Table 1 Changing of airport ownership in the UK

Airport	1980s				1990s										2000s												Ownership transfer	
	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12		
Southampton SOU	Mr Somer			PdS	BAAplc															Ferrovial								3	
Aberdeen ABZ	PS	BAA plc																		Ferrovial								2	
Edinburgh EDI	PS	BAA plc																		Ferrovial							GIP	3	From 04/2012
Gatwick LGW	PS	BAA plc																		Ferrovial					GIP			2	Global Infrastructure Partners
Heathrow LHR	PS	BAA plc																		Ferrovial								2	
Glasgow GLA	PS	BAA plc																		Ferrovial								2	
Stansted STN	PS	BAA plc																		Ferrovial (Sold to Manchester Airport 2013)								2	Announced to sell on 2012
Prestwick PIK	PS	BAA plc				Prestwick Aviation Holdings Stagecoach												Infratil											3	
Liverpool LPL	Public Sector (PS)				British Aerospace (76%)										Peel Airports (76%; 100% from 2001)													2	
Manchester MAN	Public Sector				Manchester Airport										Manchester Airport Group (MAG) public enterprise													0	
Humberside HUY	Public Sector														Manchester Airport and from 2001MAG												Eastern group	2	Announced on 08/2012
East Midlands EMA	Public Sector								National Express						MAG													2	
Bournemouth BOH	Public Sector									National Express					MAG													2	
Cardiff CWL	Public Sector										TBI									TBI (Abertis)								2	
Belfast BHD	Public Sector											TBI								TBI (Abertis)								2	
Luton LTN	Public Sector				30 years management contract with London Luton Airport Operations Ltd From 1998										London Luton Airport Operations Ltd (TBI)					London Luton Airport Operations Ltd (Abertis)								0	
Birmingham BHX	Public Sector														EEuroHub (Birmingham) Limited. (48.25%)													1	

Bristol	BRS	Public Sector			First Group (51%)			MEIF1 (50%); Teachers'(49%)*				2	
Newcastle	NCL	Public Sector					Local government (51%) Copenhagen Airport (49%)					1	
Durham Tees Valley	MME	Public Sector						Peel Airports (75%)		Vantage Airport Group (65%)		2	
Blackpool	BLK	Public Sector							MAR	Balfour Beatty		2	Balfour Beatty
Norwich	NWI	Public Sector						Omnipot (80.1%)				1	
Exeter	EXT	Public Sector							RCA			1	
Leeds Bradford	LBA	Public Sector							Bridgepoint Capital.			1	
Inverness	INV	Public Sector	Highlands and Islands Airports Limited									0	
Newquay	NQY	Public Sector										0	
London City	LCY	Mowlem		Dermot Desmod					AIG & GIP	GIP(75%)		3	
Doncaster Sheffield	DSA						Peel Airports					0	

Source: Organised by author.

* Bristol Airport is 50% owned by Macquarie European Infrastructure Fund 1 (MEIF 1), with approximately 49% held by Ontario Teachers' Pension Plan (Teachers')

provided, and the role of government has changed from owner/operator to regulator with the power to intervene in the public interest. Although the public sector deficit had disappeared by 1987/8, privatisation was still pursued as a politically attractive means to finance tax cuts without reducing public expenditures. Given the lack of a case for privatisation in terms of improved efficiency, it appears that privatisation was pursued as an ideology by the UK government. The UK experience can show how a government can privatise swiftly and maintain political popularity. The importance of whether or not ownership is public or private may be misplaced. It has been suggested that the nature of competition and the form of regulation is more important than ownership in achieving the economic aims of privatisation (Graham, 2011).

In order to deal with airport privatisation and the resulting monopoly position of BAA, the UK government has taken on role of regulator to prevent market abuse. The most common form of intervention has been the regulation of the price an enterprise can charge for its products or services (Bishop and Thompson, 1992). The principal aspects of these regulations are airport licensing and safety, economic regulation, international obligations, traffic regulation, aviation security and noise. The regulatory system aims to provide safeguards against distortion of the air travel market through predatory pricing or other monopoly abuses by airport operators. It also aims to incentivise cost control and efficiency (Gillen, 2011). The background to BAA is introduced in next section.

4. INDICATORS SELECTION AND DATA COLLECTION

In October 2012, BAA announced a rebrand from BAA Limited to Heathrow Airport Holdings, with each individual airport operating under its own name rather than the BAA banner (Heathrow Airport Holdings, 2014). Today, four airports are operated under Heathrow Airport Holdings, London Heathrow Airport, Aberdeen Airport, Glasgow Airport, and Southampton Airport.

To allow comparison with Parker's research the period of data used is from 1997/98 ~ 2008/09, to ensure that the same airports are replicated in the research. These are London Heathrow Airport, London Gatwick Airport, Aberdeen Airport, Glasgow Airport, Southampton Airport, London Stansted Airport, and Edinburgh Airport.

In addition, according to Oum et al.

(2006) and Gillen (2011), ownership and governance form of airports may be classified into the following eight categories:

(1) Government owned and operated.

(2) Mixed private-government ownership, with the private sector owning a majority.

(3) Mixed government–private ownership, with the government owning a majority share.

(4) Government ownership but contracted out to an airport authority under a long-term lease.

(5) Multi-level governments who form an authority to own and operate airports in the region.

(6) 100% government corporation ownership and operation.

(7) Fully private ownership.

(8) Independent non-profit corporations.

In this study, the ownership of BAA may be roughly categorised into three different ownerships periods:

1. From 1979/80 ~ 1986/87: Category (1): Government owned and operated.

2. From 1987/88 ~ 2005/06: Category (2): Mixed private-government ownership, with the private sector owning a majority.

3. From 2006/07-current: Category (7): Fully private ownership.

Therefore, it is appropriate to examine the efficiency of BAA during these three different periods.

The input and output indicators to assess the operational efficiency of BAA are as follows. The input indictors include number of employees, capital input, and total operating cost. Output indictors include turnover, number of passengers, and volume of cargo and mail. In this study, DEA was applied to assess the technical efficiency of BAA's financial year (to 31 March). Each year was treated as a separate DMU giving 12 DMUs in total. The study was designed to identify changes in BAA's technical efficiency over time, as a means to evaluate the performance of BAA pre and post privatisation. The input and output data was drawn from BAA's annual reports and airport statistics published by the Centre for the study of Regulated Industries (CRI, 2006).

5. MEASURING TECHNICAL EFFICIENCY: DEA APPROACH

DEA is a non-parametric mathematical programming method for frontier estimation. It constructs a relative efficiency score by transforming the multiple-input/multiple-

output into a ratio of a single virtual output to a single virtual input. Each DMU is compared with the most efficient real/virtual ones, which forms the efficient frontier and all the inefficient DMUs are thus enveloped under it (Parker, 1999; Zhu, 2009).

The DEA approach was firstly proposed by Charnes et al. (1978), who employed a mathematical programming model (CCR model) to measure the technical efficiency of decision making units (DMUs) using the Pareto optimum concept. The authors assumed that the situation involved constant returns to scale (CRS), namely that increasing one input would simultaneously create an increased output. Thus the calculation of DEA scores can be viewed as a linear programming issue. The CCR model is applied in the first stage of data envelopment analysis, which is also the first step in entering data in the envelopment analysis field. The CCR model includes both input and output oriented models. This model basically assumes constant returns to scale; however, as each DMU might operate on different returns to scale, this may cause inefficiency. In 1984, Banker, Charnes, and Cooper developed the BCC model based on the concept of the CCR model, which addressed this concern. The BCC model assumes the existence of variable returns to scale (VRS). The key component of these models is that Charnes et al. (1978) included Pareto optimality into the model, in which each DMU selects the optimum input and output multiplier for maximising its own efficiency. The only constraint is that the value of the selected multipliers must not exceed 1.0 to satisfy the constraint of the maximum efficiency value.

As mentioned above, DEA is widely used in efficiency analysis, including empirical work on the performance measurement of airports because of its simplicity and the useful interpretation of results it yields, even with limited data sets. Either a CCR or a BCC approach can be approached within this framework. The CCR hypothesis suggests that companies are flexible to adjust their size to the one optimal firm size. By contrast, the BCC approach is less restrictive in that it compares the efficiency of companies only within similar sample sizes; this approach is adapted if the airports are not free to choose or adapt their size. The comparison between the two approaches also provides some information about the underlying technology: if the results of the CCR and the BCC approaches are similar, then returns to scale do not play an important role in the process.

The determination of the efficiency score of the *i* th firm in a sample of N firms in

the CRS model is equivalent to the following optimization:

$$\begin{aligned} &\text{Min}_{\theta,\lambda}\theta \\ &\text{s.t} \\ &-y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &\lambda \geq 0 \end{aligned} \qquad (1)$$

θ is the efficiency score, and λ a Nx1 vector of constants. Assuming that the firms use E inputs and M outputs, X and Y represent E*N input and M*N output matrices respectively. The input and output column vectors for the *i*th firm are represented by x_i and y_i . The constraints ensure that the *i*th firm is compared to a linear combination of firms similar in size. To determine efficiency measures under the BCC assumption a further convexity constraint $\sum\lambda = 1$ has to be considered. The system is solved once for each firm (Coelli et al., 1998).

By employing the CCR and BBC models in the DEA method, it is possible to examine the correlative efficiency over time. In this study, the DEA-solver is adopted to calculate the efficient value in different DEA models and the DEA software: DEAP package software is employed to cross check the accuracy.

6. EMPIRICAL RESULTS AND ANALYSES

Table 2 reveals the changes in input and output statistics over the 12 years between 1997/98 ~ 2008/09. From 2009/10, the value of every indictor dropped, as BAA sold Gatwick Airport in 2010, Edinburgh Airport in 2011, and London Stansted Airport in 2012.

Table 2 Indictors when assessing relative efficiency of BAA between 1996/97 ~ 2008/09

	Input			Output		
1997/98 ~ 2008/09	**Number of Employees**	**Capital Input (£million)**	**Total Operating Cost (£million)**	**Turnover (£million)**	**Passenger Numbers (000s)**	**Cargo and Mail (tons)**
Average	8,011	7,255	1,167	1,735	130,165	1,867,450
S.D.	992	3,256	371	367	14,246	77,762
2009/10 ~ 2012/13	Number of Employees	Capital Input	Total Operating Cost	Turnover	Passenger Numbers	Cargo and Mail
Average	7,558	10,068	1,594	1,932	99,229	1,645,139
S.D.	577	91	68	129	10,251	135,638

Source: BAA Annual Reports and CRI.

Summarized in Table 3, the results of Parker's research confirmed that BAA's technical efficiency rating varied closely with the stage of business cycle, with lower relative efficiency in the years between 1988/89 and 1991/92 in particular when Gulf Crisis happened. The years 1982/83 to 1985/86, 1987/88 and 1994/95, and 1995/96, exhibited maximum relative efficiency in both models, with 1981/82 and 1992/93 also achieving efficiency under the BCC model. Looking at the average score before and after privatisation, and allowing for the effects of the economic recession, there has been no obvious change. As shown in Tables 3 and 4, Parker's result period of 1979/80 ~ 1986/87 (the Government owned and operated period) was seen to provide better operational efficiency.

Under the CCR model, the most efficient DMU is assigned an efficiency score of one, while the inefficient DMU has the efficiency score between 0 and 1. In this study, the efficiency of each BAA financial year is measured and each year is considered as a DMU. The results of using the CCR model to assess efficiency of BAA are shown in Table 3, which also displays the efficiency scores of Parker's research. It also reveals that during the last 12 years only five had a

Table 3 BAA total efficiency employ CCR model (from 1979/1980 ~ 2008/09)

Parker (1999)				This Study	
DMU	**Score**	**DMU**	**Score**	**DMU**	**Score**
1979/80	0.9812	1987/88	1	1997/98	1
1980/81	0.8842	1988/89	0.8827	1998/99	1
1981/82	0.9824	1989/90	0.8501	1999/00	1
1982/83	1	1990/91	0.7501	2000/01	1
1983/84	1	1991/92	0.7711	2001/02	1
1984/85	1	1992/93	0.9497	2002/03	0.9506
1985/86	1	1993/94	0.9426	2003/04	0.9283
1986/87	0.9587	1994/95	1	2004/05	0.9744
		1995/96	1	2005/06	1
				2006/07	0.9854
				2007/08	0.9969
				2008/09	1
Average before privatisation 1979/80 ~ 1986/87	0.9760	Average after privatisation 1987/88 ~ 1995/96	0.9050	1997/98 ~ 2008/09	0.9863

Source: Parker, 1999 and the authors.

Table 4 BAA pure technical efficiency employ BCC model (from 1979/1980 ~ 2008/09)

Parker (1999)				This Study	
DMU	**Score**	**DMU**	**Score**	**DMU**	**Score**
1979/80	0.9823	1987/88	1	1997/98	1
1980/81	0.9518	1988/89	0.8924	1998/99	1
1981/82	1	1989/90	0.9195	1999/00	1
1982/83	1	1990/91	0.8138	2000/01	1
1983/84	1	1991/92	0.8103	2001/02	1
1984/85	1	1992/93	1	2002/03	0.9522
1985/86	1	1993/94	0.9437	2003/04	0.9590
1986/87	0.9677	1994/95	1	2004/05	1
		1995/96	1	2005/06	1
				2006/07	0.9949
				2007/08	1
				2008/09	1
Average before privatisation 1979/80 ~ 1986/87	0.9877	Average after privatisation 1987/88 ~ 1995/96	0.9310	1997/98 ~ 2008/09	0.9922

Source: Parker, 1999 and the authors.

relatively inefficient DMU. Comparing the results with Parker's research, in the CCR model the average efficiency rating up to 1986/87, the year of privatisation, was 0.9760. In the following period to 1995/6 the average efficiency rating fell to 0.9050. After 20 years it can now be seen that the total efficiency in last 12 years is seen to be much better than the first ten years (1987/88 ~ 1995/96) after privatisation but also better than the period before privatisation.

The result of using BCC model to assess pure technical efficiency of BAA reveals that during last 12 years only three DMU years were comparatively inefficient at a pure technical efficiency level (Table 4). Comparing the result with Parker's research, after 20 years, the pure technical efficiency in last 12 years is not only better than first ten years after privatisation (1987/88 ~ 1995/96) but also better than the period before privatisation.

Table 5 shows the technical efficiency and the situation of returns to scale for BAA between 1997/98 and 2008/09. Through CCR the model, total efficiency (including pure technical efficiency and scale efficiency) can be derived. The efficient value in the CCR model is the product of pure technical efficiency and scale efficiency. Therefore,

Table 5 BAA technical efficiency and situation of return to scale in each year

DMU	Total efficiency	Pure technical efficiency	Scale efficiency
1997/98	1	1	1
1998/99	1	1	1
1999/00	1	1	1
2000/01	1	1	1
2001/02	1	1	1
2002/03	0.9506	0.9522	0.9983
2003/04	0.9283	0.9590	0.9680
2004/05	0.9744	1	0.9744
2005/06	1	1	1
2006/07	0.9854	0.9949	0.9905
2007/08	0.9969	1	0.9969
2008/09	1	1	1

the value of scale efficiency is equal to the value of total efficiency divided by pure efficiency. By the means of total technical efficiency, pure technical efficiency, and scale efficiency can be analysed, the reasons for inefficiency according to the technical factors or inappropriateness of scale can be realised. As shown in the results, inefficiency only occurred in five DMUs (2002/03; 2003/04; 2006/07). Since 1997/98, the efficiency of BAA has improved compared with the first ten years of privatisation. Therefore, it is shown that the benefit of airport privatisation becomes more obvious in the long-term.

7. CONCLUSION

This study has been concerned with technical efficiency at BAA plc and UK major airports between 1997/98 ~ 2005/06, this time period is eventually almost 20 years later than Airports Act 1986. In addition, this research also compared the result with Parker's research "The performance of BAA plc before and after privatisation" in 1999, in order to illustrate the revolution of airports privatisation in two different time period.

There were two main parts of this study. First part is evaluating technical efficiency within BAA between 1996/97 ~ 2007/08 was taken each year as a separate DMU. In these ten years, an obvious improvement of performance in BAA plc because of privatisation, on the other hand technical efficiency also rose as expected initially; this situation also proved airports privatisation can improve technical efficiency of BAA plc.

In addition, comparing two researches which adopted the same method and similar time range then described the differences between two different researches. There were many scholars recognise that privatisation can raise efficiency. Otherwise, comparing with Parker's research indeed gave more evidences to support this phenomenon. Second part of this study, relative technical efficiency and pure technical efficiency within UK major airports between 1997/98 ~ 2007/08 was evaluated in different year. In this section, the results can be divided into two parts. First part, total efficiency of UK major airports was evaluated by CCR model. Most of airports which owned or operated by commercial company performed better than government owned airports. Second part, pure technical efficiency can be evaluated by BCC model and compare the result with Parker's research. The consequence of comparison also revealed after operating by private company around 10 years, UK major airports owned or operated by commercial company achieve better performance than public airports.

The main objectives and findings of this research were as follow:

1. By employing DEA to evaluate the efficiency of BAA plc and other UK airports to realise the effect of airport privatisation. The findings of this study showed that airport privatisation certainly improved operational efficiency of airports, because most of private airports achieve relative better efficiency in every year between 1997/98 ~ 2007/08. Therefore, The *Airport Act* has made positive influence on airport industry in UK.
2. In this study, besides evaluated operational efficiency of UK major airports and through comparing the performance of major airports and management organizations (public and private) in UK. We also attempted to adopt a case to illustrate the real fluctuation in practice. Therefore, taken BAA as a sample to confirm the influence of airport privatisation on airport operating company. It was no doubt that since 1989, the performance of BAA was becoming better and the revenue also increasing rapidly. The further research can undertake an evaluation in different company, such as TBI or Manchester Airport plc. Even can try to compare operational efficiency between different airport operating companies not only in UK, but also over the world.
3. In first part of this research, by means of DEA relevant models to produce some data, through analysing technical efficiency and pure technical efficiency of BAA will

provide suggestions for those relative non-efficiency years.

4. The consequences of this research had already provided an important case study for policy makers worldwide that airport privatisation will make airports performed more efficient, satisfied not only passengers but also airline companies, and diminished subsidy from government.

Future research is suggested to examine the performance of non-BAA airports and also to extend the research to look at other cases of airport privatisation on a regional and international basis. In addition, this privatisation trend just raised in Taiwan in recent year, such as privatisation of telecommunication company and sea port authorities. From this study, policy maker can learn some lessons from UK experience.

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