CRANFIELD UNIVERSITY

MOHAMMED H. CHAOUK

THE USE OF A NATIONAL MACRO-ENVIRONMENTAL FRAMEWORK IN SELECTING THE APPROPRIATE AIRPORT OWNERSHIP AND MANAGEMENT MODEL

SCHOOL OF AEROSPACE, TRANSPORT, AND MANUFACTURING
CENTRE FOR AIR TRANSPORT MANAGEMENT

DOCTOR OF PHILOSOPHY (PhD)
Academic Year: 2016 - 2019

Supervisor: Dr. Romano Pagliari
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This thesis is submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy (PhD)

ABSTRACT

The continuous increase in air traffic has placed pressure on governments to develop their airports in order to accommodate increasing demand. As a result, governments are opting to implement different airport ownership and management models, especially privatization, to finance the development of projects, improve operational and financial efficiency, and to enhance the quality of service of their airports. However, it has been observed that this trend towards airport privatization, especially in developing countries, has to a large extent been guided by international consultants who seldom appreciate local political, cultural and economic contexts within which airports are managed. Consequently, there have been many examples of privatization transactions, not achieving the required and expected outcomes. Therefore, this study proposes a framework to identify the airport ownership and management model that best suits the local circumstances of a country. The framework is based on five national macro-environmental factors that are found to be significantly influencing the efficiency of airports. These national macro-environmental factors are identified by first measuring the efficiency of a sample of international airports using Data Envelopment Analysis (DEA), and secondly by conducting a truncated regression coupled with Simar and Wilson bootstrapping technique to test the significance of a set of national macro-environment factors on airport efficiency. The identification of these factors fills in the gap in the literature that is related to the relationship between the airport performance and non-discretionary variables. Finally, the proposed framework helps policymakers to identify which ownership and management model is most appropriate given prevailing national macro-environmental conditions.

Keywords:

Airport efficiency; Privatization; Framework development; DEA, Second-stage regression; Ownership and management models.

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LIST OF ABBREVIATIONS

AACO	Arab Air Carriers Organization
ACAC	Arab Civil Aviation Commission
ACI	Airports Council International
ANS	Air Navigation Service
ARFF	Aircraft Rescue and Fire Fighting
ASP	Asia Pacific
ATI	Air Transport Intelligence
ATM	Air Traffic Movement
ATO	Air Transport Output
ATRS	Air Transport Research Society
BAA	British Airports Authority
BAC	Bahrain Airports Company
BCAA	Bahrain Civil Aviation Affairs
BCC	Banker, Charnes and Cooper
BHS	Baggage Handling System
BOT	Build-Operate-Transfer
BS	Business Sophistication
BTO	Build-Transfer-Operate
CAA	Civil Aviation Authority
CAAs	Canadian Airport Authorities
CARC	Civil Aviation Regulatory Commission
CCR	Charnes, Cooper and Rhodes
CEO	Chief Executive Officer
CPI	Corruption Perception Index
CRS	Constant Return to Scales
DBOM	Design, Build, Operate and Maintain
DBOMF	Design, Build, Operate, Maintain, and Finance
DBOT	Design, Build, Operate and Transfer
DEA	Data Envelopment Analysis
DG	Director General

DMU	Decision Making Unit
ECA	Export Credit Agency
EMP	Employees
ETPS	Economic, Technical, Political, and Social
EU	European Union
FAA	Federal Aviation Administration
FDH	Free Disposal Hull
FMD	Financial Market Development
FTE	Full Time Equivalent
GA	General Aviation
GCAA	General Civil Aviation Authority
GCI	Global Competitiveness Index
GCR	Global Competitiveness Report
GDP	Gross Domestic Product
GME	Goods Market Efficiency
GPI	Global Peace Index
HDI	Human Development Index
HET	Higher Education and Training
HPE	Health and Primary Education
HVAC	Heating, Ventilation, and Air Conditioning
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IEP	Institute for Economics and Peace
IFC	International Finance Corporation
IIPS	Institute of Industrial Policy Studies
ILR	International Location Ranking
IMD	Institute for Management Development
INF	Infrastructure
INNOV	Innovation
INS	Institutions
IPO	Initial Public Offering
IT	Information Technology

JAC	Jordan Airports Company
JATM	Journal of Air Transport Management
LAC	Latin America and the Caribbean
LCCs	Low Cost Carriers
LME	Labour Market Efficiency
MAHB	Malaysia Airports Holdings Berhad
MAX	Maximum
ME	Macro-economic Environment
MENA	Middle East and North Africa
MIN	Minimum
MS	Market Size
NA	Non-Aeronautical
NAS	National Airports System
NCR	National Competitiveness Research Report
OLS	Ordinary Least Squares
PACA	Public Authority of Civil Aviation
PAX	Passenger
PBB	Passenger Boarding Bridge
PCA	Principal Component Analysis
PP	Partial Productivity
PPP	Public Private Partnership
REV	Revenue
RFPs	Request for Proposals
SEM	Structural Equation Modelling
SFA	Stochastic Frontier Analysis
SPVs	Special Purpose Vehicles
SS	Safety and Security
TFP	Total Factor Productivity
TI	Transparency International
TR	Technological Readiness
TRE	Transportation Research Part E
TS	Terminal Size

TT	Travel and Tourism
TT	Travel and Tourism Index
UK	United Kingdom
UNDP	United Nationals Development Programme
US	United States
VFP	Variable Factor Productivity
VIF	Variance Inflation Factor
VRS	Variable Return to Scales
WCY	World Competitiveness Yearbook
WEF	World Economic Forum
WLU	Work Load Unit

1 CHAPTER ONE: INTRODUCTION

1.1 Research motivation

In the Middle East and North Africa (MENA) region, the pace of change towards the liberalization of the air transport industry has increased gradually over the last two decades. The impact of this process for airport ownership and management is undeniable but still not fully understood. In fact, although the motivation for this research stems from the industrial observations in the MENA region, the rest of the thesis will focus on Europe and Asia-Pacific due to the availability of consistent and reliable data (see Chapter 5 for further details).

In 1998, members of the Arab Civil Aviation Commission (ACAC) established a multilateral accord to liberalize air transport in the region, and the result was the so-called "Damascus Convention on the Multilateral Liberalization of Air Transport between Arab Countries" which was held in Syria in 2004. The Convention was only signed by 13 out of 22 Arab Countries, and only 8 of them ratified it (ICAO, 2016). Those MENA countries that signed and ratified the Damascus Convention are shown in Table 1-1.

Variation in the application of the Damascus Convention between the Arab countries is due to the conflict between the conditions stated in the convention and the economic regulations in each country (AACO, 2011). However, this step was a clear result of the aim to advance towards a more open community.

Historically, as in most countries, the governments of MENA countries which own the airports of their countries and their flag carriers are usually reluctant advocates of deregulating the air transport industry. Giovani Bisignani, DG & CEO of IATA expressed to the representatives at the International Civil Aviation Organization (ICAO) conference in Dubai in 2006, "the case for change and greater commercial freedom is immediate, but that the government response is disappointingly slow". Bisignani also added that the role of governments is the main subject of the debate and that a robust leadership is needed to make liberalization work by updating policies to reflect the recent changes in aviation and drawing the industry's vision for the next 60 years (IATA, 2006).

Table 1-1 Countries signed and ratified the 1998 Damascus Convention

Country	1998 Damascus Convention	
	Signed	Ratified
Algeria		
Bahrain	x	
Egypt	x	
Comoros		
Djibouti		
Iraq	x	
Jordan	x	x
Kuwait		
Lebanon	x	x
Libya		
Mauritania		
Morocco		x
Oman	x	x
Palestine	x	x
Qatar		
Saudi Arabia		
Somalia	x	
Sudan	x	
Syria	x	x
Tunisia	x	
United Arab Emirates	x	x
Yemen	x	x

Source: Adapted from AACO (2011)

Therefore, the factor that determines the extent of air transport liberalization in a country is obviously the national policy of that country. For example, Bahrain, Kuwait, Lebanon, Oman and the United Arab Emirates have individually applied an open skies policy (AACO, 2011). In this regard, the liberalization of airspace within the MENA region differs from one country to another. This fact is illustrated in Figure 1-1.

ICAO is firmly insisting through its recommendations to states to allow for greater managerial autonomy, which means a separation between regulatory and operational activities. This separation enables the authorities to comply with safety and security standards easily. It is now a fact that states that adopted this approach were able to achieve quick successes and progress on many aviation-related fronts (ICAO, 2008).

In general, the bodies responsible for the air transport industry in the MENA region are established; however, there is a weakness in policy creation and efficient management. Developments are needed in the regulatory and financial systems to incentivize more private sector participation in the transport industry (El Naggar, 2009). There are only six countries in the MENA region that established their autonomous civil aviation regulator, as shown in Figure 1-2.

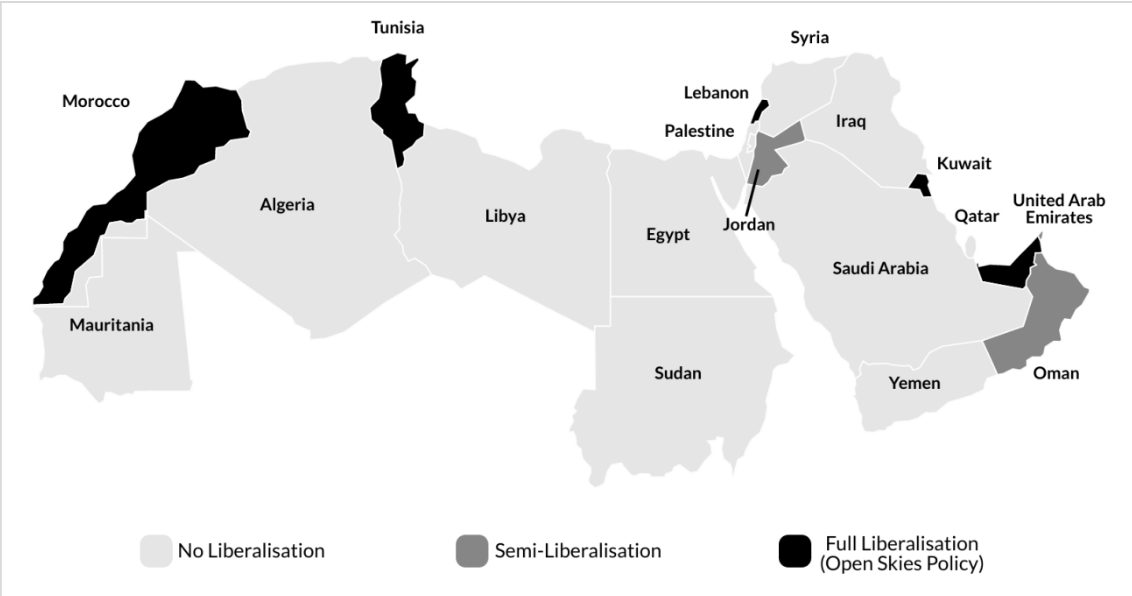

Figure 1-1 Air Transport liberalization status in the MENA region

Source: Adapted from AACO (2011)

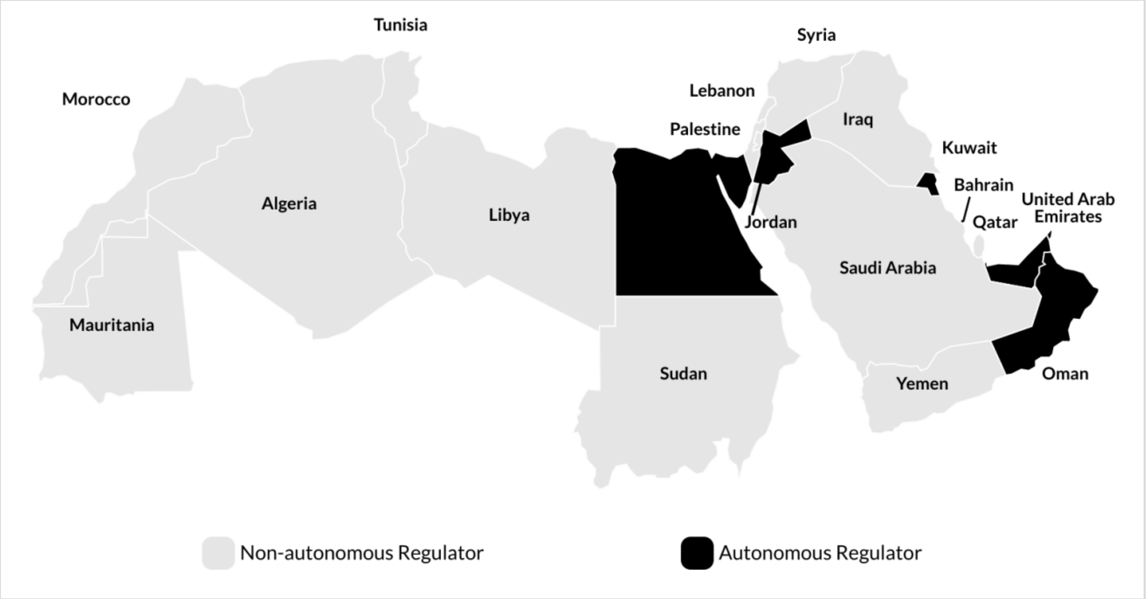

Figure 1-2 Autonomous civil aviation regulators in the MENA region

Source: Adapted from AACO (2011)

In Egypt, the Civil Aviation Authority went through significant restructuring after its establishment in 1971 until it was ended by a presidential decree in 2002 which transferred its responsibilities to the Ministry of Civil aviation. The Ministry of Civil aviation then became the civil aviation regulator of Egypt. The Civil Aviation Regulator in Egypt gained its autonomous status in the year 2002 after the establishment of the Egyptian Airports Company and the National Air Navigation Services Company. Both companies follow the same parent company, which is now called the Egyptian Airports and Air Navigation Holding Company which operates the majority of airports in Egypt.

In Jordan, activities related to civil aviation were controlled by the Civil Aviation Directorate in the Ministry of Transport until the establishment of the Civil Aviation Authority in 1982. With the aid of the EU, the Jordanian CAA went through a 4 year restructuring project starting in 2004 which resulted in a separation between the regulator and the operators such as airports and air navigation services, the establishment of the Civil Aviation Regulatory Commission (CARC) and the formation of the Jordan Airports Company (JAC).

CARC became a financially and administratively autonomous entity in the year 2007 with the issuance of the Civil Aviation law No. 41 (MOTPI, 2002).

In the Sultanate of Oman, the government wanted to improve the performance of the civil aviation sector and abide by the ICAO regulations. The Royal decree no. 33 of the year 2013 established the Public Authority of Civil Aviation (PACA) and gave it an autonomous status financially and administratively. PACA is responsible for regulating the Civil Aviation activities in the Sultanate as well as providing the ANS (MOTC, 2014). Also, the government established the Oman Airports Management Company (OAMC) to take over the management and operation of all the airports of Oman, including Muscat International Airport and Salalah Airport (OAMC, 2017).

Bahrain also separated the regulatory and operational activities of civil aviation by establishing the Bahrain Civil Aviation Affairs (BCAA) and Bahrain Airports Company (BAC) in 2008. BCAA is responsible for regulating all the Civil Aviation Activities in Bahrain and for the compliance and commitment of all the stakeholders to the regulations. In addition, all the meteorological services in Bahrain are the responsibility of BCAA. BAC, on the other hand, is responsible for the management and operation of Bahrain International Airport, the only civil aviation airport in the Kingdom of Bahrain (MOTT, 2016).

In the United Arab Emirates, control regulating the civil aviation, with all the provisioning activities on the safety and security aspects of the aviation, is the responsibility of the General Civil Aviation Authority (GCAA) which was established by Federal Cabinet Decree No. 4 of 1996. GCAA is an autonomous entity. The management and operation of airports in UAE are carried by various airport companies such as Abu Dhabi Airports Company and Dubai Airports Company…etc. (GCAA, 2017).

Other countries in the MENA region have made an effort to reform and update their air transport systems according to ICAO's requirements and recommendations. However, even the newly established civil aviation regulators are still engaged in operational activities which to some extent contravene the autonomous regulatory approach. The reason lies in the fact that the governments of countries in the MENA region are still not willing to release influence over the ownership and operation of the airports, most probably because of concerns over national security implications.

Despite all of this, the air transport market in MENA is undergoing a fast conversion as passenger traffic began to flow through the area primarily because of the rise of the Middle East carriers, and in particular airlines based in the Gulf countries, which are beginning to impact the global airline industry (O'Connell and Williams, 2010). However, the rise of the so-called "Arab Spring" in late 2010, which started in Tunisia and then spread to other countries across the MENA region, in addition to the subsequent ongoing military activities on the regional level, especially in Libya, Egypt, Syria and Yemen, lead to disruptions to the air transport industry. For example, Yemeni airspace, which is a critical airspace for some routes between Africa and Asia, was totally closed. Another example is the temporary disturbances of Iraqi airspace caused by the Russian missiles fired from the Black Sea to Syria (AACO, 2016).

Surprisingly, and despite all the above-mentioned events, the air transport market in the MENA region recorded an average annual growth of 4.95% between 2013 and 2015 in terms of international passengers it is expected to reach 6.6% after 2016. 256.7 million International passengers and 25 million domestic passengers have shaped the air transport market of MENA region in 2015, with an annual growth rate of 5.3% and 5.4% for international and domestic markets respectively since 2014. The growth of MENA air passengers between 2013 and 2016 is shown in Figure 1-3. These developments in the air transport market in the MENA region show that the air transport industry continues to play a decisive role in the sustainable economic development of the MENA region countries (AACO, 2016). More importantly, these figures are expected to continue increasing according to the forecasts of Boeing in the current market outlook 2016-2035 (Boeing, 2016).

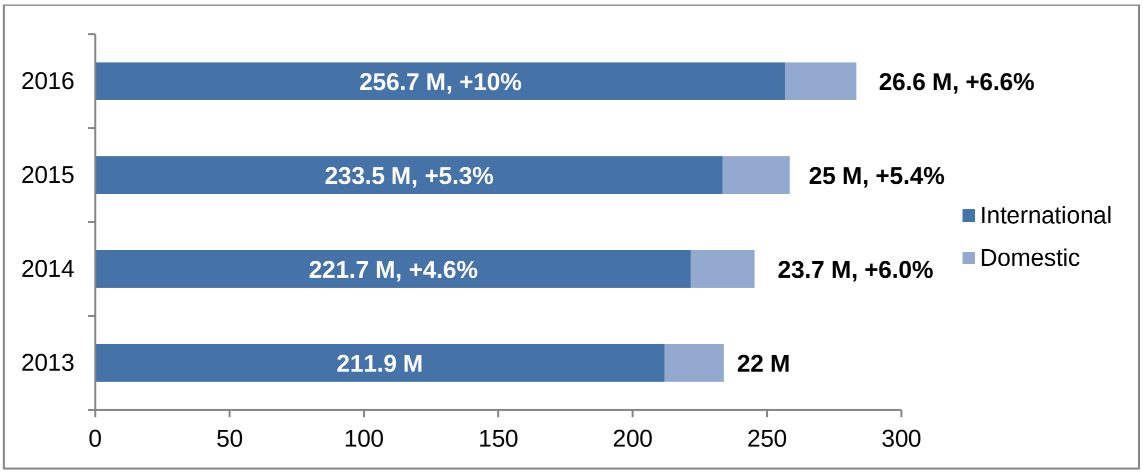

Figure 1-3 MENA air passenger traffic evolution (2013-2016)

Source: (AACO, 2016)

The ongoing expected growth of air traffic in the MENA region along with the vital contribution of the air transport industry to the MENA GDP, which has reached 7.3% ($204.6 billion) in 2015 according to AACO (2016), and to the overall regional development, have placed pressure on governments of the MENA countries to develop their airports infrastructure to accommodate the demand of the increasing traffic growth.

In the period between 2010 and 2017, around US$38 billion was invested in airport development projects in the MENA region, and some of these airports are still under construction. Some of these projects are listed in Table 1-2.

In addition, more than US$92 billion is expected to be spent on MENA new and existing airport development projects in the next decade. And interestingly, these investments are not targeting the primary international airports, but will majorly focus on developing domestic and regional secondary airports (Walker, 2018). Consequently, the massive demand for airport development and the calls for enhancing operational performance and quality of service of MENA airports have recently led airport privatization to become on the agenda of the governments of some countries in MENA.

Table 1-2 MENA concluded and current airport development projects since 2010

Country	Airport Development Project	Cost (Billion US$)	Conclusion Date
Bahrain	Development and upgrade of existing facilities of Bahrain International airport	4.7	2020*
Iraq	Construction of new airport in Duhok	0.45	N/A
	Construction of new airport in Erbil	3	2011
	Baghdad Airport upgrade and construction of 3 new terminals	2	N/A
Jordan	Expansion of Queen Alia International Airport	0.21	2016
Kuwait	Construction of Terminal 4 for 4.5 Million annual passengers	6	2018
	Construction of Terminal 2 for 25 Million annual passengers	4.3	2022*
Oman	Construction of new terminal and facilities at Muscat International Airport	5.2	2016
	Construction of new airport in Sohar	1.5	2014
Qatar	Completely new airport for A380 and 50 Million annual passengers	15.5	2014
Saudi Arabia (KSA)	Upgrading all Kingdom's Domestic Airports by 2020	10-15	2020*
	Construction of new terminals at Jeddah Airport and expansion of Hajj terminal	7.1	2019*
	Expansion and refurbishment of Riyadh Airport	4.4	2021*
	Construction of new Medina Airport	1.3	2015
United Arab Emirates (UAE)	Construction of Dubai Al Maktoum International Airport	8.2	2027*
	Expansion of Dubai International Airport	7.8	2019*
	Redevelopment of Abu Dhabi Airport and construction of a new terminal	6.8	2019*
	Construction of new airport in Ajman with other related developments	0.8	2019*
Algeria	Expansion of Algiers' Houari Boumediene Airport's	0.95	2019*
Sudan	Construction of new Airport in Khartoum	1.25	2022*

*** Expected**

Source: CAPA (2019) and various unpublished sources

Currently, there are only nine out of the 280 airports in the MENA region in which the private sector has some sort of participation in ownership and/or management. The list of these airports and their details are presented in Table

1-3. Six out of nine airports are full Public-Private-Partnership (PPP) airports-based BOT concession contracts, and the remaining three are only management contracts for the operation of the terminal.

Table 1-3 Privatized airports in the MENA region

Country	Airport	Type of Contract	Year	Period (Years)	Company
Tunisia	HBIA	MC*	2007	40	TAV Airports Holding
	EHIA	BOT	2007	40	TAV Airports Holding
Egypt	EAIA	BOT	1998	50	International Airports Company
	MAIA	BOT	1997	40	M.A. Al-Kharafi Group of Kuwait
Jordan	QAIA	BOT	2007	25	Airport International Group (AIG)
KSA	PMIA	BTO	2011	25	TIBAH Airports Development Co. LTD
	KKIA (Terminal 5)	MC*	2016	5	Dublin Airport Authority (DAA)
	PAIA	BTO	2017	30	TIBAH Airports Development Co. LTD
	KAIA (Hajj Terminal)	BTO	2022	20	Bin Laden Group
Kuwait	OKBK (Terminal 4)	MC*	2018	5	The Incheon International Airport Corporation (IIAC)

***MC: Management Contract**

This continuing trend for airport privatization in some of the MENA countries is primarily driven by international consultants and advisors who are hired by the governments to assist them in choosing the most suitable ownership and management model that can achieve efficient operational and financial performance and enhance the quality of service at their airports. For example, the PPP transaction of the first significant airport privatization experience in the Middle East, at Queen Alia International Airport in Jordan, was advised by the International Finance Corporation (IFC). Similarly, the privatization of Medina airport, the first privatized airport in the Kingdom of Saudi Arabia, was also advised by the IFC. Other countries have used the advisory services of other international consultancy firms to guide them, such as in Kuwait, Egypt, and Tunisia.

Unfortunately, most of the time, these advisers are recommending airport privatization since some of its known advantages are to improve the efficiency of the airport and the quality of service. Therefore, there is no solid strategy or framework used to justify the suitability of the recommended model. The only justifications used are some examples of successful airport privatization experiences in different parts of the world, and especially in developed countries.

However, the decision does not take into consideration that most of the countries in the MENA region are highly politicised, have shortages in local expertise, and can suffer from security instability due to military conflicts and wars in the neighbouring countries. And it is clear after the few airport privatization experiences in the MENA region, those existing problems cannot be corrected easily.

Industrially, it is evident that the outcomes of airport privatization cannot be generalised. This observation is in line with ACI's first policy recommendation published in ACI (2017), which states that "no one size fits all" regarding the airport ownership and management models.

Academically, in the field of airport performance measurement, researchers have been attempting to compare the outcomes of airports of different airport ownership and management models to conclude which model provides better performance for the airports. However, the results are far from being conclusive. Some studies, such as Barros and Dieke (2007) and Oum, Yan and Yu (2008) found that privately owned and operated airports perform better than the publically owned ones. Other such as Lin and Hong (2006), Oum, Yu and Fu, (2003), and Parker (1999), found no difference between the performance of the privately owned and managed airports and the publically-owned ones.

Other studies have attempted to compare airport performance between countries or regions by testing the influence of different factors on airport efficiency. However, although these studies intended to test factors that are out of the control of the airports' management, the majority of the factors tested in the literature can be considered as endogenous factors and directly related to the airport.

Therefore, both industry and academia indicate that there is no airport ownership and management model that can be considered as the best performing model and is able to achieve the same successful outcomes everywhere. However, there are no clear answers in both the industry and in the literature on why the same airport ownership and management model succeeds in one place but fails in other.

Therefore, there is a need for a framework that can be used by the governments or civil aviation authorities to identify which ownership and management model best suits local circumstances. These observations lead to the following research questions:

Research Question 1:

What national macro-environmental factors significantly influence the performance of the airports?

Research Question 2:

Does each airport ownership and management model have different optimum macro-environmental settings than other models?

1.2 Aim and objectives

The aim of this research is to develop a preliminary framework for governments or civil aviation authorities to identify the airport ownership and management model that best suits their national macro-environmental settings.

This research starts with the following research objectives:

1. To explore the different types and classifications of airport ownership and management models and the current trends across the world.

2. To explore the efficiency measurement techniques used in the literature with the types of input and output variables and the non-discretionary variables used.

3. To evaluate the efficiency of a sample of international airports using Data Envelopment Analysis.

4. To understand the national macro-environmental factors influencing the performance of the airports using Bootstrapped Truncated Regression.

5. To understand the optimum national macro-environmental setting area of each airport ownership and management model.

1.3 Scope and structure

This research primarily examines the influence of a set of national macro-environmental factors on the efficiency of major international airports in Europe and Asia-Pacific (the limitation of the airports sample is justified later in Chapter 5), and identifies the optimum national macro-environmental settings area of each airport ownership and management model in an attempt to propose a preliminary framework to choose a suitable airport ownership and management model. This thesis is structured into eight chapters, as follows:

Chapter 1 provides an introduction by presenting the research motivation, research questions and aim and objectives, and the structure of this thesis. It also summarises the intended contributions to policy and the literature.

Chapter 2 presents an overview of the history and evolution of airport ownership and management models. Then it lists and defines the types of airport ownership and management models commonly classified by the airport industry. This chapter fulfils Objective 1.

Chapter 3 includes a systematic literature review on airport performance measurement to confirm the research gap and to understand the different techniques used to estimate airports' efficiency and to identify the impact of external factors on the efficiency of airports. This chapter fulfils Objective 2 of this research.

Chapter 4 defines the different elements of the philosophical research approach, including philosophical assumptions, philosophical stances, research approaches, research strategies, research choices, and time horizons. Then, it examines the philosophical approach that is applicable to this research before describing the data analysis methodologies used in this research. This chapter also describes the sources from which the data are gathered and concludes by illustrating the structure of this research.

Chapter 5 describes the steps followed to evaluate the efficiency of major international airports. This chapter starts by defining the Data Envelopment Analysis (DEA) model used to measure the efficiency of the airports. Then, it justifies the selection of the input and output variables used in the DEA model from the literature. After that, the construction of the sample dataset of the airports included in the analysis is explained. Finally, the empirical results of the DEA are presented and discussed. This chapter fulfils Objective 3 of this research.

Chapter 6 presents the second stage regression used to identify the national macro-environmental factors that are significantly influencing the efficiency of the airports. This chapter starts by first explaining the concept of national competitiveness and describing the set of national macro-environmental factors to be regressed against the efficiency scores of the airports obtained using the DEA in Chapter 5. Finally, the bootstrapped truncated regression and the Tobit regression models used in the second stage and their empirical results are presented and discussed. This chapter fulfils Objective 4 of this research.

Chapter 7 proposes a preliminary framework that uses a macro-environmental approach to identify the most suitable airport ownership and management model. But first, the airport ownership and management model classification used in this framework is justified. Then, the optimum national macro-environmental settings area of each airport ownership and management model is identified and constructed. Finally, the proposed framework is presented. This chapter fulfils Objective 5 of this research.

Chapter 8 provides a discussion and presents the overall conclusions of the critical findings of this research. It also discusses the contributions to the literature and provides recommendations for policy. This chapter concludes with the limitations of this research and the recommendations for a potential continuation of this research.

Figure 1-4 illustrates the structure of the thesis with the scopes and the highlights of each chapter.

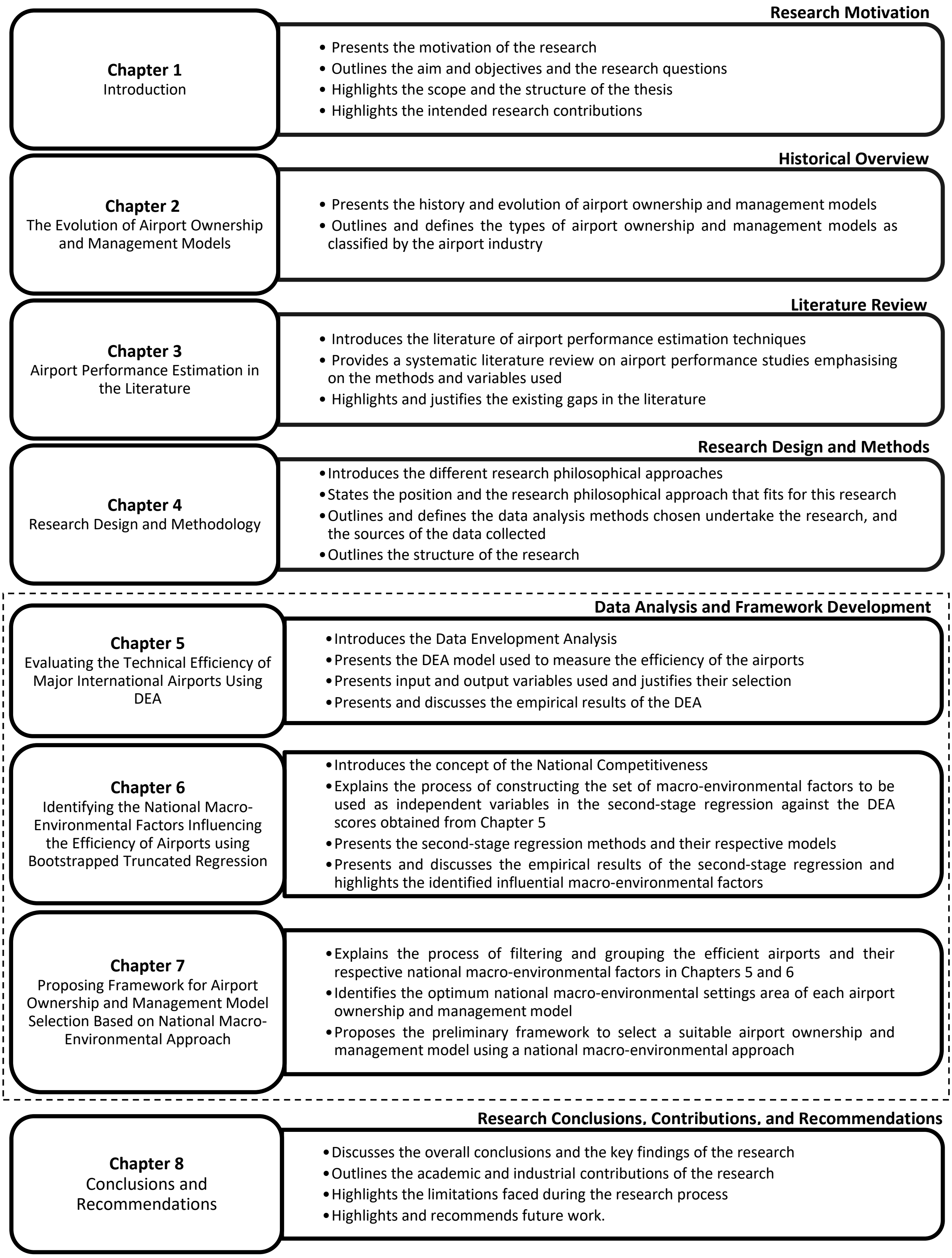

Figure 1-4 Thesis Structure

1.4 Research contributions

With the set aim and objectives of this research, it is hoped that the outcomes will provide valuable contributions to both theory and practice.

In theory, the systematic literature review would form an update to the previous reviews on the topic of airport performance estimation, which would make it a potential checkpoint for researchers who would like to perform a study on this topic. In addition, and most importantly, the identification of national macro-environmental factors that significantly influence the performance of airports would make it the first study to provide a broad picture on the relationship between airport efficiency and country-level non-discretionary variables that are not related to the airport and out of the control of the airport's management.

The theoretical findings would be used to provide practical contributions. The identified national macro-environmental factors that affect the efficiency of the airports would be used to build a preliminary framework which can be used by governments, civil aviation authorities, or consultants and practitioners to help them identify the airport ownership and management model that best suits their country's national macro-environmental settings. This would lead to significant policy implications, where policymakers will have a tool that allows them to check whether the decision regarding the airport ownership and management model is suitable or not, and will allow them to identify the points of weakness in their macro-environmental settings which would negatively affect the performance of a given airport ownership and management model.

2 CHAPTER TWO: THE EVOLUTION OF AIRPORT OWNERSHIP AND MANAGEMENT MODELS

2.1 Introduction

This chapter aims to provide a broad understanding of the historical trends and the evolution of the airport ownership and control structures which in this research are called "Airport ownership and management models". In the first subsection of the second section of this chapter, a brief history of airport ownership and management models and the emergence of new mechanisms are reviewed. Then, the drivers behind changing the ownership and management model of the airports from the traditional government-owned and operated model to other models, especially privatization, are identified based on previous literature. After that, the trend and status of airport privatization in different parts of the world are reviewed. Finally, the types of airport ownership and management models as classified by the aviation industry and the academic literature are identified.

2.2 History of Airport Ownership and Management Models

2.2.1 Historical overview

Historically airports were owned and managed by government ministries or aviation authorities as public entities since many of them appeared to have been initially developed for solely military activities during the World Wars. From the mid-20th century, the airport industry has seen early developments in the airline sector with the support of the world regulator, International Civil Aviation Organization (ICAO), and the International Air Transport Association (IATA) that were established in the late 1940s. These developments include the liberalization and the deregulation of air transport in the EU and US, which resulted in the creation of hub-and-spoke networks, the emergence of the low-cost carriers (LCCs), and thus the strengthening of global competition. These developments, along with the associated decrease in the cost of air transport, have increased the ability and tendency of customers to travel, as shown in the rapid growth rates recorded by the air transport industry in Figure 2-1. The establishment of the LCCs, which usually operate to and from airports that were underutilized and considered as secondary level airports, has resulted in the need to secure investments for their development in order to accommodate the expected growth of air traffic (Graham, 2014).

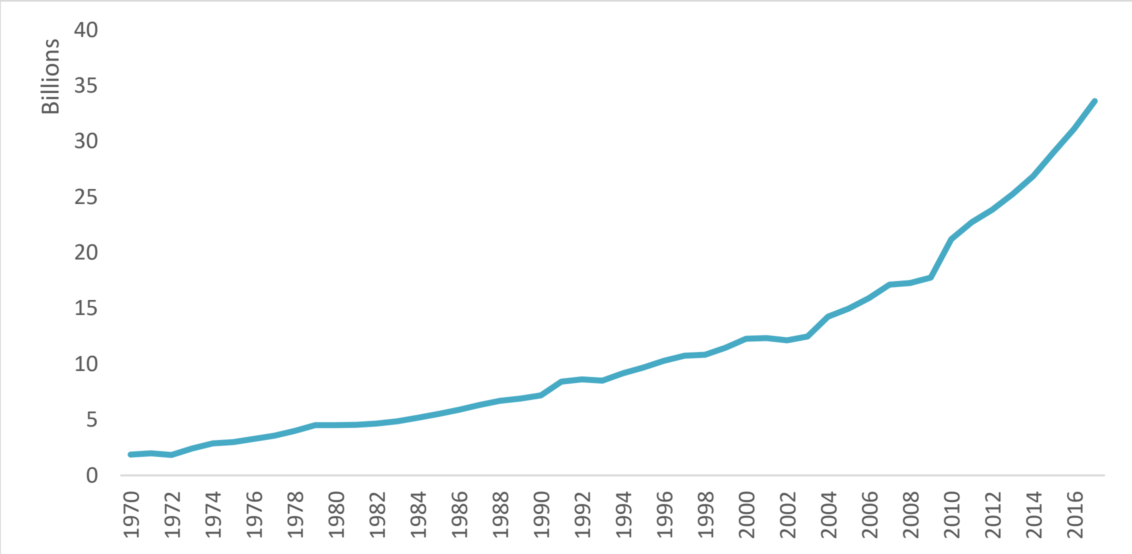

Figure 2-1 Worldwide Air transport passengers carried 1970-2016

Source: World Bank (2017)

The continuous increase in air traffic over the years has placed pressure on governments to develop their airports in order to accommodate the increase in air traffic. This includes the need to develop the secondary airports used by LCCs. This pressure led some governments to look for different financing solutions and to set up different ownership and management models (Dorian and Robinson, 2018). Therefore, different ownership and management models emerged that encompass commercialization, corporatization and privatization (Oum, Adler and Yu, 2006a). Airport privatization became a reality in 1987 with the privatization of the then British Airports Authority (Graham, 2011). Some countries chose to corporatize or commercialize their airports in order to enhance operating efficiency for the purpose of creating continuous growth and generating more revenues to support further development and economic sustainability of the airport. Some of these countries were either short of the required funds or lacked the necessary expertise and opted to go for privatization to ensure access to external sources of capital to fund the required development and to facilitate improvements in productivity and quality of services (Donnet, Keast and Walker, 2011).

Privatization, in general, started to become a worldwide interest as a result of the UK's adoption of privatization in the 1980s. In 1987 the British Airports Authority (BAA), which owned major airports in London and Scotland, was privatized with a full floatation of its shares (Doganis, 1992). The financial success of the first airport privatization experience led to the application of full and partial privatization of some regional airports in the UK, leading other countries to follow suit with subsequent privatizations of European airports like Vienna and Copenhagen in the following decade (Graham, 2011).

2.2.2 Drivers behind airport privatization

Many researchers have discussed the reasons behind governments opting to change their airports' ownership and management model or to privatize their airports. Interestingly, Graham (2011) has identified what other researchers said regarding the objectives of the airport privatization in 41 academic papers and the results are shown in Figure 2-2.

33 papers stated that the objective of privatization was increasing efficiency and improving financial performance with some papers distinguishing between efficiency in terms of productivity and profitability. The second most popular driver (stated in 26 papers) for privatizing airports was the opportunity to access private sources of capital to finance expansion. In many countries, public ownership is synonymous with limitations on the ability to access private sources of finance. Improving the quality of service comes in third place (15 papers). 14 papers stated that a driver for privatization could be improvements to management structure, or in other words, institutional innovations.

However, Kuruvilla, Fischer and Kreymborg (2011) claimed that the objectives of privatization which leads to improving the management structure are motivating competition by shrinking the dominance of natural monopolies in addition to accessing global resources which brings an inflow of expertise, talents and technology. Another common objective (13 papers) as collected by Graham (2011) is the state financial gains brought by privatization. This is summarized by Foster (1984), Stiller (2010), and Burton (2007) as enabling the state to profit from the earnings of privatization. A similar objective stated by Kuruvilla, Fischer and Kreymborg (2011) is called “Economic Opportunism”, which means that the government can benefit from the privatization’s cash incomes to reduce public finance expenditure or reduce budget deficits and long-term debt burdens. The last typical driver which is cited by 8 papers is the reduction of state influence which means that government responsibility and risk is transferred to the private sector by shrinking or eliminating its control and intrusion on the airport.

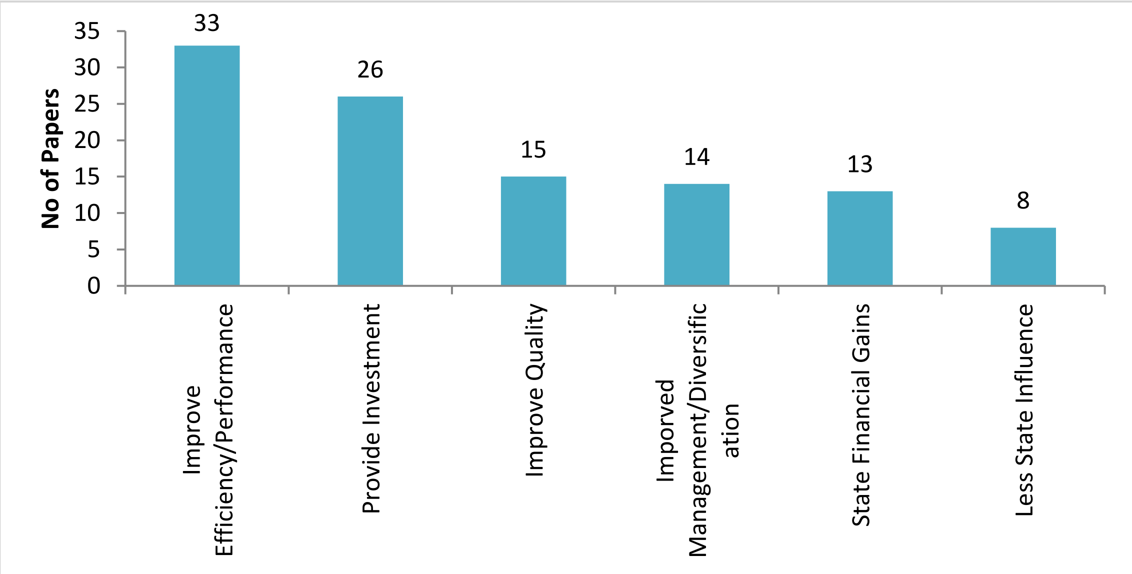

Figure 2-2 Common drivers of airport privatization identified in the literature

Source: Graham (2011)

2.2.3 The worldwide trend in airport privatization

The trend of privatizing airports has become a potent political force and as a result, the world witnessed a wave of airport privatizations that started in 1996 which took place not only in Europe but extended to other states such as New Zealand, Australia, Malaysia, South Africa and some countries in Latin America (Graham, 2011).

This wave came to an end in late 2001 as a result of the September 11 attacks in the United States, and the resultant geopolitical turbulence. Airport privatization momentum resumed in the mid-2000s with the second wave of privatization transactions involving various airports of varying sizes and in different locations (Hungary, Brussels, Paris, Cyprus, India and Turkey (Andrew and Dochia, 2006). This second wave came to an end in 2009 with the onset and after-effects of the global economic recession which actually resulted in the suspension or cancellation of some airport privatization transactions such as Prague and Chicago Midway at the time (Bentley, 2010).

Privatization activity resumed around 2012 onwards where there were private sector participation projects in airport ownership or management in a number of countries like the UK, France, Spain, Greece, Brazil and Japan. Consequently, by 2017, almost 14% of worldwide airports, which accounts for 614 airports, have seen some sort of partial or full privatization shown in Figure 2-3.

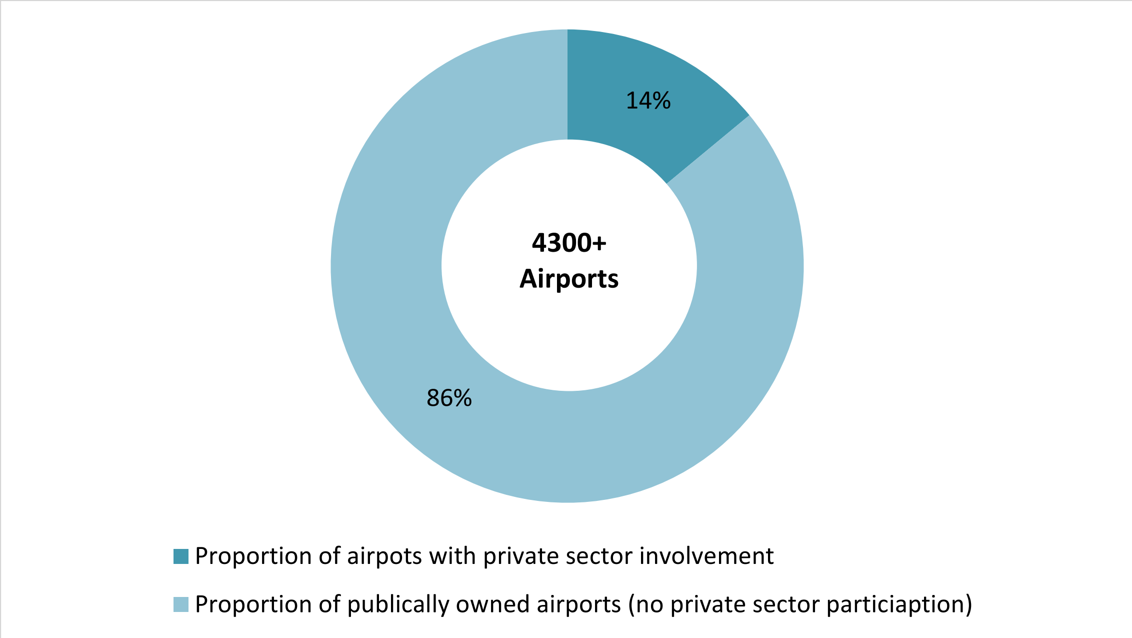

Figure 2-3 Proportions of airports by ownership structure in the world in 2017.

Source: ACI (2017)

In its 2016 inventory of privatized airports, ACI had identified the distribution of privatized airports (14% of airports in the world) according to their regions. The distribution is shown in Figure 2-4. Europe remains the region with the highest share of airports that have some level of private sector participation in their ownership and management (43% of privatized airports in the world). 26% of privatized airports in the world are in the Asia Pacific, which makes it the second region with the highest share of privatized airports. Latin America and the Caribbean come in third place, accommodating 25% of the privatized airports in the world. Finally, the remaining privatized airports are distributed among Africa, North America, and the Middle East, with 3%, 2%, and 1% of privatized airports in the world respectively.

Europe has the lead in the percentage of airports with private sector participation (31% of airports in Europe). Latin America & the Caribbean region (LAC) and Asia-Pacific region (ASP) come next with 26% and 12% of airports respectively. Africa, the Middle East and North America are still lagging behind with insignificant percentages ranging between 0.8% and 4.5%. While the majority of the airports are still publically owned, airport privatization is expected to continue being an essential future trend (Graham, 2011; Rikhy, Roberts and Cheung, 2014).

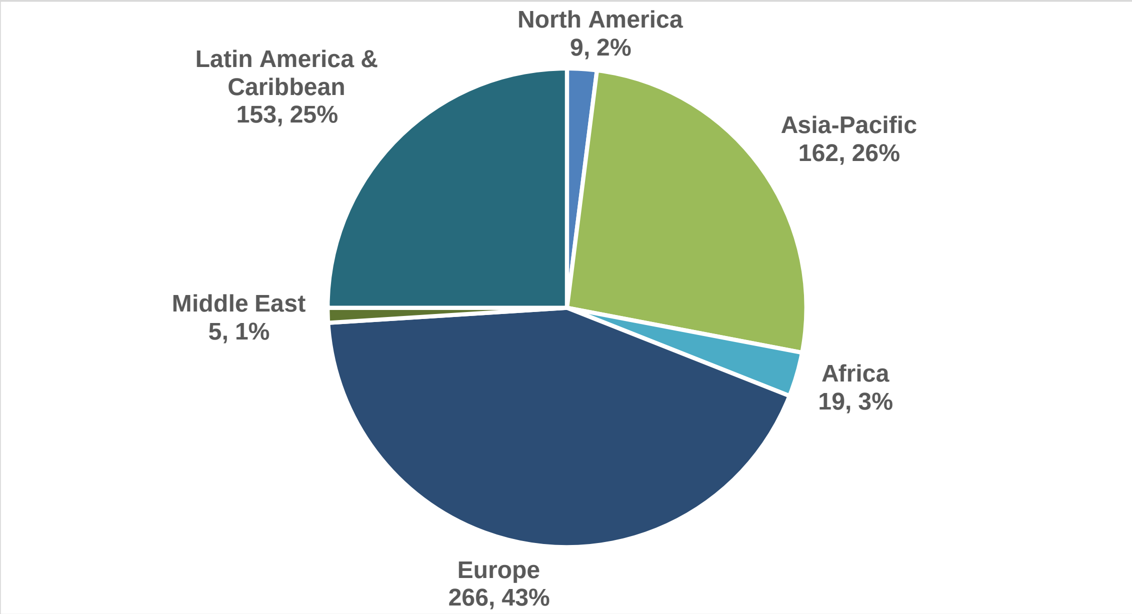

Figure 2-4 Distribution of airports with private sector participation by region (2016)

Source: (ACI, 2017)

Although Europe has the highest number of privatized airports in the world, the majority of airports in Europe are still publically owned. Only 31.1% of European airports have private sector participation in their ownership and management (ACI, 2017). However, in 2010, this figure was 21%, which means that almost 10% of the European airports have shifted towards privatization in a period of 6 years. This is evidence that the trend towards involving the private sector in airport ownership and management is still evident.

The dominance of the public sector over airports is the case in all the regions of the World. Similar to Europe, the publically-owned and managed airports in Latin America and the Caribbean are still in the majority where only 25.8% have been privatized. In Asia-Pacific, the percentage of privatized airports reached 12.3% in 2016. Africa, Middle East, and North America have very low percentages of privatized airports with 4.5%, 2.2% and 0.8% respectively. The percentage of privatized airports in each region in 2016 is illustrated in Figure 2-5.

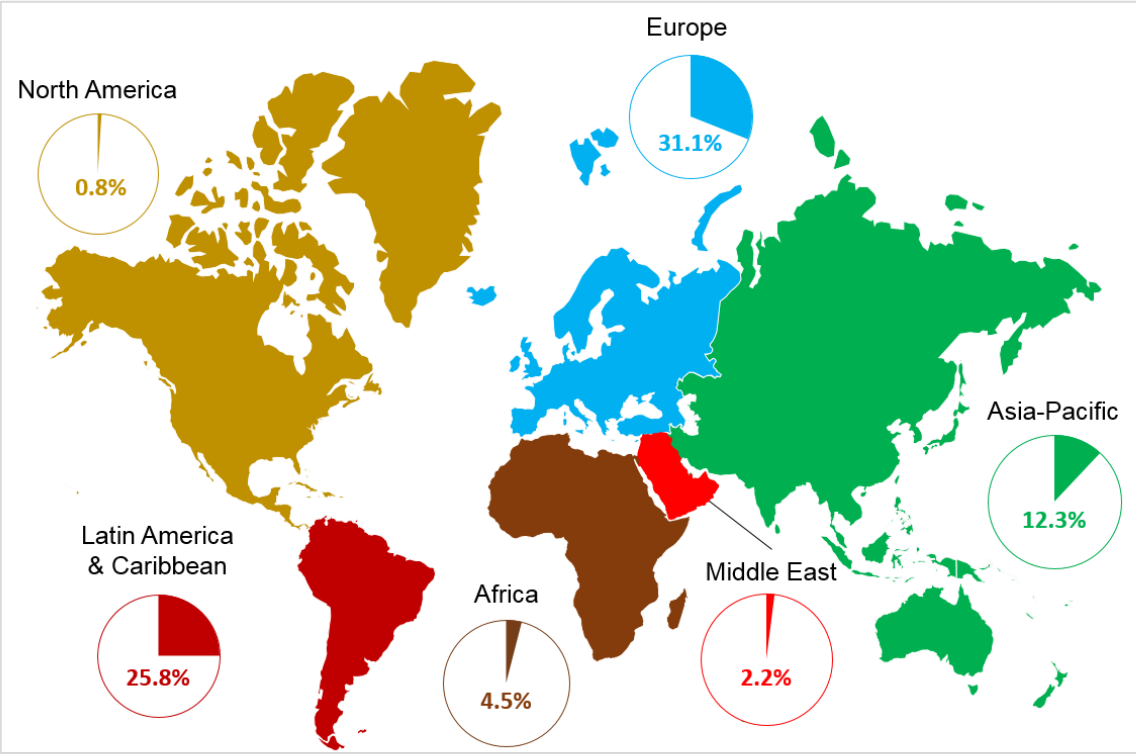

Figure 2-5 Percentage of privatized airports in each region of the World (2016)

Source: Adapted from ACI (2017)

According to ACI (2017), 41% of the privatized airports in the world are concession contracts or leased, 24% are fully privatized by divestiture, 23% are publically listed in the stock markets, 8% are management contracts, and the remaining 4% are other forms of airport ownership and management models. This indicates that the most popular model of airport privatization is the concession contract.

The types of airport ownership and management models as defined and classified in the literature and the industry are presented in the next section.

2.3 Types of Airport Ownership and Management Models

2.3.1 Industrial Classifications

There are several types of airport ownership and management models considered in the existing literature. The general types are public, private, or mixed ownership and management models. In the aviation industrial field, there are various airport ownership and management model classifications provided by different organizations. However, one of the most detailed classification is provided by Dorian and Robinson (2018) in IATA Guidance Booklet: Airport Ownership and Regulation. This booklet identifies 11 models, as shown in Figure 2-6.

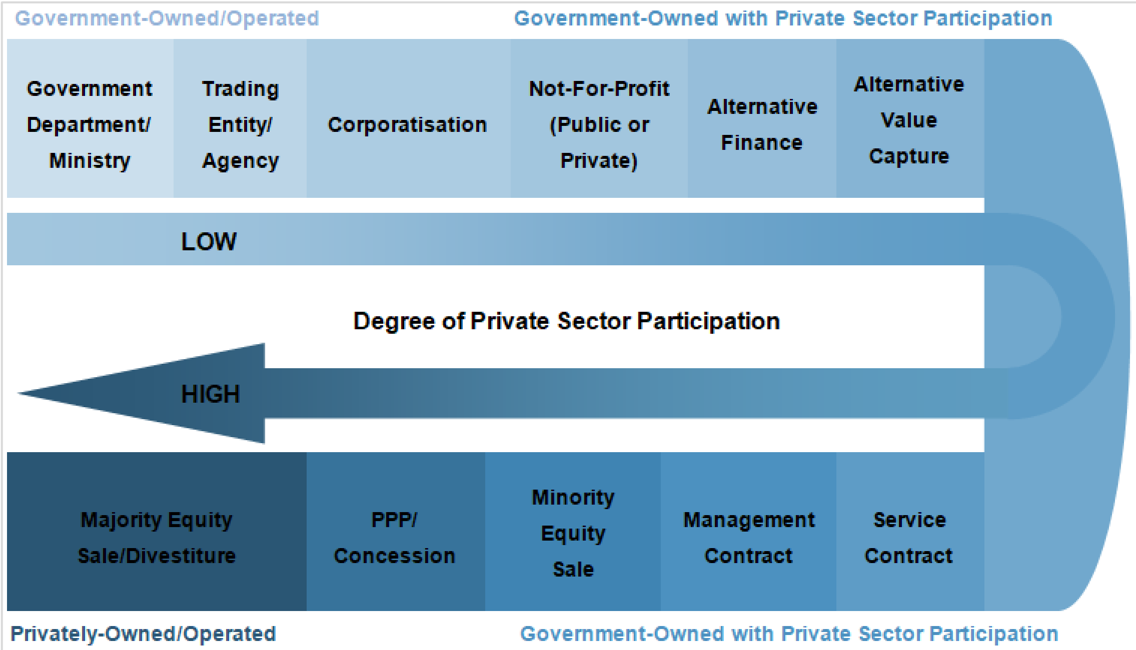

Figure 2-6 Types of airport ownership and management

Source: Adapted from Dorian and Robinson (2018)

1. **Government department or ministry**

After the end of the Second World War, the governments of the countries who primarily invested in constructing airports for military use, especially the United States of America and the United Kingdom, transferred the ownership and management of the majority of these airports to a specific department or ministry, often the Ministry of Transport or Ministry of Civil Aviation (Humphreys, 1999). By 1947, the ownership and management of 44 airports in the UK and more than 500 airports in the US were retained by governments or local authorities, and they were declared airports for civil aviation operations (Humphreys, 1999; Wells and Young, 2004). After this time, the majority of the airports came under the ownership of the public sector and were considered to be strategic national assets. Airports were also used as a vital instrument by political parties in the exercise of building and strengthening consensus among citizens (Jarach, 2005).

Although public ownership and management was the only model that existed in those times, airports could be categorized into three main groups based on the governmental departments that held a share in their ownership and control (Graham, 2014). The first group is airports that served capital and major cities and the majority of them were owned and managed by national governments (e.g. Don Mueang International Airport in Bangkok, London Heathrow Airport in London, Paris–Le Bourget Airport in Paris, Singapore Changi Airport in Singapore and Haneda International Airport in Tokyo, etc.). The second group is regional airports that were usually owned and operated by regional or municipal local governments (e.g. the majority of airports in the US and few regional airports in the UK). The third group is those airports owned and operated by multi-level governments or authorities such as local and national governments (e.g. Munich International Airport, Amsterdam Schiphol International Airport, Milan Malpensa International Airport, etc.).

The considerable growth of air traffic increased the complexity of airport operations and continuous advancements in the aviation technology over the past half-century meant that the traditional model of government or ministry ownership and management could no longer be sustained. Today, this model is not accepted in the airport industry, especially after ICAO's recommendation[1] to separate the responsibility of airport regulatory and operational activities into

[1] Recommendation mentioned in ICAO DOC 9082/7 – Policies on Charges for Airports and Air Navigation Services.

different entities Dorian and Robinson (2018). This is because better overall financial and managerial efficiency is found to be achieved by airports and air navigation services that are managed by autonomous entities (ICAO, 2004).

2. **Government trading entity**

In this model, an entity or organization within the government is dedicated to own and manage the airport. It may sound similar to corporatization, but it’s not. This is because, in the government trading entity model, the managing entity directly reports to the government and not to a corporate Board of Directors.

Although the ownership and management of the airport in the government trading entity model are not directly under the government as in the traditional government ownership model, the majority of the essential resolutions are taken by the government through the ministry. Therefore, the autonomy of the managing entity in this model is often questioned by researchers and critics.

This lack of independence makes the government trading entity model not recommended as well since it is not compliant with ICAO’s recommendation to fully separate managerial resolutions and operation actions from regulatory activities. Although the efficiency of the airport may be better under this model when compared to the traditional government ownership and management model, it is not considered sufficient to enhance airport efficiency (Dorian and Robinson, 2018).

There are some examples of large airports which succeeded using government trading entity models such as Dubai Airports.

3. **Corporatization**

The corporatization model defines the creation of a lawful and autonomous airport company that operates the airport within a commercialized and corporatized framework but is still owned and controlled by the government or the local authorities (Cook, 2001).

The main advantage of this model over the other government-owned models is the full separation of operational functions from regulatory activities by creating an autonomous corporate board only responsible for managing the operations of the airport. The regulatory and governance functions are retained by an autonomous authority or regulatory body (Dorian and Robinson, 2018).

Another key advantage is that this model enables more accountability and transparency, which provides for better airport performance (Cook, 2001).

Overall, the corporatization model may optimise the efficiency and performance of the airports. This is because the corporate entity may tend to take incentivised procedures to improve airport efficiency since it is fully accountable for the financial performance of the airport and developing plans for its long term capital investments (Dorian and Robinson, 2018).

There are also some disadvantages to this model. In some cases, the corporate entity is obliged to pay fixed rents or predefined fixed returns to the government without relating it to the performance of the airport. Market power abuse is another potential disadvantage. Also, since the corporate entity is owned by the government, it is still prone to political interference in decision-making via the Board of Directors.

A successful primary example of corporatization is Changi Airport in Singapore. In 2009, the government of Singapore announced the creation of the Changi Airport Group, an autonomous entity separate from the Civil Aviation Authority of Singapore (CAAS) (Changi, 2019). It was formed to take over the responsibility of operating and managing the airport from the CAAS, and to set plans to ensure continuous investment and profitability. Today, Changi Airport is considered one of the best airports in the World and has won many of prestigious awards such as Skytrax World Airport Awards, ACI Airport Service Quality Awards and others (Changi, 2019) and is considered to be a significant pioneer in airport retail development and passenger service experience.

4. Not-For-Profit model

In this model, the entity which holds the ownership and management of the airport transfers or leases the airport assets to a Not-For-Profit corporation. This corporation must be able to self-finance all the operational and capital costs of the airport. Then, all the gained profits are required to be re-invested into the airport after the leasing costs are paid to the owner in case the airport is leased (Dorian and Robinson, 2018).

In the Not-For-Profit model, the Board of Directors is independently appointed, unlike the corporatization where the Board of Directors is appointed by the government. This lowers the possibility of political interference and enables the Not-For-Profit corporation to allow airport stakeholders to be represented in the Board of Directors and participate in the decision making, aiming to create a cooperative environment that is driven by industry or customer requirements rather than profit generation (Dorian and Robinson, 2018).

The advantage of this model is that the government is able to transfer business risk and the Not-For-Profit entity is independent and entirely responsible for the assets and liabilities and for securing the required funds. Another observed advantage of applying the Not-For-Profit model is that it can increase customer trust as a result of involving stakeholders in the decision-making process, which is highly driven by the customer requirements (Tang, 2017).

However, a potential disadvantage of this model is that it may have lower operational efficiency outcomes since profit is not the primary motive (Tang, 2017).

The most famous example of the Not-For-Profit model for airport ownership and management is the Canadian Airport Authorities (CAAs). They were introduced in 1994 as locally owned Not-For-Profit corporations and were given the right to lease 26 airports of the National Airports System (NAS) that are owned by the Canadian Federal Government. The CAAs are fully responsible for securing funds pertinent to operational and capital costs, and they are required to reinvest all profits into the airports and their development after paying the leasing costs to the Federal Government and municipal taxes (Gagnon, 2016).

The Canadian experience in this model may be considered to be successful as the major Canadian airports are efficient and their infrastructures are well managed, maintained, and upgraded. In addition, they obtain high ranks among the best airports in the world (Dorian and Robinson, 2018). However, there are also some issues and concerns due to the high cost of rent that the CAAs have to pay to the Federal Government and similarly in relation to the municipal taxes. Due to this issue, the CAAs had to increase their tariffs to cover those costs. This led to the creation of stiff competition between the major Canadian airports and the US airports near the US-Canadian border which are subsidised by their Federal Government since the US low-cost carriers have no interest to fly to the Canadian airports due to the high tariffs (Gagnon, 2016).

5. Alternative finance model

In this model, the aim is to consider various financial approaches which can be used by the airport owner, typically the government, to finance the airport's capital developments or to receive capital receipts to finance other projects with limited financing mechanisms, without significantly changing the ownership and control of the airport.

The concept of the alternative finance model is to look for other ways of raising funds than accessing private sector finances, considering that government debt is usually cheaper than private debt (Dorian and Robinson, 2018). These lesser financing charges that the alternative finance model can offer could also lead to lowering the costs on airlines and passengers; thus, benefiting the public interest. However, this is assuming that the airport management, which is under the control of the public sector, is capable of delivering a quality of service and operational and financial efficiencies comparable to those that can be achieved by the public sector.

An example of an alternative financing mechanism is an approach commonly used in the United States where often airports and their local governments issue municipal bonds. A second mechanism is to secure single purpose bonds against particular assets of the airport. A third mechanism used to finance the development of a specific airport facility that requires substantial capital investment is financing through a different government's Export Credit Agency (ECA). Usually, financing through an ECA is based on preferential conditions, where contractors or dealers from the ECA's country are allowed to be involved to a certain threshold in the airport's project (Dorian and Robinson, 2018; Wells and Young, 2004).

To enhance the quality of service and operational efficiency of the airport, these alternative financing mechanisms can be implemented in parallel with various models such as management or service contracts (Ernico et al., 2012). However, since the airport operational system is complex, this should be implemented and planned carefully to avoid the potential risk of increasing the financial and commercial burdens.

Although these alternative financing models can raise funds for airport development projects without changing the ownership of the airport, these solutions are not as easy as they might sound and can sometimes be challenging to implement. It becomes particularly challenging to implement an alternative financing model when the government is severely constrained financially and where government borrowing is limited by various rules and regulations. In addition, the government might be required to give guarantees which exceed its capabilities and add to its accountabilities (Ernico et al., 2012).

6. Alternative value capture model

Alternative value capture is another model which aims to raise finances and release value while retaining the ownership and control of the airport under the government's possession. This type of commercial business model can enable the airport to obtain value, access private finances, generate revenues, and achieve better financial performance.

There are various types of commercial business models that can be implemented. One of the models that have been progressively applied to boost commercial revenues is associated with real estate developers through forming airport real estate Special Purpose Vehicles (SPVs) (Dorian and Robinson, 2018).

Another mechanism is to sell services or products through monetizing what was previously known as cost centres such as technology investments, human capital, and leading management capacities (Dorian and Robinson, 2018).

Large airports and leading airport groups such as Changi Airport Group and Dublin Airport Authority have been interested in implementing this mechanism as the airport industry is progressively transforming into specializations and becoming more driven by technology and data.

Developing real estate such as hotels, shopping malls, and parking buildings are also one of the alternative value capture models that can be used to boost non-aeronautical revenues (Ernico et al., 2012).

7. Service contract

Service contract or outsourcing means to delegate the operation of a particular service or activity to a third-party, most probably a private entity, which has the proper specialisation to operate, maintain, and manage that service (Ernico et al., 2012).

The most common outsourced services of an airport include maintenance services (e.g. terminal infrastructure, conveyance systems[2], and mechanical systems such as HVAC), cleaning services (e.g. terminal cleaning including windows, toilets, walkways, passenger boarding bridges etc.), ground handling, passenger boarding bridges (PBB) or jet-ways operation, baggage handling systems (BHS), fuel system operations, car parking and shuttle bus operations, financial accounting and advisory services, Information Technology (IT), procurement of capital works and equipment, etc. (Dorian and Robinson, 2018; Ernico et al., 2012).

Other less typical outsourced services include aircraft rescue and firefighting (ARFF), security, law enforcement, customer services, and commercial land development (Ernico et al., 2012).

An example of a current airport service contract is the operation and maintenance of Dubai International Airport BHS which was awarded to Siemens Postal, Parcel, and Airport Logistics in 2015 for an extendable six years (Soffritti, 2018). Another Example is the IT and infrastructure services at Indira

[2] Conveyance systems include elevators, escalators, moving walkways

Gandhi International Airport in India, which was awarded in 2009 to Wipro Airport IT Services Limited for an extendable 10 years duration (Wipro, 2010). A third example is the operations and maintenance of BHS at Honolulu International Airport and Kahului Airport which was awarded to Vanderlande in 2015 and for a period of three years (Vanderlande, 2015)

There are several advantages to service contracts or outsourcing. The main advantage is providing a reduction in the costs, especially in the airport's fixed costs, which gives the entity that owns and manages the airport greater financial flexibility to increase the salaries and benefits of its employees (Dorian and Robinson, 2018; Ernico et al., 2012). In addition, it provides access to skilled and specialised human resources and technologies which result in higher and optimised operational efficiency. This also allows the owner and operator of the airport to have more operational flexibility and emphasise on strategic and vital issues (Dorian and Robinson, 2018). Moreover, with outsourcing service, the airport management gets rid of the risks and complexity associated with the operating that service and transfers it to a third party. Therefore, the management role becomes to oversee the operational activities of the contractor to make sure it is complying with the goals and the standards of the airport (Ernico et al., 2012). Last but not least, service contracts give airport management the ability to efficiently handle traffic seasonality such as the summer holiday seasons or significant one-off events such as the World Cup or Olympics, or countries that have religious tourism which have intense seasonality such as Hajj and Umrah seasons in the Kingdom of Saudi Arabia (Dorian and Robinson, 2018).

However, some disadvantages may be faced by the airport owner and operator when outsourcing a service. For example, the airport management will have to either re-assign the employees who used to be involved in the service to different duties or to terminate their contracts, and this could cause some disruptions in the organization. In addition, labour unions could raise their voice and call for resistance to conserve public sector jobs, which the airport management may have to resolve. Another possible disadvantage of outsourcing is the potential mismatch between the aims of the airport management (to cut costs) and the contractor behind the outsourced service (to generate profit) (Ernico et al., 2012).

8. Management contract

In this model, the owner of the airport, whether it is the government, airport authority, or a private entity, appoints a contractor to undertake on its behalf the day-to-day operations of a specific function in the airport such as parking, terminal operations, or even the operations of the whole airport for a specific time and for a financial return (Dorian and Robinson, 2018; Ernico et al., 2012; Graham, 2014). The main driver for contracting out the management of the whole airport is to enhance its financial and operational efficiency (Dorian and Robinson, 2018). Other reason may be to improve the quality of service (Ernico et al., 2012). Although responsibility for managing the airport is transferred to a contractor, the owner of the airport holds a significant level of control by setting the policies and directions under which the operator has to function, especially when it is related to service quality. Also, the owner of the airport remains responsible for controlling various functions such as airline use agreement compliance, and policies for rates and charges, air service development, debt issuance, land acquisition and development, airport industrial and economic development. The owner is also responsible for strategic planning and capital investments (Ernico et al., 2012).

There are different mechanisms for financial returns which are usually related to the complexity and size of the management contract and the respective level of risk-sharing. Usually, the most common financial return of the management contract is a fixed management fee paid by the airport owner to the contractor. In some management contracts, the owner of the airport may include financial incentive mechanisms based on the performance of the airport in addition to the fixed management fee. On the other hand, revenue sharing is another example of a payment mechanism where the contractor shares the revenue of the airport with the owner (Dorian and Robinson, 2018).

The duration of the contract is also associated with the level of risk. Simple contracts that have a low level of risk transfer to the contractor are usually short-term (two to five years). However, more sophisticated contracts that may include maintaining and managing the assets of the airport have higher shares of risk level and are generally longer-term contracts (up to 10 years).

As in each model, there are advantages and disadvantages associated with implementing it. The main advantage is the opportunity that the management contract offers to bring expertise and specialised management for the duration of the contract. This leads to improvements in the financial and operational performance of the airport and the transfer of best-practice and know-how to the existing staff (Dorian and Robinson, 2018). In addition, the private contractor's efficient operations initiatives may potentially lead to an increase in airport revenues and a decrease in operating expenses (Ernico et al., 2012). A management contract may also be useful as a transition phase to pave the way for a more sophisticated and extensive change in airport ownership and management models such as PPP or full privatization (Dorian and Robinson, 2018).

However, there are also some possible disadvantages. The preparation for the request for proposals (RFPs) and the bidding process is usually time-consuming and requires lots of effort. Similar to service contracts, a management contract could cause disruption in the organization of the airport. In addition, the airport owner may have to pay compensation for employees who had their contracts terminated (Dorian and Robinson, 2018; Ernico et al., 2012; Tang, 2017).

9. Minority equity sale

In this model, the government sells a minority equity shareholding to a private entity. There are various reasons why a government would sell minority equity. Raising capital receipts for the government is one driver. A second driver is to raise capital investments to build a new airport.

Various mechanisms can be used to sell minority equity in the airport shareholding. The most common methods are private offerings and initial public offering (IPO) through stock exchange (Dorian and Robinson, 2018).

The advantage of the minority equity sale is that it gives the opportunity to the government to access external private financing. However, the amount of financial receipts that the government will get from the minority equity sale is usually lower than the amount it would get from a majority or full equity sale. The reason is that in the minority equity sale, the investor is not able to secure majority control over the airport operations and decision-making, unlike in the majority or full equity sale which provides the investor with high levels of control. Therefore, the investors will not be interested in paying higher prices for airport assets with little or no level of control over the airport management (Dorian and Robinson, 2018; Ernico et al., 2012; Tang, 2017).

One example of the initial public offering is when the French Government sold 30% of its shares in Aéroport de Paris through an IPO in 2006.

10. PPP/Concession

In the Private-Public Partnerships or concession contracts, the government transfers the responsibility of managing and operating a specific function or the whole airport to the private sector for a specific duration, after which the government recovers the assets of the airport back to its possession. PPPs or concession contracts are the most common models of private sector participation in the airport sector (Graham, 2014).

These types of contracts are most common when there is a large project that requires significant amounts of investment such as expanding or building new passenger or cargo terminals, fuel farms and fuel hydrant systems, constructing a new runway or extending an existing one with the required taxiways, building car parking garages and other landside facilities such as car rental, hotels and etc. Therefore, the main aim of the PPP or concession contracts is to finance projects by accessing private investments (Dorian and Robinson, 2018). So typically, they are implemented when there is a limited capability of the existing airport operator to enhance its operational and capital deliveries further, or when the government is not capable of funding the development of the airport infrastructure to accommodate the expected growth in the demand.

There are various types of PPP or concession contracts. Their differentiation is based on the level of the share of control and financial risk between the owner of the airport and the private sector and the point of time when the assets are reverted back to the owner. In each model, the financial and operational risks of the project are entirely borne by the private contractor. The contractor then recovers its investments from the revenues collected from operating that project. Examples of the different PPP models[3] are listed below:

- Construction manager at risk
- Terminal concession developer
- Design, Build, Operate, and Maintain (DBOM)
- Build, Transfer, and Operate (BTO)
- Build, Operate, and Transfer (BOT)
- Design, Build, Operate, and Transfer (DBOT)
- Design, Build, Operate, Maintain, and Finance (DBOMF)

In each of the models, the level of control that the government retains can differ considerably depending on its policies and strategies. In some countries, runways, taxiways, aprons and other airside assets are considered to be critical for national security, and therefore, the government keeps their operation under its control (Ernico et al., 2012). An example of such arrangement is Istanbul Atatürk International Airport where the long-term concession contract which was awarded in 2005 to TAV Airports included the management and operation of the passenger terminals only, while the airside operations were fully retained by the General Directorate of State Airports Authority of Turkey.

The duration of the contracts is generally decided considering the amount of capital invested by the private contractor. Usually, the contracts are over 30

[3] See Ernico et al. (2012) for details on the features of each PPP model and their differentiation

years but could be longer depending on the number of capital investments the project could require. In addition, the number of operating costs required to run the airport and the structure of the revenue sharing with the owner all influence the decision on the duration of the contract. The duration of some contracts can be 40 to 50 years (Dorian and Robinson, 2018; Ernico et al., 2012). For example, the concession contract of Osaka Kansai International Airport was awarded by the Japanese Government to a consortium consisting of Orix and Vinci Airports for 44 years starting April 2016. Another example is the 60-year concession contract of Kuala Lumpur International Airport, which was awarded by the Malay Government to Malaysia Airports Holdings Berhad (MAHB) on May 1998.

The advantages and opportunities that a PPP contract can bring are many. For example, PPP gives access to private investments that can replace the need for municipal debts to finance the airport project. This would save the public capital so that the government can spend it on projects where there is no way to fund them (Dorian and Robinson, 2018). PPP also gives the opportunity to benefit from private sector expertise in running infrastructure projects and managing and operating airports which could potentially lead to the delivery the project ahead of time with reduced expenses of construction. In addition, the managerial techniques of the specialized expertise of the private sector including motivated and incentive oriented mentality, and the implementation of dynamic procurement processes rather than the slow routine of the public processes, could possibly boost the operational efficiency of the airport which could also result in lowering the operational costs (Ernico et al., 2012). Finally, PPPs can significantly increase non-aeronautical revenues due to the commercial vision of the private sector contractors and the commercial strategies they set for the airport.

There are also many disadvantages of PPP or concession contract identified in the literature. One of the main disadvantages is that the owner of the airport loses, to a large extent, control over the construction site of the project and over the facility management. Another disadvantage noted by Dorian and Robinson

(2018), is that PPPs or concession contracts are often implemented where there is comparatively low maturity in the institutions and regulations and a lack of capability within government to secure funds for the airport project. So, when these features exist, there is a significant possibility that the government wouldn't end up in negotiating a fair agreement with the private sector which could lead to a substantial rise in the charges, thus negatively affecting the public interest. Moreover, one of the significant possible disadvantages is that the owner of the airport (the government) may need to intervene to save the airport project in case financial difficulties are suffered by the private contractor in the long-term. Another possible risk of PPP is the dispute that could occur between the government and the private contractor especially if the contract has some ambiguity or there is weak structuring of the airport project (Athena Infonomics, 2012). The disputes could be over meeting the contractual obligations or the interpretations of the contract's terms and conditions.

Similar to the service and management contracts, PPP or concession contracts require lots of time, efforts, and expense to prepare and plan them. In addition, they could lead to organizational disorder due to the process of reappointing existing employees to different duties or terminating the contracts of some of them.

11. Majority equity sale/Divestiture

In this model, the government sells a majority of or the full equity to one or more private entities. This doesn't include the transfer of the equity shareholding from the government to a private entity alone, but also perpetual control over the airport's management, operations, maintenance, and future development. Here, the role of the government is limited to regulatory oversight of the privatized airport through a dedicated Civil Aviation Authority that is responsible for issuing aviation policies and regulations that would protect civil aviation operations and consumers.

The drivers behind selling majority or full equity vary between raising capital receipts for the government, enhancing operational and financial efficiencies, and upgrading the quality of service provided to the passengers and airlines.

Various mechanisms can be used to sell majority or full equity of the airport shareholding. The most common methods are IPOs through stock exchange and trade sales (Dorian and Robinson, 2018; Graham, 2014). But unlike the minority equity sale, the transfer of the control associated with the majority equity sale enhances the value of the financial receipts that the government will get. The reason is that private investors usually will to pay more when it comes to controlling superiority. In some cases, the government lists the airport ownership for a majority equity sale but retains a golden share in order to preserve some degree of control over decision-making or to prevent the transfer of the shares and control to foreign investors (Ernico et al., 2012). However, this will most probably reduce the value of the shares on sale as the private investors will not be interested in paying higher values without obtaining the control premium (Dorian and Robinson, 2018; Ernico et al., 2012). The majority equity sale of British Airports Authority (BAA) in 1987, through an IPO on the London Stock Exchange, is an example where the UK Secretary of State kept a golden share for 16 years to prevent foreign investors from taking over the control. This was then recovered by private investors after the European Court of Justice judged against it (ICAO, 2013).

The advantages of selling the full or majority equity are similar to those of the PPPs and concession contracts. It gives the opportunity to develop the airport using private finances. It also allows the private sector to manage and operate the airport as a business, thus seeking and forming new non-aeronautical revenue sources(Dorian and Robinson, 2018). The expertise and techniques of the specialised private sector allow the airport management to innovate in the utilization of the present airport infrastructure and facilities and in motivating airport staff, thus enhancing the airport's operational and financial efficiencies. Majority or full equity sale to private investors also isolates, to a certain extent, airport operations from political interferences and frees it from the constraints of the public policies (Ernico et al., 2012).

Regarding the disadvantages of the majority equity sale or full divestiture, there are two major ones identified in the literature. The first major disadvantage is the government's loss of control of the airport management and decision-making. Secondly, similar to the service, management, PPP, or concession contracts, the planning and preparation of the privatization transaction process is very time consuming, expensive, and requires lots of effort from both the public sector and the private bidders (Dorian and Robinson, 2018; Ernico et al., 2012).

ACI also provides airport ownership and management model classifications. However, ACI's classifications are not as detailed as IATA's. In The Ownership of Europe's Airports report, ACI (2016), the airport ownership and management models are classified as following:

- **Public Ownership**
  - As part of the administrator
  - Corporatized
- **Mixed Public-Private Ownership**
  - With public sector owning a majority share
  - With private sector owning a majority share
  - Equal shares
- **Private Ownership**
  - Fully privatized and Corporatized

IATA's and ACI's classifications do not differ in general. The only difference is that the classifications provided by IATA are more detailed, which means each one of IATA's airport ownership and management model classification can be listed under one of ACI's general classifications as in the Table 2-1.

Table 2-1 IATA's and ACI's airport ownership and management classifications

<table>
<tr><th></th><th></th><th></th><th colspan="2">IATA</th></tr>
<tr><td rowspan="6">ACI</td><td rowspan="2">Public</td><td>As part of Administrator</td><td colspan="2">Government Department / Ministry
Government Trading Entity</td></tr>
<tr><td>Corporatized</td><td colspan="2">Corporatization</td></tr>
<tr><td rowspan="3">Mixed Public-Private</td><td>Public majority</td><td>Not-for-Profit Model
Alternative Finance Model
Alternative Value Capture
Minority Equity Sale</td><td></td></tr>
<tr><td>Private Majority</td><td>Majority Equity Sale</td><td rowspan="2">Service Contract
Management Contract
PPP/Concession</td></tr>
<tr><td>Equal</td><td></td></tr>
<tr><td>Private</td><td>Fully Private</td><td colspan="2">Full Equity Sale / Divestiture</td></tr>
</table>

Source: ACI (2016), Dorian and Robinson (2018)

2.3.2 Academic Classifications

In the previous subsection, 11 airport ownership and management models as classified by the industry were described. However, in the academic literature considering airport performance, the majority of the studies that included airport ownership and management models in their analysis have classified the airports into general ownership models as shown in Table 2-2.

Table 2-2 Airport ownership and management models classifications in the literature

Paper	Airport Ownership and Management models used
Abbott and Wu (2002)	(1) Public ownership (2) Private ownership
Ahn and Min (2014)	(1) Fully Public ownership (2) Fully Private ownership (3) Mixed Public-Private ownership
Adler and Liebert (2014)	(1) Fully Public ownership (2) Mixed Public-Private with minority private ownership (3) Mixed Public-private with minority public ownership (4) Fully Private ownership
Assaf and Gillen (2012)	(1) Fully Public ownership (2) Mixed Public-Private ownership (3) Fully Private ownership
Gutiérrez and Lozano (2016)	(1) Public ownership (2) Private ownership
Perelman and Serebrisky (2012)	(1) Public ownership (2) Private Ownership
Tsui et al. (2014)	(1) Government ownership (2) Otherwise
Vasigh and Gorjidooz (2006)	(1) Fully Public ownership (2) Mixed Public-Private ownership (3) Fully Private ownership

Table 2-2 shows that most of the studies which have used airport ownership and management model as a factor to test its effect on the efficiency of the airport have not classified the airports based on their specific and exact model, but have used the general type of ownership and management model such as private, public, or mixed public-private.

Abbott and Wu (2002), who studied the effect of ownership on the efficiency of the airports using a sample of 24 airports from Australia, New Zealand, UK, Canada, and the US between year 1990 and 2000, categorised the airports into two general ownership and management models only; either public or private ownership. The same was done by Gutiérrez and Lozano (2016) and Perelman and Serebrisky (2012) in their studies.

Other studies have categorised the airports into one of the following three ownership and management models: fully public, mixed public-private, and fully private ownership. Such studies are Ahn and Min (2014), Assaf and Gillen (2012), and Vasigh and Gorjidooz (2006).

Adler and Liebert (2014) have gone further and separated the mixed public-private model into two classifications: mixed public-private with minority public, and mixed public-private with minority private.

The reason for classifying the airports into more general ownership and management models and not into the detailed models as identified in the industry as shown subsection 2.3.1 is because the numbers of observations in the research studies are usually limited. Statistically, the reliability and robustness of the results of the analysis would be affected when the total number of observations are scattered among many types of models. Therefore, research studies with a low and limited number of observations tend to classify the airports into two to four ownership and management models.

It is clear that academic research tend to use general classifications similar to ACI (2016). Therefore, as in the case of ACI's and IATA's classifications, academic and industrial classifications of the airport ownership and management models are complementary. This is similar to what has been shown in Table 2-1.

2.4 Summary

In this chapter, the history of airport ownership and management models since the existence of civil aviation airports is reviewed to understand the reasons behind the introduction of ownership and management models. From this, the drivers behind the introduction of private sector participation in the ownership and management of the airports as identified by the literature are outlined and discussed. It is shown that improving efficiency, providing investments, and improving the quality of service of the airports are the top three drivers for airport privatization. After that, the history of airport ownership and management model is continued by reviewing the history of airport privatization since its introduction in the UK in the mid-1980s until 2017. The statistics of privatized airports in the world show that there is a significant trend towards airport privatization, although the majority of the airports are still publically-owned and managed. The majority of the privatized airports in the world are located in Europe, Asia-Pacific, and Latin America, respectively. On the other hand, the number of airport privatization experiences in Africa, North America, and the Middle East are still shy but are expected to grow in the next few decades.

After presenting the history and evolution of airport ownership and management models, the types of the models as classified by the airport industry and in the academic literature are reviewed and defined. In the airport industry, the ownership and management models are typically classified into 11 types ranging from no and least private sector participation to full privatization or divestiture. However, in the academic literature, it is shown that most of the researches that studied the effect of airport ownership and management on the efficiency of the airport used general airport ownership and management classification that includes two to four types such as fully public, mixed public-private, and fully private model. This is due to statistical reasons to avoid affecting the robustness of the results when analysing a low number of airport observations.

3 CHAPTER THREE: AIRPORT PERFORMANCE ESTIMATION IN THE LITERATURE

3.1 Introduction

The airport industry is very dynamic and continuously developing, as it has been throughout its history. As discussed in Chapter 2, airports were traditionally owned and managed by governments. Although this remains the case in many countries, airport ownership and management had experienced new models, beginning in the mid-1980s when the UK Government privatized the British Airports Authority (BAA). Since then, privatization and other models, such as commercialization and corporatization, have been implemented in many countries around the world (Graham, 2011). This change in the ownership and management models has led to the increase of commercial activities at airports. Also, the monopoly in the airport industry in some countries was broken, creating a competitive environment. This environment was evident in the competition between London Luton Airport and London Stansted Airport at the beginning of the 1990s (Starkie, 2002). The liberalization and deregulation of air transport have profoundly contributed to the increase in air traffic, which affects the queuing and slot allocation mechanism at major airports. The airport industry has also experienced change on the operational side, with many airports outsourcing some operational activities, such as ground handling, firefighting, and security. The continuous innovation in technology is also changing the way airports are run, for example, automatic baggage handling systems. All these factors have made the airport industry an exciting field for researchers and industry leaders to apply performance estimation and benchmarking techniques.

3.2 Performance Estimation Techniques

The majority of studies that focus on performance estimation used quantitative methodologies with secondary numerical data. Therefore, in this section, the different methodological approaches and techniques applied in the literature to estimate performance are outlined. Then, the most common performance estimation techniques in airport-related studies are briefly introduced; namely, index-based methods, data envelopment analysis (DEA), and stochastic frontier analysis (SFA). However, first, the definitions of and the differences between the terms ‘productivity’ and ‘efficiency’ are explained.

3.2.1 Definition and distinction of productivity and efficiency

In the literature on airport performance, two terms are often used and may appear similar. These terms are ‘efficiency’ and ‘productivity’. However, their underlying definitions are not the same. Oum and Yu (2004) state that the difference between the terms lies in the type of maximum outputs reflected.

‘Productivity’ is merely the ratio of the total observed outputs over the total inputs. So, if one output is divided by one input, partial productivity is the result. For example, dividing the number of passengers (output) by the number of employees (input) gives what is called ‘labour productivity’. Therefore, the aggregate of outputs divided by the sum of inputs gives Total Factor Productivity (TFP).

On the other hand, ‘technical efficiency’ is the comparison between the observed outputs and their optimum values while keeping the inputs constant, or between the perceived inputs and their optimum values while maintaining the outputs at a constant rate. Figure 3-1 illustrates the difference between technical efficiency and productivity. There are also other types of efficiency, such as allocative and dynamic efficiencies[4], however they will not be used in this research.

In Figure 3-1, a firm that is operating at any point on the production frontier is technically efficient such as at points B and C. Otherwise, anywhere between the production frontier and the horizontal axis (x) is considered to be technically inefficient such as at point A. The reason why a firm operating at point A is considered to be inefficient is that it has the technical ability to efficiently operate at point B, meaning that it can achieve higher outputs using the same

[4] For more information, please refer to Sickles and Zelenyuk (2019)

level of inputs. The firm at point A is also technically able to efficiently operate at point C, where it can achieve the same amount of output but using a lower level of inputs (Coelli et al., 2005).

The productivity of the firm that is operating at point A is measured by computing the slope ($\frac{y}{x}$) of the straight-line connecting point A to the origin. At point B, the slope of the straight line is larger, which means that at the productivity of a firm at point B is higher than the productivity at point A. Finally, the point where the firm can be technically efficient and achieve the optimal productivity is the point of tangency between the straight line drawn from the origin and the production frontier (Coelli et al., 2005).

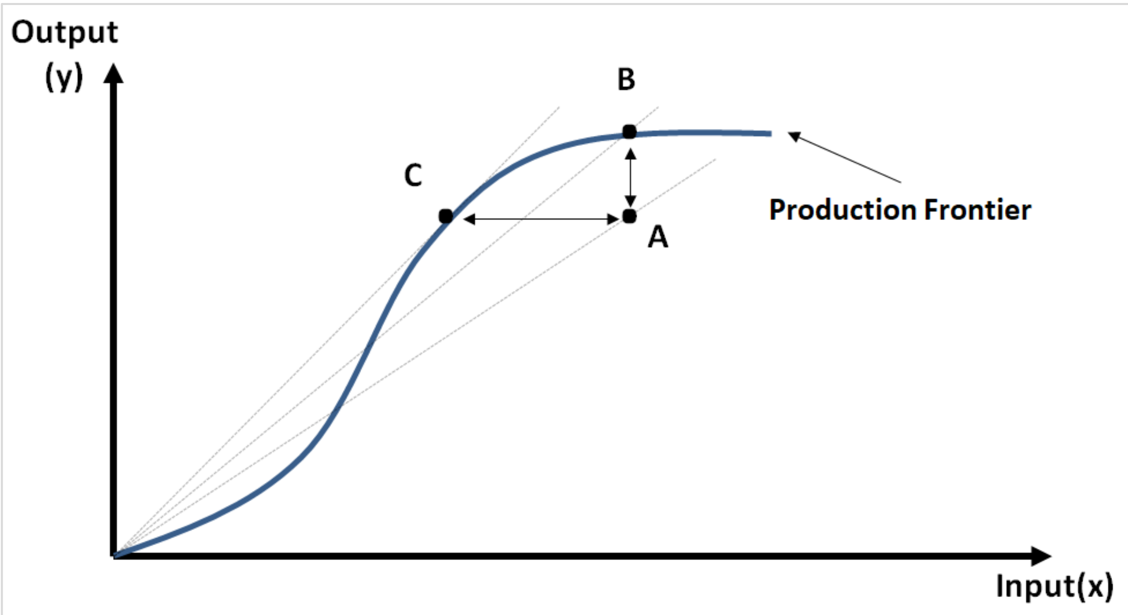

Figure 3-1 Technical efficiency and production frontier

Source: Coelli et al. (2005)

3.2.2 Productivity and efficiency estimation approaches

The first non-parametric estimation of technical efficiency was made by Farrell (1957) and formed the basis of DEA, which was developed later by Charnes, Cooper and Rhodes (1978). Other parametric methods for efficiency estimation were introduced, such as the deterministic ordinary least squares (OLS) and

SFA. Figure 3-2 lists the productivity and efficiency estimation methodologies used in the literature.

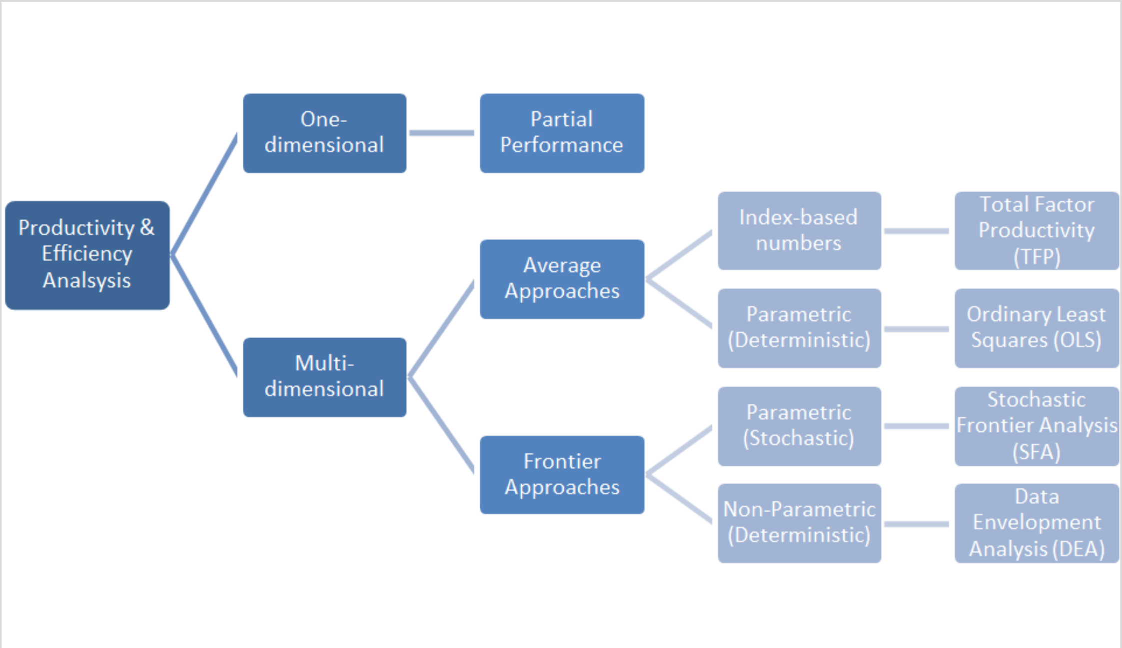

Figure 3-2 Productivity and efficiency estimation methodologies

Source: Adapted from Liebert and Niemeier (2013)

The first category for estimating performance is the one-dimensional category. In this category, the method used is called ‘partial performance’, meaning it deals with partial productivities. However, concerns have been highlighted in the literature relating to the use of the partial performance estimation technique; when the data for overall productivity are unavailable, partial performance can be used (Forsyth, Hill and Trengove, 1986); otherwise, the results of the partial performance might be biased and misleading (ICAR, 2005).

The multi-dimensional category is more reliable in terms of the accuracy of the results, as it allows for the estimation of the overall performance of airports. In this category, there are two main approaches: the average approach and the frontier approach. The average approach includes OLS and TFP methods. The frontier approach consists of the non-parametric DEA and parametric SFA methods, which are based on estimating an efficient production or cost frontier using large datasets. The significant difference in concept between the average and the frontier approaches is that the first supposes that all the observations under study are efficiently operating. However, in the airport industry, assuming that all airports are efficiently operating is not realistic, since an airport is a very heterogeneous system and many factors beyond the control of management may affect the operation of the airport and, thus, affect efficiency.

3.2.2.1 Total factor productivity

The TFP approach considers the level of utilisation of the inputs in the production process. Only a few studies have used TFP to estimate the productivity of airports, such as Hooper and Hensher (1997), Nyshadham and Rao (2000), Oum and Yu (2004), Oum, Adler and Yu (2006), and Vasigh and Gorjidooz (2006). The process of calculating TFP begins by pre-defining the weights of outputs and inputs. Then, the sum of the weighted output index is divided by the amount of the weighted input index. However, pre-defining the weights is an issue that can cause biased results (Liebert and Niemeier, 2013). Also, TFP estimates unknown production technology and does not provide information about the differences in the inefficiencies (Comin, 2008). Some researchers have found ways to overcome these limitations using parametric and non-parametric programming to estimate TFP. The Malmquist index in the DEA approach is an example of a non-parametric based approach, which was used in studies by Abbott and Wu (2002), Barros and Weber (2009), and Gillen and Lall (2001). Endogenous-weight TFP is an example of the parametric approach and was used in Oum, Zhang and Zhang (2004), Oum and Yu (2004), Yoshida (2004), and Yoshida and Fujimoto (2004).

3.2.2.2 Data envelopment analysis

The DEA approach is a linear programming technique that takes multiple inputs and outputs and produces a production frontier that resembles the relative productive efficiency based on the given sample. All the DMUs that coincide with the production frontier are efficient, and the rest that is enveloped within the boundary is considered to be inefficient.

The key advantage of DEA over other performance estimation techniques is that it demands fewer data and does not require pre-determination of the weight of inputs and outputs, which is done automatically through linear programming (Graham, 2005).

The DEA approach also allows for the consideration of external factors that might affect the efficiency of the DMUs (Banker, Charnes and Cooper, 1984). However, one of the disadvantages of DEA is that it assumes no random errors. Therefore, all the deviance from the calculated production frontier is explained as inefficiency because DEA has no statistical properties (Charnes et al., 1985). Furthermore, Russell (1985) points out that extreme attention should be paid to the presence of the outliers in the sample before using DEA, as these could falsify the calculation of the production frontier and result in unreliable efficiencies. To overcome the limitations of the basic BCC radial DEA model, another DEA application was developed. Table 3-1 illustrates the DEA basic model and its variants, as well as the studies that employed them.

Table 3-1 DEA models and variants used in airport performance and benchmarking studies

Data envelopment analysis	Cross-sectional data	Basic (CCR, BCC)	(Abbott and Wu, 2002; Barros, 2008a; Barros and Dieke, 2008; Barros and Sampaio, 2004; Bazargan and Vasigh, 2003; Fernandes and Pacheco, 2002; Gillen and Lall, 1997; de la Cruz, 1999; Lam, Low and Tang, 2009; Lin and Hong, 2006; Martín and Román, 2001; Pacheco, Fernandes and de Sequeira Santos, 2006; Pacheco and Fernandes, 2003; Parker, 1999; Pels, Nijkamp and Rietveld, 2001, 2003; Sarkis, 2000; Vogel, 2006; Yoshida and Fujimoto, 2004)
		Slack-based measure, free disposal hull (FDH)	(Lam, Low and Tang, 2009; Tsui, Gilbey and Balli, 2014)
	Panel data	Malmquist index	(Abbott and Wu, 2002; Barros and Assaf, 2009; Barros and Weber, 2009; Chi-Lok and Zhang, 2009; Fragoudaki and Giokas, 2016; Fung et al., 2008; Gillen and Lall, 2001; Murillo-Melchor, 1999; Örkcü et al., 2016; Tsui, Gilbey and Balli, 2014)
		Window analysis	(Yu, 2004b)
	Other	Statistical interference (bootstrapping)	(Assaf, 2010a; Barros and Assaf, 2009; Barros, 2008a; Barros and Dieke, 2008; Örkcü et al., 2016)
		Super-efficiency, Cross-efficiency and other ranking methods	(Adler and Berechman, 2001; Barros and Dieke, 2007; Bazargan and Vasigh, 2003; Lin and Hong, 2006; Martín and Roman, 2006, 2008; Sarkis, 2000; Sarkis and Talluri, 2004)
		Principal component analysis DEA (PCA-DEA)	(Adler, Liebert and Yazhemsky, 2013; Adler and Berechman, 2001)

The DEA approach was first developed by Charnes, Cooper and Rhodes (1978) to assume a constant return to scale, which is known as the CCR model. This study was further extended by Banker, Charnes and Cooper (1984) to assess variable returns to scale, which is known as the BCC model. The basic CCR model measures the efficiency of a DMU by calculating the maximum of the ratio of the sum of the weighted outputs to the sum of the weighted inputs as follows:

$$Max\ h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{io}}$$ **Equation 3-1**

Subject to:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1$$

$$u_r, v_i \geq 0; \qquad j = 1, \ldots, n; \qquad r = 1, \ldots, s; \qquad i = 1, \ldots, m$$

Where:

$\boldsymbol{y_{rj}}$ is the positive known output of the j[th] DMU

$\boldsymbol{x_{ij}}$ is the positive known input of the j[th] DMU

$\boldsymbol{u_r, v_i}$ are the weights of the input and output variables to be calculated by the model

The majority of the studies in the literature applied basic DEA models using cross-sectional datasets. The reason for this usage is that panel data on airports were often challenging to collect, especially in the early period of DEA studies. However, researchers observed that DEA indicates a large number of efficient airports, when using a high number of inputs and outputs, compared with the number of airports in the sample (Liebert and Niemeier, 2013). Therefore, to solve this issue, some studies included in the sample what is called a ‘virtual efficient airport’, which has input values equal to the lowest input values in the sample, and output values similar to the highest output values in the sample. This method was used by studies such as Bazargan and Vasigh

(2003), Lam, Low and Tang (2009), and Martín and Roman (2006). Other researchers, such as Adler and Golany (2001) and Adler and Berechman (2001), used methods such as principal component analysis (PCA) in addition to DEA. In this method, PCA is applied to the set of inputs or outputs, or both, to reduce their numbers into a smaller set of principal components that explains the high percentage of the variance structure of the original dataset.

Accessibility to panel datasets allows researchers to measure the variations in productivity and efficiency over a specific timescale. As mentioned in section 3.2.2.1, the Malmquist index was used with DEA in some studies, as illustrated in Table 3-1.

Another shortcoming of DEA is that it does not support hypothesis testing, which is not the case in the parametric approaches. However, airport benchmarking studies such as Assaf (2010), Barros (2008), Barros and Assaf (2009), Barros and Dieke (2008), and Örkcü et al. (2016), used a bootstrapping technique to overcome this limitation. Bootstrapping is a computerised method that falls into the category of resampling techniques. The method was first developed by Efron (2008). Then, Simar and Wilson (1998) were the first to use bootstrapping and DEA to rectify biased efficiency scores. However, Simar and Wilson (2000) warn that bootstrapping with DEA should be used carefully, as bootstrapping provides lower convergence ratios, when using a small number of observations, compared with the number of input and output variables.

3.2.2.3 Stochastic frontier analysis

The stochastic frontier analysis is a parametric frontier approach developed by Aigner, Lovell and Schmidt (1977) and Meeusen and van Den Broeck (1977) as shown in Equation **3-2**.

$$\ln(q_i) = x_i'\beta + v_i - u_i \quad ; \quad i = 1, \dots, n \qquad \text{Equation 3-2}$$

Where:

$\boldsymbol{q_i}$ is the output of the i^{th}frim

$\boldsymbol{x}$ is $k \times 1$ vector of logarithm inputs

$\boldsymbol{\beta}$ is a vector of unknown parameters

$\boldsymbol{v_i}$ An error component independently and identically distributed as $N(0, \sigma_v^2)$

$\boldsymbol{u_i}$ is a non-negative random variable associated with technical inefficiency

One advantage of SFA over DEA is that it can account for noise effects represented by a stochastic random error, which is another factor explaining inefficiency other than managerial factors.

The basic model in Equation **3-2** was further developed to include panel data and to increase the significance by recording detected and undetected heterogeneity. Table 3-2 lists various SFA models applied in airport performance and benchmarking studies.

Table 3-2 SFA models used in airport performance and benchmarking studies

<table>
<tr><td rowspan="7">Stochastic frontier analysis</td><td colspan="3">Cross-sectional data</td><td>(Wing Chow and Fung, 2009)</td></tr>
<tr><td rowspan="6">Panel data</td><td colspan="2">Unvarying time</td><td>(Pels, Nijkamp and Rietveld, 2001)</td></tr>
<tr><td rowspan="5">Varying time</td><td>Homogeneous functional arrangement</td><td>(Assaf, 2010b; Barros, 2008b; Martín, Román and Voltes-Dorta, 2009; Pels, Nijkamp and Rietveld, 2003; Tovar and Martín-Cejas, 2009, 2010)</td></tr>
<tr><td>Homogeneous functional arrangement

(records undetected heterogeneity)</td><td>(Barros, 2008c; Oum, Yan and Yu, 2008)</td></tr>
<tr><td>Heterogeneous functional arrangement</td><td>(Assaf, 2009)</td></tr>
<tr><td>Heterogeneous functional arrangement

(records undetected heterogeneity)</td><td>(Marques and Barros, 2010; Barros, 2009)</td></tr>
</table>

In the literature regarding airport performance and benchmarking, the majority of early studies used SFA estimated efficiencies by calculating a production function using input and output variables describing the physical assets of the airport (e.g. Pels, Nijkamp and Rietveld, 2001, 2003; Wing Chow and Fung, 2009). However, after 2007, the focus turned towards estimating the efficiencies by calculating a translog cost function using financial input and output variables (e.g. Barros, 2008b, 2008c; Martín, Román and Voltes-Dorta, 2009; Barros, 2009)

The SFA approach requires large datasets to provide significant results. The importance of this requirement is evident in Wing Chow and Fung (2009), who included 45 airports in their SFA, using cross-sectional data, and found that only a few parameters are significant. Therefore, they conclude that a low number of observations might lead to a weak SFA model and, thus, uncertainty in the results. Since it is very challenging to collect large cross-sectional datasets, most studies in the literature used panel datasets in their analysis, as displayed in Table 3-2. Pitt and Lee (1981) were the first to develop the random-effects panel data model, followed by Schmidt and Sickles (1984), who established the fixed-effects panel data model. Both models estimate efficiency while assuming the time to be constant. In the airport efficiency and benchmarking literature, both models were used in Pels, Nijkamp and Rietveld (2001). The limitation of the unchanging time assumption in the above-mentioned models was exposed by Cornwell, Schmidt and Sickles (1990), who states that the fixed-effects panel data model can estimate efficiency assuming the time to be varying. Battese and Coelli (1992, 1995) then formed the time-varying random-effects panel data model. Both models were used in the majority of the studies on airport performance and benchmarking (e.g. Assaf, 2010b; Pels, Nijkamp and Rietveld, 2003).

Furthermore, true fixed-effects and true random-effects panel data models were introduced later by Greene (2005). These two models can record cross-firm heterogeneity that is not associated with technical inefficiency by changing unvarying time effects to undetected heterogeneity, and the inefficiency term changes with time. Barros (2008c), Barros (2009), and Oum, Yan and Yu (2008) are among the studies in the airport performance and benchmarking literature that applied Greene's models.

3.3 Results of Systematic Literature Review

In this section, the results of the structured literature review of airport performance estimation studies are presented. This literature review aims to find, assess, and interpret all the available research on the aforementioned topic and to identify and confirm the existence of research gaps. In addition, it aims to provide the justification for the selection of the performance estimation method, models, input and output variables that will be used in this research.

To ensure that the literature review is based on consistent information, only manuscripts published in academic journals are considered. Manuscripts and reports from other sources, such as research organizations, governmental agencies, and airport authorities or operators, are excluded. Master and PhD theses, books, news articles, conference papers, and working papers that are unpublished are not included either. The primary and most important reason for focusing on academic manuscripts is because they are peer-reviewed by several academics prior to publication. Another reason for including academic papers only is that the existence of a vast number of reports and other types of papers from non-academic sources makes it very difficult to collect, classify, and interpret all of them.

To identify the relevant literature in a systematic and comprehensive manner, the author chose to follow the protocol proposed by Kitchenham (2004). The collection process began by constructing a comprehensive bibliography on the literature of airport performance estimation and benchmarking. This bibliography was compiled by searching online academic journal database search engines, such as Emerald, Science Direct (Elsevier), ProQuest Global, Google Scholar, Mendeley, and SCOPUS, using the following keywords: airport, efficiency, performance, productivity, and benchmarking. These search engines allow access to the abstracts and full texts of many high-quality manuscripts and journals covering a wide variety of topics and titles.

The literature review includes manuscripts published between 1997 and December 2016. Although only a few studies exist that were not published in an academic journal that applied performance estimation techniques to the airport industry before 1997, as mentioned by Graham (2005), the starting point was chosen following Gillen and Lall (1997) and Hooper and Hensher (1997), which are the first published journal papers to apply performance estimation techniques to the airport industry.

During the selection procedure, the papers published in high ISI-impact journals focusing on transport studies were prioritised. Then, the abstract of each article was reviewed, and those papers outside the main scope of airport performance estimation were discarded. The final bibliography includes 96 articles from 28 academic journals. The selected manuscripts and all their details are compiled in Appendix A.

To form a comprehensive understanding of the topic of airport performance estimation, a careful review was conducted of every paper in the bibliography, and all the information was organized to facilitate the classification process. This process is based on five standpoints (see Figure 3-3).

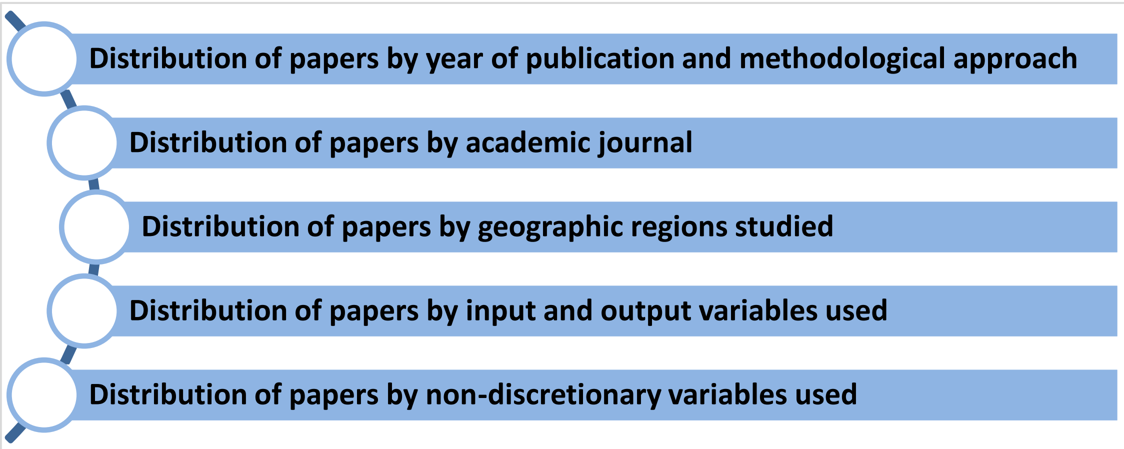

Figure 3-3 Literature classification standpoints

The classification process provides a clear understanding of the sequential development, the areas of application, and the challenges of airport performance estimation research.

3.3.1 Distribution of papers by year of publication and methodological approach

In this section, the collected papers are classified based on the methodological approach used and the year of publication. Having both these categories provides a general idea of how the interest in airport performance estimation research has evolved, and of the methodological approaches most frequently used by the researchers. Table 3-3 presents the distribution of 96 papers published between 1997 and December 2016.

Table 3-3 Distribution of papers according to years and used method

Year	One-dimensional approach	Multi-dimensional average approaches		Multi-dimensional frontier approaches		Combination	Total
	Approach partial performance (PP)	Total factor productivity or	Variable factor productivity (VFP)	Stochastic frontier analysis (parametric)	Data envelopment analysis (non-parametric)	(DEA/SFA) (DEA/Malmquist) (DEATFP) (DEA/PP) (TFP/PP)	
1997	-	1	-	-	1	-	**2**
1998	-	-	-	-	-	-	**-**
1999	-	-	-	-	2	1	**3**
2000	-	-	-	-	1	1	**2**
2001	-	-	-	-	2	2	**4**
2002	-	-	-	1	2	1	**4**
2003	-	-	-	1	2	1	**4**
2004	2	1	-	-	3	1	**7**
2005	-	-	-	-	-	-	**0**
2006	-	1	1	-	3	1	**6**
2007	-	-	-	-	1	-	**1**
2008	-	1	1	3	4	1	**10**
2009	-	-	-	4	1	2	**7**
2010	-	-	-	2	2	1	**5**
2011	-	1	-	1	3	-	**5**
2012	-	2	-	2	5	1	**10**
2013	-	-	-	-	6	1	**7**
2014	-	-	-	-	3	2	**5**
2015	-	-	1	-	5	1	**7**
2016	-	-	-	1	4	2	**7**
Total	**2**	**7**	**3**	**15**	**50**	**19**	**96**

As mentioned previously, the first recorded papers were published in 1997. Gillen and Lall (1997) were the first to apply DEA to the airport sector, in which the efficiencies of 21 major airports in the US between 1989 and 1993 were estimated. In the same year, Hooper and Hensher (1997) were the first to apply TFP to the airport industry, assessing the performance of six Australian airports between 1988 and 1922. Table 3-3 reveals that only a few papers were published prior to 2000. From 2000 to 2007, the number of papers published was an average of three articles per year. However, after 2008, this number increased to seven (more than double), indicating a rise in the level interest in researching the performance of airports, and the numbers are expected to continue increasing in the coming years.

Only a few papers used the one-dimensional approach for estimating the performance of airports, in addition to measures, such as TFP. Nyshadham and Rao (2000) used the operational cost and capital expenditure per workload unit (WLU) as partial performance measures for 25 European airports in 1995. Oum, Zhang and Zhang (2004) and Oum and Yu (2004) both used partial performance measures in addition to TFP to estimate the productivity of major worldwide airports in 1999. Other researchers, such as in Vogel (2006), used partial performance measures in addition to DEA.

The number of papers that used multi-dimensional average approaches, such as TFP or VFP, is also low when compared with the frontier approaches. The TFP approach was used as the sole method in only a few papers, such as in Chow and Fung (2012), Fung and Chow (2011), Hooper and Hensher (1997), and Vasigh and Gorjidooz (2006). The TFP approach was also used, in addition to DEA, in papers such as in Yoshida and Fujimoto (2004). It is worth mentioning that TFP and VFP were also used, albeit occasionally, in non-journal publications, such as in the ATRS Global Airport Benchmarking reports.

The use of SFA in airport performance estimation studies was rare before 2008; there are only two papers: Martín-Cejas (2002) and Oum, Yu and Fu (2003). However, the number of papers between 2008 and 2012 increased. After 2012, the use of SFA in papers as the only method declined. The SFA approach was used with DEA is some papers, such as in Lin, Choo and Oum (2013), Pels, Nijkamp and Rietveld (2001), Pels, Nijkamp and Rietveld (2003), and Yang (2010).

The DEA approach is the most-used method in airport performance estimation studies. Beginning with Gillen and Lall (1997), the application of DEA has increased steadily, with more than 50 papers by December 2016.

Other papers used combinations of methods, such as DEA with SFA, DEA with the Malmquist index, DEA with partial performance measures, and TFP with partial performance measures. However, the number of papers that applied more than one method in their analysis is not high. The majority of the papers that used combine methods were comparing the results of different methodologies on the same data sample.

3.3.2 Distribution of papers by the academic journal

Searching for relevant literature on airport performance estimation, papers were collected from several journals focusing on different subject fields: transport, operations management, economics, tourism, and applied mathematics. The collected papers stem from 28 journals. Table 3-4 displays the distribution of the collected manuscripts among the journals. The Journal of Air Transport Management (JATM) has the highest share of the collected papers, with 34 papers out of 96. Transportation Research Part E (TRE) is second, with 15 articles. The remaining 28 papers are distributed among 26 journals. The TRE journal was the first to publish studies on specific performance estimation approaches applied to the airport sector, with Gillen and Lall (1997) and Hooper and Hensher (1997). By contrast, the majority of the papers published by the JATM concentrate on the application of these approaches. Every methodology listed in Table 3-4 is used in at least in one of the 34 papers published by the JATM. The advantage of having the highest share of studies on a particular topic being published by only a few journals is that it makes it easier for researchers to find those papers. However, this factor may also affect the impact of the research, as it is confined to specialised journals.

Table 3-4 Distribution of papers based on journal

Journal	Papers	
Aeronautical Journal	(Vogel, 2006)	**1**
Energy Policy	(Barros and Assaf, 2009)	**1**
European Journal of Operational Research	(Assaf and Gillen, 2012)	**1**
International Journal of Transport Economics	(Barros and Sampaio, 2004; Gillen and Lall, 2001; de la Cruz, 1999; Murillo-Melchor, 1999)	**4**
Journal of Air Transport Management	(Ablanedo-Rosas and Gemoets, 2010; Adler, Ülkü and Yazhemsky, 2013; Ahn and Min, 2014; Assaf, 2009, 2010b; Augustyniak, López-Torres and Kalinowski, 2015; Barros, 2008a, 2008c; Barros and Dieke, 2007; Bazargan and Vasigh, 2003; Chang, Yu and Chen, 2013; Chi-Lok and Zhang, 2009; Chow and Fung, 2012; Fragoudaki, Giokas and Glyptou, 2016; Fragoudaki and Giokas, 2016; Gitto and Mancuso, 2012a; Lin and Hong, 2006; Liu, 2016; Martín and Román, 2001; Oum, Adler and Yu, 2006b; Oum, Yu and Fu, 2003; Pacheco, Fernandes and de Sequeira Santos, 2006; Scotti et al., 2012; Tovar and Martín-Cejas, 2009; Tsekeris, 2011; Tsui et al., 2014; Tsui, Gilbey and Balli, 2014; Ülkü, 2015; Wanke, 2012a; Wing Chow and Fung, 2009; Yu, 2004b; Zhang et al., 2012; Zou et al., 2015)	**34**
Journal of Air Transportation	(Vasigh and Gorjidooz, 2006)	**1**
Journal of Airport Management	(Martín-Cejas, 2002; Martín and Roman, 2008)	**2**
Journal of Operations Management	(Sarkis, 2000)	**1**
Journal of Productivity Analysis	(Martín, Román and Voltes-Dorta, 2009)	**1**
Journal of Transport Economics and Policy	(Oum, Zhang and Zhang, 2004; Parker, 1999)	**2**
Journal of Urban Economics	(Oum, Yan and Yu, 2008)	**1**
Networks and Spatial Economics	(Lozano and Gutiérrez, 2011; Martín and Roman, 2006; Martín and Voltes-Dorta, 2007)	**3**
Pacific Economic Review	(Fung and Chow, 2011)	**1**
Public Works Management & Policy	(Nyshadham and Rao, 2000)	**1**
Socio-Economic Planning Sciences	(Curi, Gitto and Mancuso, 2011; Wanke, 2012b)	**2**
The Australian Economic Review	(Abbott and Wu, 2002)	**1**
Tourism Management	(Assaf, 2010b)	**1**
Transport Policy	(Adler and Berechman, 2001; Barros, 2011; Lai et al., 2015; Örkcü et al., 2016; Pels, Nijkamp and Rietveld, 2001; Wanke, Barros and Nwaogbe, 2016)	**6**
Transport Reviews	(Barros, 2009)	**1**
Transportation Research Part A	(Adler and Liebert, 2014; Barros, 2008a; Fernandes and Pacheco, 2002; Merkert and Mangia, 2014; Pacheco and Fernandes, 2003; Randrianarisoa et al., 2015a; Sarkis and Talluri, 2004)	**7**
Transportation Research Part E	(Assaf, Gillen and Barros, 2012; Barros and Dieke, 2008; Barros and Weber, 2009; D'Alfonso, Daraio and Nastasi, 2015; Fung et al., 2008; Gillen and Lall, 1997; Hooper and Hensher, 1997; Kutlu and McCarthy, 2016; Lam, Low and Tang, 2009; Oum and Yu, 2004; Pathomsiri et al., 2008; Pels, Nijkamp and Rietveld, 2003; Tovar and Martín-Cejas, 2010; Yoshida, 2004; Yoshida and Fujimoto, 2004)	**15**
Utilities Policy	(Abbott, 2015; Perelman and Serebrisky, 2012)	**2**

Journal	Papers	
International Journal of Production Economics	(Barros, Bin Liang and Peypoch, 2013; Gitto and Mancuso, 2012b)	**2**
Omega	(Adler, Liebert and Yazhemsky, 2013)	**1**
Journal of Transportation Research Forum	(Lin, Choo and Oum, 2013)	**1**
Applied Mathematics Modelling	(Lozano, Gutiérrez and Moreno, 2013)	**1**
Computer and Industrial Engineering	(Yang, 2010)	**1**
Research in Transportation Economics	(Gutiérrez and Lozano, 2016)	**1**
Total Number of Journals 28	**Total number of papers**	**96**

3.3.3 Distribution of papers by geographic region studied

The geographic focus of the papers in the literature is divided into two categories. The first category contains papers that focus on studying the performance of the airports in a single country; whereas, the second category is for papers including two or more countries or regions. Table 3-5 lists all the geographic locations of the papers in the literature.

Of the 96 papers, 12 studied the performance of airports in Spain, which is the highest number of papers in the single country category, with 10% of the papers in the literature. The US is in second place with eight papers. The UK, China, and Italy are joint third, with seven papers for each country.

In the second geographical category, some papers studied airports in two countries, such as Canada and the US, Italy and Norway, Spain and Turkey, Angola and Mozambique. Some papers studied airports in one region, such as Europe, Asia-Pacific, and Latin America. Some other papers combined two regions, such as Europe and Australia, and the US and Europe. However, the majority of the papers in the second geographical region studied the performance of airports worldwide, with 12, which is the highest share of the papers in the literature (13%).

The objectives of the studies that focus on one country differ from those papers that include airports from two or more states or regions. The majority of the papers that studied one country compare the efficiency of different-sized airports. However, the majority of multi-country or multi-region studies examine the efficiency of airports under different ownership and governance structures to identify other factors that may affect the efficiencies of the airports. Further details are included in Section 3.3.5.

Table 3-5 reveals that only two papers studied airports in Africa (Barros, 2011; Wanke, Barros and Nwaogbe, 2016). The low number of publications on Latin-American airports is also evident but to a smaller degree. In addition, there is a total absence of studies on the Middle East and North African (MENA) airports. The main reason behind these deficiencies is the lack of proper data, especially financial figures, which are considered confidential in many parts of the MENA region and in Africa. The absence of data on airports in these regions is apparent when searching the ICAO, ACI, and CAPA databases and the airports' official websites. Also, worldwide renowned airport benchmarking databases, such as ATRS Airport Benchmarking Databases, do not include airports from MENA, Africa, or Latin America.

Furthermore, the distribution of papers by region in Figure 3-4 was compared with the distribution of privatized airports by region as published in ACI (2017). In this research, Pearson correlation test was conducted, and the results indicate that there is a strong correlation (r=0.89) between the distribution of papers and privatized airports by region. This finding clearly suggests that one of the factors which motivate airport performance research in a particular location is the existence of different airport ownership models, such as privatization.

Table 3-5 Distribution of papers based on geography

	Geographic category	Papers	
Single Country	Argentina	(Barros, 2008a)	1
	Australia	(Abbott and Wu, 2002; Assaf, 2010b; Hooper and Hensher, 1997)	3
	Brazil	(Fernandes and Pacheco, 2002; Pacheco, Fernandes and de Sequeira Santos, 2006; Pacheco and Fernandes, 2003; Wanke, 2012b, 2012a, 2013)	6
	China	(Chang, Yu and Chen, 2013; Chi-Lok and Zhang, 2009; Chow and Fung, 2012; Fung et al., 2008; Fung and Chow, 2011; Wing Chow and Fung, 2009; Zhang et al., 2012)	7
	France	(Barros, Bin Liang and Peypoch, 2013)	1
	Greece	(Fragoudaki, Giokas and Glyptou, 2016; Fragoudaki and Giokas, 2016; Tsekeris, 2011)	3
	Italy	(Barros and Dieke, 2007, 2008; Curi, Gitto and Mancuso, 2011; D'Alfonso, Daraio and Nastasi, 2015; Gitto and Mancuso, 2012b, 2012a; Scotti et al., 2012)	7
	Japan	(Yoshida, 2004; Yoshida and Fujimoto, 2004)	2
	Mexico	(Ablanedo-Rosas and Gemoets, 2010)	1
	New Zealand	(Abbott, 2015; Tsui, Gilbey and Balli, 2014)	2
	Nigeria	(Wanke, Barros and Nwaogbe, 2016)	1
	Poland	(Augustyniak, López-Torres and Kalinowski, 2015)	1
	Portugal	(Barros, 2008b; Barros and Sampaio, 2004)	2
	Spain	(de la Cruz, 1999; Lozano, Gutiérrez and Moreno, 2013; Lozano and Gutiérrez, 2011; Martín, Román and Voltes-Dorta, 2009; Martín and Roman, 2006, 2008; Martín and Román, 2001; Murillo-Melchor, 1999; Tovar and Martín-Cejas, 2009, 2010)	10
	Taiwan	(Yang, Keat Tok and Su, 2008; Yu, 2004b)	2
	Turkey	(Örkcü et al., 2016)	1
	UK	(Assaf, 2009, 2010a; Assaf, Gillen and Barros, 2012; Barros, 2008c; Barros and Weber, 2009; Parker, 1999; Barros, 2009)	7
	US	(Bazargan and Vasigh, 2003; Gillen and Lall, 1997, 2001; Kutlu and McCarthy, 2016; Pathomsiri et al., 2008; Sarkis, 2000; Sarkis and Talluri, 2004; Zou et al., 2015)	8
Two or more countries/regions	Angola and Mozambique	(Barros, 2011)	1
	Asia-Pacific	(Lam, Low and Tang, 2009; Liu, 2016; Tsui et al., 2014; Yang, 2010)	4
	Canada and the US	(Lin, Choo and Oum, 2013)	1
	Europe	(Adler, Liebert and Yazhemsky, 2013; Adler, Ülkü and Yazhemsky, 2013; Gutiérrez and Lozano, 2016; Nyshadham and Rao, 2000; Pels, Nijkamp and Rietveld, 2001, 2003; Randrianarisoa et al., 2015a; Vogel, 2006)	8
	Europe and Australia	(Adler and Liebert, 2014)	1
	Italy and Norway	(Merkert and Mangia, 2014)	1
	Latin America	(Perelman and Serebrisky, 2012)	1
	Spain and Turkey	(Ülkü, 2015)	1
	The US and Europe	(Vasigh and Gorjidooz, 2006)	1
	World	(Abbott and Wu, 2002; Adler and Berechman, 2001; Ahn and Min, 2014; Georges Assaf and Gillen, 2012; Lai et al., 2015; Lin and Hong, 2006; Martín-Cejas, 2002; Oum, Yu and Fu, 2003; Oum, Zhang and Zhang, 2004; Oum, Adler and Yu, 2006b; Oum, Yan and Yu, 2008; Oum and Yu, 2004)	12
Total number of papers			**96**

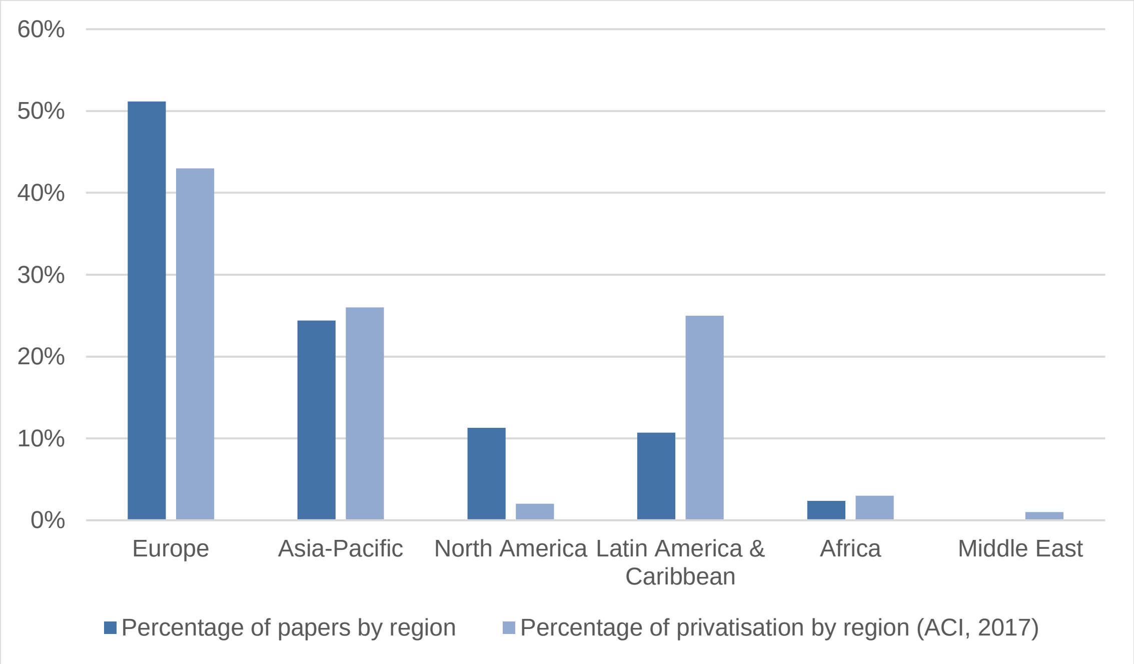

Figure 3-4 Distribution of papers and privatized airports by region

3.3.4 Distribution of papers by input and output variables used

One of the most critical elements in performance estimation techniques is the use of input and output variables. Therefore, the variables used in each of the 96 papers in the literature were extracted and classified. In this section, all the input variables and the papers that used them are presented in Table 3-6, while Table 3-7 contains the output variables.

3.3.4.1 Input variables

The input variables extraction process identified 67 variables used in existing research. The identified variables were easily classified into three categories. The first input category is the airport physical data, which describes the characteristics of the airport physical assets, such as the number of runways, gates, and employees. The second category is the airport financial data, such as labour costs and operating costs. The third input category contains time variables, such as operating hours, minimum connection time, average delay, and business hours. The most-used physical input variable is the number of employees. Older papers used the total number of employees, including full-time, part-time, and shifts, as there was a deficiency of data regarding full-time employees. Recently, with the greater availability of data, researchers have been using the full-time equivalent (FTE) number of employees instead. ‘Terminal area’ comes in second place for the frequency of use. Regarding the financial input variables, the most frequently used is ‘other operating costs’, followed by ‘the price of labour’.

Some papers used only one input variable such as Wanke (2012a). Other papers used eight input variables, such as Lin and Hong (2006). However, the majority of papers used three to six input variables.

Regarding the most-used input variables, it is clear that physical variables are more popular than financial and time variables. The popularity of physical variables is perhaps due to the availability of the data on airports’ official websites and in annual reports, ICAO and ACI airport databases, and other databases published by research organizations such as ATRS. Although financial data on some airports are becoming more available, it is still challenging to collect and use them for analysing airport performance, especially for public airports and cross-country analysis. The challenge in using financial data for cross-country analysis of airport performance is the availability of data on the same variables or in the differences in the accounting procedures of each country.

Studies that used only financial input variables, such as Hooper and Hensher (1997), Barros and Dieke (2008), and Kutlu and McCarthy (2016), analysed the financial efficiency of the airports. On the other hand, including airport physical input variables only leads to examining the technical efficiency (e.g. Chi-Lok and Zhang, 2009; Gillen and Lall, 1997; Lozano, Gutiérrez and Moreno, 2013; Pathomsiri et al., 2008). A few other papers that were able to collect data on various categories used a combination of physical and financial input variables to create a more balanced model (e.g. Bazargan and Vasigh, 2003; Lai et al., 2015; Oum, Yu and Fu, 2003).

Table 3-6 Input variables used in the literature

Input Variable	Papers	
Physical Variables		
Aircraft parking places at the terminal	Pels, Nijkamp and Rietveld (2001, 2003)	2
Aircraft parking spaces	Abbott and Wu (2002); Lin and Hong (2006); Pels, Nijkamp and Rietveld (2003); Scotti et al., (2012); Wanke, (2012b); Wanke (2013); Chow and Fung (2009)	7
Airport area	Abbott and Wu (2002); Assaf (2010a); Chow et al. (2009); Curi et al. (2011); Fernandes and Pacheco (2002); Gillen and Lall (1997); Gillen and Lall (2001); Gitto and Mancuso (2012a); Merkert and Mangia (2014); Pels et al. (2001); Pels et al. (2003); Tovar and Martin-Cejas (2009); Tovar and Martin-Cejas (2010); Wanke (2012b)	17
Apron area	Barros (2008a); Curi et al. (2011); D'Alfonso et al. (2015); Fragoudaki et al. (2016); Fragoudaki and Giokas (2016); Merkert and Mangia (2014); Tsekeris (2011); Wanke (2012b); Wanke et al. (2016); Yu (2004)	10
Apron capacity	Gutierrez and Lozano (2016); Lozano and Gutierrez (2011); Lozano et al. (2013)	3
Baggage-claim units	Pels et al. (2003); Pels et al. (2001); Scotti el al. (2012);	3
Baggage-collection belts	Gillen and Lall (1997); Gillen and Lall (2001); Lin and Hong (2006); Lozano and Gutierrez (2011); Lozano et al. (2013)	5
Baggage-claim area	Fernandes and Pacheco (2002)	1
Cargo-facilities area	Ahn and Min (2014); Chow et al. (2009)	2
Number of check-in desks	Augustyniak et al. (2015); D'Alfonso et al. (2015); Fernandes and Pacheco (2002); Lin and Hong (2006); Lozano and Gutierrez (2011); Lozano et al. (2013); Pels et al. (2001); Pels et al. (2003); Scotti et al. (2012);	9
Connections with other domestic airports	Yu (2004)	1
Kerb frontage in metres	Fernandes and Pacheco (2002)	1
Declared runway capacity	Alder and Liebert (2014)	1
Departure lounge	Fernandes and Pacheco (2002)	1
Distance to the city centre	Adler and Berechman (2001)	1
Land area	Ahn and Min (2014); Pathomsiri et al. (2008)	2
Landing distance available	Zhang et al. (2012)	1
Number of airlines	Gutierrez and Lozano (2016)	1
Number of aprons	Lin and Hong (2006)	1
Number of employees	Abbott and Wu (2002); Assaf (2009); Barros (2008a); Barros and Sampaio (2004); Barros and Weber (2009); Barros et al. (2013); Curi et al (2011); D'Alfonso et al. (2015); Gillen and Lall (1997); Gillen and Lall (2001); Gitto and Mancuso (2012a); Lam et al. (2009); Lin and Hong (2006); Lin et al. (2015); Murillo-Melchor (1999); Pacheco and Fernandes (2003); Pacheco et al. (2006); Parker (1999); Sarkis and Talluri (2004); Sarkis, (2000); Tovar and Martin-Cejas (2009); Tovar and Martin-Cejas (2010); Tsui et al (2014b); Yang (2010); Yu et al. (2008)	30

Input Variable	Papers	
Physical Variables		
Number of employees (FTE)	Assaf (2010a); Assaf and Gillen (2012); Augustyniak et al. (2015); Lin et al. (2013); Merkert and Mangia (2014); Oum and Yu (2004); Oum et al. (2003); Oum et al. (2004); Oum et al. (2006); Oum et al. (2008); Perelman and Serebrisky (2012); Scotti el al. (2012); Wanke et al. (2016)	14
Number of employees in terminal	Yoshida and Fujimoto (2004)	1
Number of gates	Augustyniak et al. (2015); Bazargan and Vasigh (2003); D'Alfonso et al. (2015); Gillen and Lall (1997); Gillen and Lall (2001); Gutierrez and Lozano (2016); Lin and Hong (2006); Lin et al. (2015); Lozano and Gutierrez (2011); Lozano et al. (2013); Oum et al. (2004); Sarkis and Talluri (2004); Sarkis, (2000); Tovar and Martin-Cejas (2009); Tovar and Martin-Cejas (2010);	16
Number of operations per hour	Ablanedo-Rosas and Gemoets (2010)	1
Number of passenger terminals	Adler and Berechman (2001); D'Alfonso et al. (2015)	2
Number of passengers per hour	Ablanedo-Rosas and Gemoets (2010)	1
Number of remote aircraft parking places	Pels et al. (2003); Pels et al. (2001)	2
Number of runways	Adler and Berechman (2001); Adler et al. (2013a); Assaf (2010a); Assaf and Gillen (2012); Bazargan and Vasigh (2003); Curi et al. (2011); D'Alfonso et al. (2015); Gillen and Lall (1997); Gillen and Lall (2001); Lin and Hong (2006); Lin et al. (2015); Merkert and Mangia (2014); Okrcu et al. (2016); Oum and Yu (2004); Oum et al. (2003); Oum et al. (2004); Pathomsiri et al. (2008); Pels et al. (2001); Pels et al. (2003); Perelman and Serebrisky (2012); Sarkis and Talluri (2004); Sarkis, (2000); Tsekeris (2011); Tsui et al. (2014a); Tsui et al. (2014b); Wanke (2012b); Wanke (2013);	32
Number of scheduled routes	Gutierrez and Lozano (2016)	1
Passenger throughput capacity	Lozano and Gutierrez (2011)	1
Predicted air traffic movement (ATM)	Chow et al. (2009)	1
Public parking spots	Chow et al. (2009); Gillen and Lall (1997); Gillen and Lall (2001); Wanke (2012b)	4
Runway capacity	Adler et al. (2013b); Scotti et al. (2012)	2
Runway dimensions	Okrcu et al. (2016)	1
Runway area	Barros (2008a); Chang et al. (2013); Gillen and Lall (1997); Gillen and Lall (2001); Gitto and Mancuso (2012a); Gutierrez and Lozano (2016); Liu (2016); Lozano and Gutierrez (2011); Lozano et al. (2013); Merkert and Mangia (2014); Pathomsiri et al. (2008); Ülkü (2015); Vasigh and Gorjidooz (2006); Wanke et al. (2016); Yu (2004)	15
Runway length	Abbott (2015); Abbott and Wu (2002); Abbott and Wu (2002); Ahn and Min (2014); Chi-Lok and Zhang (2008); Chow et al. (2009); Chow et al. (2012); Fragoudaki et al. (2016); Fragoudaki and Giokas (2016); Fung and Chow (2011); Fung et al. (2008); Lin et al. (2015); Merkert and Mangia (2014); Pels et al. (2001); Tsui et al. (2014b); Wanke (2012b); Yoshida and Fujimoto (2004); Yoshida, Y. (2004)	18

Input Variable	Papers	
Physical Variables		
Take-off distance available	Zhang et al. (2012)	1
Terminal area	Ahn and Min (2014); Assaf and Gillen (2012); Augustyniak et al. (2015); Barros (2008a); Chang et al. (2013); Chi-Lok and Zhang (2008); Chow et al. (2009); Chow et al. (2012); Fragoudaki et al. (2016); Fragoudaki and Giokas (2016); Fung and Chow (2011); Fung et al. (2008); Gillen and Lall (1997); Gillen and Lall (2001); Lam et al. (2009); Lin and Hong (2006); Lin et al. (2015); Merkert and Mangia (2014); Okrcu et al. (2016); Oum et al. (2003); Oum et al. (2004); Pels et al. (2001); Perelman and Serebrisky (2012); Scotti el al. (2012); Tsekeris (2011); Tsui et al. (2014b); Wanke (2012b); Wanke (2013); Yoshida and Fujimoto (2004); Yoshida, Y. (2004); Yu (2004);	33
Terminal capacity	Adler et al. (2013b); Wanke et al. (2016)	2
Vehicle parking places	Fernandes and Pacheco (2002)	1
Financial Variables		
Airport charges	Adler and Berechman (2001)	
Average access cost (monetary and time costs)	Yoshida and Fujimoto (2004)	1
Capital costs	Augustyniak et al. (2015); Martin and Roman (2001); Martin and Roman (2006); Martin and Roman (2008); Martin et al. (2009); Zou et al. (2015)	8
Capital expenditures per WLU	Nyshadham and Rao (2000)	1
Capital stock	Abbott and Wu (2002); Barros (2011); Barros and Dieke (2007); Barros and Dieke (2008); Barros and Sampaio (2004); Barros and Weber (2009); Gitto and Mancuso (2012a); Gitto and Mancuso (2012b); Hooper and Hensher (1997); Murillo-Melchor (1999); Parker (1999); Yu et al. (2008)	12
Contracting cost	Kutlu and McCarthy (2016)	1
Fixed assets	Assaf (2009); Martin and Voltes-Dorta (2007)	2
Labour cost	Curi et al. (2011); Gitto and Mancuso (2012a); Gitto and Mancuso (2012b); Kutlu and McCarthy (2016); Liu (2016); Zou et al. (2015)	6
Material cost	Assaf et al. (2012); Merkert and Mangia (2014); Zou et al. (2015)	3
Net total assets	Barros et al. (2013); Vasigh and Gorjidooz (2006)	2
Non-operating costs	Bazargan and Vasigh (2003)	1
Operating costs	Abbott (2015); Assaf (2009); Barros (2008b); Barros (2008c); Barros (2009); Barros et al. (2013); Bazargan and Vasigh (2003); Lin et al. (2015); Merkert and Mangia (2014); Sarkis and Talluri (2004); Sarkis, (2000); Tsui et al. (2014a); Vasigh and Gorjidooz (2006); Yang (2010)	15
Operating costs per WLU	Nyshadham and Rao (2000)	1
Other costs per WLU	Nyshadham and Rao (2000)	1

Input Variable	Papers	
Financial Variables		
Other operating costs	Adler et al. (2013a); Adler et al. (2013b); Alder and Liebert (2014); Assaf (2009); Assaf and Gillen (2012); Barros and Dieke (2007); Barros and Dieke (2008); Barros and Weber (2009); Curi et al (2011); Hooper and Hensher (1997); Lam et al. (2009); Liu (2016); Martin and Roman (2001); Martin and Roman (2006); Martin and Roman (2008); Martin et al. (2009); Murillo-Melchor (1999); Oum et al. (2003); Oum et al. (2004); Oum et al. (2006); Oum et al. (2008); Pacheco and Fernandes (2003); Pacheco et al. (2006); Parker (1999); Ülkü (2015);	28
Price of capital	Assaf, A. (2010b); Assaf et al. (2012); Barros (2008b); Barros (2008c); Barros (2009); Barros (2009); Barros (2011); Barros and Sampaio (2004); Lam et al. (2009); Martin-Cejas (2002);	11
Price of labour	Adler et al. (2013a); Alder and Liebert (2014); Assaf, A. (2010b); Assaf et al. (2012); Barros (2008b); Barros (2008c); Barros (2009); Barros (2011); Barros and Dieke (2007); Barros and Dieke (2008); Barros and Sampaio (2004); Hooper and Hensher (1997); Lam et al. (2009); Martin and Roman (2001); Martin and Roman (2006); Martin and Roman (2008); Martin et al. (2009); Martin et al. (2009); Martin-Cejas (2002); Merkert and Mangia (2014); Pacheco and Fernandes (2003); Pacheco et al. (2006); Ülkü (2015)	27
Repair cost	Kutlu and McCarthy (2016)	1
Soft costs	Adler et al. (2013b); Augustyniak et al. (2015); Gitto and Mancuso (2012a); Gitto and Mancuso (2012b); Lin et al. (2013)	5
Total costs	Assaf, A. (2010b); de la Cruz, F. (1999); Lam et al. (2009); Martin-Cejas (2002); Vogel, A. (2006);	5
Total expenditure per ATM	Martin et al. (2009)	1
Total expenditure per WLU	Martin et al. (2009)	1
Trade value	Lam et al. (2009)	1
Time Variables		
Operating hours	Tsekeris (2011)	1
Minimum connection times	Adler and Berechman (2001)	1
Business hours	Chang et al. (2013)	1
Average delay	Adler and Berechman (2001)	1
Total Number of Variables	**67**	

3.3.4.2 Output variables

The total number of output variables identified in the literature is 35. The variables are categorised into physical, such as the number of passengers, number of air traffic movement, cargo handled, and size of aircraft; financial, such as aeronautical revenues, non-aeronautical revenues, total operating costs, and sales; and time variables, such as delayed ATM. An added category includes other output variables, such as aircraft noise, level of satisfaction, and share of routes in competition. The majority of the identified variables represent desirable outputs for airport management. However, only a few papers include non-desirable output variables, such as aircraft noise (e.g. Yu, 2004), accumulated delayed fights (e.g. Lozano et al., 2013; Zou et al., 2015), delayed ATM (e.g. Lozano et al., 2013; Pathomsiri et al., 2008), and time delays (e.g. Pathomsiri el al, 2008).

The output variable most-used in the literature is the annual number of passengers (PAX) (almost 88% of the papers used PAX as an output), followed by the number of ATM and volume of cargo (83% and 69%, respectively). Humphreys and Francis (2002b) state that the number of studies that used financial output variables is rather low, although airport managers are interested in these variables. However, in the more recent studies, it is clear that they include some financial variables, such as non-aeronautical revenues, which is the most frequently used financial output variable and the fourth overall in all categories (23 papers out of 96 used non-aeronautical revenues as an output variable).

The average number of outputs used in one paper ranges between three and four, although there are papers that used only one output variable, such as Alder and Berechman (2001), Assaf (2008), Fernandes and Pacheco (2002), and Yu et al. (2008); whereas, other papers used five or more output variables, such as Bazargan and Vasigh (2003), Martin-Cejas (2002), and Pacheco and Fernandes (2003).

Table 3-7 Output variables used in the literature

Output Variable	Papers	
Physical Variables		
% of on-time operations	Bazargan and Vasigh (2003)	1
Accumulated delayed flights	Lozano et al. (2013); Zou et al. (2015)	2
Airline departures	Kutlu and McCarthy (2016)	1
ATM	Abbott (2015); Ablanedo-Rosas and Gemoets (2010); Adler et al. (2013a); Adler et al. (2013b); Ahn and Min (2014); Alder and Liebert (2014); Assaf (2010a); Assaf (2010b); Assaf and Gillen (2012); Augustyniak et al. (2015); Barros (2008a); Barros (2008c); Barros (2009); Barros (2011); Barros and Dieke (2007); Barros and Dieke (2008); Barros and Sampaio (2004); Barros and Weber (2009); Barros et al. (2013); Bazargan and Vasigh (2003); Chang et al. (2013); Chi-Lok and Zhang (2008); Chow et al. (2009); Chow et al. (2012); Curi et al. (2011); D'Alfonso et al. (2015); Fragoudaki (2016); Fragoudaki and Giokas (2016); Fung and Chow (2011); Fung et al. (2008); Gillen and Lall (1997); Gillen and Lall (2001); Gitto and Mancuso (2012a); Gitto and Mancuso (2012b); Gutierrez and Lozano (2016); Lam et al. (2009); Lin and Hong (2006); Lin et al. (2013); Lin et al. (2015); Liu (2016); Lozano and Gutierrez (2011); Lozano et al. (2013); Martin and Roman (2001); Martin and Roman (2006); Martin and Roman (2008); Martin et al. (2009); Merkert and Mangia (2014); Okrcu et al. (2016); Oum et al. (2003); Oum et al. (2006); Oum et al. (2008); Pels et al. (2001); Pels et al. (2003); Perelman and Serebrisky (2012); Randrianarisoa et al. (2015); Sarkis (2000); Sarkis and Talluri (2004); Scotti el al. (2012); Tovar and Martin-Cejas (2009); Tovar and Martin-Cejas (2010); Tsekeris (2011); Tsui et al. (2014a); Tsui et al. (2014b); Ülkü (2015); Vasigh and Gorjidooz (2006); Wanke (2012b); Wanke (2013); Wanke et al. (2016); Yoshida (2004); Yoshida and Fujimoto (2004); Yu (2004); Zhang et al. (2012); Zou et al. (2015)	80
ATM (GA)	Sarkis (2000); Sarkis and Talluri (2004)	2
The average size of aircraft	Tovar and Martin-Cejas (2009); Tovar and Martin-Cejas (2010)	2

Output Variable	Papers	
Physical Variables		
Volume of cargo	Abbott and Wu (2002); Ablanedo-Rosas and Gemoets (2010); Adler et al. (2013a); Adler et al. (2013b); Ahn and Min (2014); Alder and Liebert (2014); Assaf (2010a); Assaf (2010b); Barros (2008a); Augustyniak et al. (2015); Barros and Dieke (2007); Barros and Dieke (2008); Barros and Sampaio (2004); Barros and Weber (2009); Barros et al. (2013); Chang et al. (2013); Chi-Lok and Zhang (2008); Chow et al. (2009); Chow et al. (2012); Curi et al. (2011); D'Alfonso et al. (2015); Fragoudaki (2016); Fragoudaki and Giokas (2016); Fung and Chow (2011); Fung et al. (2008); Gillen and Lall (1997); Gillen and Lall (2001); Gitto and Mancuso (2012a); Gitto and Mancuso (2012b); Gutierrez and Lozano (2016); Lam et al. (2009); Lin and Hong (2006); Lin et al. (2015); Liu (2016); Lozano and Gutierrez (2011); Lozano et al. (2013); Martin and Roman (2001); Martin and Roman (2006); Martin and Roman (2008); Merkert and Mangia (2014); Okrcu et al. (2016); Oum and Yu (2004); Oum et al. (2004); Oum et al. (2008); Pacheco and Fernandes (2003); Pacheco et al. (2006); Parker (1999); Pathomsiri et al. (2008); Perelman and Serebrisky (2012); Sarkis (2000); Sarkis and Talluri (2004); Scotti el al. (2012); Ülkü (2015); Tsekeris (2011); Tsui et al (2014b); Wanke (2012a); Wanke (2012b); Wanke (2013); Wanke et al. (2016); Yoshida (2004); Yoshida and Fujimoto (2004); Zhang et al. (2012); Zou et al. (2015)	66
ATM (Commuter)	Gillen and Lall (1997); Gillen and Lall (2001)	3
Delayed ATM	Lozano et al. (2013); Pathomsiri et al. (2008)	2
Mail cargo	Barros and Sampaio (2004)	1
Non-delayed ATM	Pathomsiri et al. (2008)	1
Other ATM	Bazargan and Vasigh (2003)	1
Number of passengers (PAX)	Abbott (2015); Abbott and Wu (2002); Ablanedo-Rosas and Gemoets (2010); Adler et al. (2013a); Ahn and Min (2014); Alder and Liebert (2014); Assaf (2010a); Assaf (2010b); Assaf and Gillen (2012); Augustyniak et al. (2015); Barros (2008a); Barros (2008c); Barros (2009); Barros (2011); Barros and Dieke (2007); Barros and Dieke (2008); Barros and Sampaio (2004); Barros and Weber (2009); Barros et al. (2013); Bazargan and Vasigh (2003); Chang et al. (2013); Chi-Lok and Zhang (2008); Chow et al. (2009); Chow et al. (2012); Curi et al. (2011); D'Alfonso et al. (2015); de la Cruz (1999); Fragoudaki (2016); Fragoudaki and Giokas (2016); Fung and Chow (2011); Fung et al. (2008); Gillen and Lall (1997); Gillen and Lall (2001); Gitto and Mancuso (2012a); Gitto and Mancuso (2012b); Gutierrez and Lozano (2016); Lam et al. (2009); Lin and Hong (2006); Lin et al. (2013); Lin et al. (2015); Liu (2016); Lozano and Gutierrez (2011); Lozano et al. (2013); Martin and Roman (2001); Martin and Roman (2006); Martin and Roman (2008); Merkert and Mangia (2014); Murillo-Melchor (1999); Okrcu et al. (2016); Oum and Yu (2004); Oum et al. (2003); Oum et al. (2004); Oum et al. (2006); Oum et al. (2008); Pacheco et al. (2006); Parker (1999); Pathomsiri et al. (2008); Pels et al. (2001); Pels et al. (2003); Sarkis (2000); Perelman and Serebrisky (2012); Randrianarisoa et al. (2015); Sarkis and Talluri (2004); Scotti el al (2012); Tsekeris (2011); Tsui et al. (2014a); Tsui et al. (2014b); Ülkü (2015); Vasigh and Gorjidooz (2006); Wanke (2012a); Wanke (2012b); Wanke (2013); Wanke et al. (2016); Yoshida (2004); Yoshida and Fujimoto (2004); Yu (2004); Yu et al. (2008); Zhang et al. (2012); Zou et al. (2015)	84

Output Variable	Papers	
Physical Variables		
PAX (Domestic)	Adler et al. (2013b); Fernandes. and Pacheco (2002); Pacheco and Fernandes (2003)	3
PAX (International)	Adler et al. (2013b)	1
PAX revenues	Barros (2008b); Barros and Sampaio (2004);	2
WLU	Martin-Cejas (2002); Martin et al. (2009);	2
Financial Variables		
Aeronautical revenue per WLU	Nyshadham and Rao (2000)	1
Aeronautical revenues	Adler et al. (2013b); Assaf et al. (2012); Barros and Dieke (2007); Barros and Dieke (2008); Bazargan and Vasigh (2003); Curi et al. (2011); de la Cruz (1999); Gitto and Mancuso (2012a); Gitto and Mancuso (2012b); Hooper and Hensher (1997)	10
Commercial revenues	Oum and Yu (2004); Ülkü (2015)	2
Handling revenues	Barros and Dieke (2007); Barros and Dieke (2008); de la Cruz (1999)	3
Landing revenues	Barros (2008b); Barros and Sampaio (2004); Vasigh and Gorjidooz (2006)	3
Non-aeronautical revenue per WLU	Nyshadham and Rao (2000)	1
Non-aeronautical revenues	Adler et al. (2013a); Adler et al. (2013b); Alder and Liebert (2014); Assaf and Gillen (2012); Assaf et al. (2012); Barros (2008b); Barros and Dieke (2007); Barros and Dieke (2008); Bazargan and Vasigh (2003); Curi et al. (2011); de la Cruz (1999); Gitto and Mancuso (2012a); Gitto and Mancuso (2012b); Hooper and Hensher (1997); Lin et al. (2013); Oum et al. (2003); Oum et al. (2004); Oum et al. (2006); Oum et al. (2008); Pacheco and Fernandes (2003); Pacheco et al. (2006); Randrianarisoa et al. (2015); Zou et al. (2015)	23
Non-operational revenues	Vasigh and Gorjidooz (2006)	1
Operational revenues	Assaf (2009); Pacheco and Fernandes (2003); Pacheco et al. (2006); Tsui et al (2014a); Sarkis (2000); Sarkis and Talluri (2004); Vasigh and Gorjidooz (2006); Yang (2010)	8
Other revenues	Pacheco et al. (2006); Pacheco and Fernandes (2003)	2
Sales	Barros et al. (2013)	1
Share of non-aeronautical revenues	Tovar and Martin-Cejas (2009); Tovar and Martin-Cejas (2010)	2
Total operating costs	Kutlu and McCarthy (2016)	1
Total revenues	Augustyniak et al. (2015); Lin et al. (2015); Vogel (2006)	3
Time Variables		
Time delays	Pathomsiri et al. (2008)	1
Other Variables		
Aircraft noise	Yu (2004)	1
Level of satisfaction grouped into five types	Adler and Berechman (2001)	1
Share of routes in competition	D'Alfonso et al. (2015)	1
Total Number of Variables	**35**	

3.3.5 Distribution of papers by non-discretionary variables used

Around one-third of the articles in the literature studied the performance of airports across countries (see Table 3-5). Comparing the findings, it is clear that differences exist in the efficiencies of airports between the studies. For example, the VFP study conducted by Oum et al. (2006) on 116 airports around the world between 2001 and 2003 concludes that US and Australian airports outperformed airports in Asia and Europe. However, Lin and Hong (2006) found, using DEA, that US and European airports had better operating performance between 2001 and 2002 than airports in Asia and Australia. Furthermore, both these studies contradict the results of Abbott and Wu (2002), who conclude that airports in Australia performed better than European and US airports. Therefore, one of the objectives of many studies in the literature was to identify the factors behind the differences in the performance of the airports. These factors may be related to decisions taken by the airports' management. On the other hand, the factors affecting the performance of the airports may be beyond the control of the managerial body.

To identify the factors influencing the performance of the airports, second stage regression was applied by the majority of the studies that used DEA. In second stage regression, the non-discretionary variables are regressed against the efficiency scores obtained in the method used during the first stage, such as DEA. Second stage regression is conducted using various methods, but the most popular technique is the censored Tobit regression (e.g. Abbott and Wu, 2002; Barros and Sampaio, 2004; Chi-Lok and Zhang, 2009; Fragoudaki and Giokas, 2016; Perelman and Serebrisky, 2012; Ülkü, 2005; Yoshida and Fujimoto, 2004). Truncated regression including bootstrapping technique is another method used to identify significant non-discretionary variables affecting airport efficiency (e.g. Alder et al., 2013a; Assaf and Gillen, 2012; Barros, 2008a; Barros and Dieke, 2008; Chang et al., 2013; Gitto and Mancuso, 2012a; Tsekeris, 2011). Other non-parametric techniques were used to analyse the differences between the efficiencies of various groups. Examples of these methods are Mann-Whitney and Kruskal-Wallis tests, which were used by some studies, such as Bazargan and Vasigh (2003), to evaluate the differences in the efficiencies of private and public airports in the US between 1996 and 2000.

From the 96 papers, a total of 102 different non-discretionary variables were identified. These variables are categorised into four groups (after Liebert and Niemeier, 2013): airport characteristics, management strategies, governance structures, and other factors. Table 3-8 lists all the non-discretionary variables used previously in the literature.

Table 3-8 Non-discretionary variables used in the literature

Non-discretionary Variable	Papers	
Airport Characteristics		
% Cargo	Oum et al. (2003); Oum et al. (2006); Oum et al. (2008)	3
% General aviation	Pathomsiri et al. (2008)	1
% International PAX	Pathomsiri et al. (2008)	1
% International traffic	Chow et al. (2009); Chow et al. (2009); Oum et al. (2003); Oum et al. (2006); Oum et al. (2008); Ülkü (2015)	6
% Non-aeronautical revenues	Adler et al. (2013); Oum and Yu (2004)	2
% Non-aviation revenues	Oum et al. (2006)	1
% of LCC passenger	Augustyniak et al. (2015)	1
access	Tsekeris (2011)	1
Air transport movements	Alder and Liebert (2014)	1
Aircraft size	Ahn and Min (2014)	1
Aircraft standing area	Abbott and Wu (2002)	1
Airline mergers	Chi-Lok and Zhang (2008)	1
Airport size	Abbott (2015); Ahn and Min (2014); Assaf et al. (2012); Barros and Dieke (2007); D'Alfonso et al. (2015); Lin and Hong (2006); Oum et al. (2004); Oum and Yu (2004); Oum et al. (2008); Oum et al. (2006); Perelman and Serebrisky (2012)	11
Average aircraft size	Oum et al. (2006); Oum et al. (2008); Oum et al. (2004); Alder and Liebert (2014)	4
Capacity constrained airports	Oum et al. (2008)	1
Capital composition	Gitto and Mancuso (2012a)	1
Capital labour ratio	Abbott and Wu (2002)	1
Cargo load factor	Pathomsiri et al. (2008); Tovar and Martin-Cejas (2010)	2
Dummy for slot-coordinated airport	Pels et al. (2003)	1
Dummy for time restrictions	Pels et al. (2003)	1
High level of delay	Alder and Liebert (2014)	1
Hub dummy	Barros (2008a); Barros and Dieke (2008); Chi-Lok and Zhang (2008); Chow et al. (2009); Gillen and Lall (1997); Gitto and Mancuso (2012a); Gutierrez and Lozano (2016); Lin and Hong (2006); Oum and Yu (2004); Tsui et al. (2014a); Tsui et al. (2014b); Wanke (2013)	12
International dummy	Wanke (2013)	1
Market share	Barros and Sampaio (2004); Pathomsiri et al. (2008)	2
Military involvement	Adler et al. (2013); Ülkü (2015)	2
Multi-airport dummy	Oum et al. (2003)	1
New airport dummy	Chi-Lok and Zhang (2008)	1
Non-aeronautical revenues	Liu (2016); Tovar and Martin-Cejas (2010)	2
Number of airlines served	Chang et al. (2013); Liu (2016)	2
Number of destinations	Chang et al. (2013); Liu (2016)	2
Number of international routes	Chang et al. (2013)	1
Operating characteristics	Tsekeris (2011)	1
PAX service levels	Oum et al. (2008)	1
Percentage of international passengers	Tsui et al. (2014b)	1

Non-discretionary Variable	Papers	
Airport Characteristics		
PSO served	Adler et al. (2013)	1
Regular flights	Wanke (2013)	1
Runway utilisation	Alder and Liebert (2014); Oum et al. (2006)	2
Seasonality	Gitto and Mancuso (2012a); Ülkü (2015)	2
Start of operation	Yoshida and Fujimoto (2004)	1
Time dummy	Gitto and Mancuso (2012a); Pels et al. (2003)	2
WLU	Barros (2008a); Barros and Dieke (2007); Barros and Dieke (2008); Tsekeris (2011); Ülkü (2015)	5
Management Strategies		
Airport localisation programme	Chi-Lok and Zhang (2008)	1
Airport management	Tsui et al. (2014b)	1
Airport operating hours	Tsui et al. (2014a); Tsui et al. (2014b)	2
Business diversification	Oum et al. (2004)	1
Cost structure	Barros and Sampaio (2004)	1
Extent of outsourcing	Oum et al. (2004)	1
Ground handlings or fuel sales in-house	Adler et al. (2013)	1
Handling liberalization	Gitto and Mancuso (2012a)	1
Management operational and investment variables	Gillen and Lall (1997)	1
Noise strategy variables (only airside)	Gillen and Lall (1997)	1
Non-aeronautical business	Oum et al. (2008)	1
Other factors related to the financial condition and management policy	Vasigh and Gorjidooz (2006)	1
Outsourcing degree	Tovar and Martin-Cejas (2010)	1
Service quality	Liu (2016); Oum et al. (2004)	2
The total asset growth rate	Abbott and Wu (2002)	1
Governance Structures		
Airline or independent company operated terminals	Oum et al. (2008)	1
Airport ownership	Abbott and Wu (2002); Ahn and Min (2014); Alder and Liebert (2014); Assaf and Gillen (2012); Gutierrez and Lozano (2016); Lin and Hong (2006); Oum and Yu (2004); Oum et al. (2003); Oum et al. (2004); Oum et al. (2006); Perelman and Serebrisky (2012); Tsui et al. (2014a); Vasigh and Gorjidooz (2006)	13
Airport regulation	Assaf and Gillen (2012)	1
Incentive regulation dummy	Barros and Marques (2008)	1
Joint venture-owned dummy	Abbott (2015)	1
Local council-owned dummy	Abbott (2015)	1
Open sky agreements	Augustyniak et al. (2015); Chi-Lok and Zhang (2008)	2
Price-cap variation	Assaf et al. (2012)	1
Privatization dummy	Abbott (2015); Barros and Dieke (2007); Barros and Dieke (2008)	3
Public listing	Chi-Lok and Zhang (2008)	1
Regulation dummy	Assaf et al. (2012); Oum and Yu (2004)	2
The share held by regional governments	Barros and Sampaio (2004)	1
Total concession	Gitto and Mancuso (2012a)	1

Non-discretionary Variable	Papers	
Other Factors		
Airlines' load factor	Pathomsiri et al. (2008); Pels et al. (2003); Pels et al. (2003)	3
Airport hinterland population	Tsui et al. (2014b)	1
Alliance membership of dominant airlines	Tsui et al. (2014b)	1
Changes in GDP	Parker (1999)	1
City level	Chang et al. (2013)	1
Coastal city	Chi-Lok and Zhang (2008)	1
Composition of air traffic	Oum et al. (2004)	1
Congestion delays	Oum and Yu (2004)	1
Continent dummy	Oum et al. (2006); Oum and Yu (2004)	2
Corruption	Randrianarisoa et al. (2015)	1
Demand and supply shocks	Chi-Lok and Zhang (2008)	1
Distance to the city centre	Chang et al. (2013)	1
Earthquakes dummy	Tsui et al. (2014a)	1
Economic growth	Ahn and Min (2014); Lin and Hong (2006)	2
Flight area	Chang et al. (2013)	1
GDP per capita	Tsui et al. (2014b)	1
Local economy dummy	Chi-Lok and Zhang (2008)	1
Location dummy	Barros and Sampaio (2004); D'Alfonso et al. (2015); Lin and Hong (2006); Tsekeris (2011); Wanke (2013);	5
Major airlines dummy	Chow et al. (2009)	1
North dummy	Barros and Dieke (2008)	1
Population	Barros and Sampaio (2004); Chi-Lok and Zhang (2008); Ülkü (2015)	3
Population around the airport	Tsui et al. (2014a)	1
Population in the county	Yu (2004)	1
Rate of return	Abbott and Wu (2002); Barros and Marques (2008)	2
Region	Ahn and Min (2014)	1
Regional competition	Alder and Liebert (2014); Assaf et al. (2012)	2
Regional competition intensity	Chi-Lok and Zhang (2008)	1
Regional dummy variables	Oum et al. (2003)	1
Regional effects dummy	Chow et al. (2009)	1
Remote area	Adler et al. (2013)	1
Third mainland dummy	Yoshida and Fujimoto (2004)	1
Tourist city	Chi-Lok and Zhang (2008)	1
Year dummy	Abbott and Wu (2002); Gillen and Lall (1997); Pels et al. (2001); Oum et al. (2006); Barros (2008a)	5
Total Number Of Non-discretionary Variables	**102**	

Among the 102 factors, three were used the most: airport ownership (13 papers), hub status (12 papers), and airport size (11 papers).

It is evident in the literature that airport size was used as a non-discretionary variable in the majority of studies that focused on a single country in their analysis. The purpose of this variable is to compare the efficiency of airports based on airport size (categorised as small, medium, or large). Gillen and Lall (1997), for example, studied the efficiency of 21 major US airports between 1989 and 1993 using DEA, finding that large airports outperformed small airports. The same conclusion was reached by Sarkis (2002), who analysed the performance of 44 major US airports between 1990 and 1994 using DEA. However, newer studies found different results. Bazargan and Vasigh (2003) used DEA to study the efficiency of 45 small, medium, and large US airports from 1996 to 2000, finding that large airports have become less efficient than smaller airports. This conclusion is in line with the results of Pathomsiri et al. (2008) in their analysis of the performance of 56 US airports between 2000 and 2003. In the UK, studies found contradictory results. For instance, Barros (2009) analysed the performance of 27 UK airports between 2000 and 2006 using SFA, concluding that large airports tend to be less efficient than smaller airports. However, Assaf (2009), in his study using SFA, which included 16 large and 11 small UK airports, concludes that large airports outperformed smaller airports between 2002 and 2007. In Taiwan, Yu (2004) found that large airports are less efficient than smaller airports (using DEA on 14 domestic Taiwanese airports between 1994 and 2000). However, an evaluation of the performance of 10 Taiwanese airports in 2001 indicates that all the airports of different sizes achieved the same level of efficiency (Wang et al., 2004). In Spain, all the papers that researched the performance of airports indicate that large airports recorded better operating efficiency than smaller airports (e.g. Martin and Roman, 2001; Martin-Cejas, 2002; Martin and Roman, 2006; and Martin et al., 2009). In general, the results in the different countries presented above suggest that there exist fluctuating dynamics in the airport systems of the countries.

Airport ownership is one of the most-used variables in second-stage regression analysis. The majority of papers that used airport ownership in their analysis are cross-country studies comparing the efficiency between different forms of airport ownership, especially involving airport privatization. Parker (1999) was the first to study the effects of ownership on the efficiency of airports. He used DEA to evaluate the change in the technical efficiency of BAA airports prior to and following privatization. His results indicate that there is no evidence that the efficiency of airports increased following privatization. The same conclusion was reached by Oum et al. (2003), who used TFP to assess the performance of 50 airports worldwide in 1999. Lin and Hong (2006) used DEA to evaluate the efficiency of 20 major worldwide airports, and their conclusion regarding the effect of ownership on the performance of airports is in line with the conclusions of Parker (199) and Oum et al. (2003).

However, other studies did find a relationship between airport ownership and performance. Barros and Dieke (2007) used two-stage analysis, namely DEA and truncated bootstrapped regression, on 31 Italian airports under different ownership models between 2001 and 2003 and found out that the efficiency of privately owned airports is better than publicly owned airports. Oum et al. (2008) conclude the same in their study, which included 109 airports around the world in 2007. Also, Oum et al. (2006) indicate that airports that have mixed ownership with a private majority are more efficient than those with a public majority, after researching the performance of 116 airports worldwide between 2003 and 2005.

A large number of papers that applied two-stage performance analysis in their cross-country airport studies used hub status as a dummy variable. The aim was to test the effectiveness of being a hub on the performance of the airport. Gillen and Lall (1997), the first to use DEA, were also the first to use hub status in their analysis of 21 major US airports between 1989 and 1993. Their results reveal that being a hub positively affects the efficiency of the airport. Sarkis (2000), who analysed the performance of 44 US airports between 1990 and 1994, also found that US hub airports tend to be more efficient. However, he notes that the reason is perhaps that leading airlines, or flag carriers, prefer to use already efficient airports as their hubs for their operations post-liberalization. The same positive result was found by Barros (2008a), Chow et al. (2009), Fung et al. (2008), and Martin and Roman (2008).

Other studies, such as Bazargan and Vasigh (2003) and Pathomsiri et al. (2008), which researched the performance of 45 and 56 US airports, respectively, found that smaller airports are more efficient. Their conclusions contradict those of the studies mentioned above. Oum et al. (2004) found using TFP that being a hub reduces the productivity of the airport. They reason that hub airports are over-exploited during peak hours because airlines tend to operate vastly intensified arrival and departure schedules. This system means that the airports are under-exploited during off-peak hours.

An important finding regarding the variables used in second stage regression is that the vast majority are related to the airport, or, in other words, are endogenous variables. Only a few studies used variables that are beyond the control of airport management and outside the airport industry itself. For example, Randrianarisoa et al. (2015) is the only paper that tested the effects of corruption in the country on the performance of the airports. Other papers considered the population of the country, which is also an exogenous factor, such as in Barros and Sampaio (2004), Chi-Lok and Zhang (2008), and Ülkü (2015). However, no study identified the national macro-environmental factors that influence the performance of the airports. This variable could provide a better and broader understanding of the reasons for the differences in airport efficiencies between countries, as mentioned at the beginning of this section. Furthermore, this variable could connect the success of airport ownership and management models.

Chaouk, Pagliari and Miyoshi (2019) performed a critical review on the airport privatization in the Kingdom of Saudi Arabia, focusing on the case of Medina Airport, the first privatized airport in the Kingdom and in the Gulf Region. This contribution to the literature focussed on a comparison of the operational and financial performance of Medina Airport before and after privatization. Cultural dimensions, human resources strategies, administrative governance issues, and the socio-political environment were all found to be pertinent factors that affected the performance of the airport, and, thus, the success of that particular privatization transaction. The presence of these macro-environmental factors seemed particularly salient hence there is a need to research these effects quantitatively.

3.4 Summary

In this chapter, existing studies on airport performance between 1997 and 2016 were examined. The collected papers were dissected and classified according to the methodological approaches used, the year of publication, the journal, the geographical regions studied, the input and output variables, and the non-discretionary variables used.

A total of 96 papers in the literature revealed that there is increasing interest in airport performance and benchmarking studies. This interest is evident from the average number of publications doubling after 2008.

The DEA approach is the most-used methodological approach to estimate airport efficiency, although SFA has been increasingly applied in recent years. Other techniques, such as partial performance and TFP, were only used sparingly.

Regarding the geographical regions researched in previous studies, airports in Europe and Asia-Pacific are the subject of the highest number of published studies. Furthermore, there is a significant relationship between the distribution of airport performance and benchmarking studies based on the geographical region studied and the distribution of privatized airports. This relationship is perhaps due to the tendency of privatized airports to release their data more easily than governments, especially in Africa and the Middle East, where governments consider such information to be confidential. However, this suggests that, with the increasing trend of airport privatization in the MENA, future studies should be able to address the deficiency of studies on airports in this region.

The literature review revealed that many different input variables representing airports' physical, financial, and time characteristics had been used. Also, there are many studies that used only output variables to represent airports' aeronautical activities, although much attention has been paid to non-aeronautical activities at airports by researchers. The most-used input and output variables were highlighted in Section 3.3.4.1 and Section 3.3.4.2, respectively.

Finally, and most importantly, the majority of non-discretionary variables used in the literature to explain the factors affecting the performance of airports are endogenous. Only a few papers included factors that represent part of the various countries' macro-environments. However, no study identified the macro-environmental factors that, combined, affect the efficiency of airports. This research gap is critical because, if filled, it can provide a broader understanding of many research questions, including regarding differences between the efficiency of airports in different countries and under different ownership and management models.

4 CHAPTER FOUR: RESEARCH DESIGN AND METHODOLOGY

A research design is a framework that researchers follow to find answers to their research questions. According to Churchill (1987), such a framework is similar to the architectural blueprint of a house. The research design is shaped by the precedence that the researcher applies to the scope of a variety of research procedures (Bryman and Bell, 2011). In principle, a research design serves as a guidance tool during the data collection and analysis phases to ensure that the procedures are pertinent and cost-effective to the targeted research problems (Churchill and Iacobucci, 2002). This design affects the selection of the data collection and analysis methodologies, as well as the validation of the obtained results.

The research methodology is a system of knowledge that enables a researcher to answer the research questions by using several forms of collectable proof (Clark, Lotto and Astuto, 1984). Although a methodology is an assembly of processes, skills, tools, and supporting documentation, it is not only an assortment of these; a research methodology should be established based on philosophical paradigms (Avison and Fitzgerald, 2003). Therefore, in any research, a methodology is imperative to identify the assumptions and the results of the applied procedures (Miller and Salkind, 2002). Näslund (2002) advises that the choice of a research methodology ought to be supported by a research paradigm since the fundamental nature of research procedures usually demands a specific research approach or methodology.

The following section defines and discusses the different research philosophical approaches, followed by stating and justifying the philosophical approach adopted by this research, which forms the basis for selecting the research methodology.

4.1 Research Philosophical Approach

Saunders, Thornhill and Lewis (2009) describe the research approach as an onion, and the research stages are the layers of this onion. The researcher must make assumptions at each stage to conceptualise the research design and methodology. Figure 4-1 illustrates the research onion and its layers.

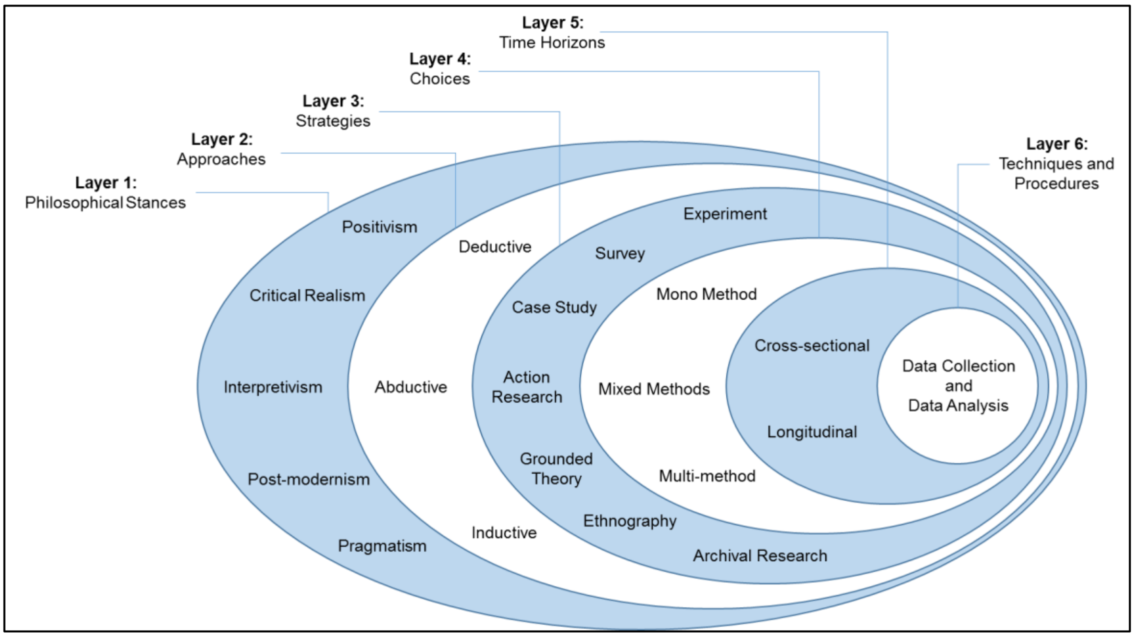

Figure 4-1 The Research Onion

Source: Saunders, Thornhill and Lewis (2009)

The research process comprises the following six major categories: philosophies, approaches, strategies, choices, time horizons, and techniques and procedures for data collection and analysis. In the following sub-sections, the philosophical assumptions that should be considered by the researcher are defined. Then, each of the six categories of the research process is briefly introduced and discussed.

4.1.1 Research Philosophical Assumption

A research philosophy consists of a set of beliefs and assumptions that the researcher makes at every phase of the study (Burrell and Morgan, 1979). The importance of these assumptions is that they focus the researcher's method of comprehending the research questions and the methodologies she/he uses to collect and analyse the data and to interpret the obtained results (Crotty, 1998). Therefore, before discussing the different research philosophies, it is imperative to understand the differences between the assumptions. There are three types of assumption in the research philosophy: ontology, epistemology, and axiology.

Ontology is the classification of actuality. This assumption entails researchers thinking about how the world functions, how civilisation is built, and how this affects the whole lot (Bryman and Bell, 2011). Also, this assumption defines the dissimilarity between actuality, what people think actuality is, and how this affects their behaviour.

Epistemology concerns asking questions about what is considered adequate knowledge in addressing realities and how to pass on the knowledge to future researchers (Burrell and Morgan, 1979). This assumption requires the researcher to delineate what knowledge is putative in her/his area of study, and what data are considered to be facts following laborious experimentation and testing. This philosophical standpoint is mostly implemented in scientific studies because it searches for data (or facts) that can be quickly and certainly proven, rather than using information based on opinions, which can change under different circumstances.

Axiology concerns evaluations about values (Saunders, Thornhill and Lewis, 2012). In particular, this assumption includes evaluating the role that the researcher's own and others' values play during all the phases of the research procedure (Li, 2016). This evaluation is essential because researchers' values affect how they execute their research and what they think is vital in their research findings.

Niglas (2010) contrasts two extremes of the research philosophy in business and management studies, namely objectivism and subjectivism; these enable the researcher to differentiate between the three philosophical assumptions. Table 4-1 outlines the two extremes with respect to the three research philosophical assumptions.

Objectivism claims that social phenomena and their implications occur without connection to social players (Saunders, Thornhill and Lewis, 2012). An example of social phenomena could be heavy snow, and the social players are passengers waiting for their flights at the airport. The snow is real, and everybody knows that it is real and happening, and it is independent of all the passengers who have had their flights delayed or cancelled. Therefore, in the ontological assumption, objectivism accepts realism. Realism, in its extreme cases, believes that there is independence between the existence of social objects from people's awareness, thoughts, and classifications. This independence of the social world from the social actors' inputs means that objectivism believes that all social actors experience only one and the same social reality. Burrell and Morgan (1979) define the social world as consolidated, granular, and comparatively unvarying objects that contain major social infrastructures into which human beings are born. Epistemologically, objectivism uses certain information that is noticeable and perceptible in an attempt to explore and generate general fundamentals about the reality of the social world. In the axiological assumption, objectivism requires research to be value-free, because it believes that the inclusion of values in research leads to biased results. Therefore, researchers who use objectivism attempt to detach their own values and thoughts during the entire process of the research.

Subjectivism is the opposite of objectivism; it believes that social phenomena and their implications are directly related to social players. For example, the behaviour of a group of people leads to the establishment of a new law that affects the same group of people. In the ontological assumption, subjectivism adopts nominalism, which believes that social actors create social phenomena via their actions, thoughts, classifications, and the use of language. Nominalism believes that there exist multiple realities since each individual has her/his own personal experiences and understanding of social reality (Burrell and Morgan, 1979). Social constructionism is another version embraced by subjectivism but is not as extreme as nominalism. This viewpoint argues that what creates reality is the collective meanings and realities that are partially formed by the social players within the continuous process of social interactions. The continuous nature of social interactions makes the social phenomena prone to constant change and reconsideration (Saunders, Thornhill and Lewis, 2012). Therefore, to recognise how social players examine realities, a researcher who adopts this viewpoint should review the history and the specific geopolitical and sociocultural contexts of the surrounding situation.

Table 4-1 Objectivism and Subjectivism regarding philosophical assumptions

Philosophical Assumption	Questions	Objectivism	Subjectivism
Ontology	What is the nature of reality?	Real	Nominal/decided by convention
	What is the world like?	External	Socially constructed
	What are organizations like?	One true reality	Multiple realities
	What is it like being in organizations?	Granular (things/objects)	Flowing (processes)
	What is like being a manager or being managed?	Order	Chaos
Epistemology	How can we know what we know?	Adopt assumptions of the natural scientist	Adopt assumptions of the arts and humanities
	What is considered adequate knowledge?	Facts	Opinions
	What constitutes good-quality data?	Numbers	Narratives
		Observable phenomena	Attributed meanings
	What kinds of contribution to knowledge can be made?	Law-like generalisations	Individuals and contexts, specifics
Axiology	What is the role of values in the research? How should we treat our own values when we conduct research?	Value-free	Value-bound
	How should we deal with the values of research participants?	Detachment	Integral and reflexive

Source: Adapted from Saunders, Thornhill and Lewis (2012)

Epistemologically, the assumptions of the arts and humanities are included in the subjectivism extreme viewpoint. In contrast to objectivism, subjectivism seeks to discover the various beliefs and stories of social players, which facilitates the consideration of various social realities. In the axiological assumption, subjectivism should include radical reflexivity. This means that while the researcher is using this information, she/he should reflect and incorporate her/his own values into the research (Cunliffe, 2003).

4.1.2 Research Philosophical Stance

Figure 4-1 reveals that there are five philosophical stances in the first layer of the research onion. These stances are positivism, critical realism, interpretivism, postmodernism, and pragmatism. In this sub-section, the five research philosophies are defined and discussed.

4.1.2.1 Positivism

Positivism seeks to develop law-like principles, such as those developed by scientists, by identifying correlations in the data (Gill and Johnson, 2010). The researcher can use these developed generalisations to assist in justifying and anticipating the attitudes and occasions in the associations. With the epistemological assumption, the researcher should aim to explore detectable and perceptible facts, believing that they are the only source that can lead to the development of dependable and relevant results (Crotty, 1998).

Positivism creates testable and explainable hypotheses that are deliberated alongside recognised knowledge in this world. Furthermore, positivism can generate a system of research that other researchers can imitate and obtain the same outcomes. Also, the dependable knowledge that is recognised using research based on the positivism viewpoint can be implemented to manipulate or standardise the conduct of a society (Benton and Craib, 2001). It is crucial for the researcher who adopts positivism to dissociate her/his values and thoughts from the research to eliminate the possibility of bias and to ensure that the results have the sufficient level of credibility, including using data that are free from social players' interpretations and ideas (Table 4-2). Therefore, deductive, profoundly structured methodology is usually used by researchers who embrace positivism to assist them or others in the process of research reproduction (Gill and Johnson, 2010). This process could, for example, be statistical analysis using measurable observations.

Table 4-2 Comparison of five major research philosophical stances

Philosophical Stance	Philosophical Assumptions			Typical Methods
	Ontology	Epistemology	Axiology	
Positivism	Real, external, independent One true reality Granular Ordered	Scientific method Detectable and quantifiable facts Law-like generalisations Numbers Causal explanation and prediction as contribution	Value-free research Researcher is detached, neutral, and independent of what is researched Researcher maintains objective stance	Typically, deductive, highly structured, large samples Measurement Typically, quantitative methods of analysis, but a range of data can be analysed
Critical Realism	Stratified/layered (the empirical, the actual and the real) External Independent Intransient Objective structures Causal mechanisms	Epistemological relativism Knowledge is historically situated and transient Facts are social constructions Historical causal explanation as contribution	Value-laden research Researcher acknowledges bias by world views, cultural experience and upbringing Researcher tries to minimise bias and errors Researcher is as objective as possible	Retroductive, in-depth historically situated analysis of pre-existing structures and emerging agency Range of methods and data types to fit subject matter
Interpretivism	Complex, rich Socially constructed through culture and language Multiple meanings, interpretations, and realities Flux of processes, experiences, and practices	Theories and concepts too simplistic Focus on narratives, stories, perceptions and interpretations New understandings and worldviews as contribution	Value-bound research Researchers are part of what is researched Subjective Researcher interpretations key to contribution Researcher reflexive	Typically, inductive small samples, in-depth investigations, qualitative methods of analysis, but a range of data can be interpreted
Postmodernism	Nominal Complex, rich Socially constructed through power relations Some meanings, interpretations, and realities are dominated and silenced by others Flux of processes, experiences, and practices	What counts as 'truth' and 'knowledge' is decided by dominant ideologies Focus on absences, silences and oppressed/repressed meanings, interpretations and voices Exposure of power relations and challenge of dominant views as contribution	Value-constituted research Researcher and research embedded in power relations Some research narratives are repressed and silenced at the expense of others Researcher radically reflexive	Typically, deconstructive – reading texts and realities against themselves In-depth investigations of anomalies, silences and absences Range of data types, typically qualitative methods of analysis

Philosophical Stance	Philosophical Assumptions			Typical Methods
	Ontology	Epistemology	Axiology	
Pragmatism	Complex, rich, external 'Reality' is the practical consequences of ideas Flux of processes, experiences and practices	Practical meaning of knowledge in specific contexts 'True' theories and knowledge are those that enable successful action Focus on problems, practices and relevance Problem-solving and informed future practice as contribution	Value-driven research, Research initiated and sustained by researcher's doubts and beliefs, Researcher reflexive	Following research problem and research question Range of methods: mixed, multiple, qualitative, quantitative, action research Emphasis on practical solutions and outcomes

Source: adapted from Saunders, Thornhill and Lewis (2012)

4.1.2.2 Critical Realism

In critical realism, it is imperative to have a systematic and staged ontology in which reality is treated as the most critical philosophical deliberation. This is a standpoint that agrees with positivism in its belief that social actuality is independent of the researcher, and, thus, the obtained results are free of bias. However, although in critical realism, reality is considered to be external and free from social actors' behaviour, this reality cannot be reached directly by being aware of it or by observing it. Critical realism believes that what people sense from their observation might be different from actuality (Saunders, Thornhill and Lewis, 2012). An example of this could be the mirages that drivers encounter in the desert. Drivers may observe objects such as trees or lakes but, in reality, there is nothing more than a mirage due to the difference in the temperature of the air layers close to the surface of the earth, which allows light to pass through these layers and create an upturned displaced image of far objects. Therefore, critical realists focus on defining the differences between what social players observe and what the actual object or phenomenon is.

Critical realism requires the researcher to explore the full picture of the observed phenomena (Table 4-2). When the researcher understands the causes of the phenomena, it becomes easier for her/him to understand the reality of the social world (Bhaskar, 1989). Therefore, the researcher might have to review the history of the social structures under observation and understand their evolution over time (Reed, 2005). Finally, critical realism believes that there is no perfection in scientific methodologies; understanding actuality is a continuous process that requires open minds and the use of new research methodologies and the reviewing of all previous theories. Therefore, researchers who follow the critical realism viewpoint may apply more than one research methodology to obtain reliable outcomes through the triangulation of results.

4.1.2.3 Interpretivism

Interpretivism highlights the significance of social players' contributions to communal and cultural life. While positivism searches for law-like generalisations regarding social phenomena, interpretivism explores different and vibrant perceptions and explanations of the social world and its associated phenomena (Saunders, Thornhill and Lewis, 2012). From this viewpoint, it is believed that every individual comes from different cultural and traditional backgrounds, which makes each person experience different social realities.

The emphasis on the difference regarding interpretations and explanations between individuals means that interpretivism is embraced by subjectivism. In the axiological assumption, this means that researchers should study people's thoughts, ideas, the meanings that are important to them, and their explanations of their own and others' behaviour to understand the existence of the revolutionary nature of the social world. In particular, researchers should focus on the effects of language, lifestyle, and past events (Crotty, 1998).

4.1.2.4 Postmodernism

Postmodernism disagrees with positivism and objectivism, emphasising the importance of the function of dialects and power relationships in shaping social reality (Saunders, Thornhill and Lewis, 2012). Furthermore, postmodernism focuses on the disorganized domination of alterations and evolution; thus, repudiating modern objectivism and ontological realism. Postmodernism believes that the order of things does not exist naturally, but can only be achieved through the use of language and human mind classifications (Chia, 2003).

Postmodernism challenges the typical methods of creating and receiving knowledge by providing opportunity and validity to abolished and disparaged views and ideas (Chia, 2003; Kilduff and Mehra, 1997). To achieve this aim, researchers should dissect the primary reality into the beliefs and power relationships that construct it (Derrida, 1976). Researchers should dissect all types of information, such as manuscripts, figures, dialogues, and expressions. Also, they should conduct painstaking analyses of the phenomena, similar to interpretivist researchers.

4.1.2.5 Pragmatism

Pragmatism seeks to bring together objectivism and subjectivism, facts and principles, precise and exact knowledge and various in-context experiences. Researchers who follow pragmatism emphasise the effects of theories, ideas, beliefs, hypotheses, and previous research outcomes on understanding behaviour. Thus, in pragmatism, the reality is considered to be the result of concepts. Also, the value of knowledge is created based on the extent to which it facilitates actions to be well accomplished (Saunders, Thornhill and Lewis, 2012).

The aim of pragmatism is to provide useful solutions to the problem that the research is addressing (Table 4-2). This practical solution aims to shape the way procedures are undertaken in the future to produce the best results. In other words, the doubts and common sense of the researcher, which were created by her/his background, beliefs, and experiences, enable her/him to detect things that are incorrect or problematic. Once the researcher identifies a practical solution, this solution becomes a newly created belief or knowledge (Elkjaer and Simpson, 2011).

Pragmatism believes that it is better to use different types of knowledge and methodological approaches unless the research problem clearly suggests that only one methodology should be conducted. This approach is because pragmatism considers that there exist various interpretations of realities that cannot be fully realised from a single perspective. However, this does not mean that pragmatists should always apply more than one methodological approach; it only means that they should use the most reliable and appropriate method or methods regarding the available data (Saunders, Thornhill and Lewis, 2012).

4.1.2.6 Philosophical Stance of This Research

With the five primary research philosophical stances defined, it is vital to decide on the philosophical stance adopted by this research.

To recall, the main objective of this research is to identify the national macro-environmental factors that influence the performance of airports. The result of this objective is to be used in developing a framework that helps select the most suitable airport ownership and management model. This process is similar to developing law-like generalisations by identifying correlations in the data, which can help the researcher to anticipate attitudes in organizations. The researcher assumes that reality is external and that there is only one true reality regarding the relationship between airport performance and external factors. Therefore, this research falls into the philosophical stance of positivism. In addition, the ownership and management of airports are considered to be objective systems. Therefore, the researcher decided to follow the objectivism standpoint to analyse specific features of airport performance.

4.1.3 Research Approach

After deciding upon the philosophical stance of this research, the next step is to select a research approach appropriate to the chosen research philosophy. Before that, however, clear definitions of the research approaches should be presented. Figure 4-1 displays three different research approaches: deductive, inductive, and abductive.

Researchers usually use the deductive approach when seeking to identify and describe the casual relationship between a concept and a set of variables. This approach includes developing a theory, or using an existing one, and rigorously testing it against a number of hypotheses (Saunders, Thornhill and Lewis, 2009). This process is generally undertaken by collecting sufficient quantitative data and analysing them using a highly structured methodological approach. In other words, the deductive approach tests theories.

The inductive approach is the opposite of the deductive. The researcher collects data, generally from interviews, and analyses them to formulate a theory or conceptual framework (Bryman and Bell, 2003). Usually, an inductive approach requires a small sample of subjects for the study (Saunders, Thornhill and Lewis, 2012).

Between deduction and induction, differences are revealed at the beginning of the research process, at the research aim, and at the timing of developing and applying hypotheses (Spens and Kovács, 2006). The differences are illustrated in Figure 4-2.

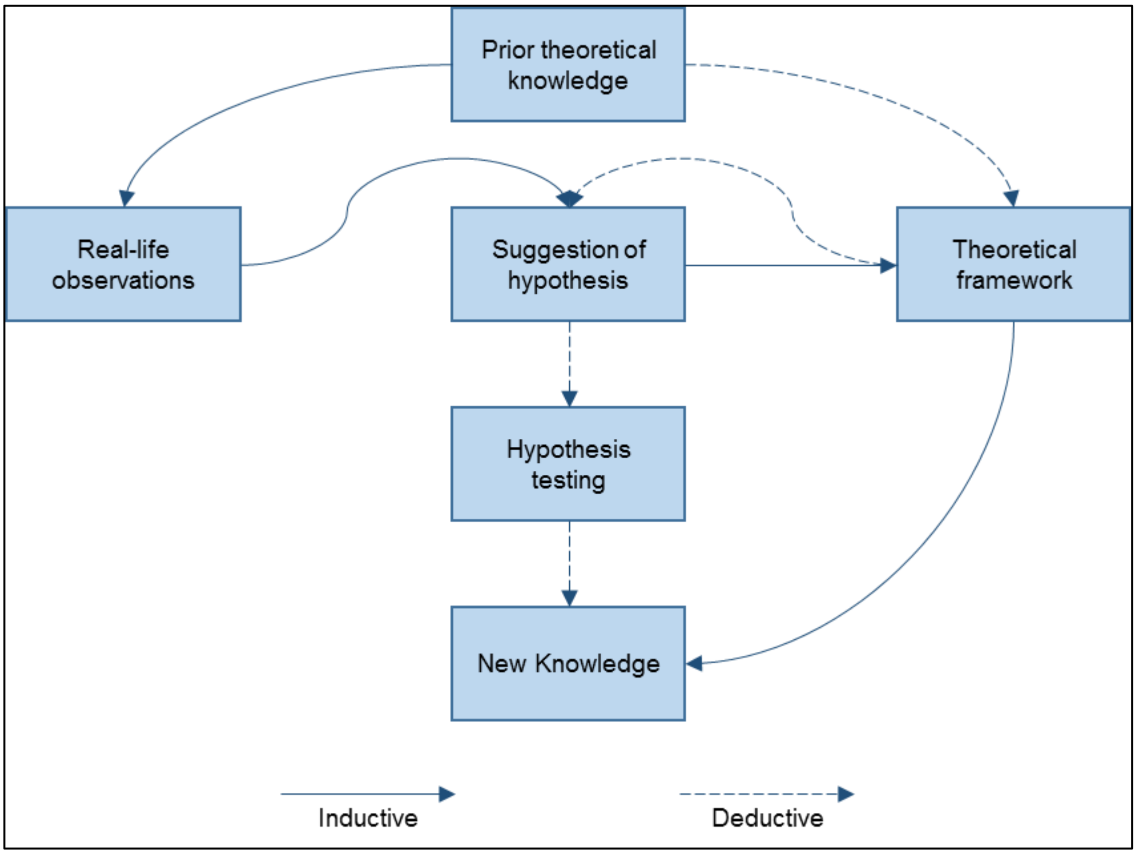

Figure 4-2 Deductive and Inductive approaches' processes

Source: adapted from Spens and Kovács (2006)

A third approach which combines deductive and inductive approaches is called the abductive approach. In principle, the abductive approach moves back and forth between theory and data, rather than deduction which moves from theory to data, or the induction which moves from data to theory. The abductive approach requires to collect rich, sufficient, and detailed data (Saunders, Thornhill and Lewis, 2012).

Since this research seeks to identify the relationship between airport performance and national macro-environmental factors, the deductive approach was adopted. This approach is the dominant approach in transport studies that adopted positivism as a philosophical stance (Aastrup and Halldórsson, 2008; Näslund, 2002; Wagner and Kemmerling, 2010). This factor supports the decision to use the deductive approach in this research.

After deciding upon the research approach, the next decision concerns the purpose of the research. There are three primary research purposes: explanatory, exploratory, and descriptive.

In explanatory, the aim is to set up or identify casual relationships between different factors pertaining to the problem addressed by the research (Saunders, Thornhill and Lewis, 2007). This process is usually conducted by studying the originator of two or more variables through the application of experimentation (Churchill, 1976).

Exploratory research seeks to investigate new concepts, develop questions, and study phenomena using new ways of thinking (Saunders, Thornhill and Lewis, 2007). Exploratory has more flexibility and creativity in finding unanticipated interpretations (Kinnear and Taylor, 1991; Saunders, Thornhill and Lewis, 2007) and is suitable for research problems that have not previously been widely explored (Churchill and Iacobucci, 2002).

Descriptive research aims to describe the attributes of individuals, groups, organizations, or events (Saunders, Thornhill and Lewis, 2007). It is used to estimate the proportions of the sample based on each attribute and to develop forecasts (Churchill, 1976). It is essential in descriptive research to consider the existing knowledge and information relevant to the research problem.

In this research, an explanatory approach is suitable for the objective of investigating the unexplored gap between airport performance and national macro-environmental factors, as identified in Chapter 3.

4.1.4 Research Strategy

The research strategy is defined as a general plan that a researcher follows to find answers to her/his research questions and fulfil her/his objectives (Saunders, Thornhill and Lewis, 2012). Generally, researchers choose their research strategy based on the objectives of their research, the magnitude of existing literature, the time allowed for research, and, most importantly, the available data and resources.

There are seven main research strategies (see Figure 4-1). These strategies are an experiment, survey, case study, action research, grounded theory, ethnography, and archival research.

The experimental strategy aims to analyse the casual relationships between variables. This strategy investigates whether a variation in one independent variable leads to a variation in a dependent variable (Hakim, 2000). Therefore, experiments are usually used to find answers to questions such as ‘how’ and ‘why’ in exploratory research and explanatory research.

The survey strategy aims to highlight the potential reasoning for specific relationships between dependent and independent variables and to generate models from these relationships (Saunders, Thornhill and Lewis, 2012). This strategy includes quantitative data collection and analysis using eloquent and statistical methodologies. The survey strategy is commonly used with a deductive research approach and often used in exploratory research and descriptive research to find answers to questions such as ‘who’, ‘what’, ‘where’, ‘how much’, and ‘how many’ (Saunders, Thornhill and Lewis, 2009).

The case study strategy includes investigating empirically a specific phenomenon in the context of real-life using evidence from multiple sources (Robson, 2002). This process allows the researcher to form a comprehensive understanding of the research context and the executed procedures (Morris and Wood, 1991). The case study strategy is usually used in exploratory research and explanatory research to find answers to ‘why’, ‘what’, and ‘how’ questions (Saunders, Thornhill and Lewis, 2012).

The action research strategy is different from the other strategies because it focuses on actions; precisely, actions that lead to changes within the studied organizations (Saunders, Thornhill and Lewis, 2009). It is usually used to find answers to ‘how’ questions. In this strategy, the researcher should participate in the action for change and should utilise the previous knowledge she/he gained from other situations (Saunders, Thornhill and Lewis, 2012).

The grounded theory strategy uses inductive and deductive approaches to build a theory. Such a process is usually used in research that aims to forecast and interpret actions and behaviours (Goulding, 2002). In the grounded theory strategy, the researcher develops a theory using data collected from several observations, without having an initial theoretical framework (Saunders, Thornhill and Lewis, 2007). This developed theory is then confirmed or refuted by testing it against additional observations.

The ethnography research strategy aims to define the social world under study according to those who are concerned with it. This is an appropriate research strategy for researchers seeking to form a general understanding and interpretations about a specific subject through the perspectives of the people involved in that subject (Saunders, Thornhill and Lewis, 2012).

The archival research strategy mainly involves explanatory, exploratory, and descriptive research that aims to answer questions related to the past and variations over time regarding the subjects under study (Saunders, Thornhill and Lewis, 2009). The principal sources of data in the archival strategy are administrative documents, records, and databases (Bryman, 1989).

In this research, quantitative secondary data on airports and macro-environmental factors were collected and analysed using data envelopment analysis (DEA) and Tobit regression to measure the efficiency of airports and to identify how national macro-environmental factors impact efficiency. Therefore, the appropriate strategy is the archival strategy.

4.1.5 Research Choice

Every piece of research is constituted from data collection procedures and data analysis techniques. Data collection procedures can be either quantitative (e.g. questionnaires, surveys, and secondary data), or qualitative (e.g. interviews and documentation). Similarly, data analysis techniques can be either quantitative (i.e. statistical analysis) or qualitative (i.e. thematic analysis).

One of the most important elements of research concerns the choice of data collection procedures and data analysis techniques. There are three research approaches that can be used (see Figure 4-1): mono-method, multi-method, and mixed-method.

With mono-method, the researcher either uses a single quantitative or qualitative data collection procedure with its corresponding single data analysis technique (Saunders, Thornhill and Lewis, 2012). For example, a researcher might choose to collect data from structured interviews and analyse them using a thematic analysis.

The multi-method is subject to the same restrictiveness as to the mono-method, meaning that data collection procedures and data analysis techniques must both be either quantitative or qualitative. However, in this method, the researcher might choose to use more than one procedure to collect data and more than one technique to analyse them (Tashakkori and Teddlie, 2010). For example, a researcher might choose to use questionnaires and secondary data to collect quantitative data and analyse them using econometrics statistical analysis.

The mixed-method choice means that the research includes both quantitative and qualitative procedures and techniques to collect and analyse data. In this method, quantitative techniques must be used to analyse quantitative data, and qualitative data must be analysed using qualitative techniques (Tashakkori and Teddlie, 2010). However, the researcher might use both types of procedure or technique either in parallel or in sequence (Saunders, Thornhill and Lewis, 2012). For example, a researcher might choose to collect qualitative data using interviews and analyse them using a thematic analysis. Then, the researcher collects quantitative data relative to the identified themes in the qualitative analysis using questionnaires and analyses them using statistical analysis.

In this current research, only one data collection procedure was used to collect data on airports and national macro-environmental factors, which is secondary data. Then, the following two data analysis techniques are used: DEA to estimate the efficiency of airports, and Tobit regression to identify the significant macro-environmental factors on the efficiency of the airports. Therefore, this research falls into the multi-method quantitative choice.

4.1.6 Time Horizon

The fifth layer of the research onion (Figure 4-1) represents the time horizon. The time horizon is an essential element in the research and is directly related to the research question (Saunders, Thornhill and Lewis, 2012). It specifies whether the study is undertaken at a particular time or over a long period. Therefore, the time horizon can be either cross-section or longitudinal.

Cross-sectional research aims to analyse the phenomenon under study at a specific time. This approach is usually used in studies that seek to describe an event or to explain how several variables are related to one another (Saunders, Thornhill and Lewis, 2012). However, in longitudinal research, the aim is usually to study the variations and the developments of a particular subject over time. For some research questions, the longitudinal time horizon might provide more valuable insights and interpretations regarding the studied phenomenon than a cross-sectional horizon, which could be challenging to apply due to time constraints. Data availability might be another constraint, especially for research that uses secondary data (Saunders, Thornhill and Lewis, 2012).

In this current research, analysing cross-sectional data to identify the relationship between airport performance and national macro-environmental factors is sufficient. It is possible also to analyse longitudinal data to fulfil the same objective and obtain further insights into how the performance of the airport changes over time. However, the choice of the time horizon was decided according to the availability of data, which is further discussed in Chapter 5, Section 5.3.4. The shortage of available data for the same airports for two or more years made it challenging to apply longitudinal research. Thus, in this study, a cross-sectional time horizon is applied. As the main objective does not require a study of the change in airport performance over a period, using a cross-sectional time horizon to fulfil the objective does not reduce the value of the outcomes of this study.

4.2 Data Analysis Methodologies

In this research, there are two steps in the data analysis. The first step includes measuring the efficiency of a set of international airports worldwide. This step fulfils the first objective of this research, as presented in Section 1.2 of Chapter 1. The second step aims to identify the national macro-environmental factors that impact the efficiency of airports. This step fills one of the gaps in the literature, as identified in Chapter 3, and covers the second objective of this study.

In Section 3.3.1 of Chapter 3, the systematic literature review of previous studies that used airport performance estimation techniques highlights the three most popular methods. These methods are DEA, SFA, and index-based TFP, with DEA being the most-used method. To choose the proper method to use in this research, three criteria were set. The first criterion is that the method should fulfil the requirements and assumptions of the philosophical stance and approach, followed by this research. The second criterion is that the method should be reliable and easy to use when combined with other methods in the second-stage analysis. Finally, the third criterion is that the method should support the analysis of the available type of data.

The frontier approaches of DEA and SFA are the most common in the literature. As mentioned in Chapter 3, both methods support efficiency estimation using multiple inputs and outputs variables. These variables can be either physical or financial. Each method has its advantages and disadvantages. The main advantage of DEA over SFA is that it automatically constructs a piece-wise linear frontier using the efficient DMUs in the sample using linear programming. However, this is not the case in SFA, in which the researcher is supposed to provide weights for the variables to construct the frontier, or, in other words, the cost function. The main advantage of SFA over DEA is that it can account for noise effects and test hypotheses. Although TFP is one of the three most popular methods used in the literature, it has not been used as much as the frontier approaches methods. The main disadvantage of TFP is that it requires data on both price and quantity.

Since this research adopts deductive positivism, SFA seems inappropriate because it requires the participation of the researcher or research participants to set the weights of the variables in the model. This approach contradicts the primary axiological assumption of positivism, which is to keep the research independent from the researcher or research participants' values. Furthermore, TFP is unsuitable because it requires data on price, which was unavailable (see Section 4.3). Therefore, DEA is the most appropriate method for airport efficiency estimation. The extensive use of DEA in the literature and the flexibility it has in combining with other methods in the second-stage analysis justify this decision and ensure the approach's reliability.

The second step of the data analysis is intended to identify the national macro-environmental factors that significantly affect the efficiency of the airports under study. As discussed in Chapter 3, many studies in the literature aimed to find a relationship between certain factors and the performance of airports by applying second-stage regression. In second-stage regression, external factors are econometrically regressed against the efficiency scores obtained from the first stage analysis. There are several techniques that can be used in second-stage regression; most of the airport studies that used DEA employed Tobit regression (e.g. Abbott and Wu, 2002; Barros and Sampaio, 2004; Gillen and Lall, 1997). However, after 2007, researchers started to use truncated regression coupled with Simar and Wilson's bootstrapping technique after Simar and Wilson (2007) claimed that Tobit regression is not an appropriate method to use and that bootstrapped truncated regression would overcome the ambiguous sequential correlation which could affect the two-stage analysis. Therefore, in this research, the truncated regression coupled with Simar and Wilson bootstrapping technique is the method chosen to conduct the second-stage regression. And Tobit regression is chosen to test for the robustness of the results of the bootstrapped truncated regression.

In the following sub-sections, a brief overview of DEA and Tobit regression is presented, in addition to the several essential assumptions made in this research.

4.2.1 Data Envelopment Analysis

The first step in the data analysis is airport efficiency estimation using DEA. Therefore, in this section, the model, characteristics, and assumptions of DEA applied in this research are described.

Data envelopment analysis was first developed by Charnes, Cooper, and Rhodes in the mid-1970s to estimate the efficiency of educational programmes designed for disadvantaged students (Charnes, Cooper and Rhodes, 1978). Since then, DEA has been applied in a wide range of areas, including education, military, agriculture, finance, and transport. By 2001, the number of academic articles using DEA in their methodology exceeded 500, as cited by Gattoufi, Oral and Reisman (2004). This led them to state that DEA has, without doubt, become a widely accepted and essential method (Gattoufi, Oral and Reisman, 2004).

The first DEA mathematical programming model developed is called the CCR model after its developers, Charnes, Cooper, and Rhodes. The CCR model uses the Pareto optimum concept to estimate the technical efficiency of DMUs. In the concept, an optimum multiplier of inputs and outputs is selected by each

DMU to increase its efficiency. However, since the maximum efficiency value is one, the multiplier value should be equal to or below one. One of the assumptions made by Charnes, Cooper and Rhodes (1978) is that an increase in the inputs would concurrently result in an increase in the outputs. This assumption is called ‘constant return to scales’ (CRS).

Later, Banker, Charnes and Cooper (1984) developed a model that resembles an extension to the CCR model. Their model is called the BCC model, again after the names of its developers. The BCC model assumes a variable return to scales (VRS), meaning that an increase in the inputs does not result in a simultaneous proportional change in the outputs.

To choose the appropriate model, it is necessary to establish some assumptions. These assumptions concern the type of data to be used and past knowledge and understanding of the targeted industry. First, the type of data should define the nature of the activities undertaken by the DMU under study. Second, it is crucial to assume the returns to scale that best fits the nature of the examined industry. The nature of these assumptions determines whether the model should adopt CRS or VRS. In the literature, the majority of studies that used DEA assumed VRS because of the presence of different sized airports in the dataset (Liebert and Niemeier, 2013). The third assumption is related to the orientation of the model, which determines the estimation of efficiency. There are two main model orientations used in DEA: input and output. An input-orientated model seeks to proportionally decrease the input vector while maintaining a constant output vector; whereas, the output-orientated model seeks to maximise the output vector while maintaining a constant input vector.

The majority of research on the efficiency of airports using DEA used the output-orientated model (Liebert and Niemeier, 2013). This is because such studies assume that once the investment in airport infrastructure has been completed, it is difficult for airport managers to reverse investment in order to reduce cost; this is essentially the inherent sunk cost aspect of airport investment. Therefore, it is better to utilise all the available resources to achieve the highest possible efficiency, or in other words, to achieve a higher level of output using the same amount of input. For all these reasons, the input-orientated model is thought to be inappropriate for this present research, and, thus, the output-orientated model is adopted in this study.

4.2.2 Bootstrapped Truncated Regression

Upon reviewing the literature of airport performance estimation using DEA, it is clear that it used to be a common approach to use Tobit regression to estimate the first-order approximation of the unknown true relationship as resembled in the following regression formula, in order to identify the significance of non-discretionary variables on the DEA efficiency scores:

$$\boldsymbol{TE_j} = \propto + \boldsymbol{Z_j \delta} + \boldsymbol{\varepsilon_j}, \qquad \boldsymbol{j = 1, \ldots, n} \qquad \textbf{Equation 4-1}$$

Where:

$\propto$ is the constant term

$\boldsymbol{\varepsilon_j}$ is error term (statistical noise)

$\boldsymbol{Z_j}$ are the observation-specific variables for DMU *j*

However, Simar and Wilson (2007) showed that this commonly used approach is not appropriate because it assumes the error terms to be independently distributed which is not a valid assumption since the efficiency score is empirically estimated and not directly observed. In addition, the DEA model estimates the production frontier based on the efficient DMUs in the sample dataset, which means that there might be other possible efficiency production units which were not observed in the sample dataset. Moreover, the second-stage regression uses non-discretionary variables which were not considered in the first stage efficiency measurement procedure, which means that the error term in the second stage must be correlated with these non-discretionary variables. Therefore, to overcome all these challenges, Simar and Wilson (2007) proposed a procedure which includes truncated bootstrapped second-stage regression which allows constant inference with models that explain the efficiency scores and at the same time generating standard errors and confident intervals for the measured efficiency scores.

Truncated regression with Simar and Wilson has been used in many airport DEA studies after 2007, and some of these studies are Adler, Ülkü and Yazhemsky (2013), Barros (2008), Barros and Dieke (2008), Chang, Yu and Chen (2013), Assaf and Gillen (2012), Gitto and Mancuso (2012), Merkert and Mangia (2014), and Tsekeris (2011).

4.2.3 Tobit Regression (Censored Regression)

The Tobit model is an econometric tool developed by Tobin (1958). It is considered a hybrid of the probit model and regression analysis. The Tobit model is an example of censored regression and was developed to estimate the relationship between a positive dependent variable and one or more independent variables. The independent variables should be different from the inputs and outputs and are not included in DEA.

Generally, when the dependent variable is left-censored (bounded from below), right censored (bounded from above), or censored from both sides, then Tobit regression is the appropriate tool (Fragoudaki and Giokas, 2016). Tobit regression has been used in many airport performance estimation studies that used DEA and included the relationship estimation between airport performance and exogenous factors (e.g. Abbott and Wu, 2002; Barros and Sampaio, 2004; Chi-Lok and Zhang, 2009; Fragoudaki and Giokas, 2016; Gillen and Lall, 1997; Perelman and Serebrisky, 2012; Ülkü, 2015; and Yoshida and Fujimoto, 2004).

In this present research, the main objective of using Tobit regression is to check for the robustness of the results of the bootstrapped truncated regression in identifying the national macro-environmental factors that contribute to the differences in the efficiencies of the airports, as explained in Chapter 3. In the first step of data analysis, DEA is conducted to measure the efficiency of the airports in the sample dataset. As mentioned in Section 4.2.1, the efficiency scores of the DMUs provided by DEA are between 0 and 1, with 1 being the most efficient. Therefore, the dependent variable in this research is bounded to the interval [0-1]. In this case, the general Tobit model, which reflects the situation in this study, is described in the following equation (Chi-Lok and Zhang, 2009; Fragoudaki and Giokas, 2016; Nahra, Mendez and Alexander, 2009; Shao and Lin, 2002):

$$Y^* = \alpha + \beta X_i + \varepsilon_i^* \qquad \text{Equation 4-2}$$

Subject to:

$$Y_i = \begin{Bmatrix} Y_i^* & if & 0 \leq Y_i^* \leq 1 \\ 0 & if & Y_i^* < 0 \\ 1 & if & Y_i^* > 1 \end{Bmatrix}$$

Where:

$\boldsymbol{Y_i}$ is the DEA efficiency score of the i^{th} DMU

$\boldsymbol{Y_i^*}$ is latent (unobserved) variable

$\boldsymbol{X_i}$ is the vector of explanatory variables

$\boldsymbol{\beta}$ is the vector of estimate parameters

$\boldsymbol{\varepsilon_i^*}$ is independent and identically normally distributed error terms

4.3 Data Sources

According to Section 4.1.4, the research strategy adopted by this study is archival research. This choice is because the data analysis in this research depends on secondary data sources. The type of variables used and the criteria followed in selecting them are explained in detail and justified in Chapters 5 and 6. However, in this section, the sources of data collected for DEA analysis in the first step, and the Tobit regression in the second step are presented.

4.3.1 Input and Output Variables for Data Envelopment Analysis

In the first step of the data analysis, the input and output variables describing the physical and financial characteristics of the airports are used in the DEA to measure the efficiency of the airports. The data on these variables are obtained from the Air Transport Research Society (ATRS) Global Airports Benchmarking Databases for the years 2009 and 2015 (ATRS, 2010, 2016).

The ATRS was launched by a group of researchers in 1995 during the 7th Triennial World Conference on Transport Research Society in Sydney, Australia. This society brings together air transport researchers from all over the world and organises conferences to share and exchange ideas and results. The members of this society include leading academics and industry experts in all areas of the aviation industry.

Since 2002, the ATRS has been creating Global Airports Benchmarking Databases, which compile information on the physical characteristics, traffic, capacity, and financial data of significant airports and airport groups in the Asia Pacific, Europe, and North America. These databases are considered the most complete and comprehensive for academic research purposes. The sources of the data present in the ATRS databases are listed in Table 4-3.

Table 4-3 ATRS Database Data Sources

Data	Sources
Traffic Statistics	
Number of airport passengers: domestic, international, transit Cargo traffic in metric tonnes: domestic, international Aircraft movements: scheduled commercial, air taxi, GA and military, total	Airport annual reports and websites ACI Online Traffic Statistics ICAO Airport Traffic Air Transport Intelligence (ATI) Online Database
Airport Capacity and Number of Employees	
Number of runways Terminal area Number of gates Number of check-in desks Number of employees (full-time equivalent)	IATA Demand / Capacity Profile Airport annual reports, newsletters, and websites ATI Online Database Request directly from airports ACI
Revenue and Expenses	
Revenues: aviation, concession, parking, other non-aviation, etc. Expenses: personnel, depreciation, amortisation, other expenses Balance sheet information: asset, liability, equity, debt, etc.	Airport annual reports/financial reports and websites US FAA Form 5100-127 ICAO Airport and Route Facilities: financial data ACI
Other Data	
Exchange rates Purchasing Power Parity Country specific GDP deflators	International Financial Statistics online database Pacific Exchange Rate Services World Bank's World Development Indicators Individual countries' statistics yearbooks

Source: (ATRS, 2011)

The ATRS Global Airports Benchmarking Database is issued every year during the annual ATRS World Conference and made available for purchase by interested researchers, institutions, and organizations.

4.3.2 National Macro-Environmental Factors

To identify the national macro-environmental factors that significantly affect the efficiency of the airports, it is necessary to find data that describes country-level national competitiveness, the safety and security environment, corruption levels, socio-economic settings, and air transport output. Therefore, quantitative data on 17 variables that are part of the country-level macro-environment were collected from secondary data sources, including online published international agencies reports such as the World Economic Forum (WEF) Global Competitiveness Report (GCR); the WEF Travel and Tourism Index Report; the United Nations Development Programme (UNDP) Human Development Index Report; the Institute for Economics and Peace (IEP) Global Peace Index Report (GPI); and the Transparency International (TI) Corruption Perception Index Report. Other source is a PhD thesis submitted at Cranfield University (Itani, 2015), from which data on air transport sector output is obtained.

These 17 variables will be first exposed to multi-collinearity test to make sure the list of variables that will be used in the second-stage regression has minimal level of collinearity. This will be further discussed in section 6.2.2 in Chapter 6.

4.4 Framework Development Process

The core of this research in presented in the Data Analysis Methodologies (Chapters 5 and 6) where research design, philosophy, and methodologies mentioned in this chapter are applied. After estimating the performance of airports using DEA in Chapter 5 and identifying the national macro-environmental factors that significantly influence the performance of the airports in Chapter 6, the identified variables be used in Chapter 7 to develop a preliminary framework for airport ownership and management model selection based on national macro-environmental approach. This will be done by conducting filtering and grouping processes to the efficient airports and identifying the optimum national macro-environmental area of each airport ownership and management model. This will be further explained in Chapter 7.

4.5 Research Structure Diagram

The overall structure of this research is illustrated in Figure 4-3. The research began by formulating research questions influenced by the research motivation (Industrial Observations), followed by setting the main research aims and objectives as in Chapter 1, section 1.1. Then, a systematic literature review was conducted on airport performance estimation studies to identify the research gaps, and justify the selection of the performance estimation method, models, and input and output variables. This fulfils Objectives 1 and 2.

Then, data collection process began. In this research, the data collection process was divided into two steps. The first step was to collect data on the input and output variables of worldwide international airports. The second step was to collect data on national macro-environmental factors. Consequently, there are two steps for data analysis. In the first step, the data on input and output variables of the airports are used in DEA to measure the efficiency of those airports. This step fulfils Objective 3. Before commencing with the second step, a multicollinearity test is applied to the set of macro-environmental factors to ensure that there is a minimal level of multicollinearity between the factors. If there is multicollinearity, an iterative elimination process must be conducted to eliminate the highly correlated factors and to achieve an ideal set, which has a minimum level of collinearity. In the second step of data analysis, the final set of national macro-environmental factors are regressed against the airport efficiency scores obtained from the DEA using bootstrapped Truncated regression. The result of this step is the identification of the national macro-environmental factors that significantly affect the efficiency of the airports. This step fulfils Objective 4.

Once the factors are identified, the efficient airports with their respective significant national macro-environmental factors are clustered into three groups based on their ownership and management model (100% private, mixed private/public, and 100% public). In each group, the minimum and the maximum value of each of the identified national macro-environmental factors are captured and a radar chart that includes the minimum and the maximum boundaries based on the capture values is constructed. The area between the minimum and the maximum boundary in the radar chart represents the best performing area of the respective airport ownership and management model based on the national macro-environmental factors. This step fulfils Objective 5.

Finally, the best performing areas identified in the previous step are used to develop a framework for governments or civil aviation authorities to choose the most appropriate airport ownership and management model based on the country's national macro-environmental setting.

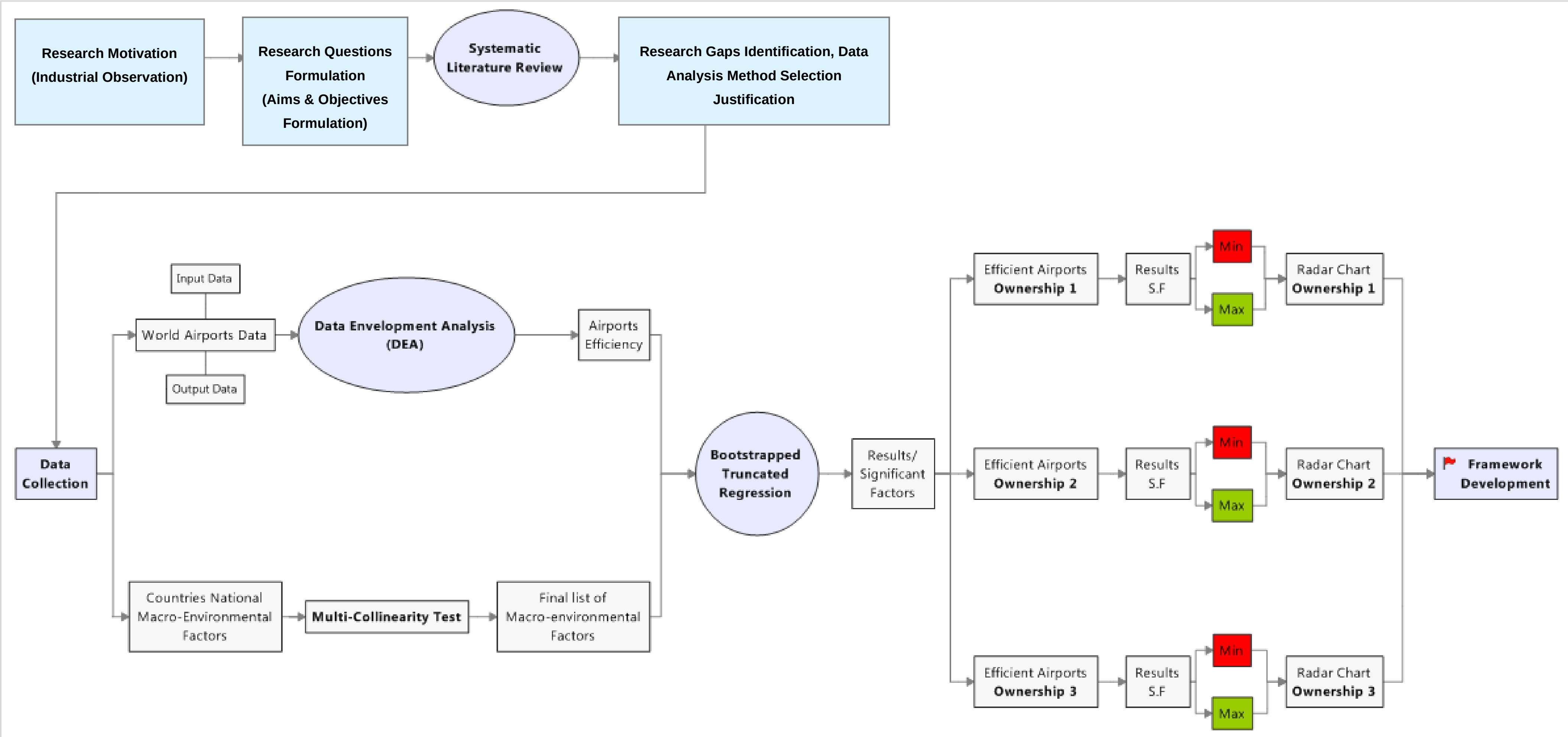

Figure 4-3 Research Structure and Plan

4.6 Summary

In this chapter, the common research philosophical approaches followed in business and management studies were defined, including philosophical research assumptions, philosophical stances, approaches, strategies, choices, and time horizons. In each element of the philosophical research approach, different options were discussed, and the position of this present research among the available options was highlighted. Consequently, this research follows objective positivism, which regards the airport as an objective and an external entity. Furthermore, this research adopts a deductive approach and follows an archival research strategy. Cross-sectional data on airports are collected from secondary data sources. This research conducts quantitative data analysis methods, namely DEA and Tobit regression, to identify the national macro-environmental factors significantly affecting the efficiency of airports. The DEA and Tobit regression methods were defined, and their fundamental aspects were presented. Finally, the sources from which the data were collected were highlighted, and the overall structure of the research structure was illustrated.

5 CHAPTER FIVE: EVALUATING THE TECHNICAL EFFICIENCY OF MAJOR INTERNATIONAL AIRPORTS USING DATA ENVELOPMENT ANALYSIS (DEA)

5.1 Introduction

The main objective of this chapter is to obtain the efficiency scores of a set of international airports in the world using DEA. Section 5.2 explains the selection of the DEA model and its respective assumptions and equations. Then, the selection process of the input and output variables, the final set of the selected variables, and the process of constructing the airports' dataset are all presented in section 5.3. The empirical results of the DEA are provided in section 5.4, followed by a discussion in section 5.5. Finally, this chapter ends with a summary in section 5.6.

5.2 The DEA Model

DEA is used to measure the efficiency of a sample of DMUs. Each DMU functions as a system that uses multiple inputs to produce multiple outputs. It is essential to have homogeneity in the selection of DMUs, and this is because it is not possible to analyse and compare organizations from very different sectors of the economy. Therefore, the DMUs in the dataset should be performing similar activities and generating similar outputs Dyson et al. (2001). As mentioned in chapters 3 and 4, the advantage of DEA is that it uses linear programming approach to automatically construct a linear frontier based on the efficient DMUs of the sample dataset. So, DEA does not require to pre-specify the functional form of the production frontier (Liebert and Niemeier, 2013). The efficiency scores of the DMUs' are measured against the automatically constructed frontier that is determined by the most efficient DMUs in the sample.

Two types of DEA model are generally used: input-oriented and output-oriented. An input-oriented DEA model seeks to decrease the inputs in a proportional manner while keeping the outputs constant. However, an output-oriented DEA model seeks to maximise the outputs generated while keeping the inputs at the same level. The decision of whether to adopt an input or output-oriented model is heavily influenced by the type of the industry that is being analysed. According to the literature, as mentioned in Chapter 4, the most appropriate model that has been used extensively in the airport performance studies is the output-oriented model. The reason lies in the fact that it is not logical for airport managers to save costs by disinvesting and underutilising the already built airport infrastructure (Liebert and Niemeier, 2013).

It is also essential to make assumptions regarding the returns to scale that best fit the nature of the industry under study. There is three primary return to scale models: Constant Return to Scale (CRS), Variable Return to Scale (VRS), and the additive model. The CRS model assumes that the outputs will vary by the same proportion when initiating a change in the inputs. Also, the CRS model measures the overall efficiency of each DMU in the dataset. On the other hand, in the VRS model, it is assumed that there could be decreasing, constant, and increasing returns to scale, and it measures the pure technical efficiency of each DMU. Again, in the literature, VRS is adopted by the majority of studies that conducted DEA to measure the efficiency of the airports. This is because datasets usually include different sizes of airports (Liebert and Niemeier, 2013).

In this study, both CRS and VRS models are conducted. This research also assumes that the level of the input variables remains constant while the efficiency of an airport is sought to increase. Therefore, the output-oriented approach is adopted.

In the basic CCR model, the efficiency of a DMU is measured by calculating the maximum of the ratio of the sum of the weighted outputs to the sum of the weighted inputs is resembled in Equation 5-1:

$$H_o = Max_{u_r,v_i} \frac{\sum_{r=1}^{m} u_r \, y_{ro}}{\sum_{i=1}^{n} v_i \, x_{io}}$$

Equation 5-1

Subject to $$\frac{\sum_{r=1}^{m} u_r y_{rj}}{\sum_{i=1}^{n} v_i x_{ij}} \leq 1 \quad j = 1, 2, 3, \dots, n.$$

$$u_r v_i \geq 0; \quad r = 1, 2, 3, \dots, m; \quad i = 1, 2, 3, \dots, n.$$

Where;

H_o: DEA efficiency index of an airport

y_{rj}: Positive known output of the j^th^ DMU

x_{ij}: Positive known input of the j^th^ DMU

u_r, v_i: Weights of the input and output variables to be calculated by the model

The DEA-BCC model is calculated as per Equation 5-2:

$$\theta = max\ \varphi + \varepsilon \left[\sum_{r=1}^{m} s_{ro}^{+} + \sum_{i=1}^{n} s_{io}^{-} \right]$$ **Equation 5-2**

Subject to $$\sum_{r=1}^{m} y_{rj} \lambda_j - s_{ro}^{+} = \varphi y_{ro} \quad r = 1, 2, 3, \dots, m;$$

$$\sum_{i=1}^{n} x_{ij} \lambda_j + s_{io}^{-} = x_{io} \quad i = 1, 2, 3, \dots, n;$$

$$\sum_{r=1}^{m} \lambda_j = 1; \quad \lambda_j \geq 0; \quad j = 1, 2, 3, \dots, l.$$

Where;

θ: DEA efficiency index of an airport

ε: Constant (greater than zero)

s_{ro}^{+}: Output slack of the DMU

s_{io}^{-}: Input slack of the DMU

λ_j: Dual variable or the scalar vector related with each DMU

According to Cooper, Seiford, & Tone (2006), when θ is equal to unity and the slacks of the inputs and outputs are equal to zero (s_{ro}^{+}= 0, $s_{io}^{-} = 0$), this means that the DMU falls on the production function, and therefore, it is considered to be an efficient DMU. However, a DMU is considered to be technically inefficient when θ is below one. In this case, it means that the DMU is producing below the production function.

5.3 Selection of Input and Output Variables

The first stage of data collection started just after setting the main objectives of this research. As mentioned before, the DEA requires input variables and output variables for a set of Decision-Making Units (DMU). The nature of the input and output variables should define the nature of the DMU under study. In this research, the DMU is an airport, so the input and output variables should describe the functionality of an airport.

Therefore, two main criteria for choosing the input and output variables are used in the DEA. The first criterion is based on the most used combination of variables in airport efficiency estimation using DEA in the literature. The second is the availability of data.

In the literature, 41 key journal papers that have used DEA to estimate the efficiency of airports in the past 20 years were collected. These papers were examined thoroughly, and the combinations of input and output variables used were recorded. Appendix A lists all the variables used in each journal paper.

5.3.1 Output Variables in the Literature

Traditionally, studies conducted on airports have focused on aeronautical activities only. Gillen and Lall (1997), the first study to introduce DEA into the airports' sector, used output variables which represent the aeronautical activities of 21 US major airports in the years between 1989 and 1993. These variables are physical data such as the number of passengers (PAX), the number of air traffic movements (ATM), and the volume of cargo.

The inclusion of aeronautical variables only continued in the airport DEA studies published in the first few years of the 21st century. Some examples of these studies are Abbott and Wu (2002), Barros and Sampaio (2004), Fernandes and

Pacheco (2002), and Pels, Nijkamp and Rietveld (2001). However, with the increasing interest in the non-aeronautical activities at airports at the beginning of the 21st century, researchers started to include output variables that represent non-aeronautical activities. Such variables are non-aeronautical revenues, or in some papers, total revenues were included. Barros and Dieke (2007), Chen, Lai and Piboonrungroj (2017), Pacheco et al. (2006), and Lai et al. (2015) are examples of studies that included non-aeronautical revenues as an output variable in their airport efficiency estimation using DEA. Although non-aeronautical activities started to be included in the DEA analysis, some recently published papers have ignored them. For example, Barros and Assaf (2009), Chi-Lok and Zhang (2009), Fung et al. (2008), and Lam, Low and Tang (2009) are all papers that have not included non-aeronautical variables in their DEA. Thus, a concern was raised by Liebert and Niemeier (2013) that biased results could be the consequence of not including the non-aeronautical activities in an analysis where the total number of employees and capital are included. In this case, attention should be given to separate between the aeronautical and non-aeronautical activities.

Typically, the output variables that were included in airport DEA studies are desirable outputs only. In other words, PAX, ATM, the volume of cargo, and non-aeronautical revenues are thought to be advantageous to any airport. So any increase in these variables would be the desire of any airport management. However, some studies were interested in including undesirable outcome variables in the analysis. The point of view of these studies is that the efficiency results of airports would be biased if they were analysed using only the desirable outputs. An example of these undesirable output variables is the delay which was included in the analysis of US airports done by Pathomsiri et al. (2008). The result of this study shows that delays affect the technical efficiency of airports. Another example is aircraft noise. It was included by Yu (2004) in an analysis of the efficiencies of 14 domestic airports in Taiwan. The result of this study shows that aircraft noise affects the technical efficiency of airports as well. Unfortunately, including undesirable outputs in the analysis of cross-border airports poses a significant challenge due to a scarcity of data on these particular airport outputs.

5.3.2 Input Variables in the Literature

When it comes to the input variables, there are two typical categories used in the literature. These are the physical operating inputs such as the number of staff or employees, and the capital physical inputs such as the number of runways, number of gates, size of the terminals, and length of the runway etc. Some studies have only included inputs of physical data in their analysis such as in Abbott and Wu (2002), Chen, Lai and Piboonrungroj (2017), Fung et al. (2008), Lin and Hong (2006) and Tovar and Martín-Cejas (2010). Other studies have included financially measured inputs related to materials or other services which are outsourced such as the other operational costs. Examples of these studies are Barros and Dieke (2008), Barros and Weber (2009), Bazargan and Vasigh (2003), Martín and Roman (2008), Lam, Low and Tang (2009), and Martín, Román and Voltes-Dorta (2009).

One of the most contested issues in the determination of appropriate input variables in the literature is in relation to the number of employees. Some studies like Fung et al. (2008), Pels, Nijkamp and Rietveld (2003), and Yoshida (2004) have argued that employees and capital are complementary to each other, so they ignored employees and included capital instead. However, Liebert and Niemeier (2013) refuted this argument and reasoned that the baggage handling systems and employees are substitutes and not considered complementary. On the other hand, the number of employees was included as an input variable in the majority of the studies that have used DEA like in Abbott and Wu (2002), Barros and Sampaio (2004), Graham and Holvad (2000), and Pacheco et al. (2006). Another argument was made by some studies that the number of employees is a broad figure which cannot differentiate between the full time and part-time employees. Therefore, Assaf (2010), Chen, Lai and Piboonrungroj (2017), Oum et al. (2004), and others have used the average number of full-time employees, or in other words the Full-Time Equivalent (FTE) employees. The reason why many studies use the general number of employees is that the data on FTE employees are scarce and very difficult to find in annual reports or open sources databases.

The price of labour, or staff costs, is another input variable that has been included in some studies. In most cases, the price of labour was included along with the number of employees in DEA to estimate to allocative efficiency (e.g. Barros and Sampaio, 2004; Lam, Low and Tang, 2009; Pacheco et al., 2006; Pacheco and Fernandes, 2003). However, it is essential to pay attention to adjusting the price of labour for a different price of labour levels when assessing cross-border airports.

One of the most difficult challenges in airport efficiency estimation is the inclusion of the physical capital value as an input variable. The difficulty lies in the problems that arise from comparing the data of cross-border airports due to different national accounting techniques. Therefore, most of the studies that have included the value of physical capital in their analysis were nationwide studies. For example, Barros and Sampaio (2004) included the price of capital as an input in a DEA study of 10 airports in Portugal. Some studies like Abbott and Wu (2002), Barros and Sampaio (2004), Barros and Weber (2009), and Murillo-Melchor (1999) have used the capital stock variable instead. However, the capital stock does not include the depreciation cost, which in this case could cause bias when having earlier built airports and recent ones in the same sample set. Other studies like Hooper and Hensher (1997) have used the perpetual inventory method (PIM), which takes into consideration the capital stock along with the anticipated lifecycle. Again, it is challenging to use this method when assessing cross-border airports because of the different considerations between countries and the considerable time it consumes (Liebert and Niemeier, 2013).

5.3.3 Identifying the mostly used input and output variables in the literature

The first criterion for selecting the set of input and output variables is based on the most used combination in the DEA studies in the literature. Therefore, after carefully examining the studies in the literature, 37 different input variables and

21 different output variables were found at least once in 41 key journal papers. Among the 37 input variables; six variables were used more frequently. Also, out of 21 output variables, four variables recorded the highest frequency of use. Table 5-1 shows the most used input and output variables and their frequencies.

The number of employees is the most frequently used input variable. It has been used in 19 out of 41 DEA studies in the literature. This is followed by the size of the terminal (17 times), number of runways (13 times), other operational costs (13 times), the price of labour (11 times), and finally the number of gates (10 times).

The output variable with the highest frequency is the number of passengers (29 times). The volume of cargo comes in second place (22 times). Then the number of air traffic movement and the non-aeronautical revenues come in the third and fourth place (20 and seven times respectively).

Table 5-1 Most-used input and output variables in DEA studies in the literature

Input Variables	Frequency	Output Variables	Frequency
Number of employees	19	Number of passengers	29
Terminal size in m^2	17	Volume of cargo	22
Number of runways	13	Number of air traffic movement	20
Other operational costs	13	Non-aeronautical revenues	7
Price of Labour	11		
Number of gates	10		

The set of input and output variables has to be further refined after completing the second criterion, which is the availability of the data. Therefore, the next step is collecting data on major international airports around the world, focusing on collecting information on the set of identified variables shown in Table 5-1.

5.3.4 Constructing major international airports' dataset

The national macro-environmental approach of this study requires the airports' sample dataset to include airports outside the borders of a single country. Therefore, the primary target was to collect information on as many major international airports as possible from all over the world, including airports of the MENA region where the trigger for this researcher started. The first attempt started by creating a list of all the registered international airports in the 192 member states of the International Civil Aviation Organization (ICAO) (ICAO, 2018). This was done using ICAO Data+. Then, information on the annual number of passengers, air traffic movement, and volume of cargo was collected to identify the major international airports in the list. The initial sample dataset included 384 international airports around the world.

At this stage, information on the input and output variables for each airport started to be collected. The first plan was to construct panel data which included information on the airports in the list for years from 2012 to 2016. Airport official websites published annual reports, CAPA centre for aviation databases, and other open-source databases were all used for the data collection. However, it proved very challenging to access information on some variables for the majority of the airports. The number of passengers, number of air traffic movement and number of runways were the simplest to collect.

On the other hand, there were significant information gaps on terminal size, the number of employees, other operational costs, the price of labour, the number of gates, and the non-aeronautical revenues for the majority of the airports. Although some variables like the number of employees were available for some airports, it was clear that there exists a discrepancy in reporting the figures. While some airports report the total number of employees working in the vicinity of the airport, other airports report the number of employees working for the airport operator or the number of full-time employees only. This inconsistency in data presents significant concerns regarding the research in relation to potentially inconsistent and incredible results.

The second plan was to look for complete, consistent, and credible airport databases for research purposes. The choice fell for on the Air Transport Research Society (ATRS) airports annual databases. ATRS is a politically autonomous association which aims to simplify the development, interchange, and distribution of aviation research concepts between several constituent organizations. These constituents include academic researchers, governmental executives, and industry leaders (ATRS, 2014). One of the products of this association is the ATRS global airport performance benchmarking database. These databases contain information on airports' performance, and they are considered to be the complete airports' database among aviation researchers. They cover over 200 airports in Asia Pacific, Europe and North America. Unfortunately, complete data on MENA airports are not available neither in the ATRS databases, nor in any other credible source. In addition, collecting data through direct contact with the management of some airports in the MENA region was not successful. The common reason is the confidentiality of these data. Therefore, airports of the MENA region were excluded from this research.

The first database was produced in the year 2003, which covers data from the 2002 financial year. The data included in the databases are presented in five categories:

- **Traffic data:** This category includes information on passengers, air traffic movements, and cargo volumes.
- **Airport capacity and employees:** This category contains data on the number of runways, size of the terminals, number of gates, number of check-in desks, and number of full-time equivalent employees.
- **Expenses and revenues:** This include information on airport revenues, including aeronautical, non-aeronautical, concession etc. Also, airport expenses with all its categories.
- **Other data:** yearly average exchange rates, GDP deflators for each country, etc.

The sources of these data are credible organizations like International Civil Aviation Organization (ICAO), Airport Council International (ACI), International

Air Transport Association (IATA), Air Transport Intelligence (ATI), Federal Aviation Administration (FAA), and World Bank. Other sources are airport annual reports, airport official websites, and some data were requested directly from the airports using surveys.

ATRS databases are highly trusted among aviation researchers and industry executives. They have been used in many airport performance and benchmarking studies like in Chen, Lai and Piboonrungroj (2017), Lai et al. (2015), Oum and Yu (2004), Oum, Yu and Fu (2003), etc. They were used in books such as Airport Economics in Latin America & the Caribbean authored by Serebrisky (2011) and published by The World Bank. They were also used in PhD research such as Vogel (2004).

Through searching the archive of the Centre for Air Transport Management at Cranfield University, it was only possible to find the ATRS global airport benchmarking database of the financial year 2009. In this database, 176 airports from 4 different areas around the world are included as following:

- 63 airports from North America
- 7 airports from Latin America and the Caribbean
- 45 airports from Europe
- 41 airports from the Asia Pacific

However, the North American airports were excluded from this research sample dataset. The reason is that the ownership and management model of US airports is unique. Although most of the airports in the US have been owned and managed by municipalities or regional administrations, they cannot be together in the same basket with the publically owned and managed airports in the rest of the world. This is due to the vast influence of the private sector on management resolutions regarding significant activities of the airport and investments. For instance, the central sponsoring bodies of some significant airport development and expansion projects in the US are the primary tenant carriers, which give them the right to interfere and control the airports' financial and development strategies Oum, Yan and Yu (2008). Therefore, it would not be possible to compare US airports with any other airports in the world when it comes to the ownership and management models.

The airports of Latin America and the Caribbean were also excluded due to missing information on the number of employees and non-aeronautical revenues.

For the remaining 86 airports in Europe and the Asia Pacific, 55 airports were excluded due to missing information on some variables and only 31 airports were included in this research sample dataset.

After examining the availability of data on the input and output variables in Table 5-1 in the database, it was decided to exclude two input variables which are the price of labour and the other operational costs due to missing data for the majority of the airports in the database. Therefore, the final set of input and output variables to be used in the DEA model is shown in Table 5-2.

Table 5-2 Final sets of input and output variables for DEA

Input Variables	Output Variables
Number of employees (EMP)	Number of passengers (PAX)
Terminal size in m2 (TS)	Volume of cargo (Cargo)
Number of runways (RWY)	Number of air traffic movement (ATM)
Number of gates (Gates)	Non-aeronautical revenues (NA Rev)

To check the validity of the selected combination of variables in Table 5-2, an isotonicity test is conducted. The concept of this test is to check whether the output variables are correlated with the input variables with positive significance as required by Charnes et al. (1985). This means that when increasing the input, the output should not decrease. Therefore, the isotonicity test conducted in this research is a correlation coefficient analysis which determines the relationship between the input and output variables. The results of the correlation coefficient analysis are presented in Table 5-3. The results show that all the coefficients between the input and output variables are positive, and the majority are significant. Therefore, these results show that variables selected in Table 5-2 pass the isotonicity test, and therefore, they are valid to use in the DEA.

Table 5-3 Correlation coefficients analysis between input and output variables

	Input variables			
Output variables	RWY	Gates	TS	EMP
PAX	0.625**	0.790**	0.794**	0.629**
ATM	0.673**	0.828**	0.764**	0.665**
Cargo	0.196	0.180	0.647**	0.265
NA Rev	0.527**	0.686**	0.787**	0.694**
**** Significant correlation at alpha=0.05**				

To increase the number of observations in the sample dataset, the 2015 ATRS global airport benchmarking database was purchased by the Centre for Air Transport Management at Cranfield University. This database includes 124 airports around the world. Again, due to missing data on some variables and the exclusion of other secondary airports, only 28 airports were chosen to be included in the sample dataset. Therefore, after obtaining the 2015 ATRS database, the number of observations in the sample dataset was raised to 59. The airports included in the sample dataset of this research are listed in Table 5-4. The decision to purchase the database of year 2015 is not intentional, but because it was the latest database to be published by ATRS. The budget for this research allowed for the purchase of only one database due to its high expense.

Therefore, the access to the databases was only available for years 2009 and 2015. Although some airports are present in both years, this research assumes airports from both years as if they were different airports. This is because the main aim of estimating the efficiency of the airport is to relate it to the national macro-environmental factors of the country later in Chapter 6 and not to study the change of the efficiency over time.

One of the most critical issues in DEA is the ratio of the number of observations or DMUs to the aggregate number of input and output variables. This ratio is shown in Equation 5-3:

$$R = \frac{N}{\sum I + \sum O}$$

Equation 5-3

Where;

R: Ratio

N: Total number of observations

$\sum I$: Total number of input variables

$\sum O$: Total number of output variables

Seiford and Thrall (1990) and Pedraja-Chaparro et al. (1999) stated that in the case when the ratio is low, the discriminatory power of the DEA model weakens. In the literature, this problem has been addressed, and some rules of thumb were produced. These rules are:

- **Rule 1:** R should be larger than 2 (Golany and Roll, 1989)
- **Rule 2:** R should be larger than 3 (Bankers, 1989; Cooper et al., 2007)

In this research, the DEA model attains a ratio (R) of 7.4, which satisfies both Rule 1 and Rule 2 as the sample dataset includes 59 statistical observations with 4 output and 4 input variables.

Table 5-4 Airports Sample Dataset

DMU	IATA Code	Airport Name	Country	Year
1	SYD	Sydney Kingsford Smith International Airport	Australia	2009
2	VIE	Vienna International Airport	Austria	2009
3	BRU	Brussels International Airport	Belgium	2009
4	CAN	Guangzhou Bai Yun Airport	China	2009
5	CPH	Copenhagen Kastrup International Airport	Denmark	2009
6	HEL	Helsinki Vantaa International Airport	Finland	2009
7	CDG	Paris Charles de Gaulle International Airport	France	2009
8	FRA	Frankfurt Main International Airport	Germany	2009
9	MUC	Munich International Airport	Germany	2009
10	ATH	Athens International Airport	Greece	2009
11	BUD	Budapest Ferihegy International Airport	Hungary	2009
12	KEF	Keflavik International Airport	Iceland	2009
13	DUB	Dublin International Airport	Ireland	2009
14	FCO	Rome Leonardo Da Vinci/Fiumicino Airport	Italy	2009
15	KIX	Kansai International Airport	Japan	2009
16	HND	Tokyo International Airport	Japan	2009
17	KUL	Kuala Lumpur International Airport	Malaysia	2009
18	AMS	Amsterdam Schiphol International Airport	Netherlands	2009
19	AKL	Auckland International Airport	New Zealand	2009
20	OSL	Oslo Airport	Norway	2009
21	WAW	Warsaw Chopin Airport	Poland	2009
22	LIS	Lisbon Portela Airport	Portugal	2009
23	SIN	Singapore Changi International Airport	Singapore	2009
24	MAD	Madrid Barajas International Airport	Spain	2009
25	ARN	Stockholm Arlanda International Airport	Sweden	2009
26	ZRH	Zurich International Airport	Switzerland	2009
27	GVA	Geneva Cointrin International Airport	Switzerland	2009
28	BKK	Suvarnabhumi Airport	Thailand	2009
29	IST	Istanbul Ataturk International Airport	Turkey	2009
30	LHR	London Heathrow International Airport	UK	2009
31	MAN	Manchester International Airport	UK	2009
32	MEL	Melbourne Airport	Australia	2015

DMU	IATA Code	Airport Name	Country	Year
33	VIE	Vienna International Airport	Austria	2015
34	CAN	Guangzhou Bai Yun Airport	China	2015
35	CPH	Copenhagen Airport Kastrup	Denmark	2015
36	TLL	Lennart Meri Tallinn Airport	Estonia	2015
37	HEL	Helsinki Vantaa Airport	Finland	2015
38	CDG	Paris Charles de Gaulle Airport	France	2015
39	FRA	Frankfurt Airport	Germany	2015
40	MUC	Munich Airport	Germany	2015
41	ATH	Athens International Airport	Greece	2015
42	KEF	Keflavik International Airport	Iceland	2015
43	DUB	Dublin International Airport	Ireland	2015
44	FCO	Rome Leonardo Da Vinci/Fiumicino Airport	Italy	2015
45	KIX	Kansai International Airport	Japan	2015
46	HND	Haneda Airport	Japan	2015
47	AMS	Amsterdam Schiphol International Airport	Netherlands	2015
48	CHC	Christchurch International Airport	New Zealand	2015
49	LIS	Lisbon Portela Airport	Portugal	2015
50	BTS	Bratislava Milan Rastislav Stefanik Airport	Slovakia	2015
51	LJU	Ljubljana Jože Pučnik Airport	Slovenia	2015
52	ICN	Incheon International Airport	South Korea	2015
53	MAD	Madrid Barajas Airport	Spain	2015
54	CMB	Bandaranaike International Airport	Sri Lanka	2015
55	ZRH	Zurich Airport	Switzerland	2015
56	GVA	Genève Aéroport	Switzerland	2015
57	IST	Istanbul Atatürk Airport	Turkey	2015
58	LHR	London Heathrow Airport	UK	2015
59	MAN	Manchester International Airport	UK	2015

For each DMU listed in Table 5-4, information on the input and output variables have been collected. The full dataset is presented in Appendix B. Table 5-5 represents the summary statistics of the input and output variables of the DEA model

Table 5-5 Summary statistics of input and output variables of the DEA model

Variables	Mean	Std. Dev	Min	Max	Skewness	Kurtosis
Inputs						
RWY	2.54	1.039	1	6	1.134	2.559
Gates	89.29	58.564	12	226	0.923	-0.014
TS	349060	326660	13000	1523886	1.641	2.748
EMP	2431.92	3238.71	200	17441	3.169	1.805
Outputs						
PAX	1.53E+07	2.26E+07	1438304	7.50E+07	1.363	0.635
ATM	2.53E+05	1.33E+05	24622	5.18E+05	0.245	-0.840
Cargo (Tons)	5.97E+05	6.82E+05	10140	2.49E+06	1.272	0.401
NA Rev ($)	4.41E+08	4.36E+08	9.80E+08	1.79E+099	1.579	1.832

Sources: ATRS (2010, 2016)

5.4 Empirical Results

The results, shown in Table 5-6 below, were obtained through the use of PIM Ver. 3.2 software, for both constant returns to scale (CRS) and variable returns to scale (VRS) models.

Table 5-6 Efficiency scores of airports included in the sample

DMU	Code	Year	Airport Name	Efficiency (CRS)	Efficiency (VRS)
AP001	SYD	2009	Sydney Kingsford Smith International Airport	1.000	1.000
AP002	VIE	2009	Vienna International Airport	1.000	1.000
AP003	BRU	2009	Brussels International Airport	0.963	0.986
AP004	CAN	2009	Guangzhou Bai Yun Airport	0.996	1.000
AP005	CPH	2009	Copenhagen Kastrup International Airport	1.000	1.000
AP006	HEL	2009	Helsinki Vantaa International Airport	0.804	0.822
AP007	CDG	2009	Paris Charles de Gaulle International Airport	1.000	1.000
AP008	FRA	2009	Munich International Airport	1.000	1.000
AP009	MUC	2009	Frankfurt Main International Airport	1.000	1.000
AP010	ATH	2009	Athens International Airport	1.000	1.000
AP011	BUD	2009	Budapest Ferihegy International Airport	0.732	0.741
AP012	KEF	2009	Keflavik International Airport	0.555	1.000
AP013	DUB	2009	Dublin International Airport	1.000	1.000
AP014	FCO	2009	Rome Leonardo Da Vinci/Fiumicino Airport	0.741	0.814
AP015	KIX	2009	Kansai International Airport	1.000	1.000
AP016	HND	2009	Tokyo International Airport	1.000	1.000
AP017	KUL	2009	Kuala Lumpur International Airport	0.591	0.638
AP018	AMS	2009	Amsterdam Schiphol International Airport	1.000	1.000
AP019	AKL	2009	Auckland International Airport	1.000	1.000
AP020	OSL	2009	Oslo Airport	1.000	1.000
AP021	WAW	2009	Warsaw Chopin Airport	0.378	0.519
AP022	LIS	2009	Lisbon Portela Airport	0.573	0.614
AP023	SIN	2009	Singapore Changi International Airport	0.815	1.000
AP024	MAD	2009	Madrid Barajas International Airport	0.763	0.991
AP025	ARN	2009	Stockholm Arlanda International Airport	0.866	0.893
AP026	ZRH	2009	Zurich International Airport	0.921	1.000
AP027	GVA	2009	Geneva Cointrin International Airport	1.000	1.000
AP028	BKK	2009	Suvarnabhumi Airport	0.849	0.891
AP029	IST	2009	Istanbul Ataturk International Airport	0.654	0.799
AP030	LHR	2009	Manchester International Airport	1.000	1.000
AP031	MAN	2009	London Heathrow International Airport	1.000	1.000

DMU	Code	Year	Airport Name	Efficiency (CRS)	Efficiency (VRS)
AP032	MEL	2015	Melbourne Airport	1.000	1.000
AP033	VIE	2015	Vienna International Airport	1.000	1.000
AP034	CAN	2015	Guangzhou Bai Yun Airport	1.000	1.000
AP035	CPH	2015	Copenhagen Airport Kastrup	0.788	0.804
AP036	TLL	2015	Lennart Meri Tallinn Airport	0.490	0.630
AP037	HEL	2015	Helsinki Vantaa Airport	1.000	1.000
AP038	CDG	2015	Paris Charles de Gaulle Airport	1.000	1.000
AP039	FRA	2015	Frankfurt Airport	1.000	1.000
AP040	MUC	2015	Munich Airport	1.000	1.000
AP041	ATH	2015	Athens International Airport	1.000	1.000
AP042	KEF	2015	Keflavik International Airport	0.633	0.954
AP043	DUB	2015	Dublin International Airport	1.000	1.000
AP044	FCO	2015	Rome Leonardo Da Vinci/Fiumicino Airport	0.803	0.814
AP045	KIX	2015	Kansai International Airport	1.000	1.000
AP046	HND	2015	Haneda Airport	1.000	1.000
AP047	AMS	2015	Amsterdam Schiphol International Airport	1.000	1.000
AP048	CHC	2015	Christchurch International Airport	0.696	1.000
AP049	LIS	2015	Lisbon Portela Airport	0.745	0.865
AP050	BTS	2015	Bratislava Milan Rastislav Stefanik Airport	0.330	0.400
AP051	LJU	2015	Ljubljana Jože Pučnik Airport	0.750	1.000
AP052	ICN	2015	Incheon International Airport	0.837	1.000
AP053	MAD	2015	Madrid Barajas Airport	0.725	0.835
AP054	CMB	2015	Bandaranaike International Airport	0.785	1.000
AP055	ZRH	2015	Zurich Airport	1.000	1.000
AP056	GVA	2015	Geneva Cointrin International Airport	1.000	1.000
AP057	IST	2015	Istanbul Atatürk Airport	0.856	0.968
AP058	LHR	2015	London Heathrow Airport	1.000	1.000
AP059	MAN	2015	Manchester International Airport	0.992	1.000

5.5 Discussion

Efficiency scores for each DMU (airport) range from 0 to 1 with 1 being an efficient DMU while any scoring less than one indicates a degree of inefficiency. As shown in Table 5-6, 31 airports out of 59 are technically efficient under the assumption of CRS while there are 39 technically efficient airports when we use the VRS model. It is also clear that all technically efficient airports under the CRS assumption are also technically efficient under the VRS assumption.

5.6 Summary

In this chapter, the process of fulfilling the objective of estimating the efficiency of major worldwide international airports using DEA is presented. First of all, the selection of the DEA model is explained in further to the explanation provided in Chapter 4. Secondly, the selection process of input and output variables is discussed. A total of 4 input and 4 output variables were selected based on the most used variables in the literature of airport efficiency measurement using DEA, and the availability of Data. Thirdly, the process of constructing the airports' dataset is presented, which includes 59 international airports from Europe and the Asia Pacific. Finally, the results of the CRS and VRS output-oriented DEA models are presented and discussed. Unlike the majority of the airport DEA studies, this study does not focus on the development and in in-depth discussions on the DEA models and their results. In this research, the DEA is used as a first step to obtain the efficiency of the airports in the dataset in order to use it in the second-stage regression against other factors as will be presented in the next chapter.

6 CHAPTER SIX: IDENTIFYING MACRO-ENVIRONMENTAL FACTORS INFLUENCING THE PERFORMANCE OF AIRPORTS USING BOOTSTRAPPED TRUNCATED REGRESSION

6.1 Introduction

In Chapter 3, it was shown that the majority of airport performance studies in the literature emphasised the use of non-discretionary variables that are directly related to the airports' physical, managerial, or financial characteristics to explain the differences in the efficiencies of the airports. Only a few studies focused on variables that are not directly related to the airport and out of the control of the airports' management. Therefore, as there are no contributions that have been identified in the literature which identify the set of macro-environmental factors, that all together, affect the efficiency of airports; this research aims to fulfil this gap.

In this chapter, the efficiency scores of the 59 airport observations obtained using DEA in Chapter 5 are used as dependent variables and are regressed against a set of national macro-environmental independent variables using truncated regression coupled with Simar and Wilson bootstrapping technique to identify the macro-environmental variables that affect the efficiency of airports. To test for the robustness of the results, Tobit regression is also carried out. But before that, the concept of national macro-environmental factors and national competitiveness is discussed, and the process of constructing the set of independent variables to use in the bootstrapped truncated regression is explained.

6.2 National Macro-Environmental Factors

6.2.1 Concept of National Competitiveness

Macro-environmental factors are generally defined as uncontrollable major exogenous factors that affect the performance and strategic planning of firms, organizations or nations and influence their decisions. Historically, macro-environmental analysis is used as a tool to scan the whole picture of the business environment within which the businesses or organizations operate. The earliest known qualitative technique to scan the business environment is called ETPS analysis which was developed by Aguilar (1967), who claimed that the business environment consists of four elements which are: Economic, Technical, Political, and Social. Then during the 1980s, variations of the mnemonic of ETPS were developed such as STEPE, and PEST with PEST being the most popular mnemonic to describe the environmental scanning technique in the research studies (Iroegbu, 2010). Then, Fifield and Gilligan (2000) built on the work of Aguilar (1967) and developed a framework called PESTLE, which includes an addition of legal and environmental dimensions. PESTLE dimensions are usually studied by the decision-makers of firms or organizations as part of their strategic planning to create a clear and decisive picture on the possible threats and opportunities that could be created by these macro-environmental factors. The importance of studying these factors lies in the fact that the performance of the organization will be influenced, to a certain extent, by the macro-environment within which this organization operates.

As this research aims to numerically identify the significance of national macro-environmental factors on the efficiency of airports, the process for identifying the factors which define the country level macro-environment led to looking at national competitiveness measurements. National competitiveness is defined as the capability of a country to use its natural, human, financial, and various sources efficiently. Therefore, this means that the country that achieves high productivity and quality of life has a high level of competitiveness (McFetridge, 1995). So, the national competitiveness and its indicators have become of significant interest to researchers and policymakers who seek to estimate, analyse and compare the performance of different nations.

There exist different approaches to measure the competitiveness of nations. However, the most popular approach which captured the attention of researchers is the one which includes a considerable number of countries in its pool and ranks them with respect to their measured national competitiveness score (Lall, 2001). This approach provides the national competitiveness score in terms of a single index formed after measuring a system of indicators and merging them together using specific weight-based formula. The most common national competitiveness reports that are published by organizations or institutes are presented in Table 6-1.

Table 6-1 Most popular national competitiveness reports

Report	Organization/Institution
Global Competitiveness Report (GCR)	World Economic Forum (WEF)
World Competitiveness Yearbook (WCY)	Institute for Management Development (IMD)
National Competitiveness Research Report (NCR)	Institute of Industrial Policy Studies (IPS)
International Location Ranking (ILR)	Bertelsmann Foundation

The quantitative form of this research led to the decision to consider the indices provided in the Global Competitiveness Report (GCR) by the World Economic Forum (WEF). The reason for choosing variables of WEF-GCR is because it looks to be an appropriate source for accessing national-level macro-environmental indicators in terms of consistency and reliability, and it has been of great interest to policymakers (Itani, O'Connell and Mason, 2014; Lall, 2001). Secondly, WEF is the first autonomous not-for-profit foundation known to publish competitiveness reports. Thirdly, WEF-GCR variables are previously used in air transport-related academic research. One of the first attempts in the literature to quantitatively test the significance of macro-environmental factors on the air transport sector is Itani, O'Connell and Mason (2014). In their study, the 12 WEF-GCR pillars were used in addition to four additional macro-environmental factors obtained from different sources, to test their significance on the national air transport sector outputs such as total passengers, aviation contribution to GDP and employment, and air connectivity, using structural equation modelling (SEM).

In 1979, the WEF collaborated with IMD to produce the first report of a national competitiveness index, which included indices on 16 countries from Europe only. In this report, the competitiveness index is the aggregation of only four measured macro-environmental factors. Then, commencing in 1996, the Global Competitiveness Reports (GCRs) have been published on a yearly basis. Through the years, the number of countries included in the WEF-GCR increased dramatically with continuous development in the methodology to measure the competitiveness index. The 2015 report used in this research includes 140 countries from all over the world, and the competitiveness index is the merger of 12 different factors (WEF, 2015a).

The 12 pillars provided by the WEF-GCR, which all together define a country's national competitiveness, are: Institutions (INS), Infrastructure (INF), Macro-economic environment (ME), Health and Primary Education (HPE), Higher education and training (HET), Goods market efficiency (GME), Labour market efficiency (LME), Financial market development (FMD), Technological readiness (TR), Market size (MS), Business sophistication (BS), and Innovation (INNOV). These factors cover the different dimensions (political, economic, social, technological, legal, and environmental) of the macro-environmental analysis, PESTLE. The definition of each variable and the scoring scales are presented in Appendix C.2.

The methodology and computation of the GCI have been continuously developed, but the latest one has been applied since 2007. In the latest methodology, the majority of the scores of the indicators of each pillar are obtained through an Executive Opinion Survey and the rest are obtained from different statistical data published by recognised international organizations such as the International Monetary Fund (IMF), the United Nations Educational, Scientific, and Cultural Organization, and the World Health Organization (WEF, 2015a). In the 2015 WEF-GCR, over 14,000 business leaders took the Executive Opinion Survey on 78 out of 114 indicators that make up the GCI. The scores of the indicators are converted to a 1-to-7 scale in order to make the aggregation possible. Then, the score of each pillar is calculated from the ratio of the aggregate scores of the indicators to the total number indicators. Then, the countries are clustered into three stages of development: factor-driven, efficiency-driven, and innovation-driven. Each stage of development is identified based on GDP per capita thresholds. Thereafter, the 12 pillars are grouped into three sub-indices: basic requirements, efficiency enhancers, and innovation and sophistication sub-index. The weight of each sub-index is assigned based on the stage of the development of the country. The sub-index weight and stage of development matrix are shown in Table 6-2. In each sub-index, the ratio of the aggregate of scores of the pillars to the total number of pillars is calculated and multiplied by the respective weigh of the sub-index. Finally, the GCI is obtained by aggregating the scores of the sub-indices. For more details on the equations and the assumptions in the pillars scoring system and GCI calculation methodology, refer to Appendices A and D of WEF (2015).

Table 6-2 Weights of GCI sub-indices based on the country stage of development

	Stage of development				
	Stage 1: Factor-driven	**Transition from stage 1 to stage 2**	**Stage 2: Efficiency-driven**	**Transition from stage 2 to stage 3**	**Stage 3: Innovation-driven**
GDP per capita thresholds (in $US)	<2,000	2,000-2,999	3,000-8,999	9,000-17,000	>17,000
Weight for basic requirements	60%	40-60%	40%	20-40%	20%
Weight for efficiency enhancers	35%	35-50%	50%	50%	50%
Weight for innovation and sophistication factors	5%	5-10%	10%	10-30%	30%

Source: WEF (2015)

Some studies critically evaluated the methodology used to obtain a competitiveness index such as Berger and Bristow (2009) and Oral and Chabchoub (1996). They claimed that the choice and the validity of the indices are the biggest challenges in computing the competitiveness index to provide rankings for the nations. However, the fact that the use of the indices and their respective competitiveness rankings by the policymakers proved their advantages in drafting national strategies validates its use in academic research despite the existence of the few criticisms (Saisana and Tarantola, 2002).

6.2.2 Independent Variables Sample Construction

In this research, the 12 pillars of the WEF-GCR of years 2009 and 2015 for the countries of the respective airports included in the DEA and presented in Table 5-4 in Chapter 5, are included in the initial list of the independent variables to be used in the second-stage regression.

In addition to these 12 pillars, Air Transport Output (ATO) obtained by Itani, O'Connell and Mason (2015) is also included in the list. ATO is an index representing the performance of the national air transport industry. It is an aggregation of total traffic growth, aviation contribution to GDP and employment, and air service connectivity. The 2009 data for the ATO variable for the countries of the airports included in Table 5-4 are taken from Itani (2015), while the values for the year 2015 are computed using the same model.

Finally, in order to cover as many national macro-environmental effects as possible, four additional independent variables are included in the list. These four independent variables are: Global Peace Index (SS) which measures the degree of safety and security, Corruption Perception Index (CPI) which measures levels of corruption in a respective state's public sector, Human Development Index (HDI) which measures population health and capabilities, and Travel and Tourism Index (TT) which measures the attractiveness of a state for the purposes of investing in its travel and tourism sector. For the sake of consistency and reliability, data on all of the independent variables included in the list are collected from 2009 and 2015 reports published by recognised international agencies such as WEF Global Competitiveness (WEF-GCR), WEF Travel & Tourism (WEF-TT), Institute for Economics and Peace (IEP), Transparency International (TI), and United Nations Development Program (UNDP). All the data are obtained for each country relative to its airport in the sample presented in Table 5-4. The summary statistics of the initial list of independent variables collected are presented in Table 6-3.

Table 6-3 Summary statistics on the independent variables included in the initial sample

Variables	Definition	Mean	SD	Min	Max	Data Source
ATO	Air Transport Output	0.876	0.241	0.007	1.0	(Itani, 2015)
INS	Institutions	5.0	0.8	3.4	6.1	(WEF, 2009a, 2015a)
INF	Infrastructure	5.4	0.8	2.9	6.6	(WEF, 2009a, 2015a)
ME	Macro-economic environment	5.0	0.8	3.3	6.6	(WEF, 2009a, 2015a)
HPE	Health and primary education	6.2	0.3	5.3	6.9	(WEF, 2009a, 2015a)
HET	Higher education and training	5.2	0.5	3.9	6.1	(WEF, 2009a, 2015a)
GME	Goods market efficiency	4.9	0.4	4.1	5.8	(WEF, 2009a, 2015a)
LME	Labour market efficiency	4.7	0.6	3.4	5.9	(WEF, 2009a, 2015a)
FMD	Financial market development	4.6	0.7	2.8	5.9	(WEF, 2009a, 2015a)
TR	Technological readiness	5.3	0.8	3.3	6.3	(WEF, 2009a, 2015a)
MS	Market size	4.9	0.9	2.4	7.0	(WEF, 2009a, 2015a)
BS	Business sophistication	5.0	0.6	3.8	5.9	(WEF, 2009a, 2015a)
INNOV	Innovation	4.5	0.8	3.1	5.8	(WEF, 2009a, 2015a)
SS	Safety and Security	4.8	0.8	2.9	6.1	IEP (2009, 2015)
CPI	Corruption perception	7.1	1.8	3.4	9.4	TI (2009, 2015)
HDI	Human Development	4.1	0.4	2.5	4.7	UNDP (2009, 2015)
TT	Travel and tourism	4.9	0.4	3.8	5.7	(WEF, 2009b, 2015b)

A multicollinearity test is applied to make sure all the independent variables which will be used in the second-stage regression have no inter-relationships, and thus, the results could be consistent and confident. To detect multicollinearity, the Variance Inflation Factor (VIF) is one way which can measure the extent of increase of the variance of an estimated regression coefficient when there is a correlation between the tested variables (Akinwande, Dikko and Samson, 2015). There is an open debate in the literature on what is considered to be an acceptable VIF value threshold, but the most common thresholds are VIF value of 5 and 10 (Hair et al., 2009; Kline, 2016). The first multicollinearity test conducted on the 17 independent variables in the initial sample shows that there exists a high level of multicollinearity across all the variables with various degrees of intensity except the Air Transport Output and Safety and Security. Macro-economic environment, goods market efficiency, human development index and travel and tourism index are found to have a high level of multicollinearity based on the VIF>5 rule. The remaining 11 variables have a high level of multicollinearity as per VIF>10 rule. The results of the first multicollinearity test are presented in Table 6-4.

Table 6-4 Multicollinearity test 1 results

Variables	Definition	Tolerance	VIF
ATO	Air Transport Output	0.376	2.66
INS	Institutions	0.024	**11.51******
INF	Infrastructure	0.087	**41.97******
ME	Macro-economic environment	0.125	**7.97*****
HPE	Health and primary education	0.099	**10.11******
HET	Higher education and training	0.045	**22.17******
GME	Goods market efficiency	0.111	**9.04*****
LME	Labour market efficiency	0.065	**15.50******
FMD	Financial market development	0.083	**12.10******
TR	Technological readiness	0.041	**24.25******
MS	Market size	0.046	**21.56******
BS	Business sophistication	0.038	**26.66******
INNOV	Innovation	0.023	**42.78******
SS	Safety and Security	0.208	4.82
CPI	Corruption perception	0.037	**27.20******
HDI	Human Development	0.143	**7.01*****
TT	Travel and tourism	0.164	**6.08*****

*** VIF > 5. **VIF > 10**

To clearly illustrate the correlations between the variables, a correlation matrix was generated (Figure 6-1). The green colour (range 0~0.3) means negligible association, yellow (range 0.3~0.5) means weak association, orange (range 0.5~0.7) means moderate association, and red (range 0.7~1) means strong association. The negative sign means the variables are negatively correlated.

Variables	INS	INF	ME	HPE	HET	GME	LME	FMD	TR	MS	BS	INNOV	SS	CPI	HDI	TT	ATO
INS	**1.000**	0.638	0.171	0.596	0.812	0.881	0.802	0.743	0.759	-0.381	0.724	0.801	-0.297	0.926	0.270	0.558	0.219
INF	0.638	**1.000**	0.176	0.542	0.661	0.640	0.464	0.315	0.762	0.176	0.775	0.803	-0.486	0.654	0.514	0.696	0.511
ME	0.171	0.176	**1.000**	0.128	0.349	0.789	0.876	0.915	0.816	-0.677	0.242	0.359	-0.119	0.310	0.107	0.042	0.216
HPE	0.596	0.542	0.128	**1.000**	0.834	0.551	0.391	0.219	0.730	-0.192	0.477	0.657	-0.631	0.638	**0.816**	0.186	0.373
HET	0.812	0.661	0.349	0.834	**1.000**	0.749	0.650	0.452	0.903	-0.635	0.621	0.785	-0.722	0.882	**0.744**	0.552	0.457
GME	0.881	0.640	0.789	0.551	0.749	**1.000**	0.808	0.695	0.738	-0.024	0.761	0.811	-0.529	0.837	0.389	0.459	0.519
LME	0.802	0.464	0.876	0.391	0.650	0.808	**1.000**	0.664	0.631	-0.155	0.594	0.013	-0.485	0.750	0.211	0.447	0.403
FMD	0.743	0.315	0.915	0.219	0.452	0.695	0.664	**1.000**	0.386	0.027	0.514	0.519	-0.359	0.646	0.027	0.452	0.285
TR	0.759	0.762	0.816	0.730	0.903	0.738	0.631	0.386	**1.000**	-0.140	0.700	0.789	-0.710	0.876	0.748	0.558	0.402
MS	-0.381	0.176	-0.677	-0.192	-0.635	-0.024	-0.155	0.027	-0.140	**1.000**	0.313	0.157	0.325	-0.216	-0.150	0.385	0.574
BS	0.724	0.775	0.242	0.477	0.621	0.761	0.594	0.514	0.700	0.313	**1.000**	0.917	-0.531	0.720	0.388	0.653	0.556
INNOV	**0.801**	0.803	0.359	0.657	0.785	0.811	0.013	0.519	0.789	0.157	0.917	**1.000**	-0.590	0.794	0.525	0.536	0.580
SS	-0.297	-0.486	-0.119	-0.631	-0.722	-0.529	-0.485	-0.359	-0.710	0.325	-0.531	-0.590	**1.000**	-0.756	-0.383	-0.426	-0.180
CPI	**0.926**	0.654	0.310	0.638	0.882	0.837	0.750	0.646	0.876	-0.216	0.720	0.794	-0.756	**1.000**	0.545	0.577	0.484
HDI	0.270	0.514	0.107	0.816	0.744	0.389	0.211	0.027	0.748	-0.150	0.388	0.525	-0.383	0.545	**1.000**	0.180	0.254
TT	0.558	0.696	0.042	0.186	0.552	0.459	0.447	0.452	0.558	0.385	0.653	0.536	-0.426	0.577	0.180	**1.000**	0.403
ATO	0.219	0.511	0.216	0.373	0.457	0.519	0.403	0.285	0.402	0.574	0.556	0.580	-0.180	0.484	0.254	0.403	**1.000**

Figure 6-1 National Macro-Environmental Factors Correlation Matrix

To solve the issue of the high levels of multicollinearity across the variables as shown in Table 6-4 and to improve the robustness of the second-stage regression model, an iterative process of removing the variables associated with the highest VIF values is conducted. A multicollinearity test is conducted every time a variable is excluded to follow the variation of the VIF values until an optimal set of variables is achieved where there is a minimal level of multicollinearity. A total of 12 variables are excluded, and the final set of independent variables that have a minimal level of multicollinearity are shown in Table 6-5.

Table 6-5 Final sets of independent variables with a limited level of multicollinearity

Variables	Definition	Tolerance	VIF
ATO	Air Transport Output	0.59	1.69
INS	Institutions	0.31	3.23
ME	Macro-economic environment	0.79	1.27
SS	Safety and Security	0.38	2.64
HDI	Human Development	0.65	1.54

The final set of independent variables that represent significant elements of the macro-environment of a country includes the air transport output (ATO), institutions (INS), macro-economic environment (ME), safety and security (SS), and human development (HDI). This final sample of independent variables will be used in the second-stage regression to test their significance on the dependent variable representing the efficiency of the airports.

In the next section, the selection of the second-stage methods and their respective models will be discussed and presented.

6.3 Second-Stage Regression Models

In order to identify the significance of independent variables on the efficiency of the airports, studies in the literature have used second-stage analysis after obtaining the efficiency or productivity of airports. Examples of second-stage regression methods used in the literature are Ordinary Least Squares (OLS), Tobit regression, and truncated regression (Barros, 2008a). As mentioned in Chapter 3, before 2007, most of the studies conducted Tobit regression to find the effectiveness of non-discretionary variables on the performance of airports. Then, Simar and Wilson published a study in 2007 which argues that Tobit regression is not an appropriate method to use as a second-stage regression, and that a proper method to overcome the ambiguous sequential correlation which could affect the two-stage analysis is to employ truncated regression analysis coupled with bootstrapping technique (Simar and Wilson, 2007). However, other studies such as Banker and Natarajan (2008) and Hoff (2007) concluded that there is nothing wrong in using OLS or Tobit regression in the second-stage regression when using DEA efficiency scores. Similarly, Latruffe et al. (2004) and Bravo-Ureta et al. (2007) said that since DEA analysis provides efficiency scores bounded between zero and one, Tobit regression is the best method to use in the second-stage analysis. As a result, it is evident that there exists an open debate on the most appropriate model to use in the second-stage regression among the econometric researchers. So, for extra validity of results, some studies such as Merkert and Hensher (2011) and Kan Tsui et al. (2014) have applied bootstrapped truncated regression followed by Tobit regression analysis to test for the robustness of the results. In this research, this approach is followed.

6.3.1 Bootstrapped Truncated Regression

In the truncated regression with Simar and Wilson bootstrapping technique, the efficiency scores of the first-stage DEA analysis are regressed against the factors that are expected to be affecting them. For more information, see Simar and Wilson (2007).

The initial first-order estimation of the unknown true relationship can be written as shown in Equation 6-1.

$$\theta_j = \alpha + z_j\beta + \varepsilon_j \qquad \textbf{Equation 6-1}$$

$$j = 1, 2, 3, \dots, n.$$

Where;

θ_j: DEA efficiency score of the j^th DMU

α: Constant

z_j: Vector of variables expected to affect the DEA efficiency scores

β: Vector of coefficients

ε_j: Error term

In the bootstrapping approach of Simar and Wilson, the distribution of the error term ε_j must be limited according to the condition $\varepsilon_j \geq 1 - \alpha - z_i\beta$. So, the distribution of ε_j becomes $\varepsilon_j \sim iidN(0, \sigma_\varepsilon^2)$. Also, the new DEA efficiency scores after applying Simar and Wilson bootstrapping technique, θ_j^*, replaces the true and unobserved dependent variable θ_j of Equation 6-1. So, the Simar and Wilson model specification is as shown in Equation 6-2.

$$\theta_j^* = \alpha + z_j\beta + \varepsilon_j \qquad \textbf{Equation 6-2}$$

$$j = 1, 2, 3, \dots, n.$$

$$\varepsilon_j \sim iidN(0, \sigma_\varepsilon^2)$$

Therefore, the final truncated regression to be calculated through the bootstrapped process[5] in the second stage regression is shown in Equation 6-3.

$$\boldsymbol{Eff^{*}_{j,t} = \beta_0 + \beta_1 ATO_{j,t} + \beta_2 INS_{j,t} + \beta_3 ME_{j,t} + \beta_4 SS_{j,t} + \beta_5 HDI_{j,t} + \varepsilon_{j,t}}$$

Equation 6-3

6.3.2 Censored Tobit Regression

The Tobit model falls into the category of censored regression. It is usually employed when the dependent variable is censored, or in other words, bounded from above, below, or both (Tobin, 1958). It is used alternatively to OLS regression. The observed dependent variable Y_i is related to a latent variable Y_i^* as follows:

$$Y_i = \begin{cases} Y_i^* \ if \ Y_i^* > 0 \\ 0 \ if \ Y_i^* \leq 0 \end{cases}$$

The Tobit regression model used in this research is expressed in Equation 6-4, which is similar to that used by Carlucci, Cirà and Coccorese (2018).

$$Y_i^* = \beta X_i + \varepsilon_i$$ **Equation 6-4**

$$i = 1, \ldots, N$$

Where;

N: Number of observations/DMUs

X_i: A vector of independent variables

β: A vector of unknown coefficients to be estimated

ε_i: Error term

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[5] For more information, see Simar and Wilson (2007)

In addition, the error term ε_i is assumed to be normally distributed and independent as following:

$$\varepsilon_i \sim N\,(0, \sigma^2)\,\beta X_i$$

Therefore, the final random effect Tobit regression model is expressed as shown in Equation 6-5.

$$\boldsymbol{Eff_i} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1 ATO_i} + \boldsymbol{\beta_2 INS_i} + \boldsymbol{\beta_3 ME_i} + \boldsymbol{\beta_4 SS_i} + \boldsymbol{\beta_5 HDI_i} + \boldsymbol{\varepsilon_i}$$

Equation 6-5

6.4 Empirical Results

Both bootstrapped truncated regression and censored Tobit regression are executed using Stata/IC 14.2. The results of the second stage regressions are shown in Table 6-6.

Table 6-6 Significance levels (P-values) of independent variables to Airport Efficiency by both bootstrapped truncated regression Tobit regression

Variables	Definition	Truncated regression with bootstrapping		Random effect Tobit regression	
		Coefficient	*P*-value	Coefficient	*P*-value
ATO	Air Transport Output	0.586	**0.000****	0.472	**0.000****
INS	Institutions	0.104	**0.027****	0.018	**0.043****
ME	Macro-economic Environment	0.091	**0.013****	0.025	**0.012****
SS	Safety and Security	-0.392	**0.004****	-0.092	**0.026****
HDI	Human Development	0.780	**0.009****	0.196	**0.038****
β_0	Constant	-0.761	0.093	0.253	0.147
	Log-likelihood	180.187		230.438	
	Observations	59		59	

** Significant at a 95% level of confidence. The results of truncated regression with bootstrapping technique of Simar and Wilson (2007) were obtained from 5000 bootstrapping iterations.

In Table 6-6, the marginal effect on the efficiency of the airport by each of the independent variables according to the bootstrapped truncated regression and the Tobit regression is denoted by their respective *P*-value. The results of the *P*-value are reported at a 95% level of confidence. Therefore, the independent variable with a *P*-value lower than 0.05 is considered to be statistically significant and therefore, is considered to have an effect on airport efficiency.

Results show that all the independent variables that were included in the regression are found to be statistically significant, with the Air Transport Output being the variable with the highest impact followed in order by Safety and Security, Human Development, the Macro-economic Environment, and finally Institutions. All the independent variables except Safety and Security recorded a positive coefficient which means that the increase in any of these variables would result in an increase in the efficiency of the airport. The negative coefficient of the Safety and Security variable explains the different scaling system of this variable as shown in Appendix C, where data on Safety and Security is reported on a scoring scale of between 1 and 5, with a score of 5 being least peaceful. This means that the higher the score of the Safety and Security index, the lower the actual level of peace and safety in the country. Therefore, the negative coefficient means that when the level of safety and security in the country deteriorates, the number of incoming and outgoing passengers decrease, the airport revenues decrease, and therefore, the efficiency of the airport becomes lower. This is a very logical result and is supported by evidence and experiences from many countries around the world. The case of Istanbul Ataturk International Airport is an example. Following the terrorist attack at the airport in 2016, the Turkish aviation market dropped 4%, and the number of passengers at Istanbul Airport dropped 2% compared to 2015. The decrease in the number of passengers has largely affected the earnings of the Airports, wherein 2016, EBITDA decreased by 9% compared to 2015 (TAV, 2016).

Air Transport Sector Output reflects the maturity of the civil aviation authority and regulations in the country, including the degree of air transport liberalization. Being the most significant variable is also logical since airport activities are regulated and monitored by the civil aviation regulatory body. This finding is in agreement with the conclusions of Chaouk et al. (2019) and Holder et al. (2008) who discussed the necessity of developing institutional arrangements where there is airport management is separated from a fully-autonomous civil aviation authority that follows a stable, robust developed regulatory framework.

The significance of the human development variable, which reflects the level of health, education, and standard of living dimensions of the population in the country, on the airport efficiency goes in line with the findings of Chaouk, Pagliari and Miyoshi (2019) who emphasised on the importance of the existence of sufficient, well-educated and trained, enthusiastic, and healthy human resources for successful and efficient performance of the airport. This finding is also in line with the conclusions of Pabedinskaitė and Akstinaitė (2014) and Sutia et al. (2013) who argue that human development affects the performance of the airport.

The Institutions variable is also shown to be significant to the efficiency of the airport. The institutions variable resembles the quality of the institutions of a country, whether they are public or private, and the administrative and legal framework within which all the elements of the institutions interact. It also reflects the level of corruption in the institutions as it indicated a large positive correlation coefficient with the corruption perception index in the first multicollinearity test. This means that the higher the score of the institutions index, the higher the quality of the public and private institutions, the more robust and advanced the administrative and legal framework, and thus the lower level of corruption among the institutions of the country. Therefore, logically, when the airport operates in an environment that has robust and institutional arrangements, this would help the airport operator in its mission to achieve higher efficiency levels. This result is also in line with Chaouk, Pagliari and Miyoshi (2019) who argued that poorly developed institutional arrangements and regulatory mechanism of a country negatively affects the performance of the airport.

Finally, the macro-economic environment variable seems to be also significant to airport efficiency. Although this term is broad and resembles the stability of the macro-environment in a country as defined in Appendix C, it was found to be also significantly affecting the total number of air passengers and to the aviation contribution to employment by a study conducted by Itani, O'Connell and Mason (2014). Therefore, it is also logical that the macro-economic environment significantly affects the performance of the airports.

The results of the bootstrapped truncated regression are further validated by the results of the Tobit regression, which is conducted to test for the robustness of the results of the latter method. It is also shown using Tobit regression that all the national macro-environmental variables tested are significant to the efficiency of the airport at a 95% level of confidence.

This finding is significant as it fills the gap in the literature, as highlighted in Chapter 3. This finding suggests that airport efficiency is not only affected by factors related to the airport physical characteristics, management strategies, governance structures, or other individual factors. The efficiency of the airport is influenced by the combination of five national macro-environmental factors, namely the air transport output, institutions, macro-economic environment, human development, and safety and security. It also suggests that the difference in the performance of airports of different airport ownership and management models (e.g. majority private, mixed public-private, and fully public ownership and management) is also related to these five national macro-environmental factors.

In the next chapter, the results of the analysis carried out in Chapter 5, and 6 will be transformed into a preliminary framework, which can be used by governments or civil aviation authorities, to identify the airport ownership and management model which best suits their country-specific settings based on the five identified national macro-environmental factors.

6.5 Summary

In this chapter, the concept of national macro-environmental factors and national competitiveness was discussed. Different national competitiveness approaches and publishers were presented, and it was noted that the World Economic Forum Global Competitiveness Report and its associated Global competitiveness index and pillars are the most appropriate to use in this research for various reasons. The reasons vary from the critical recognition WEF has achieved among the policymakers and researchers, and the consideration of the WEF-GCR pillars in previous academic researches.

In addition to the 12 pillars of the WEF-GCR, four additional macro-environmental factors were collected from similar recognised international organizations reports and included in the sample. One last additional variable representing the Air Transport output of the countries was obtained from previous PhD research. Thereafter, a multicollinearity test was conducted on the sample that includes the 17 independent variables to make sure that there is a minimal level of multicollinearity across the variables aiming for the most robust model. The results of the first multicollinearity test indicated a high level of multicollinearity, and subsequently, an iterative process of excluding the variables with the highest level of multicollinearity was conducted. The final sample of independent variables representing significant elements of the national macro-environment included five variables which are the air transport output, institutions, macro-economic environment, safety and security, and human development.

Then, the process of selecting the method to be used in the second-stage regression to identify the significance of the independent variables on the dependent variable representing the efficiency of the airports was presented. Truncated regression coupled with Simar and Wilson bootstrapping technique was found to be the most appropriate method in the literature and Tobit regression follows. The final decision was to conduct the bootstrapped truncated regression as the primary method and to work out the Tobit regression to check for the robustness of the results. The models of the bootstrapped truncated regression and the Tobit regression were discussed before the empirical results were presented.

The results of the truncated regression with Simar and Wilson bootstrapping technique showed that all the five independent variables are significantly affecting the efficiency of the airports. The robustness of this result was further validated by Tobit regression which indicated similar results.

The obtained results are significant as they fill the gap in the literature that was highlighted at the end of Chapter 3. The results prove that the efficiency of the airport is affected by a set of five national macro-environmental factors, and not only by factors directly related to the airport physical characteristics, management strategies, governance structures, or other individual factors.

7 CHAPTER SEVEN: PROPOSED FRAMEWORK FOR AIRPORT OWNERSHIP AND MANAGEMENT MODEL SELECTION BASED ON NATIONAL MACRO-ENVIRONMENTAL APPROACH

7.1 Introduction

In Chapters 5 and 6, the efficiencies of 59 airport observations were measured using DEA and then using truncated regression coupled with Simar and Wilson bootstrapping technique, five national macro-environmental factors were identified to be influencing the efficiency of the airport. In this chapter, the findings in Chapters 5 and 6 are used to identify the optimum national macro-environmental setting of each airport ownership and management model. A preliminary framework will be developed for governments or civil aviation authorities to identify the most suitable model given their national macro-environmental settings. Finally, hypothetical examples of different scenarios are presented to clarify how this preliminary framework is used. But before all of that, the classifications of the airport ownership and management models used in this research are explained with reference to the literature and the aviation industry organizations such as IATA and ACI.

7.2 Identifying Optimum National Macro-Environmental Factors Settings Area for Each Airport Ownership and Management Model

7.2.1 Airport ownership and management model classification

In Chapter 2, 11 airport ownership and management models as classified by IATA in Dorian and Robinson (2018) were described. However, it was also shown that most of the studies in the academic literature of airport performance had used general classifications of airport ownership and management models similar to the classifications used in ACI (2016).

Table 2-2 in Chapter 2 included 8 studies which attempted to test the effect of airport ownership and management model on the efficiency of the airport.

However, these studies have used a classification that is more general, such as private, public, or mixed public-private.

The reason for using the general classifications and not the particular ones is because of the limited number of airport observations included in the analysis of the research studies due to the type of the study or the availability of the data. The use of the detailed classification of airport ownership and management model on a limited number of observations would affect the reliability and robustness of the results of the analysis. This is the reason why the literature has tended to adopt two to four airport ownership and management models when their sample datasets have a limited number of observations.

In this research, the total number of observations, 59, is considered to be limited. And with the available data on the ownership and management models of the airports in the sample dataset, the airports are classified according to the ATRS Airport Databases as following:

(1) Majority Private (100% private, mixed private-public with private majority)
(2) Mixed Public-Private with public majority
(3) Fully Public (Government corporation)

The ATRS classification is similar to the classification used in the literature in Adler and Liebert (2014), and in the industry in ACI (2016). The only difference is that the Mixed Public-Private with private Majority and the Full Private are combined into one classification. The specific models that each airport ownership and management model classification of ACI (2016), and ATRS can be related in Table 2-1. However, the specific models will not be included in this research due to the low number of observations in the airports sample dataset.

7.2.2 Constructing the macro-environmental best performing area of each airport ownership and management model

In Chapter 5, the efficiency of each airport in the sample dataset was obtained using DEA, and the results are shown in Table 5-6. Then, in Chapter 6, five national macro-environmental factors were found to be significantly impacting the efficiency of the airport using bootstrapped truncated regression. These five factors are air transport output, institutions, macro-economic environment, safety and security, and human development.

To identify the macro-environmental setting, which best suits each of the three airport ownership and management models, a filtering process is conducted to eliminate all the inefficient airports in the sample dataset. The filtering process resulted in the remaining 40 observations that obtained unity as an efficiency score. The filtering process is followed by a grouping process to group each efficient airport into its respective airport ownership and management model. As a result of these processes, three groups of airports are constructed, with 13 observations in the majority private, 12 observations in the mixed public-private, and 15 observations in the fully public group. Finally, the score each of the five national macro-environmental factors of the country respective to each efficient airport is placed next to the airport as shown in Table 7-1.

Table 7-1 Efficient airports classifications and their respective national macro-environmental factors

Airport Name	Country	Year	Efficiency (DEA)	Institutions	Macroeconomic Environment	Safety & Security	Human Development	Air Transport Output
(1) Majority Private Model (100% Private, mixed private-public with private majority)								
Sydney Kingsford Smith International Airport	Australia	2009	1.000	5.600	5.600	1.476	0.866	1.000
Vienna International Airport	Austria	2009	1.000	5.600	5.200	1.252	0.794	1.000
Copenhagen Kastrup International Airport	Denmark	2009	1.000	6.100	5.700	1.217	0.799	1.000
Athens International Airport	Greece	2009	1.000	3.800	4.000	1.778	0.760	0.595
Auckland International Airport	New Zealand	2009	1.000	6.000	5.200	1.202	0.818	1.000
Zurich International Airport	Switzerland	2009	1.000	5.900	5.600	1.393	0.831	1.000
London Heathrow International Airport	UK	2009	1.000	5.100	4.600	1.647	0.775	1.000
Melbourne Airport	Australia	2015	1.000	5.300	5.600	1.329	0.939	1.000
Vienna International Airport	Austria	2015	1.000	5.200	5.100	1.198	0.893	1.000
Athens International Airport	Greece	2015	1.000	3.700	3.300	1.878	0.866	0.844
Ljubljana Jože Pučnik Airport	Slovenia	2015	1.000	3.900	4.400	1.378	0.890	1.000
Zurich International Airport	Switzerland	2015	1.000	5.800	6.500	1.275	0.939	1.000
London Heathrow Airport	UK	2015	1.000	5.500	4.200	1.685	0.909	1.000
			Min	**3.700**	**3.300**	**1.198**	**0.760**	**0.595**
			Max	**6.100**	**6.500**	**1.878**	**0.939**	**1.000**
(2) Mixed Public-Private Model with public majority								
Guangzhou Bai Yun Airport	China	2009	1.000	4.400	5.900	1.921	0.499	1.000
Paris Charles de Gaulle International Airport	France	2009	1.000	5.000	4.700	1.579	0.779	1.000
Frankfurt Main International Airport	Germany	2009	1.000	5.500	5.300	1.392	0.801	1.000
Kansai International Airport	Japan	2009	1.000	4.900	4.200	1.272	0.814	1.000
Amsterdam Schiphol International Airport	Netherlands	2009	1.000	5.700	5.200	1.531	0.830	0.998
Manchester International Airport	UK	2009	1.000	5.100	4.600	1.647	0.775	1.000
Guangzhou Bai Yun Airport	China	2015	1.000	4.100	6.500	2.267	0.738	1.000
Paris Charles de Gaulle Airport	France	2015	1.000	4.800	4.700	1.742	0.897	1.000
Frankfurt Airport	Germany	2015	1.000	5.200	6.000	1.379	0.926	1.000
Kansai International Airport	Japan	2015	1.000	5.500	3.700	1.322	0.903	1.000
Amsterdam Schiphol International Airport	Netherlands	2015	1.000	5.600	5.700	1.432	0.924	1.000
Manchester International Airport	UK	2015	1.000	5.500	4.200	1.685	0.909	1.000
			Min	**4.100**	**3.700**	**1.272**	**0.499**	**0.998**
			Max	**5.700**	**6.500**	**2.267**	**0.926**	**1.000**

Airport Name	Country	Year	Efficiency (DEA)	Institutions	Macroeconomic Environment	Safety & Security	Human Development	Air Transport Output
(3) Fully Public Model (Government corporation)								
Munich International Airport	Germany	2009	1.000	5.500	5.300	1.392	0.801	1.000
Keflavik International Airport	Iceland	2009	1.000	5.600	3.600	1.225	0.797	1.000
Dublin International Airport	Ireland	2009	1.000	5.200	4.600	1.333	0.762	0.874
Tokyo International Airport	Japan	2009	1.000	4.900	4.200	1.272	0.814	1.000
Oslo Airport	Norway	2009	1.000	5.900	5.900	1.217	0.869	1.000
Singapore Changi International Airport	Singapore	2009	1.000	6.100	5.200	1.533	0.718	1.000
Geneva Cointrin International Airport	Switzerland	2009	1.000	5.900	5.600	1.393	0.831	1.000
Helsinki Vantaa Airport	Finland	2015	1.000	6.100	5.400	1.277	0.895	1.000
Munich Airport	Germany	2015	1.000	5.200	6.000	1.379	0.926	1.000
Dublin International Airport	Ireland	2015	1.000	5.500	4.500	1.354	0.923	1.000
Haneda Airport	Japan	2015	1.000	5.500	3.700	1.322	0.903	1.000
Christchurch International Airport	New Zealand	2015	1.000	6.000	5.900	1.221	0.915	1.000
Incheon International Airport	South Korea	2015	1.000	3.900	6.600	1.701	0.901	1.000
Bandaranaike International Airport	Sri Lanka	2015	1.000	4.100	4.100	2.188	0.766	1.000
Geneva Cointrin International Airport	Switzerland	2015	1.000	5.800	6.500	1.275	0.939	1.000
			Min	**3.900**	**3.600**	**1.217**	**0.718**	**0.874**
			Max	**6.100**	**6.600**	**2.188**	**0.939**	**1.000**

In each group, the minimum and maximum scores for each macro-environmental factor are captured using the *MIN* and *MAX* functions in Microsoft Excel. This allows the construction of the minimum and maximum boundaries of the five national macro-environmental scores, within which the respective ownership and management model could help in achieving an efficient airport performance. This area which is bounded by the minimum and maximum boundary is named the optimum macro-environmental settings area to the respective airport ownership and management model.

To visualise the optimum macro-environmental setting areas for each of the three airport ownership and management models, radar charts are constructed. Figure 7-1, Figure 7-2, and Figure 7-3 represent the optimum macro-environmental setting areas for the majority private, mixed public-private, and fully public model respectively.

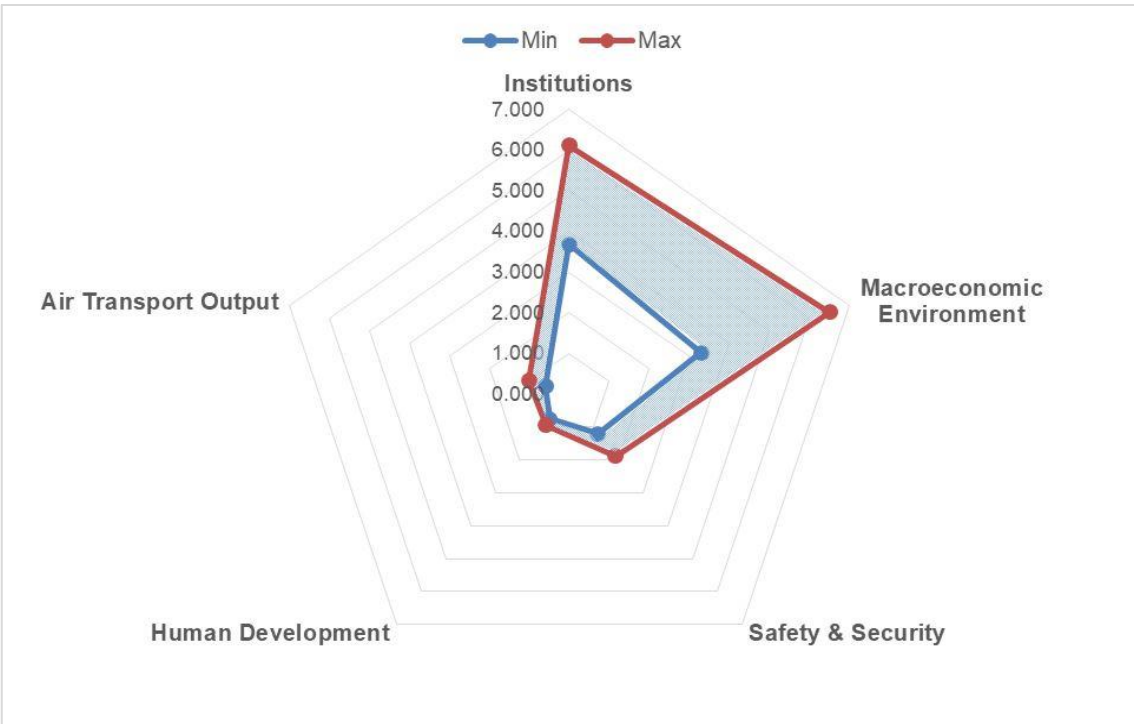

Figure 7-1 Optimum macro-environmental setting area for Majority private model

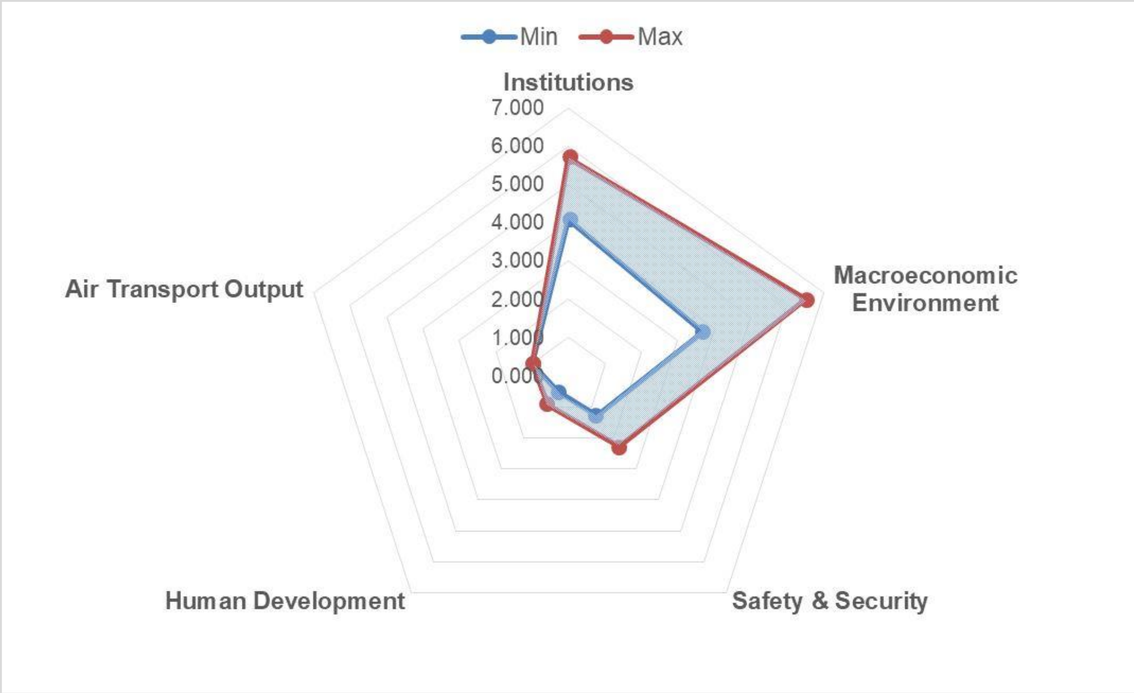

Figure 7-2 Optimum macro-environmental setting area for mixed public-private model

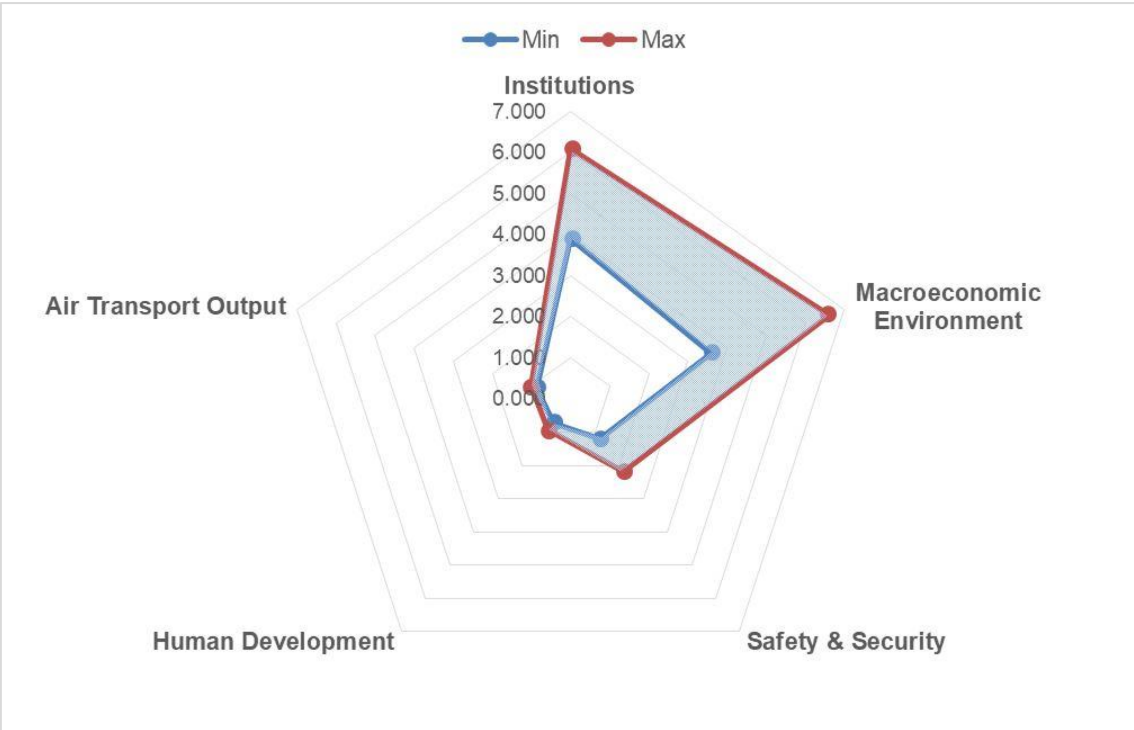

Figure 7-3 Optimum macro-environmental setting area for fully public model

Although it might seem that the three airport ownership and management models have the similar macro-environmental optimum setting areas, this is due to the small score indexing used to measure the macro-environmental factors, especially for the Human Development and Air Transport Output, by their respective organizations as shown in Appendix C.

Institutions and Macro-economic Environment are scaled using a score index from one to seven. Human Development is a 0 to 1 index score, with one representing the highest human development score. Similarly, the Air Transport Output is scaled by a 0 to 1 index score with one being the most efficient output. Finally, the Safety and Security is indexed over 1 to 5 score index with 5 being the least safe and peaceful environment.

To better visualise the optimum macro-environmental setting areas for the airport ownership and management models, the scaling of the five national macro-environmental factors are unified. The 1 to 7 scaling of the Institutions and Macro-economic Environment is used as the reference scale since it is the highest scale among the scales of the five national macro-environmental factors.

To transform the scale of the Human Development and Air Transport Output, their scores are multiplied by a factor of 7. However, regarding the Safety and Security factor, the scale is inverted, which means that the higher its score is, the lower the actual level of peace and security in the country is. Therefore, its scores are inverted in the first place. Then, after inverting the scores of the Safety and Security factor, they are multiplied by a factor of 7. Therefore, by doing this process, all the five national macro-environmental factors have the same 1 to 7 score indexing, as shown in Table 7-2.

After unifying the score indexing of the national macro-environmental factors, radar charts the optimum national macro-environmental setting area for each airport and ownership model based on the new unified score indexing are constructed.

Table 7-2 Efficient airports classifications and their respective national macro-environmental factors (Unified scaling)

Airport Name	Country	Year	Efficiency (DEA)	Institutions	Macroeconomic Environment	Safety & Security	Human Development	Air Transport Output
(1) Majority Private Model (100% Private, mixed private-public with private majority)								
Sydney Kingsford Smith International Airport	Australia	2009	1.000	5.600	5.600	4.743	6.062	7.000
Vienna International Airport	Austria	2009	1.000	5.600	5.200	5.591	5.558	7.000
Copenhagen Kastrup International Airport	Denmark	2009	1.000	6.100	5.700	5.752	5.593	7.000
Athens International Airport	Greece	2009	1.000	3.800	4.000	3.937	5.320	4.162
Auckland International Airport	New Zealand	2009	1.000	6.000	5.200	5.824	5.726	7.000
Zurich International Airport	Switzerland	2009	1.000	5.900	5.600	5.025	5.817	7.000
London Heathrow International Airport	UK	2009	1.000	5.100	4.600	4.250	5.425	7.000
Melbourne Airport	Australia	2015	1.000	5.300	5.600	5.267	6.571	7.000
Vienna International Airport	Austria	2015	1.000	5.200	5.100	5.843	6.254	7.000
Athens International Airport	Greece	2015	1.000	3.700	3.300	3.727	6.061	5.908
Ljubljana Jože Pučnik Airport	Slovenia	2015	1.000	3.900	4.400	5.080	6.232	7.000
Zurich Airport	Switzerland	2015	1.000	5.800	6.500	5.490	6.574	7.000
London Heathrow Airport	UK	2015	1.000	5.500	4.200	4.154	6.366	7.000
			Min	**3.700**	**3.300**	**3.727**	**5.320**	**4.162**
			Max	**6.100**	**6.500**	**5.843**	**6.574**	**7.000**
(2) Mixed Public-Private Model with public majority								
Guangzhou Bai Yun Airport	China	2009	1.000	4.400	5.900	3.644	3.493	7.000
Paris Charles de Gaulle International Airport	France	2009	1.000	5.000	4.700	4.433	5.453	7.000
Frankfurt Main International Airport	Germany	2009	1.000	5.500	5.300	5.029	5.607	7.000
Kansai International Airport	Japan	2009	1.000	4.900	4.200	5.503	5.698	7.000
Amsterdam Schiphol International Airport	Netherlands	2009	1.000	5.700	5.200	4.572	5.810	6.985
Manchester International Airport	UK	2009	1.000	5.100	4.600	4.250	5.425	7.000
Guangzhou Bai Yun Airport	China	2015	1.000	4.100	6.500	3.088	5.164	7.000
Paris Charles de Gaulle Airport	France	2015	1.000	4.800	4.700	4.018	6.282	7.000
Frankfurt Airport	Germany	2015	1.000	5.200	6.000	5.076	6.480	7.000
Kansai International Airport	Japan	2015	1.000	5.500	3.700	5.295	6.324	7.000
Amsterdam Schiphol International Airport	Netherlands	2015	1.000	5.600	5.700	4.888	6.470	7.000
Manchester International Airport	UK	2015	1.000	5.500	4.200	4.154	6.366	7.000
			Min	**4.100**	**3.700**	**3.088**	**3.493**	**6.985**
			Max	**5.700**	**6.500**	**5.503**	**6.480**	**7.000**

Airport Name	Country	Year	Efficiency (DEA)	Institutions	Macroeconomic Environment	Safety & Security	Human Development	Air Transport Output
(3) Fully Public Model (Government corporation)								
Munich International Airport	Germany	2009	1.000	5.500	5.300	5.029	5.607	7.000
Keflavik International Airport	Iceland	2009	1.000	5.600	3.600	5.714	5.579	7.000
Dublin International Airport	Ireland	2009	1.000	5.200	4.600	5.251	5.334	6.118
Tokyo International Airport	Japan	2009	1.000	4.900	4.200	5.503	5.698	7.000
Oslo Airport	Norway	2009	1.000	5.900	5.900	5.752	6.083	7.000
Singapore Changi International Airport	Singapore	2009	1.000	6.100	5.200	4.566	5.026	7.000
Geneva Cointrin International Airport	Switzerland	2009	1.000	5.900	5.600	5.025	5.817	7.000
Helsinki Vantaa Airport	Finland	2015	1.000	6.100	5.400	5.482	6.262	7.000
Munich Airport	Germany	2015	1.000	5.200	6.000	5.076	6.480	7.000
Dublin International Airport	Ireland	2015	1.000	5.500	4.500	5.170	6.459	7.000
Haneda Airport	Japan	2015	1.000	5.500	3.700	5.295	6.324	7.000
Christchurch International Airport	New Zealand	2015	1.000	6.000	5.900	5.733	6.404	7.000
Incheon International Airport	South Korea	2015	1.000	3.900	6.600	4.115	6.307	7.000
Bandaranaike International Airport	Sri Lanka	2015	1.000	4.100	4.100	3.199	5.365	7.000
Genève Aéroport	Switzerland	2015	1.000	5.800	6.500	5.490	6.574	7.000
			Min	**3.900**	**3.600**	**3.199**	**5.026**	**6.118**
			Max	**6.100**	**6.600**	**5.752**	**6.574**	**7.000**

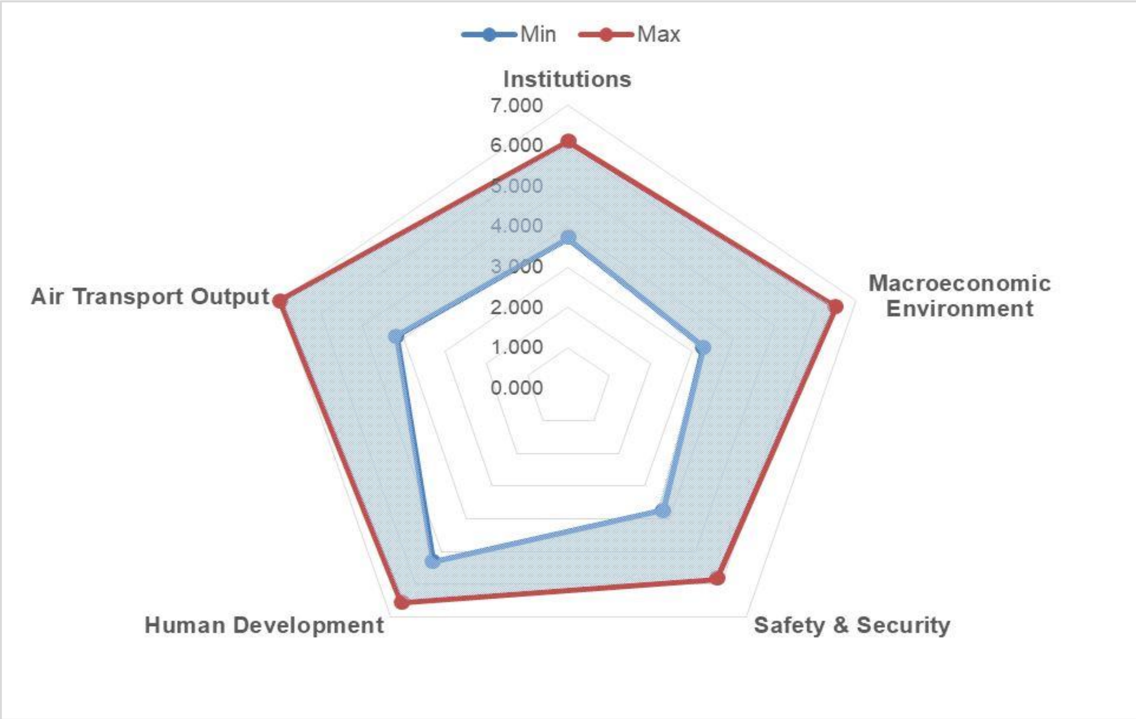

Figure 7-4 Optimum macro-environmental setting area for Majority private model (Unified Scaling)

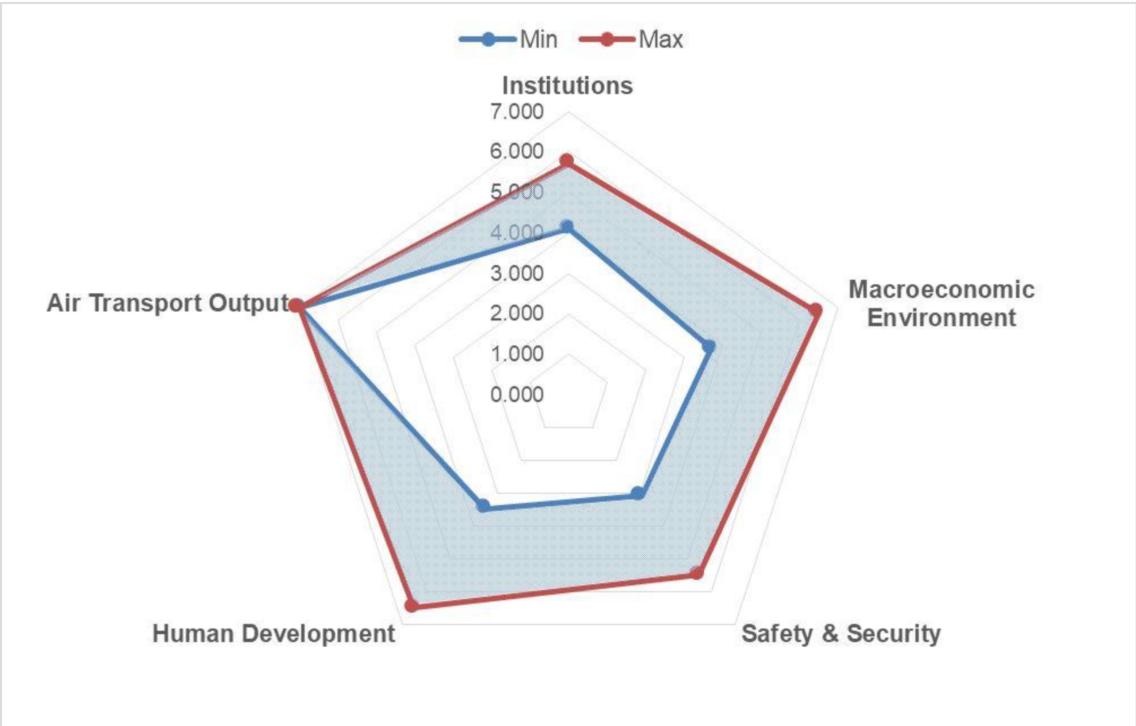

Figure 7-5 Optimum macro-environmental setting area for mixed public-private model (Unified Scaling)

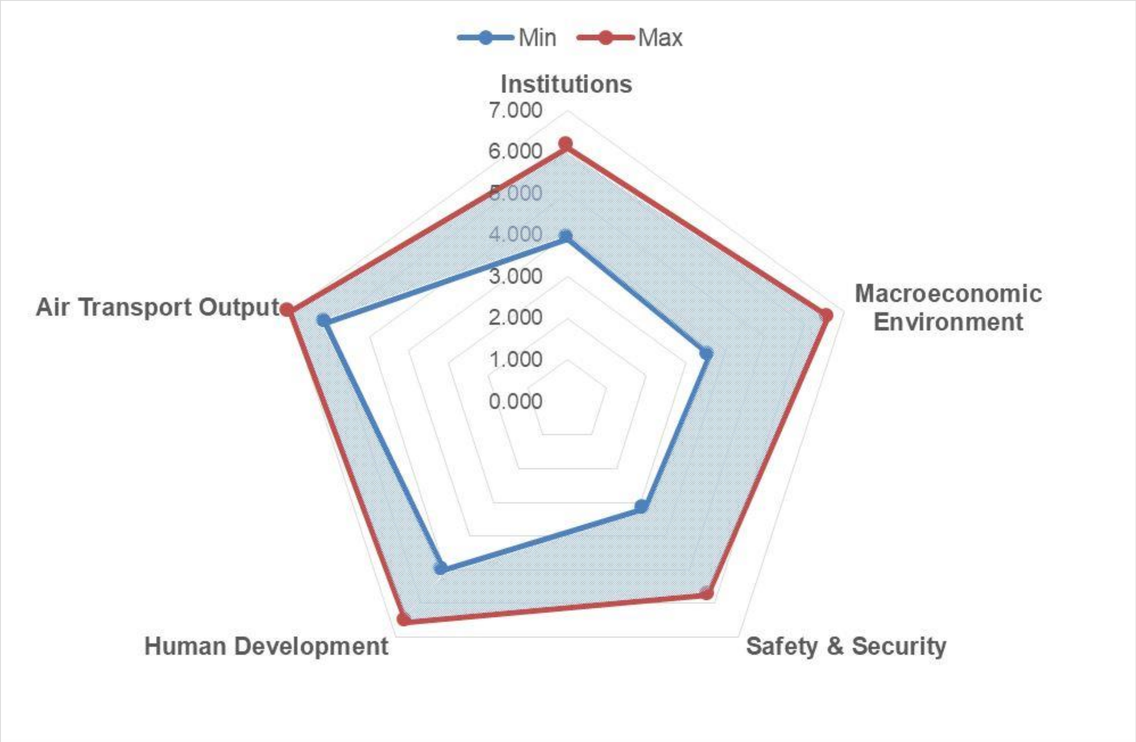

Figure 7-6 Optimum macro-environmental setting area for fully public model (Unified Scaling)

Figure 7-4, Figure 7-5, and Figure 7-6 clearly show the difference between the areas of the optimum national macro-environmental settings of the airport ownership and management models.

In this research, the accuracy of the optimum national macro-environmental setting area of an airport ownership and management is constrained by the low number of observations in each model. But a number of logical observations can be drawn upon comparing the three different areas shown in Figure 7-4, Figure 7-5, and Figure 7-6. The most critical observations relate to the minimum boundary of the optimum national macro-environmental setting area since it reflects the minimum allowable boundary for which the airport ownership and management model can achieve an efficient airport performance. However, the maximum boundary may not indicate valuable observations since it is assumed that higher values in the national macro-environmental factors will always lead to better outcomes. Therefore, the following discussions focus on the minimum values of the national macro-environmental factors.

The Institutions factor is least flexible in the mixed public-private model (min: 4.1, max: 5.7) when compared to the majority private and the fully public models that allow for more flexibility in the score of the Institutions (min: 3.7, max: 6.1 and min: 3.9, max: 6.1 respectively). The highest minimum score of the institutions in the mixed public-private model over the other models could reflect the complexity of the interaction between public and private sectors which requires both parts to be highly professional and working under a high quality administrative and legal framework to limit any possible dispute over the management, and the control of the airport. This kind of interaction between public and private sectors is highly limited in the majority private or fully public models, where the whole airport is usually controlled by one party, which could explain the greater flexibility in the minimum value that both models offer over the Institutions scores. Nevertheless, both majority private and fully public prefer high Institutions score, which is reflected by the highest maximum value of Institutions (max: 6.1).

In the Macro-economic Environment, the majority private model offers more flexibility than the mixed public-private and fully public models. The lowest minimum score allowed by the majority private model is 3.3, which is lower than both mixed public-private and fully public that allow for 3.7 and 3.6, respectively. Since this factor reflects the condition of the macro-economic environment of a country including the government budget balance and past government debts, it is logical that the models where the public sector is involved in the ownership and management of the airport demand robust macro-economic environment for an optimum airport performance. However, in the majority private model, the government or the public sector has no share in the responsibility of the airport finances. Therefore, the effect of the macro-economic environment on the majority private airport would be lower than its effect on the mixed public-private and the fully public airport. Thus, this explains the flexibility that the majority private model offers in the minimum allowable value of the macro-economic environment over the two other models that involve the participation of the public sector in the ownership and management of the airport.

The majority private model also has the highest minimum allowable value for Safety and Security when compared to the two other models where the minimum value of Safety and Security allowed in the majority private model is 3.727, which is reasonably higher than 3.199 and 3.088, which are the minimum values allowed by the fully public and the mixed public-private models respectively. This means that the models where the public sector is participating in the ownership and management of the airport can achieve efficient airport outcomes in environments that have, to a certain extent, lower degrees of safety and security, unlike the majority private model. The logic behind this observation lies in the fact that the private sector and private investors alike prefer safe and secure environments. Usually, where the level of safety and security reduces, the private sector becomes significantly more reluctant to finance the required developments. However, the effect of lower safety and security levels on the models that include the public sector is usually lesser, since governments or public entities usually do not put the required development on hold as long as the level of safety and security in the country is controllable.

The Human Development Index is another important factor for efficient airport performance. Among the three-airport ownership and management models, the majority private model demands the highest minimum allowable value of the Human Development index (5.32), followed by the fully public model (5.02), and the mixed public-private model (3.49). This means that while both the majority private and the fully public models require a high Human Development index to be able to achieve efficient airport outcomes, the mixed public-private model is more flexible and can handle lower levels of human development. From an industrial experience, it was shown that it is essential for the majority private model to operate an airport in an environment that has a high level of human development in order to operate efficiently. Otherwise, the private sector will have to bring in experienced and professional expatriates with high salaries to cover local skills shortages as indicated by Chaouk et al. (2019). In addition, in many countries, privatising an airport that used to be operated by the public sector may face public resistance aimed at protecting existing rights of employment where they are at risk of being diluted. Some cultures may find it difficult to accept the privatization of what many consider to be public and socially essential assets, especially if ownership was to be transferred to entities owned by foreign nationals or interests.

Finally, in the Air Transport Output, the most flexible airport ownership and management model is the majority private with a minimum allowable value of 4.16, lower than both mixed public-private and fully public model with 6.98 and 6.11 respectively. This is in line with the belief that airport privatization could be more successful where there are a robust air transport system and framework of regulations. Chaouk et al. (2019) and Itani (2015) also discussed the importance of a mature and robust air transport system in the country in order to have successful airport privatization outcomes. However, the Air Transport Factor also encompasses total air passenger traffic, the national aviation sector's contribution to GDP and employment, and level of air connectivity, so this might explain why the majority private model could achieve efficient airport performance in an environment that has lower Air Transport Output values. This might be because of the experience and the technology that privatization can bring in to enhance terminal and airside operations, improve quality of service, and enhance route development strategies which could all drive and increase the traffic to and from the airport. In addition, privatization is well known in its tendency to focus on increasing non-aeronautical revenues and activities, which leads to a better airport contribution to the overall GDP and employment in the country (Itani, 2015; Oum, Adler and Yu, 2006a).

7.3 Preliminary Framework Proposition for a Macro-Environmental Approach in Selecting a Suitable Airport Ownership and Management Model

After constructing the optimum macro-environmental setting areas for each airport ownership and management model, the next step is to build on these optimum areas to propose a preliminary framework which can be used by policymakers in government or civil aviation authorities to select an airport ownership and management model which best suits their national macro-environmental settings. It is preliminary because as said before, the results might be well refined in the case of more observations being added to the statistical analysis in Chapters 5 and 6.

Selecting an airport ownership and management model is a critical decision. This is because first of all, choosing the right model could protect the capital and other resources invested in the airport project. Secondly, it could provide the conditions necessary to facilitate and incentivise an improvement in airport performance which could potentially enhance customer satisfaction and the financial and social returns not only to the airport owner and operator but also to the state and society in general.

Therefore, having a framework which the decision-makers can use to help them identify the airport ownership and management model that is most suitable for their national macro-environmental settings is essential, as it could reduce the risk of airport under-performance and resource misallocation.

The proposed framework consists of four main steps. The first step is to understand the type of the airport project. The second step is to understand the requirements of the decision-maker in terms of airport ownership and management model. The third step is to benchmark the national macro-environmental factors of the country against the optimum national macro-environmental setting area for each airport ownership and management model. The fourth and final step is deriving conclusions and making decisions based on the information given from the first three steps. Figure 7-7 illustrates the proposed preliminary framework.

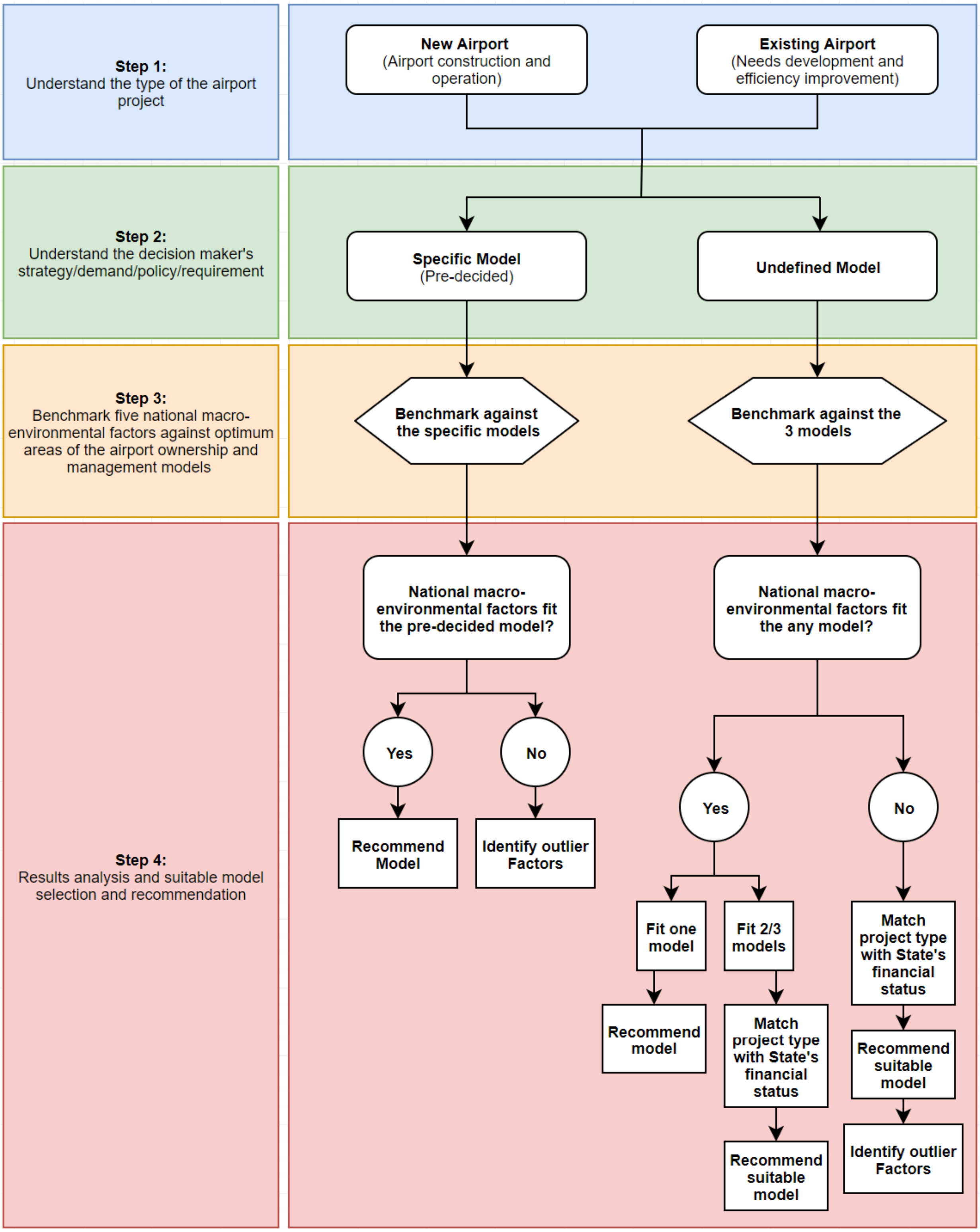

Figure 7-7 Proposed Preliminary Framework for Airport Ownership and Management Model Selection

Step 1: Understanding the type of the airport project

It is imperative to understand the planned airport project for which the decision-maker, government or civil aviation authority, seeks to implement or decide on the appropriate ownership and management model. Two main basic types of airport projects could exist. The first type is a Greenfield airport development, which involves the construction of an entirely new asset. The second type is where an existing airport needs to undertake a significant development, such as an airport expansion or the building of a new terminal.

Step 2: Understanding the requirement of the Decision Maker

It is well known to management consultants and other professionals who provide advisory services to the airport industry that governments or Civil Aviation authorities rarely seek advice determining which ownership and management model is best suited to their context and macro-environment. In many countries, the ownership model is pre-determined by decision-makers, and then management consultants are invited to advise on the preparation and implementation processes. Therefore, in this step, there could be two main scenarios. The first scenario is when the decision-maker has decided on the ownership and management model, whether it is majority private, mixed public-private, or fully public. The second scenario is when the decision-maker has not pre-defined the model.

Step 3: Benchmarking national macro-environmental factors

In this step, the scores of the five national macro-environmental factors of the country are benchmarked against the three optimum national macro-environmental setting areas of each airport ownership and management model. The benchmarking shows whether the country's national macro-environmental settings fits into one or more optimum areas respective to the three different airport ownership and management models.

Step 4: Model selection

In this final step, in case there is no pre-decided specific model, the decision-maker has to look at the result of the benchmarking to decide on the suitable model. However, in those cases where the decision-maker has already decided on a specific model, the benchmarking results will either indicate that this decision suits the state's national macro-environmental settings, or will identify the factors which are outliers to the optimum area of the selected model.

In the following two sub-sections, the two scenarios related to the decision maker's requirement are explained and detailed for further clarification on the framework and its respective steps. For each scenario, a hypothetical example is presented to illustrate how the framework works. The choice of the examples is based on the countries which have all the scores of the five national macro-environmental factors available.

7.3.1 Scenario 1: Pre-defined ownership and management model

As previously said, for several reasons, including the government's strategy and policies, some governments pre-decide on a specific ownership and management model for an airport. These governments often request the advisory services of an international consultant who have demonstrated previous international experience in designing privatization models and transaction frameworks. However, the implementation of an airport ownership and management framework in an unfamiliar macro-environmental setting may increase the risk of airport financial under-performance Therefore, besides its main objective to identify suitable ownership and management model for an airport, this framework can also identify the outlier factors that make the national macro-environmental settings not suitable for the pre-decided model. The identification of the outlier factors could form a point of emphasis for the government in its long-term strategy to work on strengthening those factors for better outcomes of the selected airport ownership and management model. The importance of this process is to avoid the long-term losses incurred due to the inappropriate selection of an airport ownership and management model.

So, in this scenario, the decision-maker of a country (X) has previously decided on implementing one of the three airport ownership and management models for either a new airport development project or an already existing airport.

After understanding the type of the airport project and identifying the required ownership and management model by the decision-maker, the scores of the five national macro-environmental factors of the country (X) are drawn against the optimum national macro-environmental setting area of the respective selected model. Upon this benchmarking process, two possibilities can occur:

The first possibility is that the scores of the five national macro-environmental setting of the country (X) fall inside the optimum national macro-environmental setting area of the selected model; thus the selected model is said to be suitable and is expected to achieve efficient airport performances if implemented.

The second possibility is that some of the scores of the five national macro-environmental setting of the country (X) do not fall into the optimum area of the selected model; thus it is said that the selected model is not going to be implemented in the national macro-environmental setting that can enable it to achieve efficient airport performance. In this case, and since the policies and the strategies of the government of the country (X) insists on implementing this specific airport ownership and management model, the government will be informed on the outlier factors. This information might help the government to identify the points of weaknesses in its national macro-environmental setting, which makes the selected airport ownership and management model not suitable to be implemented for its airport. This may also drive the government to focus on strengthening the areas of outlier factors as part of its strategy in order to avoid the potential long-term financial losses of the airport as a result of the wrong ownership and management model choice.

7.3.1.1 Scenario 1 Hypothetical Example: Sri Lanka

In this example, Scenario 1 is applied hypothetically to a country in the sample dataset of this research to clarify the process of this framework. The 2015 scores of the national macro-environmental factors are used in this example.

Let's assume that in 2015, the Sri Lankan Government decided to fully privatise Bandaranaike International Airport as part of its strategy to privatise all the airports in Sri Lanka by 2025. The main reason for the airport privatization program is to transfer the responsibility of executing the required airport developments to the private sector in order to accommodate the increasing demand for the air traffic in Sri Lanka. The second reason is to enhance the quality of service at the Sri Lankan airports.

Now, knowing the type of airport project and the requirement of the decision-maker, which is the Government of Sri Lanka, the third step is to benchmark the five national macro-environmental factors of Sri Lanka in 2015 against the optimum national macro-environmental setting area of the majority private airport ownership and management model.

In 2015, the scores of the five national macro-environmental factors were as shown in Table 7-3.

Table 7-3 Sri Lanka 2015 national macro-environmental scores

Institutions	4.1
Macroeconomic Environment	4.1
Safety & Security	3.2
Human Development	5.4
Air Transport Output	7

Sources: (IEP, 2015; UNDP, 2015; WEF, 2015a)

The scores the five national macro-environmental factors presented in Table 7-3 are drawn against the optimum national macro-environmental setting area of the fully public ownership to check if the decision of the Sri Lankan

Government suits the macro-environmental settings of Sri Lanka. Figure 7-8 shows the result of the benchmarking process.

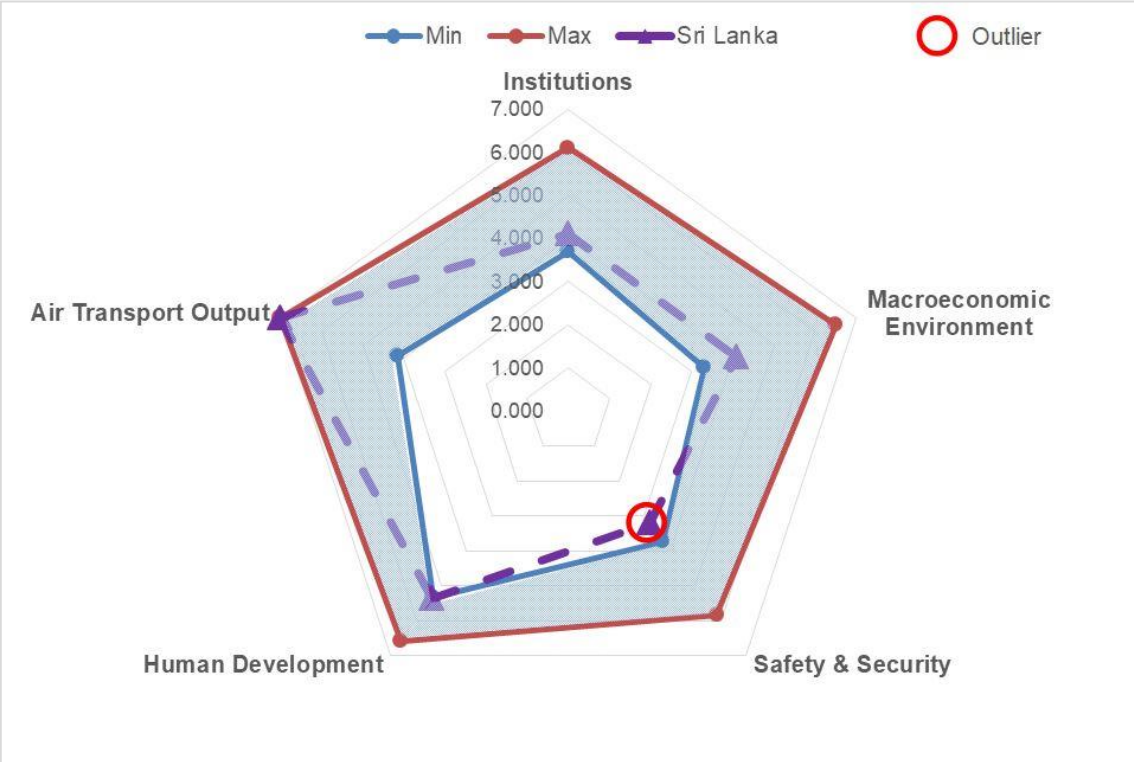

Figure 7-8 Sri Lanka macro-environmental setting benchmark against the optimum national macro-environmental setting area of the majority private model

The result of the benchmarking process shows that the scores of Institutions, Macroeconomic Environment, Human Development, and Air Transport Output of Sri Lanka, all fall into the optimum national macro-environmental setting area of the majority private airport ownership and management model. However, there exists one outlier factor, which is Safety and Security, which makes the majority private model not fully suitable for Sri Lanka's macro-environmental setting.

Therefore, this framework indicates that the national macro-environmental setting of Sri Lanka is not entirely in favour of the full privatization of airports, and the reason is that the level of safety and security in the country is slightly less than the minimum level allowed by the majority private model. And in order for the majority private model to achieve a better airport performance at

Bandaranaike International Airport, the Government has to work on enhancing the level of safety and security in Sri Lanka.

7.3.2 Scenario 2: Undefined ownership and management model

This is the typical scenario for which this framework is developed. It is when the decision-maker of the airports of a country, either the government or the civil aviation authority, is unsure which airport business model to implement for its airport.

So, the first step is to understand the situation of the airport that the decision-maker of the country (X) wants to select an ownership and management model for it. As mentioned in the description of Step 1 of this framework, it can be either a new airport that needs to be constructed and operated, or an existing airport that needs development, or an existing airport that needs improvement in its performance and quality of service.

Since the decision-maker has not pre-defined the ownership and management, the scores of the five national macro-environmental factors of the country (X) are benchmarked against the three different airport ownership and management models. The benchmarking process can lead to three possible results:

The first possibility is that the five national macro-environmental factors of the country (X) fit inside one of the three optimum national macro-environmental setting areas of the respective airport ownership and management models. Thus, the model of the respective optimum area is said to be the most suitable for the national macro-environmental settings of the country (X), and it is recommended to be implemented for the airport for better airport performances.

The second possibility is that the five national macro-environmental factors fit inside more than one of the three optimum national macro-environmental setting areas of the respective airport ownership and management models. In this case, the type of the airport project and the requirements of the decision-maker have to be looked at.

In case the airport project requires capital investments such as building a new airport or developing an existing one, the financial capabilities of the government have to be checked. If the government is capable of securing funds for the airport development project, then the focus has to be towards the model with the least private sector participation. However, if the government is not capable of securing the required funds, the model with most private sector participation has to be selected.

In the case where the airport requires performance and quality of service improvements without the need for significant capital investments, then the model of the respective optimum national macro-environmental setting area that is closest to fit for the macro-environmental setting of the country (X) has to be selected with an informing the government of the outlier factors.

The third and last possibility is that the five national macro-environmental factors of the fit inside none of the three optimum national macro-environmental setting areas of the respective airport ownership and management models. In this case, the same process as in the second possibility has to be done. The type of the airport project and the requirements of the decision-maker have to be studied.

In case the airport project requires significant capital investments, the financial capabilities of the government have to be checked. If the government is capable of securing the required funds for the airport project, then the model with the least private sector participation is recommended to be selected, and the government has to be informed of the outlier factors. If the government is not financially capable, then the model with the most private sector participation is recommended to be selected, whilst informing the government of the factors that are outside the optimum area.

In the case where no significant capital investment is needed for the airport project, then the model of the respective optimum national macro-environmental setting area that is the closest fit for the macro-environmental setting of the country (X) is recommended to be selected with an informing the government of the outlier factors.

7.3.2.1 Scenario 2 Hypothetical Example 1: Greece

In this example, Scenario 2 is hypothetically applied to a country in the sample dataset. Similarly to the hypothetical example of Scenario 1, the 2015 scores of the national macro-environmental factors are used. In addition, this hypothetical example shows a case where the scores of the five national macro-environmental factors of the country fit entirely inside one of the optimum national macro-environmental setting areas of the three airport ownership and management models.

This example assumes that Greece wants to implement a suitable ownership and management model for one of its airports for the aim to achieve better airport performance and improve the quality of service. However, the Government of Greece doesn't know which model to choose.

In this case, the five national macro-environmental factors of Greece in 2015 are benchmarked against the three optimum national macro-environmental setting areas respective to the three different airport ownership and management models. Table 7-4 lists the scores of the five national macro-environmental factors of Greece in 2015.

Table 7-4 Greece 2015 national macro-environmental scores

Institutions	4.1
Macroeconomic Environment	4.1
Safety & Security	3.2
Human Development	5.4
Air Transport Output	7

Sources: (IEP, 2015; UNDP, 2015; WEF, 2015a)

The results of the benchmarking process against the optimum national macro-environmental setting areas of the majority private, mixed public-private, and fully public models are shown in Figure 7-9, Figure 7-10, and Figure 7-11respectively.

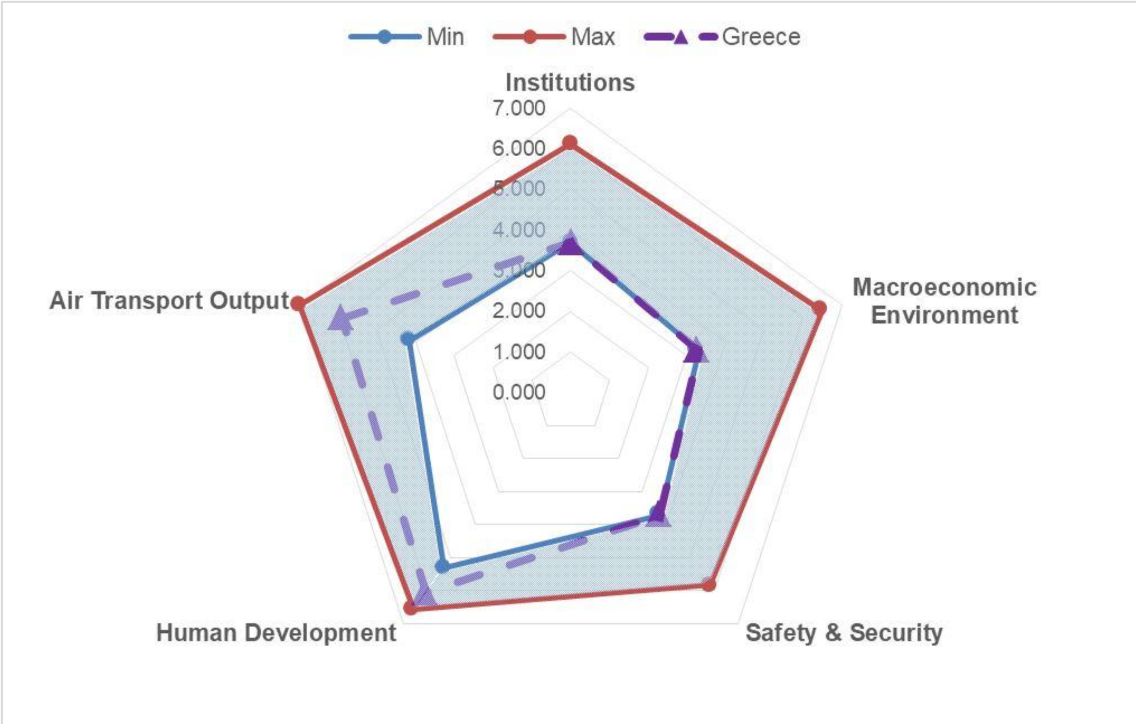

Figure 7-9 Greece macro-environmental setting benchmark against the optimum national macro-environmental setting area of the majority private model

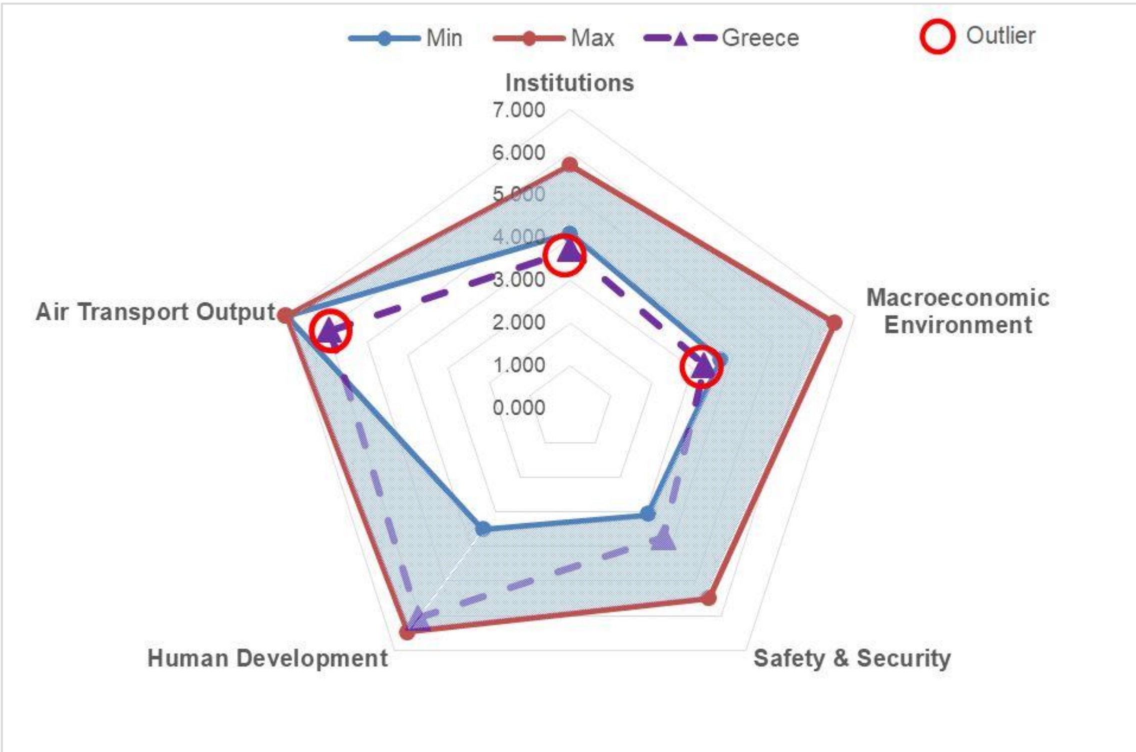

Figure 7-10 Greece macro-environmental setting benchmark against optimum national macro-environmental setting area of the mix public-private model

Figure 7-11 Greece macro-environmental setting benchmark against the optimum national macro-environmental setting area of the fully public model

The results of the benchmarking process show that the scores of the five national macro-environmental factors of Greece completely falls inside the optimum national macro-environmental setting area of the majority private model (Figure 7-9). However, the scores do not completely fall into the optimum national macro-environmental setting area of both the mixed public-private and the fully public models, where there exist three outlier factors. The outlier factors in both the mixed public-private and the fully public are Air Transport Output, Institutions, and Macroeconomic Environment.

These results show that the airport ownership and management model that best suits the macro-environmental setting of Greece is the majority private model. Therefore, it is recommended that the government of Greece choose to implement the majority private model for its airport as it is expected to be able to achieve better airport performance than the other models. In reality, the national hub at Athens and the regional airports are fully privatized, and Athens International Airport has been considered the most efficient airport in Europe for 10-25 million passenger category according to ATRS (ATRS, 2018).

7.3.2.2 Scenario 2 Hypothetical Example 2: Egypt

This hypothetical example shows a case where none of the three optimum areas fits for the scores of the national macro-environmental factors of a country. The country chosen is a MENA country and is not included in the sample data-set of this research. However, since data on the Air Transport Output for Egypt is available, it is decided to use Egypt as an example as it gives an idea of how to generalise the use of this framework for countries that were not included in the sample dataset of this research.

Let's assume that Egypt is seeking to build a new airport in Cairo, and the Egyptian Government is undecided as to the ownership and management model that it should pursue. Again, the five national macro-environmental factors of Egypt in 2015 are benchmarked against the three optimum national macro-environmental setting areas respective to the three different airport ownership and management models. The scores of the five national macro-environmental factors of Egypt in 2015 are listed in Table 7-5.

Table 7-5 Egypt 2015 national macro-environmental scores

Institutions	3.6
Macroeconomic Environment	2.8
Safety & Security	2.9
Human Development	4.8
Air Transport Output	4.8

Sources: (IEP, 2015; UNDP, 2015; WEF, 2015a)

Figure 7-12, Figure 7-13, and Figure 7-14 show the results of the benchmarking process, where none of the optimum national macro-environmental setting areas of the three airport ownership and management models seems to fit for the scores of the macro-environmental factors of Egypt.

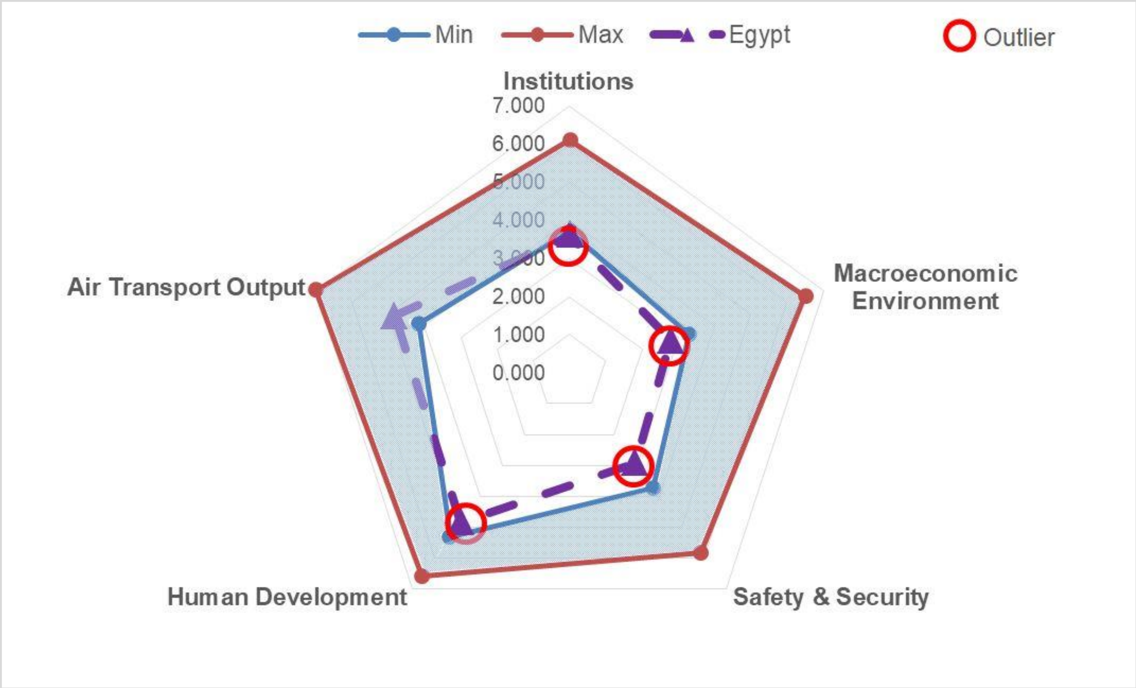

Figure 7-12 Egypt macro-environmental setting benchmark against optimum national macro-environmental setting area of the majority private model

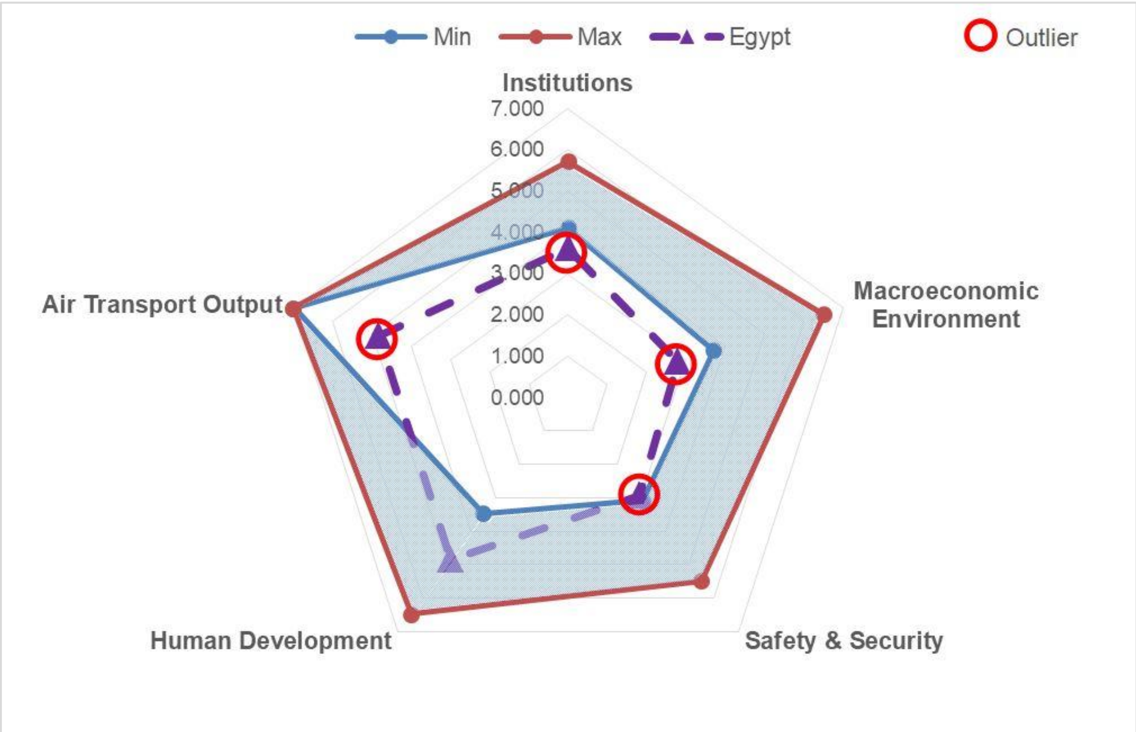

Figure 7-13 Egypt macro-environmental setting benchmark against optimum national macro-environmental setting area of the mix public-private model

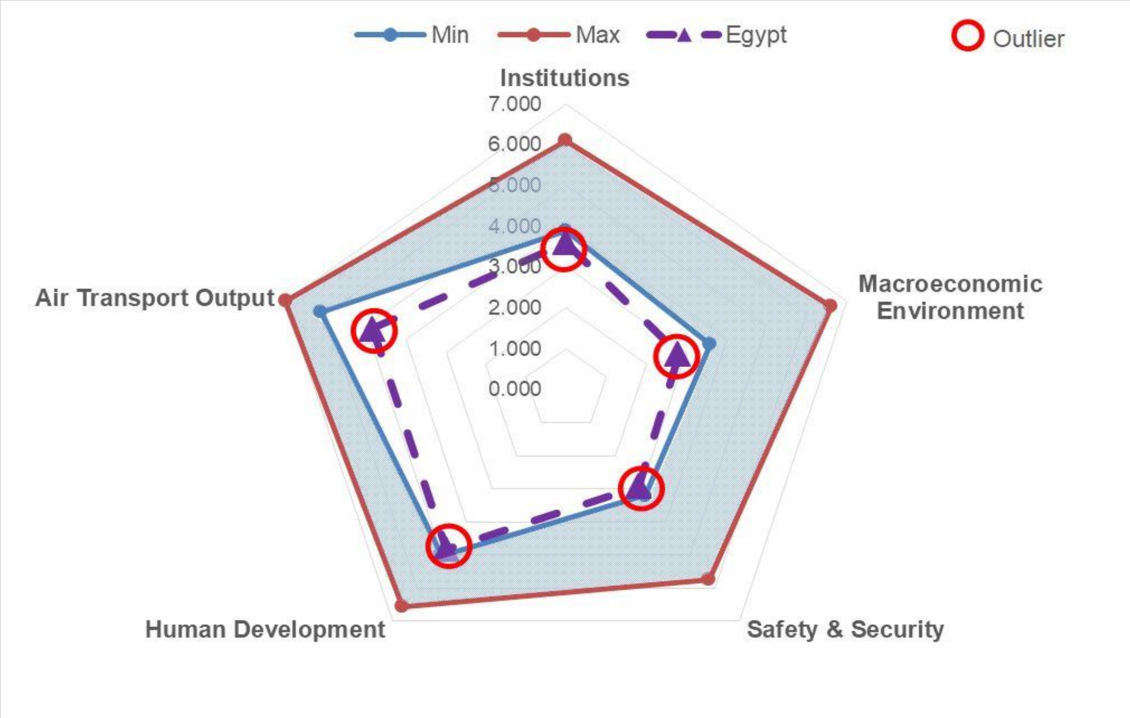

Figure 7-14 Egypt macro-environmental setting benchmark against optimum national macro-environmental setting area of the fully public model

The benchmarking of Egypt's five national macro-environmental factors against the optimum national macro-environmental setting area of the majority private model in Figure 7-12 shows that four out of the five factors are outliers and only the Air Transport Output falls inside the optimum area.

In the mix public-private model, the benchmarking in Figure 7-13 also shows that there are four out the five national macro-environmental factors of Egypt are outliers, but the only factor that falls inside the optimum area is the Human Development.

The worst result is for the fully public model, where none of the five national macro-environmental factors of Egypt falls inside the optimum area, as shown in Figure 7-14.

As there is no model that entirely fits for the macro-environmental setting of Egypt, and the two other models have the same number of outlier factors, the choice of the most suitable model has to take into consideration the type of the airport project.

The targeted airport is a new airport to be constructed; this means that significant capital investments are required to be spent on the airport project. And since there is a substantial overall deficit in the 2015 budget financing of the Egyptian Government as published by the Egyptian Ministry of Finance in EMOF (2015), the focus should be on selecting the model with the highest level of private sector participation in order to access private funds for executing the airport project.

Therefore, the most suitable ownership and management model for this airport project is the fully privatized model. This decision is further supported by the fact that the optimum national macro-environmental setting area of the majority private model in Figure 7-12 is the closest fit for the scores of the five national macro-environmental factors of Egypt when compared with the optimum area of the mix public-private model in Figure 7-13. This also means that a majority private model is able to outperform the mix public-private airport.

Therefore, the Egyptian Government is recommended to implement the majority private model as it is the most suitable among the other models. However, to be able to achieve better airport performance, the Government needs to strengthen the outlier factors, which are the Institutions, Macroeconomic Environment, Safety and Security, and Human Development, in its long-term strategy.

7.3.2.3 Scenario 2 Hypothetical Example 3: United Arab Emirates

In the hypothetical example 1 of Scenario 2, the case of a one suitable airport ownership and management model is shown. In hypothetical example 2, the case of no suitable model is presented. In this hypothetical example, the case of more than one suitable airport ownership and management model for the national macro-environmental setting of a country is discussed. Similarly to hypothetical example 2, the country played in this example is a MENA country which is not included in the sample dataset of this research. The country is the United Arab Emirates (UAE). It is chosen because its data are also available. In addition, the UAE’s financial status is the opposite of Egypt; therefore, using it as an example shows a different application of this framework for airports in financially capable countries.

In this hypothetical example, it is assumed that a new airport is planned to be built in Abu Dhabi. However, the local government of Abu Dhabi is not sure which ownership and management model that might achieve the best performance outcomes in this airport. Therefore, the scores of the five national macro-environmental factors of UAE in 2015 have to be benchmarked against the three optimum national macro-environmental setting areas respective to the three different airport ownership and management models. Table 7-7 lists the scores of the five national macro-environmental factors of UAE in 2015. Figure 7-15, Figure 7-16, and Figure 7-17 show the results of the benchmarking process.

Table 7-6 UAE 2015 national macro-environmental scores

Institutions	5.7
Macroeconomic Environment	6.5
Safety & Security	3.9
Human Development	5.9
Air Transport Output	7

Sources: (IEP, 2015; UNDP, 2015; WEF, 2015a)

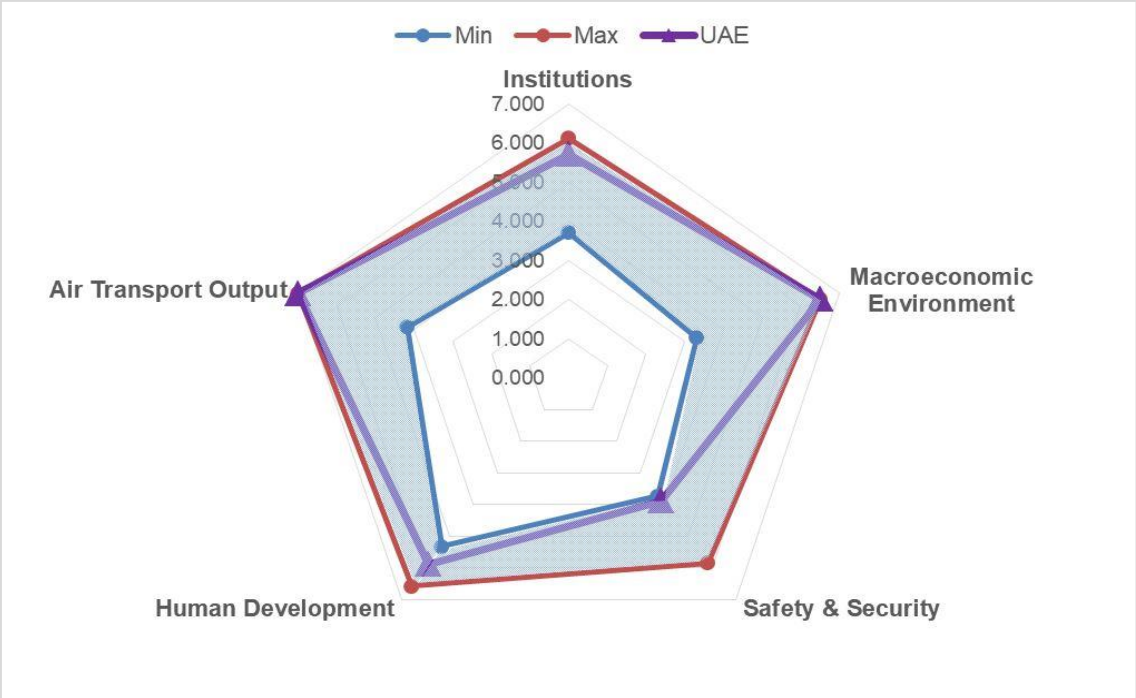

Figure 7-15 UAE macro-environmental setting benchmark against optimum national macro-environmental setting area of the majority private model

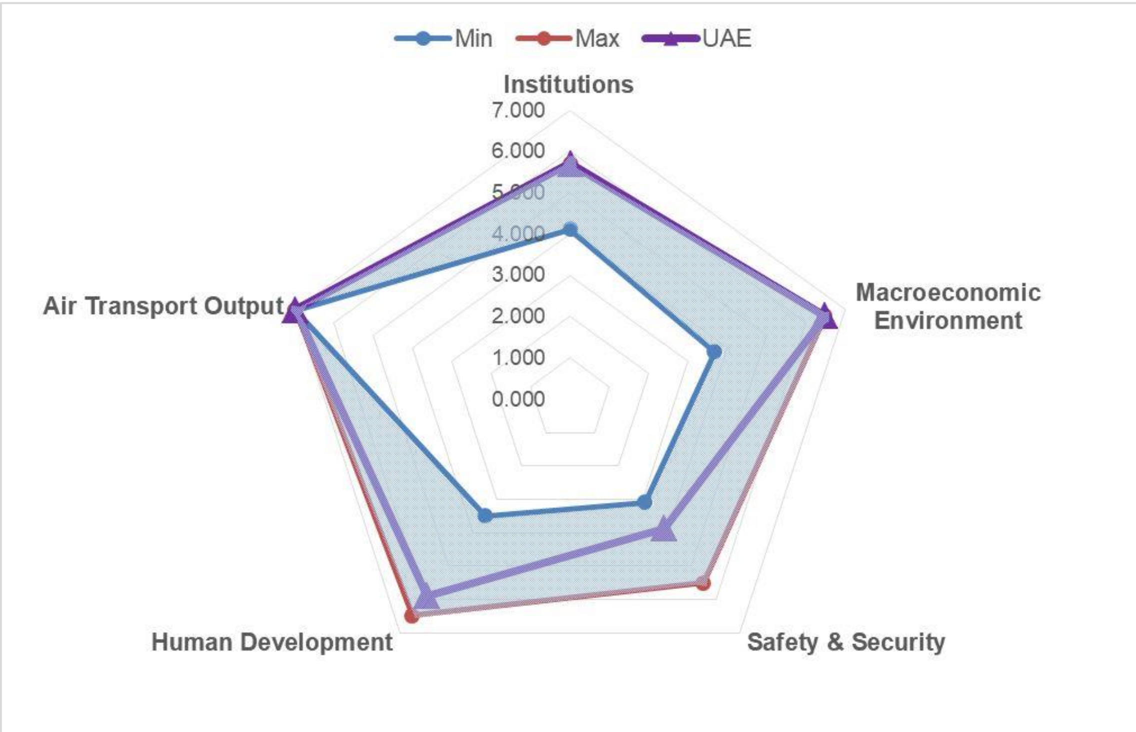

Figure 7-16 UAE macro-environmental setting benchmark against optimum national macro-environmental setting area of the mix public-private model

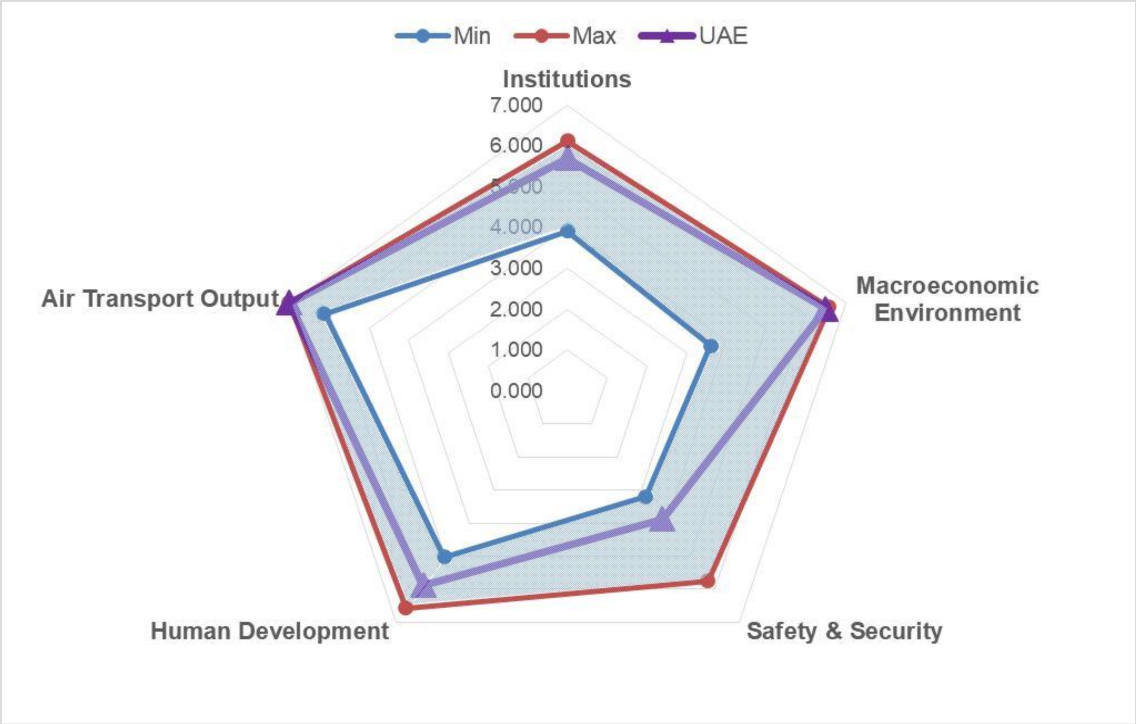

Figure 7-17 UAE macro-environmental setting benchmark against optimum national macro-environmental setting area of the fully public model

The results in Figure 7-15, Figure 7-16, and Figure 7-17 show that the scores of the five national macro-environmental factors of UAE fit inside all of the three optimum national macro-environmental settings area respective to the three airport ownership and management models. This means that the majority private, mix public-private, and the fully public models are all suitable to be implemented in UAE airports. Since more than one model is suitable, then the choice will depend on the type of project at first, and secondly, the financial status of the country in case the project requires substantial capital investments.

Since the project is a new airport construction and operation, and since UAE is a financially capable country, especially the local government of Abu Dhabi, it is recommended to choose the model with the least airport privatization which is the fully public model.

7.4 Summary

In this Chapter, a preliminary framework to select suitable airport ownership and management model using macro-environmental approach is proposed. This is done by deciding to use the three types classification of the airport ownership and management models; majority private, mix public-private, and fully public. This decision is justified by the classifications used in the academic literature and in the airport industry.

Then, the optimum national macro-environmental settings area for each of the three airport ownership and management models is constructed. This is done using the results of the DEA and the bootstrapped truncated regression in Chapters 5 and 6, where a filtering process is conducted to eliminate the inefficient observations from the sample dataset of this research. Then, the remaining efficient airports are clustered based on their model respective to the three airport ownership and management models. Thereafter, in each airport ownership and management group, the minimum and maximum scores of each of the five identified national macro-environmental factors in Chapter 6 are captured using *MIN* and *MAX* functions in Microsoft Excel. Finally, the highlighted area between the minimum and the maximum boundaries of the national macro-environmental factors is called the optimum national macro-environmental settings area of the respective airport ownership and management model.

The abovementioned process resulted in having an optimum national macro-environmental settings area respective to each of the majority private, mix public-private, and the fully public models. Therefore, a preliminary framework aimed to assist governments or civil aviation authorities in identifying the airport ownership and management model that is suitable to their airports is proposed. In addition, in the case where the decision-maker has pre-decided on specific airport ownership and management model, this framework checks whether the chosen model is suitable, or identifies the outlier factors that make it not suitable for the national macro-environmental settings of the decision maker's country.

The proposed framework consists of 4 steps. The first step is to understand the type of the airport project, whether it is a new airport that needs construction and operation, or an existing airport that requires development and operation, or an existing airport that only requires improvement in the efficiency or service quality. This is followed by understating the requirements of the decision-maker in the second step, whether it has pre-decided on a specific model or doesn’t know which model best suits it's country’s national macro-environmental settings. In the third step, the scores of the five national macro-environmental factors of the decision maker’s country are benchmarked against either specific or all the optimum national macro-environmental settings areas depending on the decision maker’s requirements. Finally, the results of the benchmarking process are analysed in the fourth step, and a recommendation of the most suitable model is given.

8 CHAPTER EIGHT: CONCLUSIONS AND RECOMMENDATIONS

8.1 Research Conclusions

The ongoing increase in the air travel figures worldwide has placed pressures on many governments to develop their airports in order to accommodate increasing demand, improve efficiency, and enhance the quality of service. Consequently, this has led to an increase in private sector participation in the ownership and management of airports across the world over the last two decades; this momentum is expected to intensify in the coming years.

When states establish a policy on the future development of their infrastructure, in particular airports, they are often guided by international advisers who mostly recommended airport privatization. However, their recommendations are seldom based on an objective evaluation of the context but on the perceived advantages of airport privatization shaped by their experience of providing advisory services to clients in other, usually more developed regions. It is the case that one is able to find successful examples and experiences of airport privatization in several regions of the world. However, several unsuccessful cases can also be cited where investors have struggled with their assets as a result of a poorly conceived privatization framework.

The literature is not in agreement regarding the outcomes of different airport ownership and management models, especially the impact of privatization. Some contributions found that privately owned and managed airports out-perform those under public ownership. Others have reached the opposite conclusion while others found that ownership had no effect on airport performance. Therefore, there is a shortage of research on why a specific airport ownership and management model performs well in a particular environment but doesn't in others.

Therefore, the aim of this research was to propose a preliminary framework that governments or civil aviation authorities can use to identify which airport ownership and management model best suits their national macro-environmental settings. But in order to achieve this aim, the relationship between airport efficiency and the national macro-environment had to be hypothesised, and the influential factors had to be identified using different analytical methodologies.

After introducing the motivation, aim, objectives, and structure of this research in Chapter 1, an overview on the history and evolution of airport ownership and management models, including the drivers of airport privatization and the current situation of airport ownership and management models in the world, are presented in Chapter 2. The types of airport ownership and management models as classified by the airport industry and in the academic literature are also listed and defined in Chapter 2.

Then, the literature on airport performance studies is systematically reviewed to identify the research gaps related to the topic of this research in Chapter 3. The structural literature review also provided interesting findings on the methodological approaches used to estimate the efficiency of the airports, the academic journals that published studies on this topic, the geographic regions studied, the input and output variables used in the efficiency measurement methods, and the non-discretionary variables used to identify their influence on the efficiency of the airports. These findings were also used to help the author decide on the methodological approach to use for this research. Therefore, the philosophical approach of this research was presented and justified in Chapter 4. This research adopted a positivist deductive approach using multi-method quantitative analysis to analyse cross-sectional archival data.

The efficiency of a sample of major international airports in Europe and Asia-Pacific was measured using basic DEA models in Chapter 5. The aim of using DEA was purely to obtain the efficiency scores of airport observations included in the sample dataset of this research in order to use these efficiency scores as the dependent variable in the second-stage regression. The primary method used for the second-stage regression was the truncated regression coupled with Simar and Wilson bootstrapping technique, and Tobit regression was conducted to test the robustness of the results of the latter method (see Chapter

6). The second-stage regression is used to identify the national macro-environmental factors (independent variables) that significantly influence the efficiency of the airports (dependent variable). The findings of the second-stage regression were all discussed in Chapter 6.

Finally, the results of the DEA and the bootstrapped truncated regression were put through a combination of filtering and grouping processes to identify the optimum national macro-environmental settings area of each airport ownership and management model in Chapter 7. Thoughts on the minimum and maximum values of the national macro-environmental factors for each airport ownership and management model were described. The identified optimum national macro-environmental setting areas are used to propose a preliminary framework which can be used to identify the airport ownership and management model that best suits the national macro-environment of a country.

8.2 Research Findings

Revisiting the objectives which were set to fulfil the aim of this research in Chapter 1, this section summarises the key findings in accordance with each of the five objectives.

8.2.1 Objective 1 Findings

<u>Objective 1:</u> *To EXPLORE the different types and classifications of airport ownership and management models and the current trends across the world.*

The review of the history and the evolution of airport ownership and management models, and their various classifications according to the airport industry and the academic literature, have led to the following key findings:

1.1 After the financial success of the first airport privatization experience in the UK in the mid-1980s, countries started to opt to implement full or partial privatization to cover either the shortage in the required funds for their required airport development, or the shortage in the local expertise to improve the performance and the quality of service of their airports, or both.

1.2 According to the literature on airport privatization, among the many drivers behind privatising airports, the top three common drivers are to improve efficiency, access private sector finances to provide investment and improve the quality of service of the airport.

1.3 Although the pace of airport privatization has varied in line with economic and geopolitical cycles over the past three decades, since 2012, there has been an almost consistent increase in the volume of transactions, and this is widely expected to continue into the future. Nevertheless, the publically owned and managed airports in the world are still the majority, with 86% of worldwide airports.

1.4 Airport privatization is most prevalent in Europe, Asia-Pacific, and Latin America. However, the scale and extent of airport privatization in Africa, North America, and the Middle East have been much lower.

1.5 The standard classification of airport ownership and management models in the airport industry consists of 11 types starting from the fully owned and operated by the government, passing through 9 types ranging between least and most private sector participation, and ending with the fully owned and operated by the private sector.

1.6 Unlike the detailed classification of the ownership model provided by the airport industry (Dorian and Robinson, 2018), the literature has tended to fewer airport ownership and management model classifications. These classifications include general types of airport ownership and management models, usually between two and four types, such as majority private, mixed public-private, and fully public. The use of short classifications in academic research is purely for statistical reasons, as the number of observations included is usually insufficient for statistical estimation purposes.

8.2.2 Objective 2 Findings

Objective 2: *To EXPLORE the efficiency measurement techniques used in the literature with the types of input and output variables and the non-discretionary variables used.*

The systematic literature review, which included 96 journal published papers on airport performance estimation techniques, led to the following findings:

2.1 The first study to apply the performance estimation technique was published in 1997. The number of papers on this topic started to increase after the year 2000. However, the average number of papers published per year was doubled starting in 2008, which indicates an increasing research interest in the field of airport performance.

2.2 More than half of the studies in the literature of airport performance have used Data Envelopment Analysis (DEA) to measure the efficiency of airports which makes it the most preferred performance estimation method among the researchers. The following most used method is the Stochastic Frontier Analysis (SFA) (19 out of 96 papers). Both methods are related to the multi-dimensional frontier approach.

2.3 The 96 papers included in the literature review are distributed among 28 academic journals with the highest concentration of these papers are published in the Journal of Air Transport Management (JATM) (34 papers), and in Transportation Research Part E (16 papers). The concentration of the published papers among two journals might make it easier for researchers to find them but might also negatively affect the impact of the research topic by insulating it between specialised journals.

2.4 There are two types of airport performance studies. Some studies included single country airports in their analysis, while others included airports from two or more countries or regions. The majority of the studies that included single country airports are aimed to compare the efficiency of different size airports. However, the majority of other studies focused on comparing the efficiency of airports of different ownership and management models in addition to identifying non-discretionary variables affecting the efficiency of the airports.

2.5 In the literature, there exists research that studied the performance of airports in different regions of the world such as Europe, Asia-Pacific, and Latin America, and Africa, although studies on Latin American and African airports are low when compared to other regions. However, it is evident that there is no single study on the performance of the Middle East and North Africa airports. The scarcity of studies on airports of some regions such as Latin-America, Africa, and the Middle East is mainly due to the shortage of the available data on airports of these regions.

2.6 It is found that there is a strong relationship between the number of published papers on the performance of airports of a particular region and the number of privatized airports of the same region. This suggests that research on airport performance in a particular region is motivated by the existence of different airport ownership and management models, especially privatization.

2.7 67 different input variables used in studies airport performance estimation techniques were identified. These factors can be classified into three categories: physical, financial, and time variables. The top five most used input variables are the number of employees, terminal area, number of runways, other operating costs, and price of labour.

2.8 The use of physical input variables is more popular due to the availability of data that are easy to be accessed. However, data on financial variables are still challenging to collect, although they are becoming more and more available. And if available, it is challenging to use them in studies that include airports from different countries and regions due to the differences in accounting procedures in each country.

2.9 35 different output variables were identified. The output variables are classified into four categories: physical, financial, time and other variables. The most commonly used output variables are the number of passengers, number of air traffic movement, volume of cargo, and non-aeronautical revenues.

2.10 The average number of input variables included in a single study ranges between 3 and 5, while the average number of output variables included in a single study ranges between 3 and 4.

2.11 Some studies used second-stage regression to identify the non-discretionary variables that significantly affect the efficiency of the airports. The most used second-stage regression method before 2007 is Tobit regression. However, after 2007, most of the studies used truncated regression coupled with bootstrapping technique after it was proposed by a study published by Simar and Wilson in 2007, the same study in which they claimed that Tobit regression is not the appropriate method to use in the second-stage regression.

2.12 The number of different non-discretionary variables identified is 102. These variables are classified into four categories as following: airport characteristics, management strategies, governance structures, and other variables. Three variables were found to be most commonly used: airport ownership, hub status, and airport size.

2.13 The studies which used airport ownership as a discretionary variable are majorly cross-country studies aiming to compare the efficiency of different airport ownership types and especially privatization.

However, the results of these studies are far from conclusive, as different studies reached different conclusions.

2.14 It was found that the extreme majority of the studies that aimed to identify non-discretionary variables affecting the efficiency of airports have used endogenous variables that are directly related to the airport. Few papers have tested the effect of variables that are out of the control of the airport's management and outside the airport industry such as the level of corruption in the country and the population in the country.

2.15 A critical review of airport privatization in one of the Middle Eastern countries showed that cultural dimensions, human resources strategies, administrative governance, and socio-political environment of the country are all factors that affect the performance of the airport.

2.16 No empirical study was found to go beyond and identify the country-level factors that all together influence the efficiency of the airport. Such country-level factors are the national macro-environmental factors of the country.

8.2.3 Objective 3 Findings

Objective 3: *To EVALUATE the efficiency of a sample of international airports using Data Envelopment Analysis*

The results of the CCR and BCC DEA output-oriented models on 59 major international airports in Europe and Asia-Pacific led to the following findings:

3.1 Under the CCR, or the constant returns to scale assumption, 31 airport observations out of 59 airports are found to be technically efficient.

3.2 Under the BCC, or the variable returns to scale assumption, 40 airport observations out of 59 were found to be technically efficient.

3.3 It was also found that all the efficient airports under the CRS assumption were also efficiency under the VRS assumptions. This means that the VRS is the source of efficiency.

3.4 Unlike the majority of the DEA studies that aim to provide developments and discussions on the DEA models, or to compare DEA with other efficiency estimation methods, the use of DEA in this study is just to obtain efficiency scores of the airports in the sample data-set of this study. Therefore, there is not much room for discussions over the results of the DEA other than what has been mentioned in the previous two key findings related to Objective 2.

8.2.4 Objective 4 Findings

Objective 4: *To UNDERSTAND the national macro-environmental factors influencing the performance of the airports using Bootstrapped Truncated Regression.*

The results of the bootstrapped truncated regression and Tobit regression between the efficiency scores of the airports obtained using DEA and a set of national macro-environmental factors the country of each airport included in the sample dataset led to the following key findings:

4.1 The multicollinearity test on the 17 collected national macro-environmental factors resulted in the elimination of 12 high correlated factors. The aim of this test is to reach a sample of national macro-environmental factors with a minimal level of multicollinearity as required by the second-stage regression methods.

4.2 It is found using bootstrapped truncated regression that five national macro-environmental factors have a significant effect on the efficiency of the airport. These factors are the institutions, macro-economic environment, safety and security, human development, and the air transport output of the country.

4.3 Tobit regression showed similar results, thus validating the results of the truncated regression with bootstrapping technique.

4.4 Air transport output of a country is found to have the highest impact on the efficiency of the airport, followed in order by safety and security, human development, macro-economic environment, and institutions.

4.5 The findings of the second-stage regression fill the identified gap in the literature review and prove the hypothesis that airport efficiency is not only affected by managerial decisions or airport physical characteristics, but also by a combination of country-level factors.

4.6 These findings also explain the difference in the efficiencies of the airports of the same ownership and management models that are located in different countries.

8.2.5 Objective 5 Findings

<u>Objective 5:</u> *To UNDERSTAND the optimum national macro-environmental setting area of each airport ownership and management model.*

5.1 The elimination of the inefficient airport observations from the sample data-set and the grouping of the efficient ones according to their ownership and management model allowed the identification of the minimum and maximum scores for macro-environmental factor and the construction of the of the minimum and maximum boundaries of the five national macro-environmental scores respective to each airport's ownership and management model.

5.2 The area between the minimum and the maximum boundaries of the national macro-environmental factor is called the optimum national macro-environmental setting area of the airport ownership and management model.

5.3 Due to the small scoring index of some macro-environmental factors, it was found that rescaling the score indexes to a unified higher score index would result in better visualisation of the optimum national macro-environmental settings area as resembled by the radar charts.

5.4 The critical observations regarding the optimum national macro-environmental settings area of a particular airport's ownership and management model are related to the minimum boundary since it reflects the minimum allowable boundary for which the ownership and management model can achieve better or efficient airport performance.

5.5 However, no valuable observations could be drawn out of the maximum boundaries since it is assumed that as long as the score of the national macro-environmental factor is above the allowable minimum, the particular national macro-environmental setting would be suitable for the airport ownership and management model.

5.6 The institutions factor was found to require a minimum score in the mixed public-private model that is higher than the required minimum scores of both the majority private and the fully public. This finding reflects the complexity of the interaction between the public and the private sector in the mix public-private ownership and management model, unlike the other models where the interaction is very minimal or doesn't exist.

5.7 The minimum allowable score of the macro-economic environment factor is the lowest in the majority private model. Since by definition, the macro-economic environment factor includes the government budget balance and the past government debts, this means that the effect of the macro-economic environment on the private sector is less than its effect on the public sector. This explains why the private model allows for more flexibility to the macro-economic environment factor.

5.8 The safety and security factor was found to demand a minimum allowable score in the majority private model that is significantly higher than the minimum allowable scores of both the fully public and the mix public-private models. This finding is also logical due to the fact that private-sector money is attracted by safe environments. In addition, a lower level of safety and security affects the performance of expatriates more than it affects the performance of the citizens' employees.

5.9 Similarly, the majority private model requires the highest minimum score for human development among the airport ownership and management models, slightly higher than the fully public model. However, the mixed public-private model offers more flexibility.

5.10 For the air transport sector output factor, it was found that the model which offers more flexibility in the score is the majority private model. This surprising finding can be explained when looking at the definition of air transport output. The technology and the experience which the private sector can bring to the airport can enhance the operational activities and the service quality at the airport and can improve the route development strategies. All these might lead to an increase in air traffic and thus improving the air transport output of the country.

8.3 Research Contributions

In this research, the contributions are related to both theory and practice.

8.3.1 Theoretical contributions

Referring to the systematic literature review that has been conducted, this research can be considered as the first to provide a comprehensive assessment of the factors that relate the country-level national macro-environment to airport efficiency. Previous literature tended to focus on individual factors, which can be considered as part of the macro-environment of a country, such as Randrianarisoa et al. (2015) who studied the effect of corruption on the performance of 48 European airports. Other studies such as Ahn and Min (2014) and Lin and Hong (2006) have studied the effect of economic growth on the performance of a number of airports around the world. However, no previous effort was identified, which sought to test the effect of multiple factors related to the national macro-environment of the country and to identify the significant ones. The identification of these significant national macro-environmental factors suggests that future researchers should consider these factors when conducting cross-country airport benchmarking analysis.

Secondly, the systematic literature review on the airport performance estimation, which is conducted in this research, provides an update on the previous systematic literature reviews on the same topic up to December 2016. The latest paper on systematic literature review on the topic of airport performance estimation is Liebert and Niemeier (2013), which covers studies published from 1997 till 2012. The systematic literature review of this research also provided detailed information and statistics on the different efficiency estimation methodologies, input and output variables, and non-discretionary variables used in the literature. It also provided some exciting highlights on the number of journals that published studies on the same topic, the journal that includes the highest number of these studies, and the geographic regions that were covered. Therefore, the systematic literature review of this research can be check-point for future researchers on the topic of airport performance estimation.

8.3.2 Contribution to policy

Practically, the identification of the national macro-environmental factors that influence the performance of the airports and the development of the preliminary framework for airport ownership and management model selection may help governments, civil aviation authorities, decision-makers, and consultants identify the model that best suits the national macro-environmental setting of the country.

The preliminary framework can be used in the first stages of the decision-making process regarding airport ownership and management model, where it can be considered as a top-down approach. Using this approach, the decision-maker will identify what options are suitable for the country, and eliminate the options which are not, before studying the detailed features of each airport ownership and management model. This would save time and cost, and the elimination of the non-suitable options will avoid potential losses in finances and resources that would occur as a result of a wrong decision.

In addition, in the cases where the decision-maker has previously decided on a specific model, this preliminary framework can be used to check if the right decision has been made. If it shows that the decision is inappropriate, and the decision-maker insists on taking that decision, the framework will identify the factors which make the national macro-environmental setting of the country not suitable for the implementation of that decision. This would help the government and policymakers in identifying the points of weakness in their national competitiveness that need to be addressed in the strategic planning of the country. In other words, the government will be able to know the areas of the national macro-environment of the country that needs to be improved for better outcomes of the selected airport ownership and management model. This also applies in the cases where the framework indicates no airport ownership and management model is suitable for the national macro-environmental setting of the country.

8.4 Research Limitations and future research suggestions

Research limitations are usual and are encountered by any study, and so does this study. These limitations form the basis for further research on the same topic.

The most significant limitation encountered by the research is the availability of data. The initial plan of this study was to collect data on a large number of airports around the world, possibly a panel data on a sample of airports over a period of time. However, this study was successful in gathering data on 59 airport observations from Europe and Asia-Pacific only for the reasons stated in Chapter 5. Therefore, would a study be able to access airports data on multiple of years such as the ATRS world airports databases, the confidence of the results of the DEA would be increased, and so will be the results of the relationship between the national macro-environmental factors. Moreover, should consistent and reliable data on airports in regions that were not covered in this study become available in the future, such as the Latin American and Middle Eastern airports, a study which includes these airports in the sample data-set would be able to obtain more realistic results that describe the worldwide situation regarding the relationship between the efficiency of the airports and the national macro-environmental factors.

Increasing the number of airports in the sample dataset and covering airports of various regions around the world would not only result in improving the DEA and second-stage regression results, but would lead to a substantial refinement and increased accuracy of the minimum and maximum scores of the five national macro-environmental factors that form the boundaries of the optimum national macro-environmental settings area of each airport ownership and management models. Having a larger number of airports in the sample dataset would allow more detailed classification of airport ownership and management models, and this would lead to a considerable transformation of the framework from being preliminary to being detailed.

Since this research obtained the efficiency scores of the airports using DEA only, another study could measure the efficiency using another efficiency measurement technique, such as Stochastic Frontier Analysis (SFA), and compare with the results of this study. This would broaden the picture of this research by providing insights on the differences or similarities of the results of the second-stage regression when including efficiency scores that are obtained using different efficiency measurement technique.

It is also suggested that future research undertakes qualitative approach using industrial interviews and surveys to identify the national macro-environmental factors affecting the performance of the airports and how they are related to the success or failure of the different airport ownership and management models. The results of such qualitative research would be compared to the outcomes of this quantitative research, and valuable conclusions could be reached.

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APPENDICES

Appendix A Literature Review Table

Table 8-1 Literature review table

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Gillen and Lall (1997)	Transportation Research Part E	21 major US airports	US	1989 - 1993	DEA (Terminal: BBC; ATM: CCR; output max.)	Tobit regression	**Terminal Services** Number of Runways Number of Gates Terminal area Employees Baggage collection belts Public parking spots **Movement Model** Airport area Number of Runways Runways area Employees	**Terminal Services** Pax Cargo **Movement Model** ATM Commuter ATM	**Different sets of variables clustered according to:** Year dummy Hub dummy Noise strategy variables (only airside) Management operational and investment variables

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Hooper and Hensher (1997)	Transportation Research Part E	6 Australian airports	Australia	1988-1992	TFP (CCD)	-	Capital stock Staff costs Other op. Costs	Aeronautical revenue Non-aeronautical revenue	-
de la Cruz (1999)	International Journal of Transport Economics	16 Spanish airports (largest airports)	Spain	1993-1995	DEA (CCR and BCC; input min.)	-	Total economic costs (operational, current costs and internal interests on net assets)	Pax Aeronautical revenues Handling revenues Non-aeronautical revenues	-
Murillo-Melchor (1999)	International Journal of Transport Economics	33 Spanish civil airports run by AENA	Spain	1992 - 1994	Malmquist-DEA (CCR, BCC and NIRS)	-	Employees Capital stock Other op. Costs	Pax	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Parker (1999)	Journal of Transport Economics and Policy	(1) BAA as a whole and (2) 22 UK airports	UK	1979-1995 and 1988-1996	DEA (CCR and BCC)	Banker and Morey (1986)	Employees Capital input Other op. Costs	Pax Cargo	Changes in GDP
Nyshadham and Rao (2000)	Public Works Management & Policy	25 European airports (Doganis et al. data)	Europe	1995	Partial Performance and TFP (CCD)	-	Op. cost per WLU Capital expenditures per WLU Other costs per WLU	Aeronautical revenue per WLU Non-aeronautical revenue per WLU	-
Sarkis (2000)	Journal of Operations Management	44 Major US airports	US	1990 - 1994	DEA (CCR and BCC; Aggressive Cross-Efficiency, Ranked Efficiency , Radii of Classification Rankings)	-	Op. costs Employees Number of Gates Number of Runways	Operational revenue Pax ATM ATM (GA) Cargo	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Adler and Berechman (2001)	Transport Policy	26 airports in Western Europe, North America and Far East (mainly Europe)	World	1998	PCA-DEA (BCC; input min.; super efficiency for ranking)	Banker and Morey (1986)	Objective data Airport charges Passenger terminals Number of runways Minimum connection times Distance to city centre Average delay	Level of satisfaction grouped into five types	-
Gillen and Lall (2001)	International Journal of Transport Economics	22 major US airports	US	1989 - 1993	Malmquist-DEA (Terminal: BCC, ATM: CCR; output max.)	-	**Terminal Services** Number of Runways Number of Gates Terminal area Employees Baggage collection belts Public parking spots **Movement Model** Airport area Number of Runways Runways area Employees	**Terminal Services** Pax Cargo **Movement Model** ATM Commuter ATM	-
Martin and Roman (2001)	Journal of Air Transport Management	37 Spanish airports (AENA)	Spain	1997	DEA (CCR and BCC; output max.)	-	Staff costs Capital expenditures Other op. costs	Pax Cargo ATM	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Pels et al. (2001)	Transport Policy	34 European airports	Europe	1995 - 1997	DEA (input min.) and SFA (homogenous CD production function with ML; z-Var in u)	-	**Terminal Model:** Terminal size (in sq. m) Aircraft parking places at the terminal Remote aircraft parking places Check-in desks Baggage-claim units Number of baggage-claim units Number of aircraft parking places at the terminal Number of remote aircraft parking places **Movement Model:** Total airport area Total length of runway Aircraft parking positions at the terminal Remote aircraft parking positions Number of Runways Number of aircraft parking places at the terminal Number of remote aircraft parking places	**Movement Model** ATM **Terminal Model** Pax	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Abbott and Wu (2002)	The Australian Economic Review	12 main airports (all private except SYD)	Australia	1990 - 2000	Malmquist-DEA (BCC; input min.)	Tobit regression	Employees Capital stock Runway length	Pax cargo	Rate of return Capital labour ratio Aircraft standing area Total asset growth rate Ownership dummy Year dummy
Abbott and Wu (2002)	The Australian Economic Review	24 airports from Australia (12), NZ (3), UK (2), Canada (2) and US (5)	World	1998-1999	DEA (BCC, CCR; input min.)	-	Employees Total runway length Airport area Aircraft standing positions	Pax cargo	-
Fernandes and Pacheco (2002)	Transportation Research Part A	35 Domestic Brazilian airports	Brazil	1998	DEA (BCC; output max.)	-	Airport surface area Departure lounge Check-in-desks Curb frontage in metres Vehicle parking places Baggage-claim area	Pax (domestic)	-
Martin-Cejas (2002)	Journal of Airport Management	40 worldwide airports	World	1996-1997	translog cost function estimation with OLS	-	Total costs Price of labour Price of capital	WLU	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Bazargan and Vasigh (2003)	Journal of Air Transport Management	45 US airports (15 small, medium, and large hub airports)	US	1996 - 2000	DEA (CCR)	Kruskal-Wallis-Test and pairwise Mann-Whitney-Test among the three hub sizes	Op. costs Non-operating costs Number of Runways Number of Gates	Pax ATM Other ATM Aeronautical revenue Non-aeronautical revenue % of on-time operations	-
Oum et al. (2003)	Journal of Air Transport Management	109 worldwide airports	World	2001-2004	SFA (homogeneous translog cost function with Bayesian approach, random effects, ownership enters u and other NDs enter the technology)	see SFA model	Employees (FTE) (and price) Other op. costs (and price) Runways (fixed) Terminal size (fixed)	Pax ATM Non-aeronautical revenues	% int. traffic % cargo Regional dummy variables Ownership dummy (see paper) Multi-airport dummy (in model 2)
Pacheco and Fernandes (2003)	Transportation Research Part A	35 Brazilian Domestic airports (Infraero)	Brazil	1998	DEA (BCC; input min.)	-	Employees Staff costs Other op. costs	Pax (domestic) Cargo Operating revenue Non-aeronautical revenue Other revenues	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Pels et al. (2003)	Transportation Research Part E	34 Europea n airports	Europe	1995 - 1997	DEA (input min.) and SFA (homogeno us translog production function, ML, z-Var in u)	see SFA model	**Movement Model** Airport surface area Aircraft parking places at terminal Remote aircraft parking places Number of Runways **Terminal Model** Check-in desks Baggage claim units	**Movement Model** ATM **Terminal Model** Pax	**Movement Model** Dummy for slot-coordinated airport Dummy for time restrictions **Terminal Model** Time dummy Airlines' load factor
Barros and Sampaio (2004)	International Journal of Transport Economics	10 Portugue se airports	Portugal	1990 - 2000	DEA (CCR and BCC)	Tobit regression	Employees Capital stock Price of labour Price of capital	ATM Pax Cargo Mail cargo Landing revenues Pax revenues	Market-share Share held by regional governments Location dummy Agglomeration (population) Cost structure (ratio of op. costs to sales)

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Oum et al. (2004)	Journal of Transport Economics and Policy	50 major worldwide airports	World	1999	partial productivity measures and EW-TFP	Regression analysis to obtain residual TFP	Employees (FTE) Number of Runways Gates Total terminal area Other op. Costs	Pax Cargo Non-aeronautical revenues	**Factors beyond managerial control:** Ownership dummy Airport size Average aircraft size Composition of air traffic **Factors within managerial control:** Business diversification Extent of outsourcing Service quality
Oum and Yu (2004)	Transportation Research Part E	60 major worldwide airports (only 50 of 1999 in TFP)	World	1999-2000	partial productivity measures and gross EW-TFP	-	Employees (FTE) Runways Gates Total terminal area Other op. Costs	Pax Cargo Commercial revenues	Airport size Congestion delays Hub dummy Ownership dummy Continent dummy % non-aeronautical revenues Regulation dummy

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Sarkis and Talluri (2004)	Transportation Research Part A	44 Major US airports	US	1990 - 1994	DEA (CCR; Basic and Cross-Efficiency models) and clustering method to receive appropriate benchmarks	-	Op. costs Employees Number of Gates Number of Runways	Operational revenue Pax ATM ATM (GA) Cargo	-
Yoshida (2004)	Transportation Research Part E	30 Japanese airports	Japan	2000	EW-TFP	-	Terminal size Runway length	Pax Cargo ATM	-
Yoshida and Fujimoto (2004)	Transportation Research Part E	67 Japanese airports	Japan	2000	DEA (CCR and BCC) and EW-TFP	DEA: Tobit Regression EW-TFP: OLS	Runway length Terminal area Employees in terminal Average access cost (monetary and time costs)	Pax Cargo ATM	**Both:** Third mainland dummy Start of operation

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Yu (2004)	Journal of Air Transport Management	14 domestic Taiwanese airports	Taiwan	1994-2000	DEA (directional output distance function / window analysis with 2 years window)	Banker and Morey (1986)	Runway area Apron area Terminal area Connections with other domestic airports	**Desirable:** ATM Pax **Undesirable:** Aircraft noise	Population in the county
Lin and Hong (2006)	Journal of Air Transport Management	20 major airports worldwide	World	2001 or 2002	DEA (CCR and BCC; super efficiency for ranking, cross-efficiency and FDH)	Hypothesis Testing	Employees Check-in counters Number of Runway Parking spaces Baggage collection belts Number of aprons Boarding gages Terminal area	Pax Cargo ATM	Ownership dummy Size Hub dummy Location dummy Economic growth of the country

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Martin and Roman (2006)	Networks and Spatial Economics	34 Spanish airports	Spain	1997	SMOP and DEA [cross-efficiency, super-efficiency for ranking (NIRS and BCC) and virtual-efficiency]	-	Staff costs Capital expenditures Other op. costs	Pax Cargo ATM	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Oum et al. (2006)	Journal of Air Transport Management	116 worldwide airports	World	2001 - 2003	VFP (CCD)	Regression analysis	Employees (FTE) Other op. costs	Pax ATM Non-aeronautical revenues	**Airport Characteristics:** Airport size (aggr output) Average aircraft size % int. traffic % cargo Runway utilization (ATM/runway) **Management Strategies:** % non-aviation revenue **Ownership:** Ownership form (see paper) **Other:** Continental dummy variable Year dummy
Pacheco et al. (2006)	Journal of Air Transport Management	58 Brazilian airports administered by Infraero	Brazil	1998-2001	DEA (BCC; input min.)	-	Employees Staff costs Other op. costs	Operating revenue Non-aeronautical revenue Other revenue Pax Cargo	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Vasigh and Gorjidooz (2006)	Journal of Air Transportation	22 major airports in the US and Europe (8 US public, 7 BAA, 7 busiest EU private and public)	US and Europe	2000-2004	TFP (CCD)	stepwise-regression between TFP-results and ownership structure	Op. cost Net total assets Runway area	Operational revenues Non-operational revenues Pax ATM Landing revenues	Ownership dummy other factors see paper p.157 clustered acc. to financial condition and management policy
Vogel (2006)	Aeronautical Journal	31 European airports and 4 airport systems	Europe	1990-2000	DEA (CCR and BCC), partial performance, financial ration analysis	-	Total costs	Total revenues	-
Barros and Dieke (2007)	Journal of Air Transport Management	31 Italian airports	Italy	2001-2003	DEA (CCR and BCC; output max.; Cross-Efficiency, Super-Efficiency for ranking)	Mann-Whitney-Hypothesis-Test on super-efficiency scores	Staff costs Capital invested Other op. costs	ATM Pax Cargo Handling revenues Aeronautical revenues Non-aeronautical revenues	Airport size Privatization dummy WLU

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Assaf (2008)	Journal of Air Transport Management	27 UK airports (16 large and 11 small)	UK	2002-2006	SFA (heterogeneous Cobb-Douglas production-Metafrontier with ML)	see SFA model: two group frontiers for small and large airports and the Metafrontier)	Employees Fixed assets Operational costs Other costs	Operational income	-
Barros (2008a)	Journal of Air Transport Management	33 Argentine airports that are operated by Aeropuertos Argentina 2000	Argentine	2003-2007	DEA (BCC; output max.)	Truncated bootstrap regression (Simar and Wilson 2007)	Employees Runway area Apron area Pax terminal area	Pax Cargo ATM	Year dummy Hub dummy Work Load Unit
Barros (2008b)	Transportation Research Part A	13 Portuguese airports	Portugal	1990 - 2000	SFA (homogenous translog cost function, calculating technical change with Malmquist indices with ML)	-	Op. costs Price of capital Price of labour	Landing revenues Pax revenues Non-aeronautical revenues	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Barros (2008c)	Journal of Air Transport Management	27 UK airports	UK	2000-2005	SFA (comparison of homogenous and heterogeneous long-run translog cost function based on true random effects with ML)	-	Op. costs Price of workers Price of capital premises Price of capital investment	Pax ATM	-
Barros and Dieke (2008)	Transportation Research Part E	31 Italian airports	Italy	2001-2003	DEA (CCR and BCC; output max.)	Truncated bootstrap regression (Simar and Wilson 2007) on CCR efficiency	Staff costs Capital invested Other op. costs	ATM Pax Cargo Handling revenues Aeronautical revenues Non-aeronautical revenues	Hub dummy WLU (airport size) Privatization dummy North dummy
Fung et al. (2008)	Transportation Research Part E	25 Chinese regional airports	China	1995-2004	DEA (CCR; output max.) and Malmquist-DEA (dynamic)	-	Runway length Terminal size **both inputs are fixed in each period but variable over time**	Pax Cargo ATM	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Martin and Roman (2008)	Journal of Airport Management	34 Spanish airports of different sizes	Spain	1997	DEA [cross-efficiency, super-efficiency (VRS and NIRS) and virtual rank-efficiency models; output max.]	-	Staff costs Capital expenditures Other op. costs	Pax Cargo ATM	-
Oum et al. (2008)	Journal of Urban Economics	76 worldwide airports	World	2000-2001	VFP (CCD)	Regression analysis to obtain residual VFP	Employees (FTE) Other op. costs	Pax Cargo ATM Non-aeronautical revenues	**Factors beyond managerial control:** Airport size Average aircraft size % int. traffic % air cargo in total traffic Capacity constrained airports **Factors within managerial control:** Pax service levels Non-aeronautical business Airline or independent company operated terminals

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Pathomsiri et al. (2008)	Transportation Research Part E	56 US airports	US	2000-2003	Directional distance function with Luenburger productivity indicator (instead of Malmquist)	correlation to analyse factors affecting airport productivity	Land area Number of Runways Runway area	**Desirable Outputs:** Non-delayed ATM Pax Cargo **Undesirable Outputs:** Delayed ATM Time delays	Load factor (Pax/ATM) Cargo load factor % General Aviation % Int. Pax Market share
Yu et al. (2008)	Journal of Air Transport Management	4 Taiwan Airports	Taiwan	1995-1999	DEA	-	Employees Accumulated capital stock intermediate expense	Pax	-
Chi-Lok and Zhang (2009)	Journal of Air Transport Management	25 Chinese (major) airports	China	1995-2006	DEA and Malmquist-DEA	OLS and Tobit regression	Runway length Terminal size	Pax Cargo ATM	Airport localization program Regional competition intensity Public listing Further (airport characteristics: Hub, local economy, coastal city, tourist city, population, demand and supply shocks, event: airline mergers, open sky agreements, new air)

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Barros (2009)	Transport Reviews	27 UK airports	UK	2000-2006	SFA (heterogeneous Translog cost function latent class model with ML)	see SFA model: data set is clustered in three homogenous groups in terms of market share	Op. costs Price of labour Price of capital Price of capital investment	Pax ATM	-
Barros and Weber (2009)	Transportation Research Part E	27 UK airports	UK	2000-2004	Malmquist-DEA	-	Employees Capital stock Other op. Costs	Pax Cargo ATM	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Chow and Fung (2009)	Journal of Air Transport Management	46 Chinese airports (three int hubs, six reg hubs and 37 regional airports)	China	2000	SFA (1) estimated homogenous single output translog production function with ML (2) partial translog input distance function	see SFA model	**Single output** **First stage:** Airport area Runway length Number of terminal parking positions **Second-stage:** Both: Predicted ATM APM: Terminal area Car-park area ACM: Cargo handling facility area **Multi-output:** ATM (intermediate output) Terminal area Cargo facilities area Number of aircraft parking positions Airport area Runway length	**Single output** **First-stage:** ATM **Second stage:** **APM:** Pax **ACM:** Cargo **Multi-output:** Pax Cargo	**Single output:** **Both:** Regional effects dummy Major airlines dummy **ACM:** % international cargo **Multi-output:** Regional effect dummy Major airlines dummy Int. or reg. hub dummy % int. traffic

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Lam et al. (2009)	Transportation Research Part E	11 major Asia-Pacific airports	Asia-Pacific	2001-2005	DEA (CCR and BCC; input min; SBM)	-	Total costs Employees Price of labour Other op. costs Price of capital Terminal area Trade value	Pax Cargo ATM	-
Martin et al. (2009)	Journal of Productivity Analysis	37 Spanish airports (AENA)	Spain	1991-1997	SFA (homogeneous translog multiproduct long-run cost function with Bayesian)	-	Staff costs Capital expenditures Other op. costs Price of labour Price of other (totex per ATM, totex per WLU)	WLU ATM	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Tovar and Martin-Cejas (2009)	Journal of Air Transport Management	26 Spanish airports	Spain	1993-1999	SFA (homogeneous translog production input distance function /decomposing TFP into its components)	-	Employees Surface area Number of Gates	ATM Average size of aircraft Share of non-aeronautical revenues	-
Assaf (2010a)	Journal of Air Transport Management	27 small and large UK airports	UK	1998	DEA (CCR, BCC and NIRS; Bootstrapping)	-	Employees (FTE) Airport area Runways	Pax Cargo ATM	-
Assaf (2010b)	Tourism Management	13 major Australian airports (post-privatization)	Australia	2002-2007	SFA (homogenous Cobb-Douglas cost function with Bayesian)	-	Total costs Price of labour Price of capital premises	Pax Cargo ATM	-
Tovar and Martin-Cejas (2010)	Transportation Research Part E	26 Spanish airports	Spain	1993-1999	SFA (homogenous with input-oriented translog distance function, z-Var in u, ML)	see SFA model	Employees Surface area Number of Gates	ATM Average size of aircraft Share of non-aeronautical revenues	Outsourcing degree Non-aeronautical revenues Cargo

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Ablanedo-Rosas and Gemoets (2010)	Journal of Air Transport Management	37 Mexican airports	Mexico	2009	DEA	-	Number of operations per hour Number of passengers per hour	ATM PAX Cargo	-
Yang (2010)	Computer and Industrial Engineering	12 Airports in Asia Pacific	Asia-Pacific	1998-2006	DEA and SFA	-	Employees Runways Operational cost	Operational revenue	-
Curi et al. (2011)	Socio-Economic Planning Sciences	18 Italian Airports	Italy	2000-2004	DEA-bootstrapping DEA	-	**(1)** Employees Number of runways Apron Size **(2)** Airport Area Labour cost Other cost	**(1)** Pax ATM Cargo **(2)** Aeronautical Revenue Non-Aeronautical revenue	-
Lozano and Gutierrez (2011)	Networks and Spatial Economics	41 Spanish Airports	Spain	2006	DEA (non-radial)	-	Runway Area Apron capacity Passenger Throughput Capacity Number of baggage belts number of check-in counters number of boarding gates	ATM Pax Cargo	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Tsekeris (2011)	Journal of Air Transport Management	39 Greek Airports	Greece	2007	DEA	Truncated Bootstrapped regression	Number of runways Terminal Size Apron Area Operating Hours	Pax cargo ATM	Location Size operating characteristics Access
Fung and Chow (2011)	Pacific Economic Review	41 Chinese Airports	China	1995-2004	TFP Malmquist Index	-	Length of runway Terminal size	Pax ATM Cargo	-
Barros (2011)	Transport Policy	17 Angola and Mozambique airports	Angola and Mozambique	2000-2010	SFA	-	Price of capital premises Price of workers Price of capital investment	Pax ATM	-
Assaf and Gillen (2012)	European Journal of Operational Research	73 International Airports	World	2003-2008	Bayesian distance SFA and DEA	Truncated Regression	Employees (FTE) Other operating costs Number of runways Terminal size	Pax ATM Non-aeronautical revenues	Airport Regulation Ownership
Gitto and Mancuso (2012a)	Journal of Air Transport Management	28 Italian Airports	Italy	2000-2006	DEA - biased corrected	Truncated Regression	**(1)** Capital Invested Labour cost Soft Costs **(2)** Employees Runway Area Airport Area	**(1)** Aeronautical Revenue Non-Aeronautical revenue **(2)** Pax ATM Cargo	Total Concession Capital composition Handling Liberalization Hub Seasonality Time

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Scotti el al (2012)	Journal of Air Transport Management	38 Italian Airports	Italy	2005-2008	SFA	-	Runway Capacity Number of aircraft parking positions terminal surface area number of check-in desks number of baggage claims Employees (FTE)	ATM cargo Pax	-
Assaf et al. (2012)	Transportation Research Part E	27 UK airports	UK	1998-2008	SFA (Bayesian model)	-	Price of Labour Price of Capital price of material	aeronautical revenues non aeronautical revenues	Airport size competition regulation price cap variations
Chow and Fung (2012)	Journal of Air Transport Management	30 Chinese Airports	China	2000-2006	TFP	-	Terminal Size Length of runway	PAX cargo ATM	-
Gitto and Mancuso (2012b)	International Journal of Production Economics	28 Italian Airports	Italy	2000-2006	TFP and Bootstrapped technique	-	Labour cost capital invested soft costs	Pax cargo ATM aeronautical revenues non aeronautical revenues	-
Perelman and Serebrisky (2012)	Utilities Policy	21 Latin American airports	Latin America	2000-2007	DEA	Tobit regression	Employees runways terminal size	Pax ATM Cargo	Airport size Ownership
Wanke (2012a)	Journal of Air Transport Management	65 Brazilian airports	Brazil	2009	DEA (DEA and bootstrapping technique)	-	ATM	Pax Cargo	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Wanke (2012b)	Socio-Economic Planning Sciences	63 Brazilian Airports	Brazil	2009	DEA (bootstrapping)	-	Terminal Size Apron Size Runways length of runways number of aircraft parking positions size of airport number of parking spaces	Pax cargo ATM	-
Zhang et al. (2012)	Journal of Air Transport Management	37 Chinese airports	China	2009	DEA	-	Take of distance available Landing distance available	Pax cargo ATM	-
Adler et al. (2013a)	Journal of Air Transport Management	85 airports from Europe	Europe	2002-2009	DEA	OLS and Truncated regression	Staff costs Other operating costs Number of runways	Pax ATM Cargo Non-aeronautical revenues	% Commercial revenues Ground handlings or fuel sales in-house Military involvement PSO Served Remote Area
Chang et al. (2013)	Journal of Air Transport Management	41 Chinese Airports	China	2008	DEA	Truncated regression	Business Hour Runway Area Terminal size	Pax ATM Cargo	City Level Distance to CBD Flight Area Number of international routes Number of Airlines Served Number of destinations

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Wanke (2013)	Journal of Air Transport Management	63 Brazilian Airports	Brazil	2009	DEA (Network DEA centralized efficiency)	-	Terminal Size Aircraft Parking spaces Number of runways	Pax Cargo ATM	Regular flights Location International Hub
Barros et al. (2013)	International Journal of Transport Economics	27 Airports in France	France	2005-2008	DEA (B-convex model)	-	Employees Total operating costs total assets	Pax cargo ATM Sales	-
Adler et al. (2013b)	Omega	43 European Airports	Europe	1998-2007	DEA (Network DEA, PCA-DEA)	-	Staff costs Other operating costs Runway capacity Terminal Capacity	International Pax Domestic Pax Cargo ATM Non aeronautical revenues Aeronautical Revenues	-
Lin et al. (2013)	Journal of Transportation Research Forum	62 Canadian and American	Canada and America	2006	DEA and SFA	-	Soft costs Employees	Pax ATM Non-aeronautical revenues	-
Lozano et al. (2013)	Applied Mathematics Modelling	39 Spanish airports	Spain	2008	DEA (Network DEA)	-	Runway area Apron Capacity Gates Baggage belts Check-in counters	ATM PAX Cargo Delayed Flights Accumulated Delayed flights	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Ahn and Min (2014)	Journal of Air Transport Management	23 world airports	World	2006-2011	DEA and Malmquist Index	-	Land area Runway Length Passenger Terminal area Cargo Terminal Area	ATM Pax Cargo	Region Ownership Airport size Aircraft Size Economic Growth
Tsui et al (2014a)	Journal of Air Transport Management	11 Major New Zealand Airports	New Zealand	2010-2012	DEA (SBM and Malmquist Productivity Index)	-	Operating Expenses Number of Runways	Operating revenue ATM Pax	Population around the airport Airport Hub Status Airport Operating hours Airport Ownership Dummy Christchurch earthquakes dummy Rugby World Cup 2011 dummy
Tsui et al (2014b)	Journal of Air Transport Management	21 Asia-Pacific Airports	Asia-Pacific	2002-2011	DEA	Simar-Wilson bootstrapping regression analysis	Number of employees number of runways Runway Length Passenger terminal area	Pax Cargo ATM	GDP per capita Percentage of international passengers Airport Hub Status Airport Management Airport operating hours Airport hinterland Population Alliance membership of dominant airlines

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Alder and Liebert (2014)	Transportation Research Part A	51 internatio nal airports	Europe and Australia	1998-2007	DEA-SBM	Linear Regression Model	Staff costs Other Operating costs Declared runway capacity	Pax ATM Cargo Non-aeronautical revenues	High level of delay runway utilization air transport movements average aircraft size ownership form regional competition
Merkert and Mangia (2014)	Transportation Research Part A	35 Italian and 46 Norwegia n	Italy and Norway	2007-2009	DEA	Truncated Regression	**(1)** Terminal Size Apron Area Number of Runway Runway Length Runway Area Total Area Employees (FTE) **(2)** Operating Cost Staff Cost Material Cost	**(1) (2)** ATM Cargo Pax	-
Lin et al. (2015)	Transport Policy	24 major internatio nal airports	World	2010	AHP/DEA-AR	-	Employees Number of gates Number of runways Terminal size Length of runway Operational Expenditure	Pax Cargo ATM Total Revenues	-

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Abbott (2015)	Utilities Policy	13 New Zealand Airports	New Zealand	1991-2012	DEA-Malmquist	-	Runway length Operating Expenses	ATM PAX	Airport Size Private Ownership Dummy Local Council Owned Dummy Joint Venture Owned Dummy
Zou et al. (2015)	Journal of Air Transport Management	42 US airports	US	2009-2012	DEA	-	Labour cost material cost capital cost	PAX Enplanements ATM cargo non aeronautical revenues total flight delay	Runway utilization Year Dummy Hub Dummy
D'Alfonso et al. (2015)	Transportation Research Part E	34 Italian Airports	Italy	2010	DEA (conditional DEA)	-	Airport area Number of runways number of terminals gates check-in desks employees	PAX ATM Cargo Share of route in competition	competition
Augustyniak et al. (2015)	Journal of Air Transport Management	4 polish regional airports	Poland	2000-2004 and 2005-2010	DEA	-	Staff costs Capital costs Employees terminal area Number of gates check in counters	total revenues Pax ATM Cargo	% of Pax LCC Liberal market Country dummy

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Ülkü (2015)	Journal of Air Transport Management	41 Spanish and 32 Turkish airports	Spain and Turkey	2009-2011	DEA	OLS and Tobit regression	Staff costs Other operating costs Runway area	Pax ATM Cargo commercial revenues	Weekly opening hours ppp dummy % of international traffic WLU population density seasonality joint military civil airport year
Randrianarisoa et al. (2015)	Transportation Research Part A	47 Europea n airports	Europe	2003-2009	VFP	OLS and Random effects	Soft costs Employees purchased services	ATM Pax Non aeronautical revenues	Corruption
Fragoudaki et al. (2016)	Journal of Air Transport Management	38 Greek Airports	Greece	2010-2014	DEA, Malmquist Productivity Index	-	Runway Length Apron size Terminal Size	ATM Pax Cargo (All converted to WLU)	-
Kutlu and McCarthy (2016)	Transportation Research Part E	All medium and large hub Airports in the US	US	1996-2008	SFA	-	Labour Cost Repair Cost Contracting Cost	Airline Departures Total Operating Costs	

Authors	Journal	Sample	Geography	Time Period	Model	Account for observed heterogeneity	Inputs	Outputs	Non-discretionary variables
Okrcu et al. (2016)	Transport Policy	21 Turkish Airports	Turkey	2009-2014	DEA, Malmquist Productivity Index	Simar-Wilson bootstrapping regression analysis	Runways Runway Dimensions Terminal Size	ATM Pax Cargo	Population around the airport Airport Hub Status Airport Operating hours Joint military-civil Airports Percentage of International Traffic
Wanke et al. (2016)	Transport Policy	30 Nigerian Airports	Nigeria	2003-2013	DEA (Fuzzy DEA)	-	Terminal capacity runway area apron area employees	Pax ATM cargo	-
Fragoudaki and Giokas (2016)	Journal of Air Transport Management	38 Greek Airports	Greece	2010-2014	DEA	Tobit regression	Runway length Apron area Terminal area	PAX ATM cargo	Island airport dummy connectivity dummy hotel infrastructure
Gutierrez and Lozano (2016)	Research in Transportation Economics	21 small and medium sized airports	Europe	2013	DEA	-	Runway size Boarding gates Apron Stands Number of Scheduled routes Number of airlines	ATM Pax Cargo	Ownership Hub
Liu (2016)	Journal of Air Transport Management	10 major airports in East Asia	Asia-Pacific	2009-2013	DEA	-	Runway area Staff costs other operating costs	Pax ATM Cargo	Service Quality Number of destinations number of airlines served Non aeronautical revenues

Appendix B Airports Sample Dataset

Table 8-2 Data on airports included in the sample dataset

IATA Code	Airport Name	Country	Year	Ownership	(i)Runways	(i)Gates	(i)Terminal Size (sq. m)	(i)Employees	(o)PAX	(o)ATM	(o)CARGO (Tons)	(o)Non_Aero (US$)
SYD	Sydney Kingsford Smith International Airport	Australia	2009	1	3	65	394787	307	32998000	289741	595000	375751045.8
VIE	Vienna International Airport	Austria	2009	1	2	61	70536	4148	18114000	243430	254006	395949472.1
BRU	Brussels International Airport	Belgium	2009	3	3	109	190804	732	16999000	231668	449132	179373308.5
CAN	Guangzhou Bai Yun Airport	China	2009	2	2	74	320000	3552	37049000	308863	955270	258238922.8
CPH	Copenhagen Kastrup International Airport	Denmark	2009	1	3	108	96965	1852	19715000	236172	312181	324513155.3
HEL	Helsinki Vantaa International Airport	Finland	2009	3	3	50	145101	600	12592000	171000	111115	75475726.5
CDG	Paris Charles de Gaulle International Airport	France	2009	2	4	124	542595	3858	57907000	518018	2050000	1794369492
FRA	Frankfurt Main International Airport	Germany	2009	2	3	147	800000	17441	50938000	463111	1917227	1351483830
MUC	Munich International Airport	Germany	2009	3	2	206	458000	4376	32681000	396805	242150	651760216.8
ATH	Athens International Airport	Greece	2009	2	2	55	185000	702	16226000	210147	104521	383319219.4
BUD	Budapest Ferihegy International Airport	Hungary	2009	1	2	51	75800	1319	8095000	109811	62870	181699397.3
KEF	Keflavik International Airport	Iceland	2009	3	2	14	56000	364	1658000	44723	36880	59825981.94
DUB	Dublin International Airport	Ireland	2009	3	2	71	40000	1350	20504000	176811	97411	391976180.9
FCO	Rome Leonardo Da Vinci/Fiumicino Airport	Italy	2009	1	3	86	285000	3278	33808000	324497	138988	398155599.7
HND	Tokyo International Airport	Japan	2009	3	3	54	656600	266	70800000	351728	715048	962232837
KIX	Kansai International Airport	Japan	2009	2	2	52	303443	392	15330000	128105	726306	373745970.6
KUL	Kuala Lumpur International Airport	Malaysia	2009	3	2	135	514694	1578	29682000	225251	601620	61560197.73
AMS	Amsterdam Schiphol International Airport	Netherlands	2009	2	6	99	591885	2241	43570000	406974	1286372	965355537.7
AKL	Auckland International Airport	New Zealand	2009	1	1	28	115200	321	13013000	156781	197528	141482652.3
OSL	Oslo Airport	Norway	2009	3	2	71	150040	429	18088000	219573	78000	393733778.2

IATA Code	Airport Name	Country	Year	Ownership	(i)Runways	(i)Gates	(i)Terminal Size (sq. m)	(i)Employees	(o)PAX	(o)ATM	(o)CARGO (Tons)	(o)Non_Aero (US$)
WAW	Warsaw Chopin Airport	Poland	2009	3	2	67	140000	2120	8321000	115934	50143	50878830.01
LIS	Lisbon Portela Airport	Portugal	2009	3	2	46	174119	340	13278000	132380	83367	74847446.74
SIN	Singapore Changi International Airport	Singapore	2009	3	2	102	1046220	1300	38611000	245526	1700892	499629634.6
MAD	Madrid Barajas International Airport	Spain	2009	3	4	224	1000000	1200	48437000	435187	302836	314771241.5
ARN	Stockholm Arlanda International Airport	Sweden	2009	3	3	92	133000	795	16064000	192551	152400	200368216.4
ZRH	Zurich International Airport	Switzerland	2009	1	3	76	200000	1302	21927000	262121	344415	420670485.8
GVA	Geneva Cointrin International Airport	Switzerland	2009	3	2	55	89200	650	11324000	172671	52804	133704252.1
BKK	Suvarnabhumi Airport	Thailand	2009	2	2	120	563000	2775	38483000	241962	978119	215993617.8
IST	Istanbul Ataturk International Airport	Turkey	2009	1	3	32	318500	1996	29757000	264481	825000	231756715.7
LHR	London Heathrow International Airport	UK	2009	1	2	195	632064	5407	66037000	466393	1348914	1224550894
MAN	Manchester International Airport	UK	2009	2	2	103	136400	2040	18265000	172515	107000	191638597.2
MEL	Melbourne Airport	Australia	2015	1	2	66	233311	200	32104279	228444	297449	77404027.37
VIE	Vienna International Airport	Austria	2015	1	2	96	147000	4360	22775054	226881	272575	435066016
CAN	Guangzhou Bai Yun Airport	China	2015	2	2	97	370000	5333	55201900	407300	1537800	253398710.8
CPH	Copenhagen Airport Kastrup	Denmark	2015	1	3	106	215000	2260	26610332	254838	372748	365507439.6
TLL	Lennart Meri Tallinn Airport	Estonia	2015	3	1	12	28000	590	2166663	41513	16156	22936693.5
HEL	Helsinki Vantaa Airport	Finland	2015	3	3	53	150000	300	16422266	169597	161527	52271935
CDG	Paris Charles de Gaulle Airport	France	2015	2	4	208	1523886	6213	65766986	469338	2090795	1466147757
FRA	Frankfurt Airport	Germany	2015	2	4	145	1300000	15929	61040613	468153	2114579	1519014526
MUC	Munich Airport	Germany	2015	3	2	206	469400	8347	40998553	379911	336162	733747854
ATH	Athens International Airport	Greece	2015	1	2	44	187675	620	18086894	176156	80443	271253796.4
KEF	Keflavik International Airport	Iceland	2015	3	2	16	55000	736	4858776	39500	44734	125738281.9
DUB	Dublin Airport	Ireland	2015	3	2	72	150000	2302	25049319	197870	143563	433641370.6
FCO	Rome Leonardo Da Vinci/Fiumicino Airport	Italy	2015	1	4	84	312000	2453	40463208	315217	138235	461642285.9
KIX	Kansai International Airport	Japan	2015	2	2	53	300000	457	23972519	163506	745606	112545029.9

IATA Code	Airport Name	Country	Year	Ownership	(i)Runways	(i)Gates	(i)Terminal Size (sq. m)	(i)Employees	(o)PAX	(o)ATM	(o)CARGO (Tons)	(o)Non_Aero (US$)
AMS	Amsterdam Airport Schiphol	Netherlands	2015	2	6	198	600000	1878	58285118	450681	1655482	997239964.2
CHC	Christchurch International Airport	New Zealand	2015	3	2	33	74918	308	5915785	74715	27670	25018567.27
LIS	Lisbon Portela Airport	Portugal	2015	1	2	50	174119	641	20090254	166498	100796	101035792.9
BTS	Bratislava Milan Rastislav Stefanik Airport	Slovakia	2015	3	2	13	43613	561	1564311	24622	21067	9800241.193
LJU	Ljubljana Jože Pučnik Airport	Slovenia	2015	1	1	13	13000	397	1438304	32893	10140	17965096.12
ICN	Incheon International Airport	South Korea	2015	3	3	186	662000	1696	49413000	308000	2490000	530016648.7
MAD	Madrid Barajas Airport	Spain	2015	3	4	226	1000000	696	46828279	366605	381069	261684112.5
CMB	Bandaranaike International Airport	Sri Lanka	2015	3	1	22	90000	3872	8508346	62000	221000	230020134.2
GVA	Genève Aéroport	Switzerland	2015	3	1	36	89200	967	15772081	188829	51433	197013330.9
ZRH	Zurich Airport	Switzerland	2015	1	3	106	200000	1474	26281228	265095	439761	586832873.4
IST	Istanbul Atatürk Airport	Turkey	2015	1	3	63	345270	2761	61322729	447159	1907028	490323788.1
LHR	London Heathrow Airport	UK	2015	1	2	174	632064	6104	74959000	472067	1496657	1611805496
MAN	Manchester Airport	UK	2015	2	2	57	230000	2819	23116554	173124	103922	340006210.4

Ownership: (1): Full Private/ Mixed Public-Private with Private Majority (2): Mixed Public-Private with Public Majority (3): Full Public

Sources: (ATRS, 2010, 2016)

Appendix C National Macro-Environmental Factors

C.1 National macro-environmental scores data

Table 8-3 National Macro-Environmental factors scores

Country	Year	INS	INF	ME	HPE	HET	GME	LME	FMD	TR	MS	BS	INNOV	SS	CPI	HDI	TT	ATO
Australia	2009	5.6	5.2	5.6	6.2	5.3	5.2	5.2	5.5	5.4	5.1	4.8	4.4	1.5	8.7	0.9	5.2	1.000
Austria	2009	5.6	5.9	5.2	6.1	5.2	5.1	4.7	4.8	5.4	4.6	5.5	4.5	1.3	7.9	0.8	5.5	1.000
Belgium	2009	5.0	5.6	4.7	6.4	5.5	5.1	4.7	4.9	5.3	4.8	5.3	4.6	1.4	7.1	0.8	4.9	0.890
China	2009	4.4	4.3	5.9	5.7	4.1	4.5	4.7	4.1	3.4	6.6	4.5	3.9	1.9	3.6	0.5	4.3	1.000
Denmark	2009	6.1	5.8	5.7	6.3	5.9	5.2	5.5	5.3	5.9	4.3	5.5	5.0	1.2	9.3	0.8	5.1	1.000
Finland	2009	6.0	5.9	5.8	6.5	6.0	5.0	4.9	5.3	5.6	4.2	5.4	5.5	1.3	8.9	0.8	5.1	1.000
France	2009	5.0	6.5	4.7	6.2	5.3	4.9	4.4	4.9	5.2	5.8	5.3	4.5	1.6	6.9	0.8	5.3	1.000
Germany	2009	5.5	6.6	5.3	6.0	5.1	5.0	4.3	4.7	5.6	6.0	5.8	5.1	1.4	8.0	0.8	5.4	1.000
Greece	2009	3.8	4.3	4.0	5.8	4.4	4.1	3.8	4.0	3.9	4.6	4.0	3.1	1.8	3.8	0.8	4.9	0.595
Hungary	2009	3.8	4.0	4.5	5.6	4.6	4.2	4.4	4.2	4.4	4.4	3.9	3.5	1.6	5.1	0.7	4.5	0.509
Iceland	2009	5.6	5.9	3.6	6.5	5.6	4.7	5.4	4.0	5.6	2.5	4.9	4.5	1.2	8.7	0.8	5.1	1.000
Ireland	2009	5.2	4.2	4.6	6.2	5.1	5.1	4.9	4.6	5.3	4.3	5.0	4.3	1.3	8.0	0.8	5.0	0.874
Italy	2009	3.4	4.0	4.1	6.0	4.4	4.2	3.7	3.8	4.5	5.7	4.9	3.4	1.6	4.3	0.8	4.8	0.504
Japan	2009	4.9	5.8	4.2	6.1	5.1	5.1	5.1	4.7	5.2	6.2	5.9	5.5	1.3	7.7	0.8	4.9	1.000
Malaysia	2009	4.5	5.0	5.0	5.9	4.5	4.8	4.7	5.4	4.5	4.7	4.8	4.1	1.6	4.5	0.6	4.7	0.389
Netherlands	2009	5.7	5.7	5.2	6.2	5.5	5.2	4.8	4.9	6.0	5.1	5.5	4.8	1.5	8.9	0.8	5.1	0.998
New Zealand	2009	6.0	4.6	5.2	6.4	5.5	5.2	5.1	5.7	5.2	3.9	4.6	4.1	1.2	9.4	0.8	4.9	1.000
Norway	2009	5.9	5.0	5.9	6.2	5.5	4.9	5.0	5.3	5.8	4.3	5.1	4.5	1.2	8.6	0.9	5.0	1.000
Poland	2009	3.9	2.9	4.6	5.9	4.8	4.3	4.5	4.6	4.0	5.1	4.3	3.3	1.6	5.0	0.7	4.2	0.473
Portugal	2009	4.5	5.2	4.5	5.9	4.6	4.4	4.0	4.3	4.7	4.4	4.3	3.7	1.3	5.8	0.7	5.0	0.575

Country	Year	INS	INF	ME	HPE	HET	GME	LME	FMD	TR	MS	BS	INNOV	SS	CPI	HDI	TT	ATO
Singapore	2009	6.1	6.4	5.2	6.2	5.6	5.8	5.9	5.9	5.9	4.5	5.2	5.1	1.5	9.2	0.7	5.2	1.000
Spain	2009	4.4	5.4	4.7	5.8	4.7	4.4	4.1	4.5	4.8	5.5	4.7	3.6	1.6	6.1	0.8	5.3	0.944
Sweden	2009	6.1	5.8	5.7	6.2	5.8	5.3	4.9	5.2	6.2	4.6	5.7	5.4	1.3	9.2	0.8	5.3	1.000
Switzerland	2009	5.9	6.3	5.6	6.1	5.6	5.2	5.8	5.1	6.0	4.6	5.8	5.6	1.4	9.0	0.8	5.7	1.000
Thailand	2009	4.0	4.6	5.4	5.5	4.3	4.5	4.8	4.5	3.7	5.0	4.4	3.3	2.4	3.4	0.6	4.5	0.967
Turkey	2009	3.5	3.9	4.7	5.3	3.9	4.3	3.7	4.1	3.8	5.2	4.3	3.1	2.4	4.4	0.6	4.2	0.445
UK	2009	5.1	5.4	4.6	6.1	5.2	5.0	5.2	4.9	5.8	5.8	5.2	4.6	1.6	7.7	0.8	5.2	1.000
Australia	2015	5.3	5.7	5.6	6.5	5.8	4.8	4.5	5.4	5.6	5.1	4.7	4.5	1.3	7.9	0.9	5.0	1.000
Austria	2015	5.2	5.7	5.1	6.4	5.6	4.9	4.5	4.2	5.6	4.6	5.4	4.9	1.2	7.6	0.9	4.8	1.000
China	2015	4.1	4.7	6.5	6.1	4.3	4.4	4.5	4.1	3.7	7.0	4.3	3.9	2.3	3.7	0.7	4.5	1.000
Denmark	2015	5.5	5.5	6.3	6.4	5.8	5.0	5.1	4.6	6.1	4.3	5.4	5.1	1.2	9.1	0.9	4.4	1.000
Estonia	2015	5.0	4.9	6.2	6.3	5.5	4.9	5.0	4.6	5.3	3.1	4.3	4.0	1.7	7.0	0.9	4.2	0.082
Finland	2015	6.1	5.4	5.4	6.9	6.1	5.0	4.7	5.4	6.0	4.2	5.3	5.7	1.3	9.0	0.9	4.5	1.000
France	2015	4.8	6.0	4.7	6.4	5.3	4.6	4.4	4.5	5.9	5.8	5.1	4.9	1.7	7.0	0.9	5.2	1.000
Germany	2015	5.2	6.1	6.0	6.5	5.6	4.9	4.6	4.7	6.0	6.0	5.7	5.5	1.4	8.1	0.9	5.2	1.000
Greece	2015	3.7	4.8	3.3	6.1	4.8	4.2	3.7	2.8	4.9	4.3	3.8	3.2	1.9	4.6	0.9	4.4	0.844
Iceland	2015	5.3	5.6	5.2	6.5	5.7	4.7	5.1	3.9	6.2	2.4	4.7	4.5	1.1	7.9	0.9	4.5	1.000
Ireland	2015	5.5	5.3	4.5	6.5	5.6	5.4	5.1	4.0	6.1	4.2	5.1	4.8	1.4	7.5	0.9	4.5	1.000
Italy	2015	3.4	5.4	4.1	6.3	4.8	4.3	3.5	3.2	4.9	5.6	4.8	3.9	1.7	4.4	0.9	5.0	0.623
Japan	2015	5.5	6.2	3.7	6.7	5.4	5.2	4.8	4.7	5.7	6.1	5.8	5.5	1.3	7.5	0.9	4.9	1.000
Netherlands	2015	5.6	6.3	5.7	6.6	6.0	5.3	4.9	4.4	6.1	5.1	5.6	5.4	1.4	8.4	0.9	4.7	1.000
New Zealand	2015	6.0	5.2	5.9	6.6	5.8	5.4	5.3	5.7	5.9	3.9	4.8	4.5	1.2	9.1	0.9	4.6	1.000
Portugal	2015	4.4	5.5	3.6	6.3	5.2	4.6	4.3	3.4	5.5	4.3	4.3	4.0	1.3	6.4	0.8	4.6	0.280
Slovakia	2015	3.4	4.3	5.2	6.0	4.6	4.4	3.9	4.4	4.6	4.0	4.1	3.3	1.5	5.1	0.8	3.8	0.070
Slovenia	2015	3.9	4.8	4.4	6.4	5.4	4.5	4.0	2.8	5.1	3.4	4.2	3.8	1.4	6.0	0.9	4.2	1.000
South Korea	2015	3.9	5.8	6.6	6.3	5.4	4.8	4.1	3.6	5.5	5.6	4.8	4.8	1.7	5.4	0.9	4.4	1.000

Country	Year	INS	INF	ME	HPE	HET	GME	LME	FMD	TR	MS	BS	INNOV	SS	CPI	HDI	TT	ATO
Spain	2015	3.9	5.9	4.0	6.2	5.1	4.3	4.0	3.8	5.6	5.4	4.5	3.7	1.5	5.8	0.9	5.3	0.643
Sri Lanka	2015	4.1	4.2	4.1	6.1	4.4	4.4	3.4	4.1	3.3	4.1	4.3	3.6	2.2	3.7	0.8	3.8	1.000
Switzerland	2015	5.8	6.2	6.5	6.5	6.0	5.4	5.8	5.1	6.3	4.7	5.8	5.8	1.3	8.6	0.9	5.0	1.000
Turkey	2015	3.8	4.4	4.7	5.7	4.6	4.5	3.5	3.9	4.1	5.4	4.1	3.4	2.4	4.2	0.8	4.1	1.000
UK	2015	5.5	6.0	4.2	6.4	5.6	5.2	5.3	4.8	6.3	5.7	5.5	5.0	1.7	8.1	0.9	5.1	1.000

Sources: (IEP, 2009; Institute for Economics and Peace, 2015; Itani, 2015; TI, 2009, 2015; WEF, 2009b, 2009a, 2015b, 2015a)

C.2 National macro-environmental factors definitions and indexing system

Variable	Description	Type of data	Source
Institutions	Measurement of the quality of public and private institutions of a country which depends on the administrative and legal framework within which individuals, businesses, and governments interact.	1 to 7 score index	(WEF, 2009a, 2015a)
Infrastructure	Measurement of the quality of the general infrastructure including the systems which ensure the effective functioning of the country's economy such as modes of transportation (high-quality roads, railroads, seaports, and airports), telecommunications network, electricity supplies, and sewage and water systems.	1 to 7 score index	(WEF, 2009a, 2015a)
Macroeconomic environment	Measurement of the stability of the macro-environment through examining government budget balance, past government debts, control of inflation, national rate of savings and the spread of the rate of interests.	1 to 7 score index	(WEF, 2009a, 2015a)
Health and primary education	Measurement of the health services quality of the country, the level of health of the population and the cost of health on the overall economy. In addition, it includes the measurement of the quality of the basic education received by the population, such as education expenditure, quality of primary education and education enrolment rates.	1 to 7 score index	(WEF, 2009a, 2015a)
Higher education and training	Measurement of the secondary and tertiary enrolment rates in addition to the quality of education systems and training (examining expenditure on higher education, quality of management schools, Internet access in schools and universities and the availability of research and training institutions). Staff training is also taken into consideration in this measurement.	1 to 7 score index	(WEF, 2009a, 2015a)
Goods market efficiency	Measurement of the capability of a country to generate the right proportion of products and services according to its specific supply-and-demand settings. It takes into consideration domestic and foreign competition as well as the degree of customer orientation and buyer sophistication.	1 to 7 score index	(WEF, 2009a, 2015a)
Labour market efficiency	Measurement of the flexibility and efficiency of the labour market in terms of rigidity of employment, redundancy costs, the effect of taxation, pay versus productivity rates and the reliance on professional management. It takes into consideration the ability of the labour market to shift employees from one economic activity to another in a rapid and low-cost process, the presence of incentives and meritocracy at the workplace, and the gender equity in the business environment.	1 to 7 score index	(WEF, 2009a, 2015a)

Variable	Description	Type of data	Source
Financial market development	Measurement of the productivity and efficiency of the financial by examining the appropriate distribution of national resources and foreign investments to achieve the most productive economic outcomes.	1 to 7 score index	(WEF, 2009a, 2015a)
Technological readiness	Measurement the nimbleness with which an economy implements existing technologies to improve the productivity of its industries. It emphasises on the nation's capacity to influence information and communication technologies in daily production processes for increased efficiency and innovation.	1 to 7 score index	(WEF, 2009a, 2015a)
Market size	Measurement of the total volume of a certain market in terms of the sizes of the domestic market and foreign market.	1 to 7 score index	(WEF, 2009a, 2015a)
Business sophistication	Measurement of the quality of a country's overall business networks (by examining the quantity and quality of local suppliers and the extent of their interaction) and the quality of individual firms' operations and strategies. These two factors are most important for countries at an advanced stage of development.	1 to 7 score index	(WEF, 2009a, 2015a)
Innovation	Measurement of the capacity for innovation in a certain economy by examining the degree of investment in research and development (R&D), especially by the private sector; the presence of high-quality scientific research institutions that can generate the basic knowledge needed to build the new technologies; the existence of extensive collaboration in research and technological developments between universities and industry; and the degree of protection of intellectual property	1 to 7 score index	(WEF, 2009a, 2015a)
Travel and tourism competitiveness	Measurement of the factors and policies that urge-on and ease the growth of travel and tourism (T&T) sector in a certain country. It emphasises on the T&T regulatory framework, business environment and infrastructure, in addition to human, cultural and natural resources.	1 to 6 score index	(WEF, 2009b, 2015b)
Safety and security stability	Measurement of the level of safety and security in a particular country. It considers internal and external factors extending from the level of military expenditure to the country's relations with neighbouring countries. It also considers the level of democracy and respect for human rights.	1 to 5 score index (5 being least peaceful)	(IEP, 2009, 2015)
Corruption perception	Measurement of the level of corruption in the public sector of a particular country through the perception of the experts and business people.	1 to 100 score index with 100 being least corrupted	(TI, 2009, 2015)

Variable	Description	Type of data	Source
Human development	Measurement of the average achievement in key dimensions of human development including health dimension (measured by the life expectancy at birth), education dimension (measured by the mean of schooling years for adults above 25 years old and expected schooling years for children of school entering age), and the standard of living dimension (measured by the gross national income per capita)	0 to 1 index score with 1 being very high human development	(UNDP, 2009, 2015)
Air Transport Output	The measurement of the air transport sector's performance of a particular country taking into consideration the total air passenger traffic, aviation contribution to GDP and employment, level of air connectivity, air liberalization, and airport ownership.	0 to 1 index score with 1 being the most efficient	(Itani, 2015)