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The KPI Challenge for European Airports

A comparative study on the Performance Measurement activities of commercial airports in Europe

by Swen Franken (i6057102)

Thesis Supervisor: Dr. Lieven Quintens

Maastricht University
School of Business and Economics
Faculty of Marketing and Supply Chain Management

Master of Science in International Business

Track Supply Chain Management

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Abstract

The European airport sector currently faces great challenges around the topics of commercialization, privatization, cost efficiency and environmental pressures. As a major consequence of these effects, aerodromes are adopting more and more business-like practices to develop from formerly public owned infrastructure providers to privatized commercial businesses. One milestone to realize this process is to successfully measure the own performance and apply internal, as well as external, benchmarking.

In this research, the characteristics of European airports in terms of their performance measurement activities are examined. Underlying factors why different airports apply a more or less diverse set of KPI´s are revealed as well, thereby contributing a new stream of knowledge to the academic literature. In collaboration with ACI EUROPE (Airports Council International), the European division of the largest trade organization of airports in the world, a survey among 338 European airports was conducted. In the end 50 airports of various dimensions participated in the research project, which represents 30.8% of the annual passenger volume in Europe and serves as a profound database. In a second step, Kruskal-Wallis-tests, chi-square test of independence and path modeling via partial least squares (PLS) are applied to examine relationships within the data. Through incorporating the *ACI Guide to Airport Performance Measures* into the survey it was also tested to which extent this framework is regarded as a standard in the airport industry.

The results paint a vivid and diverse picture of the performance measurement (PM) practices of European airports. Airport size, number of FTE´s devoted to performance measurement, ACI membership, guide usage and the use of other standards were found to significantly influence the number and diversity of applied KPI´s, whereas ownership does not. To compare the set of KPI´s applied by airports, a new metric called Total Performance Measurement Sophistication (TPMS) is introduced and proofed as useful. Performance improvements and benchmarking are the most important motivations for airports to engage in performance measures, whereas strategic plans, competition, senior management goals and regulation are among the most important drivers.

Approximately one quarter of the airport organizations in Europe already apply the guide, especially airports with an annual passenger volume between 1 and 25 million passengers. Based on their feedback, possible options for improvement and further development of the guide are identified, as well as steps are suggested to ACI EUROPE to increase knowledge and usage of the guide in their region.

The theoretical concept of the influence of individual airport contextual situations on airport performance was transferred to the area of partial performance measurement. Through constructing three contexts, 34.84% of the variance within the TPMS data can be explained.

Based on these results a tool to compare the performance measurement approaches of airports is proposed that can be of use for both, airports that participated in this study as well as for those which did not.

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List of Abbreviations

ACI	Airport Council International
ACRP	Airport Cooperative Research Program
ADV	Arbeitsgemeinschaft Deutscher Verkehrsflughäfen
BAA	British Airport Authority
BCG	Boston Consulting Group
CE	Copenhagen Economics
CEO	Chief Executive Officer
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
EFQM	European Foundation of Quality Management
EU	European Union
ENAC	École Nationale de l'Aviation Civile
EUROCONTROL	European Organization for the Safety of Air Navigation
FAA	Federal Aviation Administration
FTE	Full Time Equivalent
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IFR	Instrumental Flight Rules
KPA	Key Performance Area
KPI	Key Performance Indicator
LCC	Low Cost Carrier
MoU	Memorandum of Understanding
O&D	Origin & Destination
Pax/pax	Passengers
PLS	Partial Least Squares
PM	Performance Measurement
PMS	Performance Measurement Sophistication
SFM	Stochastic Frontier Method
TFP	Total Factor Productivity
TPMS	Total Performance Measurement Sophistication
UN	United Nations
VFP	Variable Factor Productivity
VFR	Visual Flight Rules
VIF	Variance Inflation Factor

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1 Introduction

1.1 Thesis Context

With about 10 million flights per year and forecasted future growth (EUROCONTROL, 2012), the European airspace is one of the busiest and most complex in the world. In 2011 a total of 1,569,907,313 passengers travelled from and between European airports, representing a share of around 28.84% of total passengers travelled in the world (ACI World, 2011). Despite the impact of the financial crisis and other external pressures, industry experts still expect enormous growth in the long-run, as forecasts of various institutions predict increasing traffic volumes for the next decades (Airbus, 2012; Boeing, 2012; EUROCONTROL, 2012). As aerodromes are the "*nodes of the air traffic world"* (SESAR JU, 2010, p. 6) they represent one of the major bottlenecks for future expansion of the global air transport system. However, in contrast to airlines, which can increase their offered capacity relatively fast through acquisitions of new planes, airports need to enlarge their capacities through huge infrastructure investments, while at the same time the fees they can charge their customers are capped by national laws (De Neufville & Odoni, 2003).

This leads to a growing importance of non-aeronautical and commercial revenues, which today account for around 50% of an airports total earnings, with variations across global regions (Graham, 2009). According to the *ACI Airport Economic Survey 2007* commercial revenues of European airports represent 48.1% of the total revenue, with retail concessions, property income and car parking being the most important sources (ACI World, 2007a). Other challenges the airport industry faces today are e.g. new patterns of demand growth, pressure for reduced charges, fewer subsidies (BCG, 2004), environmental issues (Humphreys, Francis, & Fry, 2002), increased regulation and the change from governmental owned infrastructure providers towards privately operating companies (De Neufville & Odoni, 2003; Graham, 2005; Marques & Barros, 2011).

In their famous report *Airports-Dawn of a New Era* the Boston Consulting Group states that airports face a "*Pressure to act more like businesses"* (BCG, 2004, p. 21). This development, described by the terms of "*airport commercialization", "privatization"* or *"airport ownership diversification"* (Graham, 2008, pp. 8-9) represents an important cornerstone of the long term strategies of most European airports. Although characterized by different definitions, the basic process behind these terms can be described as airports moving from public sector ownership and national requirements towards an industry ruled by the private sector and global corporations. However, turning former public administration structures into competitive companies requires business practices. One aspect of this change is the measurement of the own performance. Due to the described increased commercial focus, airports try to get deeper insights into their operations by measuring their performance with the right indicators (Humphreys et al., 2002). Besides using the metrics as business steering instruments, measuring the right metrics enables airports to use this knowledge for internal and external benchmarks as well (ACI World, 2012; Graham, 2005). To realize operational safety, gain financial efficiency and monitor environmental impacts (Doganis, 1992; Francis, Fry, & Humhpreys, 2001), airport managers rely more than ever on trustworthy and effective performance measurement.

1.2 Research Objectives

While the topic of assessing the performance and efficiency of individual airports is discussed heavily in academia, as will be shown in the literature review, the topic of how airports measure their performance in terms of which metrics they already use and as how useful they perceive them is rarely researched so far, especially within an European context.

Therefore, this study aims at identifying the common practices of European airports in the area of performance measurement. Through conducting a survey among commercial airports in Europe, the differences between various types of airports will be analyzed based on the framework of ACI´s (Airport Council International) *"Guide to Airport Performance Measurement"* (ACI World, 2012). In addition, this allows for testing to which extent the guide is already applied among the European airport industry and whether it is accepted as an industry standard. Strengths and weaknesses of the current version of the guide can be identified, which will point to potential areas for improvement in the future. The setting of using a common framework enables this thesis also to shade light on the differences between various types of airports in terms of performance measurement. Unlike in former studies, the focus is not only on large hub airports, as the opinions and practices of small and medium sized airports are of equal importance.

In addition, the gathered data are used to test whether different *airport contexts*, *performance measurement contexts* and general *ACI guide contexts* influence the performance measurement activities of airports.

To collect viable data for this project, the author collaborated with ACI EUROPE, the European division of Airports Council International, which is a global trade association and the body of 1,751 airports in 174 countries and, thus, represents 95% of the worldwide airport traffic (ACI World, 2013).

The objectives can be summarized briefly in the following way:

1) Characterization of Performance Measurement activities of European Airports
2) Acceptance and Application of the ACI guide across Airports in Europe
3) Influence of different Airport Contexts, Performance Measurement Contexts and ACI Guide Contexts

As a practical application based on the research results, a tool will be developed to compare the performance measurement activities of airports in form of individual airport profiles.

1.3 Thesis Structure

As point of origin for reaching the goals mentioned above, an in-depth literature review on the research topic of airports and their performance measurement will lay a theoretical foundation for this thesis (chapter 2). To reveal how the information for this study is gathered and which methods are used, chapter 3 explains the methodology as well as the details of the cooperation with ACI EUROPE, followed by a detailed and objective analysis of the results (chapter 4). A discussion of the findings (chapter 5) in combination with outlining what implications the results

have from both, the academic and the managerial point of view (chapter 6), will highlight the contribution of this thesis, which will conclude by identifying limitations and areas for further research.

2 Literature Review

2.1 Airports in Europe

The following subchapter gives a short introduction into the most common terms and concepts regarding airport systems and classifications, followed by an overview over the European airport landscape. In a subsequent step, the recent developments and challenges for the airport industry are summarized briefly.

2.1.1 Definitions and Characteristics of Airports

Together with airlines and air traffic control providers, airports are the key players within the global aviation system, as they provide the essential infrastructure to enable the connection of ground transportation and air transportation modes for passengers and freight (Graham, 2008). Although different terms and definitions exist due to regulations on country level, the International Civil Aviation Organization (ICAO), which is a sub-organization of the United Nations (UN) and the highest legislative institution in aviation on a global level, defines an aerodrome in general as a *"defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft"* ICAO (pp. 1-2). Based on this open definition, 43,794 airports existed worldwide in 2012, including very small airfields with paved or even unpaved runways (CIA, 2013). For each airport two different nomenclatures exist: While ICAO gives every airport a four-letter abbreviation reflecting the geographical location, e.g. EDDF for Frankfurt/Main Airport, the International Air Transport Association (IATA), which is the global organization of airlines, uses three-letter codes, e.g. FRA for Frankfurt/Main Airport. Since the ICAO code is rather technical, it is widely used for air traffic control and operational means, while in the public the IATA code is preferred.

One of the most essential concepts within the aviation sector is the classification of the infrastructure elements as airside and landside of an airport (Horonjeff & McKelvey, 1994). Looking at the aerodrome from a systems perspective, the airside deals with the flow of the aircraft from entering the Terminal Airspace[1], the landing process and ground movement through using runway and taxi ways until it reaches its final position on the apron or at the gate. The complementary part is the landside, which deals with the flow of the passenger and includes ground access via train, car or other public transport means, parking lots, hotels as well as other buildings and most important the passenger terminal including all passenger handling processes, among others: Check-in, security check, customs control, baggage drop off and claim, shopping

[1] The airspace around an aerodrome within a certain radius is called Terminal Airspace. Within this area, the air traffic controllers of the local control tower take over responsibility for the aircraft from their en-route colleagues.

and dining. Since airports serve as the connection between aircraft and passenger, they can be regarded as enabler of the whole aviation system or as *"two-sided platforms"* (Gillen, 2011, p. 11) that add value to both, the airline and the passenger. [2] Hence, airports have to fulfill the needs of two different customer groups.

As the different elements of air- and landside already suggest, airports are complex and diverse systems and, thus, are categorized differently in every corner of the world. Nearly every country uses its own classification system, which is often embedded within the national aviation law or defined by the national airport authority, e.g. Luftverkehrsgesetz (LuftVG) (Germany, 2013) in Germany or the classification of the Federal Aviation authority (FAA) in the US (FAA, 2013). Orientation at often unique and country specific conditions makes it difficult to apply these categorization schemes on an international level and, thus, is not suitable for this research. Other possibilities to differentiate between various types of airports are runway layouts (single, multiple, parallel, crossed runways etc.), the provision of air traffic control service (controlled/uncontrolled airports) and the number of aircraft movements per year (Maurer, 2003). However, within a European context, the European Union (EU) differentiates airports from airfields, as airports are required to be open for commercial air traffic services (EU, 2003).

Despite the heterogeneity of the airport industry (Oum, Yu, & Fu, 2003), some general categorization schemes exist on a global level. ICAO differentiates airports according to their infrastructure and technical facilities, known as ICAO Airport Reference Code (ICAO, 2009a), indicating the length of the runway, the wingspan and outer main gear wingspan of the largest plane that can use the airports infrastructure. [3] ACI, looking at the topic from an airport perspective, organizes aerodromes into four groups based on their number of passengers per year (ACI EUROPE, 2013a). Academic papers and business reports in general also identify this technique as suitable in a research context and, depending on the topic, even specify it further by assigning key characteristics like share of transfer traffic, operative function (Hub, O&D, regional, airport etc.) and size of catchment area (BCG, 2004) or by using more differentiated groups (SEO, 2012). Therefore, the research framework at hand also uses passenger figures as key distinctive features and distinguishes between the six categories displayed in Table 1. [4]

Airport Categories	Passengers per Year
Group 1	> 25 mio
Group 2	10-25 mio
Group 3	5-10 mio
Group 4	1-5 mio
Group 5	0.5-1 mio
Group 6	< 0.5 mio

Table 1: Airport categories within the research framework (based on ACI EUROPE (2013a))

[2] Ashford and Wright (1992) as well as De Neufville and Odoni (2003) are recommended for further information on the topic of airport infrastructure components and system design.
[3] For more information on ICAO, the airport reference code, please consider the extensive information available in ICAO Annex 14 or ICAO Doc 9157 (Aerodrome Design Manual).
[4] The categorization follows the suggested practice of ACI EUROPE, but extends it by using two additional groups for smaller airports (groups 5 & 6).

With a share of 28.84% of total passengers travelled in the world (1.57 billion out of 5.44 billion in total), the ACI 2011 World Airport Traffic Report finds Europe to be the largest aviation market in the world in terms of passenger travel, second largest in terms of flight movements and third largest regarding cargo volumes (ACI World, 2011). This illustrates the importance and sheer size of the European airport industry also from a global perspective. Taking into account only airports with IFR flights [5], the European aviation landscape consists of 2,087 airports (EUROCONTROL, 2007). Within this population, the top 75 airports account for 90% of the total traffic volume (EUROCONTROL, 2007), indicating a high concentration of traffic density on relatively few airports. From a geographical point of view, the area of Western Europe shows the largest amount of air traffic. Based on 2011 data, the top 10 airports in terms of passengers per year are listed in Table 2.

Airports 2011	Country	IATA Code	ICAO Code	Passengers
LONDON HEATHROW Airport	UK	LHR	EGLL	69,475,746
PARIS-CHARLES DE GAULLE Airport	France	CDG	LFPG	60,871,921
FRANKFURT/MAIN Airport	Germany	FRA	EDDF	56,561,629
AMSTERDAM/SCHIPHOL Airport	Netherlands	AMS	EHAM	49,838,392
MADRID/BARAJAS Airport	Spain	MAD	LEMD	49,574,061
ROMA/FIUMICINO Airport	Italy	FCO	LIRF	37,897,931
MUNCHEN Airport	Germany	MUC	EDDM	37,851,113
ISTANBUL ATATURK Airport	Turkey	IST	LTBA	37,452,187
BARCELONA Airport	Spain	BCN	LEBL	34,339,549
LONDON GATWICK Airport	UK	LGW	EGKK	33,698,225

Table 2: Top 10 airports in Europe 2011 (eurostat, 2013)

2.1.2 Changing Business Environment for European Airports

In spite of all opposing views among scholars, if there is one thing that all aviation industry experts and academics could possibly agree on, it is the fact of a changing business environment for airports. Among others, the main challenges for aerodromes in the near future are long-term growth, commercialization, globalization, technical change (De Neufville & Odoni, 2003), pressure of low fare airlines (Barret, 2004) and increased regulation (Marques & Barros, 2011). Other, more recently emerging challenges are the environmental pressure of various airport stakeholders and the increased competition among European airports (ACI EUROPE, 2013b; CE, 2012). Although the examples above reveal a diverse set of influences on the future airport business, the following paragraphs will concentrate on the most important facts within the context of this thesis, namely growth & globalization, commercialization & privatization and environmental pressure.

Long-Term Growth & Globalization

Historically, the global air traffic market has grown constantly from year to year and has doubled every 15 years in terms of passengers travelled, with this trend mainly driven by the airline

[5] IFR flights are all flights following the Instrumental Flight Rules issued by ICAO. Instead of VFR (Visual Flight Rules), where pilots navigate mainly through visual contact to the ground, VFR flights require flight navigation instruments.

industry through larger and more efficient aircraft, reduced regulation and increased competition among airlines, low salaries of aviation staff, low fuel prices in the past and the use of revenue/yield management systems (De Neufville & Odoni, 2003). As Figure 2 shows, aircraft producers like Airbus (2012) and Boeing (2012), as well as neutral institutions like EUROCONTROL (2007) or ICAO (2013a) expect this trend to continue over the next decades, although it is expected that larger airports will benefit more than smaller competitors (BCG, 2004).

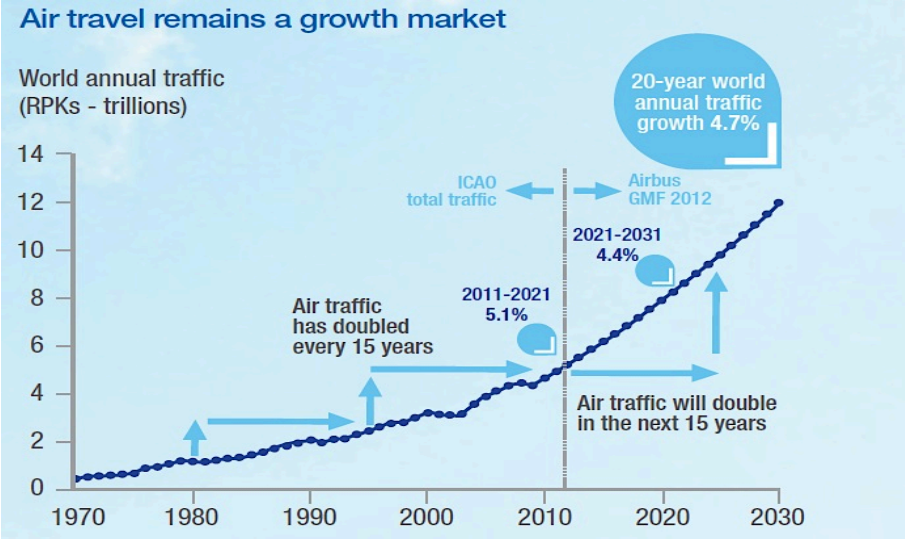


Figure 1: Air Traffic Forecast 2012-2030 (Airbus, 2012, p. 13)

While this in general represents a positive outlook for aerodromes, it raises the questions of how airports can handle this increased amount of traffic. Already today a lot of airports operate close to their maximum capacity (Gelhausen, Berster, & Wilken, 2013; Marques & Simões, 2010) and building of new infrastructure elements like runways and terminals requires extensively time consuming planning processes and large sums of investment capital. A survey of EUROCONTROL among aviation experts found that *"air transport is moving from unlimited resources (runway, airspace, fuel, emissions, time, etc.) to scarcity. The issue will no longer be to increase capacity to cope with demand, but more and more to manage scarce resources"* (EUROCONTROL, 2009, p. 56).

Another factor contributing to the immense growth is globalization. After a phase of extensive deregulation in the US and European airline market, global airline partnerships and alliances emerged, as well as consolidation among air carriers increased (De Neufville & Odoni, 2003). Aerodromes followed this trend and international airport companies evolved as well, since by managing several airports in parallel they can apply economies of scale (De Neufville & Odoni, 2003) and increase their market power.

Commercialization & Privatization

As mentioned earlier, the deregulation and privatization within the aviation sector started with the airline companies, especially with the in 1978 initialized US airline liberalization phase (Graham,

2008). In the following years other countries and communities of states like the EU implemented the concept as well, leading to a more and more privatized airline sector and the development of new business models like low cost carriers (LCC) and extremely powerful airline alliances (Graham, 2008).

Although aerodromes were traditionally owned, managed and subsidized by governments or governmental institutions (Humphreys & Francis, 2002; Oum, Adler, & Yu, 2006), the view of airports as mere provider of infrastructure serving the local communities radically started to change also during the 1980s. Within this context Graham (2008, pp. 8-9) distinguishes between three different terms:

- Airport commercialization: "*transformation of an airport from a public utility enterprise to a commercial enterprise along with the adoption of more businesslike management philosophy"*
- Airport privatization: *"transfer of the management of an airport, and in many cases the ownership as well, to the private sector"*
- Airport ownership diversification: *"emergence of a number of different types of new investors and operators of airports"*

Despite characterized by different definitions, the basic process behind these terms can be described as airports moving from public sector ownership and national requirements towards an commercially focused industry ruled by the private sector and global corporations. All three phenomena are connected and closely related.

Starting with the evolution of airport authorities, aerodromes during the 1970s to 1980s began to understand that aeronautical revenues, like passenger or landing fees, are insufficient to cover the capital required for future infrastructure investments and increased their focus on management of financial capital, commercial accounting methods, marketing and non-aeronautical revenues (Graham, 2008). This resulted in the rise of commercialization. Besides their traditional main goal of the provision of transport infrastructure to the local region, airports today offer a wide range of commercial facilities, like shopping malls, hotels, bars, conference centers and office complexes (Graham, 2008), resulting in increased importance of these revenue generators. In fact ACI EUROPE´s Economics Report 2011 found that non-aeronautical revenues represent on average 48% of an airport´s total revenue when excluding ground handling services (ACI EUROPE, 2012).

According to Graham (2008), from the 1990s onwards the focus of the airport industry was enlarged by the rise of privatization and a debate on the advantages and disadvantages.[6] By putting the British Airport Authority (BAA) up for sale in 1987, Europe was among the pioneers on the privatization front and many other countries followed the British example[7] (Graham, 2008, 2011; Oum et al., 2006). Privatization provided a way to secure future infrastructure investments

[6] For an in-depth discussion of the advantages and disadvantages of privatization Beesley (1997) is highly recommended, especially chapters 1 to 4.
[7] A detailed summary of the privatization timeline in Europe and the topic of airport privatization in general can be found in Graham (2008) and (Graham, 2011).

through external (non-governmental) capital, especially in an environment of reduced governmental subsidies. However, privatization provides not for every airport the perfect approach to tackle the challenges ahead and different forms, models and ownership structures exist today (Gillen, 2011; Graham, 2008; Oum et al., 2006).

Environmental Pressure

The third essential challenge considered within this thesis is the growing focus on environmental issues due to external pressures (ACI World, 2007a). In general, five areas of consequences on the environment can be distinguished (ACI World, 2007b; Graham, 2008): (1) noise, (2) emissions (e.g. CO_2, $NO_{x,}$) and air quality, (3) water pollution and consumption, (4) energy management and waste, (5) wildlife protection, land usage and heritage. To counter these effects, actions have to be taken on both, a global and a local level. In a position paper on "*Airports and the Environment"* ACI, representative for all member airports, states that airports are *"part of worldwide environmental problems"* (ACI World, 2007b, p. 1) but that a holistic approach of all players within the aviation industry with ICAO as central focal point is required to solve the problem. Considering the fact that the main source of noise and emissions are the engines of aircrafts operated by airlines and developed by aircraft manufacturers, a holistic approach seems indeed to be necessary. To design and apply this collaboration, as well as sharing the costs in a successful way will be one of the major tasks for the aviation industry in the 21st century.

2.2 Airport Performance Measurement

As outlined above, the business environment for European airports is changing fundamentally due to growing demand, increased environmental orientation and an increased focus on commercial activities. Besides other consequences, airports had to change the way they operate towards applying more business-like practices (BCG, 2004; Graham, 2008), among which measuring the own performance is of highest importance (Francis et al., 2001; Graham, 2005; Humphreys et al., 2002). This is also underlined by the result of a literature review by Graham (2011), which revealed that realizing improvements in airport performance and efficiency is the most important objective of airport privatization (see also Hooper, 2002). A vast of amount of literature on the topic of airport performance was published throughout the last two decades and an overview of the most important findings and the status quo will be presented in the following chapter.

2.2.1 Status Quo and Scope of Airport Performance Measurement

Within the context of the airport industry and governmental institutions, Performance Management and Measurement are relatively new concepts (Graham, 2008; Humphreys & Francis, 2002). The Airport Cooperative Research Program (ACRP) of the Transportation Research Board defines Performance Management as a business practice used for *"monitoring performance, identifying when it is off track, evaluating why, and taking action to bring it back to*

where you want it" (ACRP, 2010, p. 132) and Performance Measurement as the *"process of assessing progress towards achieving predetermined goals"* (ACRP, 2010, p. 132). In short: While Performance Measurement means only the real measurement process of gathering the right data through the right metrics, Performance Management is the broader term, implying also the consequences and actions resulting from the analysis of the measured data.

To realize operational safety, gain financial efficiency and monitor environmental impacts, Airport Managers rely more than ever on trustworthy and effective performance measurement. Airports try to get deeper insights into their operations by measuring their performance with the right indicators (Humphreys et al., 2002). But aerodrome managers themselves are not the only ones interested in adequate performance data. Like Humphreys and Francis (2002, p. 80) explain, key stakeholders also benefit from performance measurement activities:

- Governments: Use for regulation (economic, environmental)
- Airlines: Compare offers, prices and service standards of different airports
- Passengers: Compare service standards among airports
- Owners & Investors: Evaluate investments

Besides using the metrics as business steering instruments, measuring the right metrics enables airports to use this knowledge for internal and external benchmarks as well (ACI World, 2012; Graham, 2005, 2008). However, heterogeneity of the airport landscape makes measuring airports performance and applying them for reasons of comparison a "*tricky business*" (Oum et al., 2003, p. 286). Although airports tried to catch up during the last decades, the sector still lags behind compared to other industries when it comes to performance management abilities (Graham, 2005).

The topic of airport performance receives special attention in academia when it comes to comparing the performance of individual airports through combining various output and input variables to one overall airport efficiency value. The most famous techniques in this area are Data Envelopment Analysis (DEA), variations of the Total Factor Productivity (TFP), Stochastic Frontier Method (SFM) and Grey Relation Analysis (see Table 3).

DEA is a statistical linear programming technique, where individual decision making units (DMUs), e.g. companies or airports, are compared based on their efficient use of weighted inputs and output (Baker, 2011; Ragsdale, 2008).The calculated DEA values indicate how well a DMU performs in relation to the most efficient DMU in the sample. The most important advantages of this technique are the requirement of only a limited amount of data and no need for estimation of cost or production functions, however, it tends to overestimate outliers and does not show whether the most efficient unit itself is performing efficiently (Graham, 2008).

TFP and VFP (Variable Factor Productivity) are other mathematical tools and basically estimate *"the amount of aggregate output produced by a unit of aggregate input*" (Oum et al., 2003, p. 289) and can be applied by a parametric approach, e.g. through underlying cost functions, a non-

parametric index figure approach (no underlying functions) or an endogenous weight approach (multi-input/output production function) (Graham, 2008).

A third category of methods is the Stochastic Frontier Method (SFM), first introduced by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broek (1977), states that corporations do not break a necessary cost or production frontier and are, thus, inefficient (Oum, Yan, & Yu, 2008). This approach incorporates a random error term (Aigner et al., 1977), reflecting the effect of coincidental developments on the production process. The Alvarez Frontier Method is a further development of SFM, proposed by Alvarez, Arias, and Greene (2004) and aims at establishing a link between technical efficiency and management activities.

Grey Relation Analysis, promoted by Deng (1982, 1989) is a special technique with the underlying assumption that real life situations always lack some information and, are therefore, regarded as *grey*, instead of white (perfect information) or black (no information). Grey in this context "*means poor, incomplete, uncertain, etc"* (Deng, 1989, p. 1) and the method tests to what extent development trends to measure the relation of two systems exist (Wang, Ho, Feng, & Yang, 2004).

While these overall efficiency values may be useful to compare the performance levels of airports at a glance, this aggregation into one value may harm the usefulness for management purposes (Graham, 2008). To explore the real strength and weaknesses of a company, additional effort is required by management to identify underlying causes.

Authors	Year	Methodology[8]	Research Focus
(Gillen & Lall)	1997	DEA	21 US airports
(Parker)	1999	DEA	22 UK airports
(Murillo-Melchior)	1999	DEA	33 Spanish airports
(Nyshadham & Rao)	2000	TFP	25 European airports
(Sarkis)	2000	DEA	44 US airports
(Martin & Roman)	2001	DEA	37 Spanish airports
(Abbott & Wu)	2002	TFP	12 Australian airports
(Oum et al.)	2003	TFP	50 major global airports
(Pacheco & Fernandes)	2003	DEA	33 Brazilian airports
(Bazargan & Vasigh)	2003	DEA	45 US airports
(Sarkis & Talluri)	2004	DEA	44 US airports
(Yoshida)	2004	TFP	30 Japanese airports
(Wang et al.)	2004	Grey relation analysis	10 Taiwanese airports
(Yu)	2004	DEA	14 Taiwanese airports
(Oum et al.)	2006	TFP/VFP	116 major global airports
(Lin & Hong)	2006	DEA	20 major global airports
(Pacheco, Fernandes, & de Sequeira	2006	DEA	58 Brazilian airports

[8] DEA: Data Envelopment Analysis; SFM: Stochastic Frontier Method TFP: Total Factor Productivity; VFP: Variable Factor Productivity

(Pacheco et al.)	2006	DEA	58 Brazilian airports
(Barros & Dieke)	2007	DEA	31 Italian airports
(Barros)	2008	DEA	32 Argentine airports
(Oum et al.)	2008	SFM	109 major global airports
(Tovar & Martín-Cejas)	2009	TFP	26 Spanish airports
(Ablanedo-Rosas & Gemoets)	2010	DEA	37 Mexican airports
(Diana)	2010	SFM	3 New Yorker airports
(Curi, Gitto, & Mancuso)	2010	DEA	36 Italian airports
(Marques & Barros)	2011	Alvarez Frontier Method	32 European airports
(Marques)	2011	TFP	3 Portuguese airports
(Tsekeris)	2011	DEA	39 Greek airports
(Gitto & Mancuso, 2012)	2012	DEA	28 Italian airports
(Zhang, Wang, Liu, & Zhao)	2012	DEA	37 Chinese airports
(Adler, Liebert, & Yazhemsky)	2013	DEA	43 European airports

Table 3: Selection of airport efficiency research articles

As Table 3 illustrates, the majority of airport efficiency studies have been conducted on country level, while only a limited amount of studies focus on an international perspective, which might be due to the problem of getting adequate and comparable data across country borders (Graham, 2005). Within the existing international exemptions, the geographical focus is either on a global (Lin & Hong, 2006; Oum et al., 2006; Oum et al., 2008; Oum et al., 2003) or European level (Adler et al., 2013; Marques & Barros, 2011; Nyshadham & Rao, 2000). All studies either define the performance of certain airports or try to develop new techniques for this purpose, while none of them focuses on how the metrics at the aerodromes are measured and used. In addition, the most of these articles focus on large, major airports, while the activities of small and medium-sized airports remain unexplored. Another characteristics of most of the articles above is that they focus mainly on certain aspects of airport performance, e.g. technical/operational efficiency (Barros, 2008; Chow & Fung, 2012; Diana, 2010; Gillen & Lall, 1997; Lin & Hong, 2006; Murillo-Melchior, 1999; Tsekeris, 2011; Wang et al., 2004; Yu, 2004; Zhang et al., 2012).

A topic that receives strong attention among authors of overall efficiency value papers is the question whether privatization influences performance or not. According to a recent literature review by Graham (2011), at least 21 different articles have been published on this topic during the last twelve years, with fundamentally opposing results. While some scholars promote the view, that privately operated countries perform better than governmentally owned (Barros & Dieke, 2007; Marques & Barros, 2011; Pacheco et al., 2006), others reject this hypothesis, as they find no significant performance differences (Oum et al., 2006; Oum et al., 2003; Parker, 1999). Nevertheless, the majority of papers indicate a positive relationship. One difficulty in comparing the outcomes of the individual studies can be the presence of different concepts of privatization within each country and in each research. As an example, Oum et al. (2006) uses five different degrees of organizational and ownership structure, whereas Gillen (2011) distinguishes between eight. Another factor contributing to this inconclusive research area is the

difficulty of attributing potential performance changes to privatization or commercialization, as both phenomena affected the airport sector in parallel. As Graham (2011, p. 12) states it: ”(*I)t is difficult to determine if it is actually commercialisation or privatisation that is the key driving force and whether the observed changes would have taken place anyway without privatisation”.* However, what has proven to be relevant is the existence of controllable (diversification of business, outsourcing, quality of service) and uncontrollable factors (ownership structure, size of the airport, size of average aircraft, traffic mix) that affect airport performance (Oum et al., 2003). Among these, the factor *airport size* has a significantly positive influence on performance, while the results on *traffic mix* – counter intuitively - indicate a negative influence on performance for a high share of international passengers (Oum et al., 2003). The results for *diversification of business* yield a significantly positive influence for non-aeronautical revenues and concentration on commercial activities (Oum et al., 2003). In addition, larger airports are more likely to benefit from privatization efforts than smaller ones, with 500,000 passengers as a possible threshold (Pacheco et al., 2006). Following the results of Barros and Dieke (2007), Oum et al. (2003), Oum et al. (2006) and Oum et al. (2008), one can also conclude that pure private or governmental ownership/control should be preferred over mixed options due to conflicting objectives and lower overall airport performance in general.

Notwithstanding the inconclusiveness with regard to the effect of privatization on performance, within the framework of this thesis three kinds of airport ownership structures are distinguished for reasons of simplification: Private ownership, public ownership and partial private/public ownership.

2.2.2 Airport Performance Measurement Standards

Instead of overall efficiency values, partial performance measures can be used to overcome the mentioned drawbacks, since these metrics *“usually require limited data only (…), are relatively easy to compute, and are intuitively simple to understand”* (Graham, 2008, p. 87). Although a wide variety of metrics was compiled in academia (Doganis, 1992; Graham, 2005, 2008), there is limited research on how useful airport professionals perceive these indicators and to what extent they are using them. To the best knowledge of the author, so far only Francis et al. (2001) explored this area with a survey among 58 major global airports. Their results indicate that performance measurement is seen as a critical activity for industry experts and that indeed the trend of commercialization effects the nature of performance measurement activities of airports (Francis et al., 2001). However, they suggest further research within this area on a regular basis to review how performance measurement activities develop over time (Francis et al., 2001). The importance of this recommendation becomes even more evident by recognizing the facts that they only examined the areas of financial, service and environmental performance, chose a rather broad global focus and did not differentiate between various kinds of airports.

Unlike in other industries, although a wide selection of indicators is available and applied in practice, no common industry standard exists so far (Oum et al., 2003). This holds to be true for

both, overall efficiency values, as well as partial performance metrics and might be due to the heterogeneous structure of the sector. Nevertheless, some guidelines are currently present. Within the academic literature many collections of performance indicators exist. Among these, Graham (2005) suggests 20 metrics divided within three categories (economic, operational and environmental performance), whereas in one of her later works (Graham, 2008) she uses six categories (cost efficiency, labor productivity, capital productivity revenue generation, commercial performance and profitability) for 22 metrics and Humphreys and Francis (2002) introduce two categories (cost and revenue) with 19 indicators, observed from their interviews with members of the FLAP group (Frankfurt, London, Amsterdam and Paris airports).

The global aviation institutions and organizations also provide some material on the topic, with ICAO, ACI and the American FAA (through ACRP) being the most important ones. While the last one (ACRP, 2010) has a rather technical approach and focuses on the implementation of a performance management system, ICAO takes a more strategic focus and splits its regulation on airport performance in two documents. In the first one (Doc 9082) it is mentioned that governments should ensure that "*appropriate performance management systems"* (ICAO, 2009b, p. 5) are in place and specifies further what appropriate really means. Without going too much into detail it can be said, that airports should define at least one metric and objective for a minimum of four different key performance areas (KPA) in order to monitor their performance on a regular basis in cooperation with its stakeholders (ICAO, 2009b). On the other hand, the second document (Doc 9562 – ICAO´s Airports Economic Manual, 3rd edition, revised 2013) further specifies the four KPAs, namely *"Safety", "Quality of Service", "Productivity"* and *"Cost Effectiveness"* (ICAO, 2013b, pp. App 1-1 - 1-4) and lists sample metrics. Another, more recently developed framework is ACI´s *"Guide to Airport Performance Measures"* (ACI World, 2012). It consists of six different KPA´s and contains 42 measures[9] (Table 4).

KPA					
Core	**Safety and Security[10]**	**Service Quality**	**Productivity/ Cost Effectiveness**	**Financial/ Commercial**	**Environmental**
1. Passengers	1. Runway Accidents	1. Practical Hourly Capacity	1. Passengers per Employee	1. Aeronautical Revenue per Passenger	1. Carbon Footprint
2. Origin and Destination Passengers	2. Runway Incursions	2. Gate Departure Delay	2. Aircraft Movements per Employee	2. Aeronautical Revenue per Movement	2. Waste Recycling

[9] For a detailed overview, including definitions of all metrics, section 2 of the ACI Guide to Airport Performance Measures is recommended.

[10] Although the terms safety and security are used interchangeably, they describe different topics in the field of aviation. Whereas "Safety" refers to the technical or operational issues and problems that can appear during a flight or at an airport (fire protection, elasticity of wings, etc.), "Security" describes all external dangers that can impact the flight processes, like terroristic attacks or trespassing.

3. Aircraft Movements	3. Bird Strikes	3. Taxi Departure Delay	3. Aircraft Movements/Gate	3. Non-Aeronautical Operating Revenue as % of Total Operating Revenue	3. Waste Reduction Percentage
4. Freight or Mail Loaded/Unloaded	4. Public Injuries	4. Customer Satisfaction	4. Total Cost per Passenger	4. Non-Aeronautical Operating Revenue per Passenger	4. Renewable Energy Purchased by the Airport (%)
5. Destinations - Nonstop	5. Occupational Injuries	5. Baggage Delivery Time	5. Total Cost per Movement	5. Debt Service as % of Operating Revenue	5. Utilities/ Energy Usage per Square Meter of Terminal
		6. Security Control Clearing Time	6. Total Cost per WLU	6. Long-Term Debt/ Passenger	6. Water Consumption per Passenger
		8. Check-in to Gate Time	7. Operating Cost per Passenger	7. Debt to EBITDA	
			8. Operating Cost per Movement	8. EBITDA /Passenger	
			9. Operating Cost /WLU		

Table 4: KPA´s and metrics within the ACI performance measurement framework, based on ACI World (2012, p. iii)

The guide is a rather open construct, since it incorporates the fact that different airports require different performance metrics due to the different individual contextual situations (ACI World, 2012). Hence, it is in line with Humphreys et al. (2002), who advocate in favor of greater consideration of the airport´s context within performance measurement. Each airport can choose which metrics to use. What makes it outstanding among the concepts mentioned so far, is the fact that it provides detailed descriptions of how the metrics are computed, discusses influencing factors and addresses advantages, as well as disadvantages (ACI World, 2012). Consequently, all organizations, which use one metric proposed in the guide, will measure their performance in the same units and understand the metrics in the same way, thereby enabling them to compare their performance. Under the current status quo of performance measurement in the airport industry ACI´s guide seems to be the concept with the best chances of wide applicability. Therefore, the ACI Guide to Airport Performance Measures can be regarded as closest to an industry standard in the current situation. Figure 2 summarizes the position of this thesis within the broader research context discussed above.

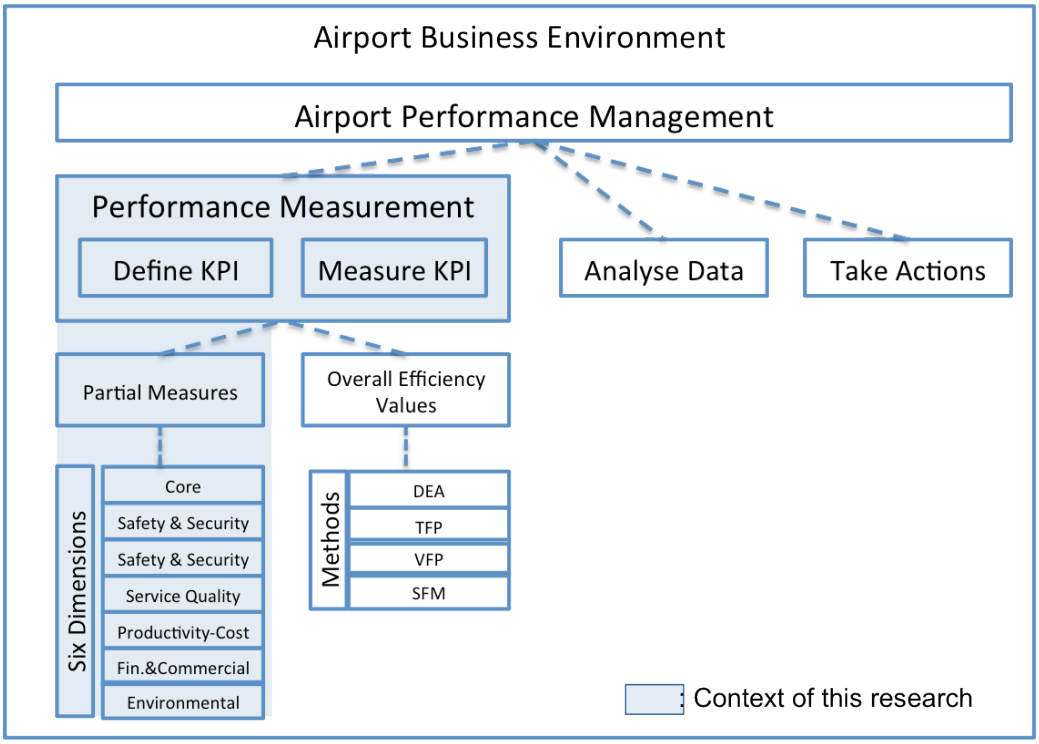


Figure 2: Context of Thesis

2.2.3 Airport Contextual Situation

Together with the changing focus of airport ownership and organization, the need for benchmarking against competitors grew throughout the last decades (Adler et al., 2013; Francis, Humhpreys, & Fry, 2002; Graham, 2005, 2008; Oum et al., 2003). However, the heterogeneous structure of the sector (Marques & Barros, 2011; Oum et al., 2003) made it difficult to realize valid comparisons between airports. Therefore, Humphreys et al. (2002) argue in favor of a greater consideration of the contextual situation of airports before benchmarking against each other and claim the development of a *"contextual profile"* (Humphreys et al., 2002, p. 273) for each airport, as "*the performance* (…) *needs to be explained in the context of each airport´s operating characteristics*" (Humphreys et al., 2002, p. 271). These profiles could consist of eight contingent variables, among which each has different influences on an airport´s performance (Humphreys et al., 2002) (Figure 3).

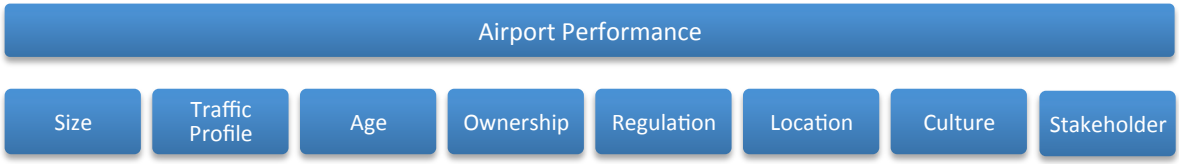


Figure 3: Possible Contingent Variables for Airport Performance (based on Humphreys et al. (2002)

The factor size (passenger and freight volumes) is of major importance, as it allows the realization of economies of scales and, among others, influences the ability to generate income from commercial activities (Humphreys et al., 2002). The general traffic profile, e.g. international

vs. national, business vs. leisure passengers, express freight vs. standard cargo etc., shapes the aerodrome´s infrastructure and, hence, makes it difficult to objectively compare. Similarly, the age of the airport and its organization affects the facilities as well as the management styles (Humphreys et al., 2002). For example, it is difficult to compare an airport that is very new and built as whole, like Munich Airport, with a competitor whose main infrastructure exists for more than 50 years and was consequently enlarged over time to meet the future demand levels (Frankfurt Airport). When comparing the performance of both airports, this is definitely a factor worth considering, as Frankfurt will have to deal with a far higher degree of complexity. Another variable that is of importance is ownership. Like the authors explain, privatized airports may measure different performance indicators than those operated by governmental agencies (Humphreys et al., 2002). Closely related to this is the factor regulation, as the ownerships may have an influence on which measures are used and how performance is measures. Also the locations of airports play vital roles when it comes to airport performance, as specific characteristics like night curfews, catchment areas and population etc. influence the traffic volumes (Humphreys et al., 2002). Just as an example, it is difficult to compare an airport which is open for flights 24h a day to another airport, where a night curfew prohibits takeoffs and landings between 23:00h and 05:00h. Other factors that shape the performance of airports are different organizational cultures and the influence of various stakeholders (Humphreys et al., 2002).

In conclusion, the contextual situation seems to have a great influence on an airports performance and, thus, a *"lack of appreciation of the contingent context may make comparisons of little practical or meaningful use"* (Humphreys et al., 2002, p. 273). Therefore, the concept of considering different airport contexts will be transferred to the topic of airport performance measurement within the framework of this research project (see chapter 2.2.4).

2.2.4 Hypothesis Development

Based on the outcomes of the literature review, this chapter develops research hypotheses, which are structured according to the main objectives of the thesis. As already explained in the introduction, the objectives of the research project are threefold:

1) Characterization of Performance Measurement activities of European Airports
2) Acceptance and Application of ACI Guide across Airports in Europe
3) Explore influence of different Airport Contexts, Performance Measurement Contexts and ACI Guide Contexts

In the following, hypotheses will be discussed for each of these goals.

<u>1) Characterization of Performance Measurement activities of European Airports</u>

First, this thesis aims at enriching the knowledge about partial airport performance measurement practices by setting a special focus on European airports, exploring the differences between different sizes of airports and choosing a holistic approach through incorporating six dimensions

of airport performance. These dimensions are the KPAs of the ACI performance measurement framework, namely: Core, Safety & Security, Service Quality, Productivity & Cost Effectiveness, Financial & Commercial and Environment. For the framework of this research, the extent to which an airport applies the performance indicators within a certain dimension is called *Performance Measurement Sophistication (PMS)* and is computed by building the sum of the product of the perceived usefulness (1-5) and the usage (0 or 1) of all metrics per category, e.g. 1x5 + 1x4 + 1*2…etc. To analyze how diverse the set of applied metrics is across all dimensions, the results per dimension are added, yielding the *Total Performance Measurement Sophistication (TPMS).*

The airport sector is strongly regulated (e.g. ICAO, EU, individual countries etc.) by extensive legal requirements that are present today and some guidelines on performance measurement exist already in the market (ACI World, 2012; ACRP, 2010; Graham, 2005, 2008; ICAO, 2006, 2013b). Therefore, some of the dimensions above are expected to be applied to a similar extent across varying airport seizes (airport groups 1 to 6). Among these are *Core*, due to legal and regulatory requirements as well as the essential nature and importance of these measurements ((ACI World, 2012), *Safety & Security* since the aviation industry is extremely sensitive with regards to these topics and, thus, pays paramount attention to them (ACI World, 2012), as well as *Service Quality* due to the high importance of both, airline and passenger customers (Gillen, 2011). In addition, all of these dimensions are already included to a certain extent in existing other performance measurement frameworks than the ACI guide. Hence, the following hypotheses can be stated:

H1a: *All airport groups apply the metrics within the Core dimension to a similar extent.*

H1b: *All airport groups apply the metrics within the Safety & Security dimension to a similar extent.*

H1c*: All airport groups apply the metrics within the Service Quality dimension to a similar extent*.

However, as a very heterogeneous industry (Oum et al., 2003), aerodromes of different sizes are expected to apply some of these dimensions to a different extent because of their individual contexts and characteristics (ACI World, 2012). As the understanding of airports as independent and even privatized commercial businesses grew throughout the last decades (Graham, 2008), the dimensions *Productivity & Cost Effectiveness*, as well as *Financial & Commercial* are expected to be applied to a greater extent at larger airports than at smaller airports. Major airports are more interesting for private investors and maybe more capable of becoming independent from governmental subsidiaries. A similar pattern is expected for the dimension *Environment*, as larger airports face higher pressures from local governments and communities to reduce negative environmental impacts. As a more recently emerging topic (ACI World, 2007b, 2012; Graham, 2008), the requirements to monitor their environmental performance are likely to be imposed on larger airports earlier. In summary, this leads to hypotheses H2a-c):

H2a: *Group 1, 2, 3 airports apply Productivity & Cost Effectiveness indicators to a greater extent than Group 4, 5, 6 airports.*

H2b: *Group 1, 2, 3 airports apply Financial & Commercial indicators to a greater extent than Group 4, 5, 6 airports.*

H2c*: Group 1, 2, 3 airports apply Environmental performance indicators to a greater extent than Group 4, 5, 6 airports.*

Following the hypothesis above and similar to the results of Oum et al. (2003), who found a significant relationship between airport size and overall performance, it is expected that larger airports are more likely to apply a more diverse set of performance measurements in total than their smaller competitors. Another factor that is linked to the general size of the airport is the amount of resources devoted to the topic of Performance Measurement. Some employees are necessary to ensure that the respective data is monitored and analyzed throughout the whole company. Thereby, it is assumed, that the staff specifically devoted to Performance Measurement activities (expressed in Full Time Equivalents, FTEs), has a significant influence of the applied set of indicators.

H3a: *Larger airports are more likely to apply a diverse set of performance measurements indicator than smaller ones.*

H3b: *The amount of human resources (FTEs) specifically devoted to Performance Measurement activities has a significant influence on the applied set of performance indicators.*

Although the literature review revealed that there exists to a certain extent inconclusiveness about the question whether privatized airports reach a higher performance than governmental owned, the majority of articles on that topic argue in favor of a positive relationship between privatization and firm performance. In line with this reasoning, privatized airports are expected to apply a more diverse set of performance indicators in total than governmental owned. Like Humphreys et al. (2002) explain with several examples of British and Scandinavian Airports, the character of the ownership has an influence on the metrics that an airport uses. According to them, airports belonging to the privatized British Airports Authority BAA measure "*more than 30 quality-of-service indicators*", whereas public owned Scandinavian airports "*do not measure quality of service or any retail-related measures at all*" (Humphreys et al., 2002, p. 272).

Additionally, a mixed ownership structure can result in conflicting objectives and limited overall airport performance (Barros & Dieke, 2007; Oum et al., 2006; Oum et al., 2008; Oum et al., 2003) suggesting that partial private/governmental owned airports apply a less diverse set of performance measurements than pure privatized and governmental owned airports. The need to find compromises between the different owners may constrain the diversity of monitored metrics.

H4a: *Privatized airports apply a more diverse set of performance indicators than governmental owned airports.*

H4b: *Partially private/governmental owned airports apply a less diverse set of performance indicators than pure privatized and governmental owned airports.*

2) Acceptance and Application of ACI Guide across Airports in Europe

Incorporating the ACI Guide to Airport Performance Measures in the research allows for testing, whether it really is applied and accepted as a standard among airports in Europe. This might also point to areas of improvement for the future of ACI´s guide. Since the research addresses both, ACI member airports and non-member airports, it can be tested whether ACI membership influences the set of performance measurements used. As the organization represents airports with a volume of around 95% of worldwide air traffic (ACI World, 2013) it has much power to promote and communicate new ideas and, thus, is in an unique position to establish a common standard. Especially in an industry where some guidelines on Performance Measurement are present (ACI World, 2012; ACRP, 2010; ICAO, 2009b, 2013b), but no common standard has been enforced so far (Oum et al., 2003), airports are expected to apply the suggestions of such a reliable source like ACI to a large extent. Therefore, the acceptance and application of the guide should intuitively be higher among ACI members. Airports that use the guide are, hence, in a position where they are likely to use a more diverse set of metrics. However, if an airport applies other standards in addition to the ACI guide, this is likely to have a significant influence on the set of indicators it uses, because different frameworks recommend different KPIs (ACI World, 2012; ACRP, 2010; Francis et al., 2001; Graham, 2005, 2008; ICAO, 2009b, 2013b). Therefore, the usage of other standards is expected to lead to a more diverse set of indicators.

In summary, the following is expected with regard to the application of the ACI guide:

H5a: *Knowledge about the ACI Guide to Airport Performance Measures is higher among member airports than among non-member airports.*

H5b: *Application of the ACI Guide to Airport Performance Measures is higher among member airports than among non-member airports.*

H5c: *ACI member airports in general apply a more diverse set of performance indicators than non-member airports.*

H5d: *Airports, which use the ACI Guide to Airport Performance Measures, apply a more diverse set of performance indicators than others.*

H5e: *Airports, which additionally use other Performance Measurement Standards, apply a more diverse set of performance indicators than others.*

3) Influence of different Airport Contexts, Performance Measurement Contexts and ACI Guide Context

As explained in the previous chapter, Humphreys et al. (2002) claim for a greater incorporation of the contextual situations of individual airports into the measurement of overall performance, as well as Marques and Barros (2011, p. 34) state that *"heterogeneity must be considered a major issue in the European airports".* Hence, this idea is transferred to the consideration of partial performance measurement indicators within this thesis. As the individual contexts of airports are important for their overall performance, they should also play a vital role when it comes to application of a diverse set of partial performance indicators. But, whereas the variables suggested by Humphreys et al. (2002) concern the issue of actually comparing the performance

values of different airports, this research project wants to find out whether different variables influence the set of indicators used to measure airport performance. Within the framework of this thesis, the individual airport characteristics are composed of three latent (dependent) variables: Airport Context, Performance Measurement Context and ACI Guide Context, each of which is formed by three or more independent variables (see Figure 4):

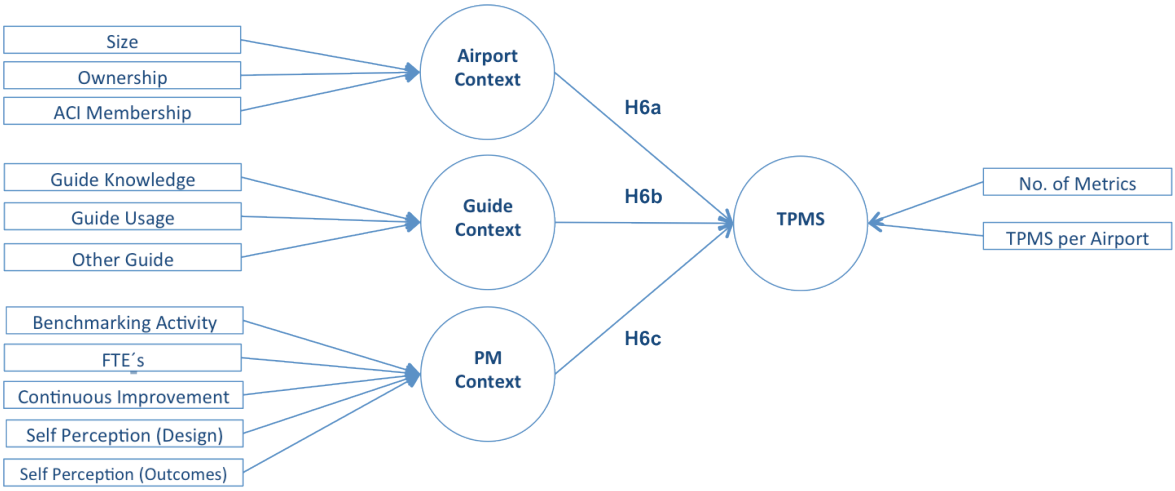


Figure 4: Conceptual Model for Testing Hypothesis 6a-c

In line with the results of the literature review, as well as the findings of Humphreys et al. (2002), the latent variable Airport Context is formed by airport size and ownership. ACI Membership is also expected to be of importance due to the huge geographical coverage of Airports Council International (ACI World, 2013), which results in an unique and powerful position of ACI to establish and promote a standard.

The second latent variable construct is the Guide Context, which deals with the knowledge and acceptance of the ACI Guide to Airport Performance Measures. Intuitively and similar to H5a-e), it is expected, that participants who know and use the guide, apply the metrics in it to a greater extent than those who do not.

Specifically the latent variable Performance Measurement (PM) Context is expected to be of significance, as it represents the characteristics of the PM activities of a certain airport. Whether an organization uses its metrics to engage in internal and/or external benchmarking activities or not is expected to be an important characteristic of the performance measurement practices at an airport, together with the amount of human resources (FTE´s) and the application of continuous improvement practices. As an example, airports which benchmark against external competitors are likely to apply more indicators, as they need to incorporate additional metrics to be able to do so. Likewise, if an airport wants to apply industry best practices, it is possible, that they incorporate service quality indicators that are used by competitor X and environmental metrics applied by competitor Y.

Another element that distinguishes the PM Context is the own opinion of the participant, on how advance he or she perceives the measurement system in place in comparison to competitors. Thereby, the data are split in perceptions regarding the design and the outcomes of the system.

In total, the influence of the described independent variables is summarized to three latent constructs, which are expected to have a significant influence on the Total Performance Measurement Sophistication (TPMS). Hence, the following hypotheses are formulated:

H6a: *The individual Airport Context has a significant influence on the set of performance indicators it uses.*

H6b: *The individual Performance Measurement Context of an airport has a significant influence on the set of performance indicators it uses.*

H6c: *The ACI Guide Context of an airport has a significant influence on the set of performance indicators it uses.*

3 Methodology

The following chapter explains the approach and the execution of the research. It serves the purpose of illustrating how the information is gathered and describes the cooperation between the author and ACI Europe in more detail.

3.1 Questionnaire Design & Collaboration with ACI EUROPE

As already explained before, only a limited amount of literature on how airports measure their performance is available in academia. Especially, no research is conducted on the topic with a European focus and across all sizes of airports. Therefore, a survey was conducted among all commercial European airports with 100,000 passengers or more. To collect the necessary data for analyzing the performance measurement activities of airports, the author and ACI EUROPE collaborated in the development and distribution of a questionnaire. Communication with the ACI EUROPE headquarter in Brussels was established through personal meetings and telephone calls. To agree upon responsibilities and to create an area of trust between the two parties, a Memorandum of Understanding (MoU) was signed, which contains all tasks and duties of ACI EUROPE and the author, as well as a confidentiality agreement. A detailed summary of the cooperation between both parties (MoU) can be found in the appendix.

The questionnaire consists of a total of 18 questions and is four pages long (please consult the appendix for a full version of the questionnaire and the cover letter). The top of the first page contains the logo of Maastricht University and ACI EUROPE, as well as a short introduction to the purpose of the study and instructions of how to send back the filled questionnaire. In order to increase ease and time efficiency of answering, it is developed as a word form and consists mainly of check boxes. All questions inside the survey reflect both, the academic interests of the thesis at hand, as well as the research interests of ACI EUROPE. While the first few questions serve as a filter to organize and categorize respondents (classification information), the remaining

questions are utilized to give detailed answers about individual topics (basic information) (Malhotra & Birks, 2007). Besides questions 8, 16 and 18, all questions are closed questions with predefined answers. Question 8 is the major part of the survey, asking for information about the use and perceived usefulness of several performance metrics, as well as the targets on these for 2013. All metrics are taken from and structured according to the six dimensions of airport performance of the *Guide to Airport Performance Measures* mentioned above. On a Likert scale from 1 to 5, with 1 meaning "not useful" and 5 meaning "very useful", respondents are able to indicate the usefulness of individual metrics. The same logic holds to be true for question 16, where respondents are asked to state their perceived sophistication of the overall measurement system, with 1 meaning "Basic" and 5 meaning "State of the Art". The last question in the survey, number 18, serves as a possibility to express individual opinions about the future trends, challenges etc. in the field of airport performance measurement. To stimulate participation, all respondents were given the opportunity to leave their contact details on the last page of the questionnaire (identification information) (Malhotra & Birks, 2007) and to request a short report on their results. A link to open the e-mail program of the respondent was embedded in the questionnaire containing already a message subject (PM Research Response) to reduce effort required by the participants.

3.2 Data Collection

Prior to the real start of the survey, Pilot Testing was used to verify the applicability of the questionnaire and to test the acceptance among airport professionals. According to Malhotra and Birks (2007) the participants in the Pilot Testing should stem from the same population as the respondents of the real survey and have similar characteristics. For this purpose the questionnaire was distributed among the members of ACI EUROPE´s Economics Committee Strategy Working Group, which consists of selected airport managers of member airports. Their feedback was very positive and their remarks and comments were integrated in the final version of the questionnaire. Overall, the Pilot-Test revealed a high interest among industry experts regarding the topic of airport performance measurement.

The survey officially started on 16th of April 2013 and was open for six weeks with the 31st of May 2013 as the final deadline. In total, 338 airports (all with 100,000 passengers or more) have been contacted and asked to participate. The list with potential target airports was compiled from EU air transport passenger data from eurostat (2013) and member airports of ACI EUROPE within their geographical region. In phase one of the data collection, ACI EUROPE contacted the members of its Economic Committee and asked them to participate in the survey. In the meantime, all other airports outside that committee were contacted based on personal contacts of the author and official e-mail addresses available on the internet. All potential respondents received the questionnaire and an accompanying cover letter via e-mail. On the 6th of May, a first reminder letter was sent to all airport professionals without any reply at this time. At the same

time, the Director General of ACI EUROPE distributed the survey to the CEO´s of all member airports across Europe. Two weeks later, on May 21st, a second reminder letter was sent out.

3.3 Methodology for Data Analysis

Since the topic of airport performance measurement within a European context is a rarely researched field so far, descriptive statistics play a fundamental role in describing the status-quo of the activities inside the airport sector. They will help to define a clear picture on how different airports approach the topic and how useful the ACI Guide is.

For analysis of hypotheses 1a-5e the Kruskal-Wallis Test and Chi-Square Test for Independence are used to test for significant relationships and differences between various groups. Both approaches are non-parametric techniques and share the advantage of no need for assumptions about an underlying distribution of the population (Pallant, 2011), e.g. normal or Poisson distribution. Although their parametric counterparts are in general more precise, non-parametric tests are especially useful when dealing with ordinal and nominal data, as well as when the sample size is comparably small (Pallant, 2011). As the questionnaire asks for a lot of categorical/nominal data, and the response rate is below 15%, these requirements are met. Additionally, all observations should be independent from each other (Pallant, 2011), which is also true since per airport only one answer is allowed and each airport will only be assigned to one group at a time during the data analysis.

The Kruskal-Wallis Test, developed by Kruskal and Wallis (1952), tests whether there is a significant effect on a certain dependent variable for three or more groups (independent variable) (Kruskal & Wallis, 1952; Pallant, 2011). Thereby, the independent variable should be categorical or grouped (e.g. airport groups 1-6), whereas the dependent variable should be continuous (e.g. TPMS). The null hypothesis is that both variables are independent from each other and that there is no relationship between them. However, if the test yields a significant p-value, this means that the variance within the dependent variable can be explained to a significant extent through the variance within the groups and the null hypothesis needs to be rejected. Hence, the grouped variable influences the continuous variable.

The Chi-Square Test for Independence allows to examine relationships between two categorical variables (Pallant, 2011) by comparing the expected frequencies that would be present if there is no relationship between the variables with the actually observed frequencies (Malhotra & Birks, 2007). One additional assumption is that the smallest expected frequency should be five or that at least 80% of the cells should have a cell count greater than five (Malhotra & Birks, 2007; Pallant, 2011). Similar to the Kruskal-Wallis Test, the null hypothesis is that the two compared variables are statistically independent, while the alternative hypothesis states that there exists a significant relationship (dependency) between both.

To analyze hypotheses H6a-c, path modeling through Partial Least Squares (PLS), a technique developed by H. Wold (1966, 1973, 1975), is applied to test for the expected relationships. As a

Software-tool SmartPLS version 2.0 (Ringle, Wende, & Will, 2005) was chosen because of its user-friendliness (Temme, Kreis, & Hildebrandt, 2006) and since it is free of charge. PLS enables the researcher to aggregate the effects of many independent parameters into few latent variables (Rosipal & Krämer, 2006). One of the major advantages of PLS is that it allows for examination of relatively small sample sizes (Cassel, Hackl, & Westlund, 2000; Haenlein & Kaplan, 2004) since no assumptions about underlying distributions are necessary (Chin, 1998; Haenlein & Kaplan, 2004). As an example for this, Chin and Newsted (1999) found that PLS can be used with a sample size of 50 data sets or even below (Haenlein & Kaplan, 2004).

4 Data Analysis

This chapter presents the results of the airport performance measurement survey and the respective tests in an objective way. Thereby, every topic of the threefold research objectives is considered individually. Given the vast amount of collected data on the one hand and the restricted size of thesis on the other, only the most important findings are mentioned. The subjective conclusions and interpretations derived from these findings can be found in chapter five.

4. 1 Sample Characteristics

In total 338 airports have been contacted via email, representing the whole population of commercial airports in Europe with 100,000 passengers per annum or more. Out of these, 50 aerodromes participated in the survey, yielding a response rate of 14.79% (Table 5). Although this figure seems to be rather low, a closer look at the passenger volumes reveals that these 50 airports represent in fact 30.82% of the total passengers travelled via all airports in Europe (Tables 5 & 6), which indicates that the sample is appropriate for this research. Appendix 4 contains a list with all participating airports in this study.

Also the chosen categorization into six groups suits the purpose of this research, as the sample means of each group are very close to the population mean with deviations ranging between 0.1% (group 4) and 10.00% (group 6) (Figure 1). One exemption from this is group 1, where the deviation is 19.75%, which might be due to the considerably small sample group size of four airports. However, the total population for this group consists only of 13 airports and, thus, these four airports represent already 36.85% of all aerodromes with more than 25 million passengers per year, which is the second largest intra-group response after group 2 (41.67% of all group 2 airports). Contrasting to this, only 5.04% of group 6 airports sent back a filled out questionnaire, however, this groups is the largest with 119 different airports belonging to it. The standard deviations of the sample and population mean, as well as the total averages themselves, are remarkably different (around 5 million passengers), indicating that large airports are over-represented.

Airport Classification & Group Characteristics								
	Airport Size	# of Airports (Sample)	# of Airports (Population)	% of Airports in Group	% of Passenger Volume within each Group	Avg. Size of Airport (Sample)	Avg. Size of Airport (Population)	Deviation of Sample & Population Mean
Group 1	> 25 mio pax	4	13	30.77%	36.85%	50,247,351	41,959,877	1.1975
Group 2	10-25 mio pax	10	24	41.67%	40.89%	16,936,501	17,258,786	0.9813
Group 3	5-10 mio pax	8	36	22.22%	24.15%	7,740,257	7,121,711	1.0869
Group 4	1 - 5 mio pax	13	108	12.04%	12.15%	2,366,649	2.343,982	1.0097
Group 5	0,5-1 mio pax	9	38	23.68%	22.61%	722,252	756,476	0.9548
Group 6	< 0,5 mio pax	6	119	5.04%	4.54%	228,454	253,813	0.9001
	Total	**50**	**338**	**14.79%**	**30.82%**	**9,418,278**	**4,521,215**	**2.0831**
					St. Dev.	14,509,230.5	9,216,827.441	

Table 5: Airport Classification & Group Characteristics

While the 338 airports are situated in 36 countries, answers were received from airports located in 26 different countries, accounting for a geographical coverage of 72.22%. However, as can be derived from Appendix 5, some countries are over- or under-represented as their relative proportion on the amount of airports in the sample deviates from that within the population. As an example, Norwegian airports represent 14% of the sample size, while they represent only 5.3% in the total population and are, hence, over-represented. Also Belgian and Bulgarian airports are over-represented, whereas French, British and Spanish airports are under-represented, which is due to the relatively high airport density within these countries (Appendix 5).

Represented Passenger Volume	
Total Passengers all Countries	1,528,170,766
Passengers of responded airports	470,913,885
Share of total passengers	**30.82%**

Geographical Coverage	
Total Countries	36
Responded countries	26
% of responded countries	**72.22%**

Table 6: Represented Passenger Volume & Geographical Coverage

Another important characteristic of the sample is the ownership structure. 14% of the airports are operated by the private sector, while the majority of organizations are still owned by local governments (Figure 5). Mixed or partial private & public ownership represent the second largest group with 32%. By looking at the job function of the people who filled out the questionnaires it can be said, that none of the perspectives is dominant, which indicates a good distribution among several fields of management activities, although the planning function is largely under-represented (Figure 6). CEO or Senior Management was the most frequent used description within the category “Other”.

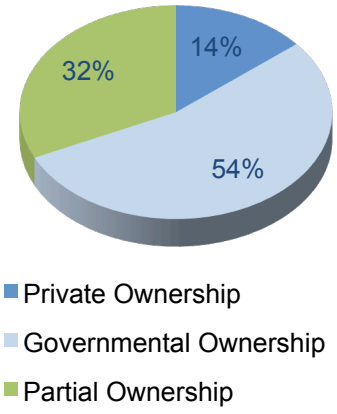


Figure 5: Ownership structure of sample



Figure 6: Job Function of respondents

4.2 Analysis of Results

Based on the previous definition of sample characteristics, the findings of the survey are objectively analyzed with regard to the hypotheses and research objectives of the thesis.

4.2.1 Performance Measurement Characteristics

The most important motive for European airports to actively engage in performance measurement is to improve performance. 48% of the survey participants ticked the respective box, followed by regulatory requirements and benchmarking purposes, which both scored 46%, whereas performance related payment seems to be a less important reason with only 14% (Figure 7).

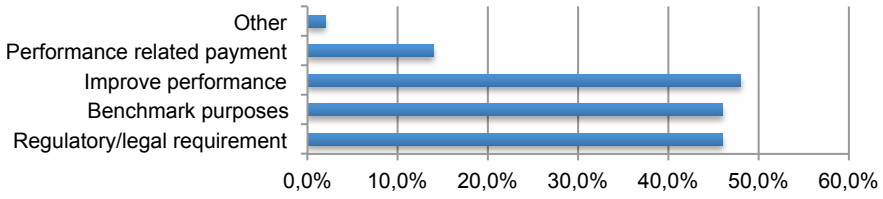


Figure 7: PM Motivation

Looking at the benchmarking activities in more detail reveals that nearly every participating airport uses benchmarking (see Appendix 7). The majority engages in both, external and internal means of comparisons (58%), while 14% strictly focus on external and 16% on internal benchmarking. Just 10% of the airports in the sample apply none of these approaches. These airports belong to groups 4-6. Regarding the tools to actually gather the necessary data for performance monitoring (Figure 8), internal surveys are the most common method (70%), followed by passively data gathering systems[11] (58%) and partner information

[11] Systems that passively gather data are not exclusively designed for this purpose but can be used to collect data. Examples for this are reports from baggage transport systems. Although their main purpose is to transport baggage, theycan also be used to collect data about number, destinations, etc. of bags. In contrast, other systems are specifically designed to collect data, e.g. Bluetooth devices that monitor the number of people waiting in front of security control areas and that count their waiting times.

(50%), which refers to information sharing with airlines, air traffic control providers, border control, police, etc., e.g. flight numbers, delay figures and seat-load-factors.

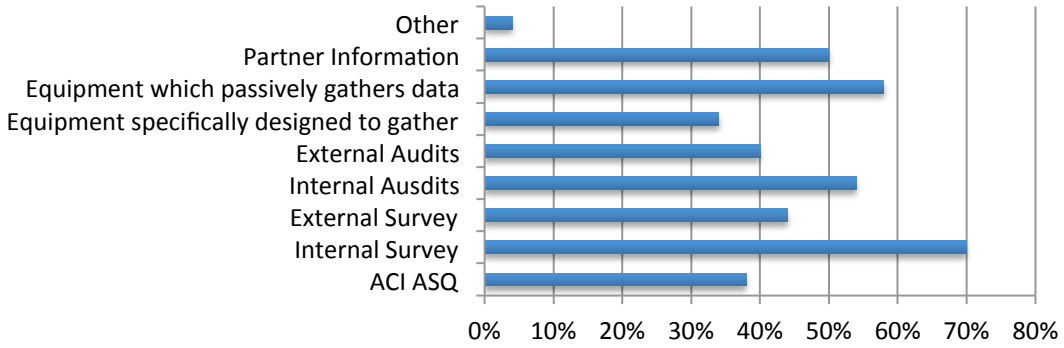


Figure 8: Common data gathering tools

Other tools are also quite common, however, the more expensive tools like specific equipment, external surveys and audits are wider applied among larger than among smaller airports (group 5-6). The same is true for Environmental and Quality Management Systems (ISO 14001 and 9001), as more of the larger airports are certified than smaller, while the cut here seems to be between groups 3 and 4.

As Figure 9 suggests, deriving KPI´s from a strategic plan is the most preferred practice to choose a metric (72%), although other methods are common, too. Senior Management (54%), competitors (52%), operational needs (48%) and regulatory requirements (46%) also influence the decision of which metrics are measured, while customers seem to have the least impact (34%). A comparison of the decision process among the different groups (see Appendix 7) reveals the trend that strategic plans, regulation, senior management and consumer demands are more influential reasons to larger (categories 1-4) than to smaller airports (categories 5-6).

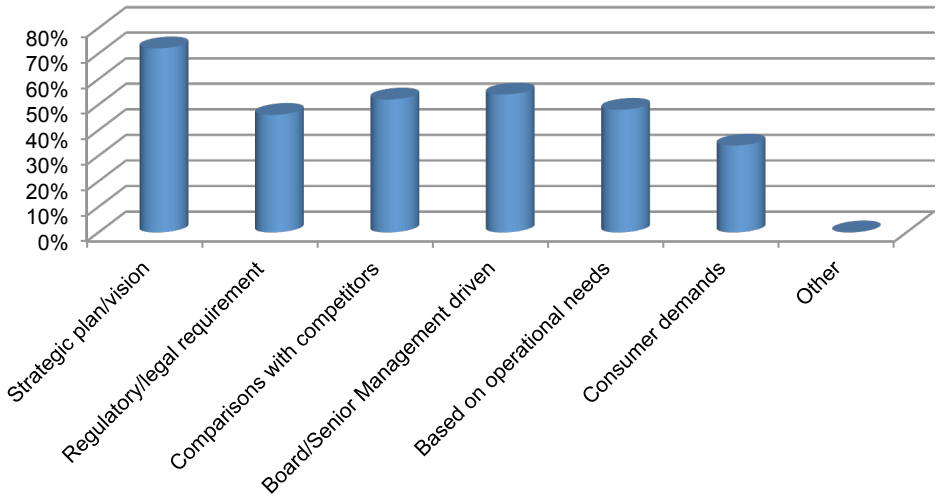


Figure 9: How airports choose metrics

As already mentioned in chapter three, the Kruskal-Wallis method tests whether there is a significant difference in the data caused by a categorical variable. If the test result is judged as significant, this means that the groups are different with regard to the dependent variable. In

case of hypotheses H1a)-c), it was expected that there is no difference between the six airport categories when it comes to performance measurement sophistication for the respective dimension. Hence, the test result should be not significant in order to support H1a)-c). To come to a conclusion whether test results are significant or not, the χ^2−value (chi-square) is used to derive a p-value from the upper tail area of a χ^2-distribution. Thereby, for the framework of this research a p-value smaller than 0.05 is regarded as significant (5%-level of significance) and a value below 0.10 implies low significance (10%-level). All p-values larger than 0.10 are considered as not significant.

Given these characteristics, **H1a)** needs to be rejected, as the p-value of 0.0430 (Table 7) is smaller than 0.05 and, thus, significant, which means that all groups apply the performance indicators within the dimension *Core* to a different extent. A look at the median values of all airport groups indicates that especially group 2 with a median PMS value of 24.5 varies from the others and may be the reason for the outcome of the test.

In contrast to the above findings **H1b)** and **H1c)** are correct, as their p-values of 0.2500 and 0.2110 are insignificant and, thus, the null hypothesis (H_0) needs to be accepted. Regarding the dimensions Safety & Security, as well as Service Quality, all airport groups apply a relatively equal set of performance indicators.

					Median PMS Values of Airport Groups						
Hypothesis	**PM Dimension**	**Chi-Square**	**df**	**p-value**	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
H1a	Core	11.48	5	0.0430	19.5	24.5	19.0	19.0	21.0	17.5	21.0
H1b	Safety & Security	6.62	5	0.2500	23.5	24.0	20.0	20.0	20.0	16.5	21.5
H1c	Service Quality	7.13	5	0.2110	31.0	25.5	24.0	28.0	13.0	9.0	24.0
H2a	Productivity & Cost	5.13	5	0.4000	16.5	24.0	21.0	32.0	20.0	13.5	22.5
H2b	Financial & Commercial	10.71	5	0.0570	19.0	20.0	17.5	28.0	19.0	3.0	20.0
H2c	Environmental	15.28	5	0.0090	25.0	17.5	12.0	14.0	3.0	0.0	13.0
H3a	All Dimensions	12.30	5	0.0310	141.0	131.0	122.5	149.0	79.0	75.0	125.0

Table 7: Influence of airport size on PMS and TPMS

Coming to the second subset of hypotheses, which states that there is a difference in PM values for different airport sizes, **H2a)** needs to be rejected, as the p-value of 0.4000 is above the threshold of 0.05. All airports seem to apply an equally sophisticated set of metrics for the dimension Productivity & Cost. The test for the factor *Financial & Commercial* (**H2b**) yields a low significant result on the 10%-level (0.0570). **H2c)** provides the lowest p-value of all tests so far (0.0090), H_0 can be rejected and the outcome is significant. Consequently environmental indicators are applied to a different extent among various airport groups. In line with these results, the test for **H3a)** whether airport size has a significant effect on the aggregated Total Performance Measurement Sophistication (TPMS) across all dimensions yields a significant result with a p-value of 0.0310.

By exploring the median PMS and TPMS values one can explore another interesting fact about the influence of airport size. Unlike anticipated beforehand, the sample cannot be divided in larger (group 1,2,3) and smaller airports (group 4,5,6). Instead, the turning point

seems to be between groups 4 and 5, which on average provide the lowest numbers, suggesting the conclusion that these two groups are largely different than the others. Plotting the mean values of TPMS per group vs. the mean TPMS value of all groups supports the finding of a separation between groups 1-4 and 5-6 (Figure 10). Hence, airports below the critical level of 1,000,000 passengers per year use a less diverse set of indicators or do have no need for these due to increased administrative complexity. Again group 4 airports show a high average TPMS value, which is also contradicting to the initial belief and results from relatively high PMS values for most of the individual dimensions.

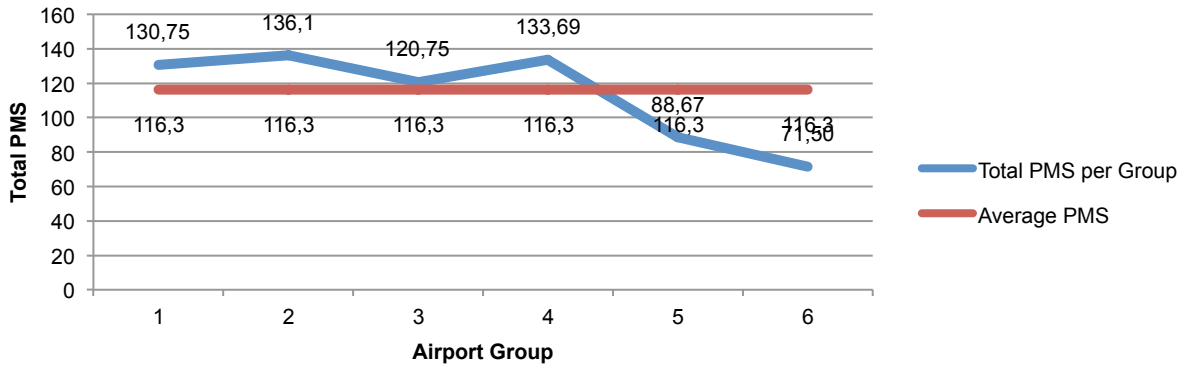


Figure 10: Mean TPMS per group vs. overall mean TPMS

Additionally, a radar chart (Figure 11) of the TPMS values for all groups on every performance dimension reveals the individual strengths and weaknesses of each group. Whereas groups 4 and 5 score below the average of all airports (black line) in every dimension besides *Core*, group 3 and 4 airports are very close to the mean, although group 4 receives very high values in dimensions D) and E). Group 2 airports are also relatively close to the average, however, they outperform all other groups when it comes to PMS values for Environment and Service Quality. Group 1 airports differ from the average with respect to *Core, Safety & Security* and *Service Quality,* while group 3 airports are generally very close to the mean. In addition the dimension *Environment* in general seems to be underdeveloped compared to others, as its average score is low for nearly all groups.

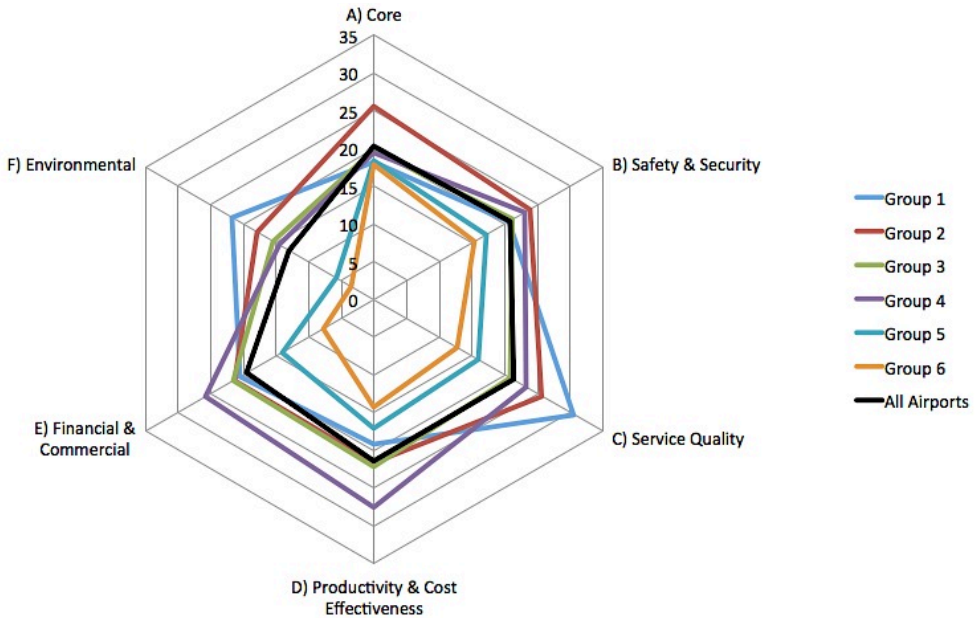


Figure 11: Radar Chart: TPMS comparison of all groups

Both, the general influence of airport size on TPMS and the clear cut between group 1-4 and 5-6 airports is also supported by the self-perception of airport professionals. The perceived sophistication of the PM system increases from the bottom left corner of Table 8 to the upper right corner (>15% highlighted in green), indicating a trend: The larger the airport, the higher the PM sophistication in general. What is interesting though is the fact that only two airports evaluate themselves as State-Of-The-Art and five as Basic, while the majority (46%) indicates average.

	# of Airports	Basic	Below Average	Average	Advanced	State-Of-The-Art
Group 1	4	0.0%	0.0%	0.0%	75.0%	25.0%
Group 2	10	0.0%	20.0%	40.0%	30.0%	10.0%
Group 3	8	0.0%	0.0%	62.5%	25.0%	0.0%
Group 4	13	0.0%	15.4%	76.9%	7.7%	0.0%
Group 5	9	33.3%	33.3%	22.2%	11.1%	0.0%
Group 6	6	33.3%	16.7%	33.3%	16.7%	0.0%
Total	**50**	**10.0%**	**16.0%**	**46.0%**	**22.0%**	**4.0%**

Table 8: Self Perception of Performance Measurement System

A similar picture composes by looking at the resources devoted to performance measurement activities (Table 9). The majority of all sample aerodromes employs 2-5 FTE´s only for matters of PM. Again, a clear trend is visible that smaller airports assign relatively few resources to PM, while larger airports occupy comparably more employees for PM activities. Another Kruskal-Wallis test confirms also the expectations that there is a relationships between FTE´s used and applied TPMS: With a p-value of 0.0480 **H3b)** is accepted (Table 10), indicating that airports that spend more resources on PM also achieve the higher TPMS score within the ACI Guide to Airport Performance Measures.

	# of Airports	<1 FTE	1 FTE	2-5 FTEs	6-10 FTEs	10< FTEs
Group 1	4	0.0%	0.0%	25.0%	0.0%	75.0%
Group 2	10	10.0%	0.0%	70.0%	20.0%	0.0%
Group 3	8	12.5%	0.0%	62.5%	25.0%	0.0%
Group 4	13	7.7%	23.1%	53.8%	15.4%	0.0%
Group 5	9	66.7%	33.3%	0.0%	0.0%	0.0%
Group 6	6	33.3%	16.7%	50.0%	0.0%	0.0%
Total	**50**	**22.0%**	**14.0%**	**46.0%**	**12.0%**	**6.0%**

Table 9: Resources devoted to PM

Contradicting to the initial belief, ownership has no significant effect on the extent to which airports apply a more diverse set of performance indicators. A large p-value as high as 0.9100 for **H4a)/b)** leads to the fact that H_0 cannot be rejected, meaning no significant association between both variables exists. The variation within the TPMS is not explained through the variation within the ownership data. However, the small sample size for privatized airports may be a limitation for researching this particular issue.

FTEs	# of Airports	Mean Rank	Median
<1 FTE	11	15.00	79.0
1 FTE	7	21.14	123.0
2-5 FTEs	23	29.91	126.0
6-10 FTEs	6	31.67	146.0
10 < FTEs	3	28.00	131.0
Total	50		125.0
Chi-Square	9.6090		
df	4		
p-value	0.0480		

	# of Airports	Mean Rank	Median
Private	7	24.50	118.00
Governmental	27	25.00	125.00
Partial	16	26.78	125.50
Total	50		125.00
Chi-Square	0.1880		
df	2		
p-value	0.9100		

Table 10: Influence of FTE´s devoted to PM & ownership on TPMS

4.2.2 ACI Guide Acceptance and Application

The high geographical coverage of Airport Council International is also reflected by the number of members among participating organizations. Out of the 50 sample airports, 88% are members, whereas merely 6% explicitly state that they are non-members and another 6% are unsure (Table 11).

	Absolute	Percentage
Yes	44	88.0%
No	3	6.0%
Don´t know	3	6.0%
Total	**50**	**100.0%**

Table 11: ACI membership

Thereby the knowledge about the existence of the ACI guide is greater than 60% for all groups except for the smallest airports in group 6 (Table 12). Thus, the ACI guide seems to be relatively well known inside the airport professional's community regarding the fact that it was issued in 2012. Nevertheless, the usage frequencies paint a different picture. Just around one quarter (26%) of all airports say they apply the guidelines, while roughly one third (32%) does not. Especially the result for group 1 is surprising, as all airports (100%) know about the guide,

but 75% do not use it. Additionally, 42% of all aerodromes use other standards in addition to the ACI guide, while 46% do not.

		Q5a) Knowledge		Q5b) Usage			Q6a) Other Standard		
	# of Airports	Yes	No	Yes	No	Don´t know	Yes	No	Don´t know
Group 1	4	100.0%	0.0%	25.0%	75.0%	0.0%	50.0%	25.0%	25.0%
Group 2	10	70.0%	30.0%	40.0%	20.0%	10.0%	30.0%	60.0%	10.0%
Group 3	8	62.5%	37.5%	37.5%	25.0%	12.5%	62.5%	25.0%	12.5%
Group 4	13	61.5%	38.5%	23.1%	30.8%	15.4%	46.2%	38.5%	15.4%
Group 5	9	66.7%	33.3%	11.1%	55.6%	0.0%	33.3%	66.7%	0.0%
Group 6	6	16.7%	83.3%	16.7%	0.0%	0.0%	33.3%	50.0%	16.7%
Total	**50**	**62.0%**	**38.0%**	**26.0%**	**32.0%**	**8.0%**	**42.0%**	**46.0%**	**12.0%**

Table 12: ACI Guide Acceptance (knowledge, usage, other standards)

As the χ^2-test of independence for **H5a)** shows low significance on the 10% level due to a p-value of 0.0740 (Table 13), knowledge about the ACI guide is indeed higher among member than among non-member airports. However the small number of non-member airports might have influenced the data negatively. Nevertheless the Cramer´s V for H5a of 0.32, which determines the strength of a relationship between two variables (Malhotra & Birks, 2007; Pallant, 2011), indicates a medium strong effect (for 2 degrees of freedom: 0.32 >0.21). The insufficient p-value of 0.1690 illustrates that **H5b)** is not significant and, thus, application of the ACI guide is not dependent upon the ACI membership. Another Kruskal-Wallis test, similar to the ones in the previous chapter, reveals that ACI members reach higher TPMS scores, however, **H5c)** is only significant on the 10% level, possibly as well due to the low sample size of only three non-members.

	Chi--Square Value	df	p-value	Cramer´s V
H5a*	5.208	2	0.0740	0.32
H5b*	6.435	4	0.1690	0.25
H5c**	5.156	2	0.0760	-

Table 13: H5a-c) ACI Guide Acceptance & Application (*chi-square test of independence; ** Kruskal-Wallis test)

Finally, the last subset of hypotheses for this part of the analysis deals with the question, whether use of the ACI guide (H5d) and of other standards (H5e) has an influence on the achieved TPMS levels. **H5d)** is significant with a low p-value of 0.009 and the median values indicate a large difference between answers 1 (Yes) and 2 (No). The same facts are true for **H5e)** with the difference being the lower significance level with a p-value of 0.076. Consequently, as you apply another standard in addition to the ACI guide, the TPMS value increases.

					Median Values			
Hypothesis	PM Dimension	Chi-Square	df	p-value	1 Yes	2 No	3 Don´t Know	Total
H5d	Usage	9.426	2.00	0.009	163.0	119.5	119.0	125.0
H5e	Other standards	5.156	2.00	0.076	146.0	113.0	131.0	125.0

Table 14: Influence of guide usage and usage of other standards on TPMS

Among these other standards (Table 15), internally developed guidelines are most common (18%), followed by Balanced Scorecard and ACI´s Airport Service Quality (ASQ) survey with 6%, a benchmarking program specifically designed to improve the service performance of airports through identification of best practices (ACI EUROPE, 2012; ACI World, 2008). Another group of frameworks are guides from national organizations: ENAC (France), ADV (Germany) and Italian Civil Aviation Authority. Surprisingly, the already mentioned ICAO standard is only used once. Standards of consulting organizations, like Leigh Fisher or EFQM (European Foundation of Quality Management), are as well only marginally applied.

Other Standard	# of Airports	Percentage
Internal Standard	9	18.0%
ASQ – Airport Service Quality	3	6.0%
Balanced Scorecard	3	6.0%
ENAC Standard	2	4.0%
ICAO Standard	1	2.0%
Leigh Fisher Airport Performance Indicators	1	2.0%
Mystery Shopping of Service Quality	1	2.0%
Flughafen Kennzahlen ADV	1	2.0%
European Foundation of Quality Management (EFQM)	1	2.0%
Italian Civil Aviation Authority Standard	1	2.0%

Table 15: Other standards used by sample airports

Another valuable result regarding the application of the ACI guide is an overview of the average perceived usefulness of each metric (see Appendix 6). On a range from 1 to 5, with 1 being not useful and 5 being very useful, the majority of KPI´s scored “4” and is rated as useful. Nevertheless, some metrics (marked orange in Appendix 6) scored below four, while at the same time they are frequently used. This indicates the existence of improvement potential for the guide since the metrics are less demanded or a lack of knowledge on how to use and interpret these metrics exists within the respective airport organizations.

All *Core* and *Safety & Security* measures score above “4”, while within *Service Quality* only Taxi Departure Delay seems to be of average importance (score: 3.87). All other dimensions have three or four indicators that scored below 4. Within the *Productivity & Cost* dimension metrics that relate the output aircraft movements to the inputs employees or gates are less useful, as well as metrics that refer to the combined output Work Load Unit (WLU)[12]. For the KPA *Financial & Commercial* the lowest usefulness scores received measurements related to debt, with *Long-term debt per passenger* being the least useful metrics as it received an average rating of 2.79 .Out of the six original KPI´s within the dimension *Environment* only two scored above 4 (*Carbon Footprint* and *Utilities/Energy use per* m^2). Nevertheless, *Waste Recycling* and *Waste Reduction Percentage* are rated very close to 4 (3.94 and 3.96), so they can be regarded as useful, too.

[12] WLU: Work Load Unit is a combined output measure that tries to make the different outputs of cargo/freight and passengers comparable. 1 WLU = 1 passenger or 100kg of cargo (Doganis, 1992; Graham, 2008)

Within each of the six performance categories, all airports together mention 6 to 17 additional metrics per dimensions by filling out the "Other"-option of question eight in the survey. These additional values score on average above "4" and, thus, are regarded as useful complements to the existing framework. A complete list including all suggested additional KPI´s can be found in Appendix 8. Although there is no new metric that clearly dominates its category, some general trends can be identified.

The area *Core* experienced the fewest number of new metrics (7) and the most frequently proposed additional KPI is seat load factor (three times), which is heavily used by airlines as well. A look at the dimension *Safety & Security* reveals a clear need for additional airside indicators, as all mentioned metrics (17) focus on problems and emergencies that happen on the airside of an aerodrome. Thereby, Foreign Object Damage (FOD)[13] and airside safety incidents are most frequently proposed. In terms of the area *Service Quality* a trend is visible to add metrics that focus on the customer "passenger", while the other customer "airline" is less considered in the additional metrics. However, airlines will indirectly benefit from more satisfied passengers as well. Regarding *Productivity & Cost* the lowest number of metrics is proposed (6) and airports tend to focus on metrics that refer to a single output or input (passengers, baggage, staff), instead of combined ones like the WLU mentioned above. The new *Financial & Commercial* metrics are equally split between financial and commercial indicators with a clear focus on EBIT/EBITDA related ratios and variations of non-aeronautical revenue measures. Regarding the *Environment* perspective no clear trend is visible. Basically, the airports suggested different metrics for emission topics ($C0_2$, NO_x, water, noise, de-icing liquids and energy).

	# of Airports	Core	Safety & Security	Service Quality	Productivity & Cost	Financial & Commercial	Environment	None of these areas	Don´t know
Group 1	4	0.0%	25.0%	25.0%	50.0%	25.0%	25.0%	0.0%	0.0%
Group 2	10	20.0%	30.0%	60.0%	70.0%	50.0%	50.0%	0.0%	0.0%
Group 3	8	37.5%	50.0%	50.0%	50.0%	50.0%	50.0%	0.0%	0.0%
Group 4	13	23.1%	38.5%	53.8%	61.5%	61.5%	53.8%	0.0%	0.0%
Group 5	9	11.1%	55.6%	55.6%	33.3%	22.2%	44.4%	0.0%	0.0%
Group 6	6	0.0%	0.0%	16.7%	33.3%	33.3%	16.7%	0.0%	0.0%
Total	**50**	**18.0%**	**36.0%**	**48.0%**	**52.0%**	**44.0%**	**44.0%**	**0.0%**	**0.0%**

Table 16: Areas of future developments

Considering the future of airport Performance Measurement, around half of the participants agreed upon that *Service Quality (48%)* and *Productivity & Cost* (52%) will be the areas on which the development of new metrics, concepts, etc. will be focused. Close behind scored *Financial & Commercial*, as well as the *Environmental* dimension, both with 44%. The areas *Core* (18%) and *Safety & Security* (36%) are less expected to contain new indicators in the

[13] FOD: Within the aviation industry FOD (Foreign Object Damage or Foreign Object Debris) describes an incident where an insignificant or small item causes huge damages to aircrafts and their passengers. For example, small devices like bolts, screw drivers etc. which are lying on a runway or were forgotten by a mechanic in a landing gear can cause an aircraft to crash.

future. Noticeable is also the fact that among group 1 and 6 airports in general fewer airports expect developments in the future.

4.2.3 Influence of Contextual Situations

The contextual situation of individual airports was decomposed into the three sub-contexts Airport Context, Guide Context and PM Context, as already explained within the methodology section. To model these latent variables, a formative measurement model was chosen instead of a reflective because the observed independent variables (e.g. size and ownership) form the dependent variables and do not reflect them. In a first step the PLS algorithm of SmartPLS is applied, yielding the specific weights (β) of all variables, which indicate how important a certain variable is in relation to the overall model, and the coefficient of determination (R^2). The higher the beta value, the more positive is the described effect and the lower (for negative numbers), the more negative is the association. Subsequently, t-statistics were calculated via the bootstrapping[14] option in SmartPLS. In order to be significant, the t-statistics should be higher than 2.57 for a 1% level of significance, larger than 1.98 for 5% level of significance or at least above 1.66 for a 10% level (Hair et al., 2011; Huber, 2012).

To evaluate the model, a differentiation between measurement model and structural model is necessary (Haenlein & Kaplan, 2004; Hair et al., 2011; Huber, 2012). The measurement model describes the relationship between independent variables (e.g. Size) and the exogenous latent variable constructs (e.g. Airport Context). The structural model refers to the hypotheses or, in a more precise way, to the relationship between the exogenous latent variable constructs and the endogenous latent variable (e.g. TPMS).

The main method to evaluate formative measurement models is to look at the t-statistics and eliminate the insignificant variables one after another (Haenlein & Kaplan, 2004; Hair et al., 2011; Huber, 2012). Following these procedures would result in eliminating *Ownership, ACI Membership, Benchmarking Activity, FTE´*s and *Self Perception* one by one, as their t-values are below 1.66, however, this yields no significant change for the overall model and their presence does not harm the outcomes. Although this violates some of the general procedures of how to conduct a PLS analysis, the respective insignificant variables remain inside the framework on purpose to show the multiple causality of the effect on TPMS. Similar, the input values for TPMS are not significant, but they cannot be deleted as, otherwise, there would be no independent variable for the latent construct TPMS. Thus, all independent variables in Figure 12 are assumed to be of importance given the specific framework of this research.

[14] As setting for the bootstrapping 100 cases and 5000 samples were chosen, following the advise of Hair, Ringle, and Sarstedt (2011).

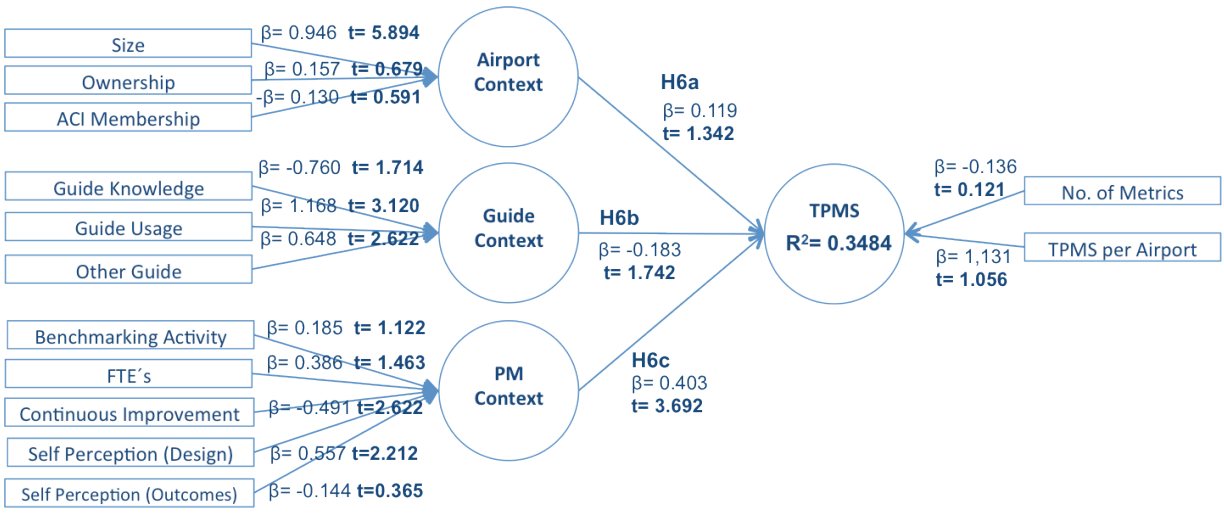


Figure 12: Results for H6a-c)

In case of the structural model, the β-values of **H6a)** and **H6b)** are rather low (0.119 and -0.183), whereas **H6c)** shows a good β-value of 0.403. In combination with the t-statistics of 1.342, 1.742 and 3.692 respectively, it can be concluded that **H6a)** is not significant, **H6b)** is significant on the 5% level and **H6c)** is significant on the 1% level. Through looking again at the beta values, this leads to the result that *Guide Context* has a rather low negative impact (β= -0.183) on the set of performance indicators used, while *Performance Measurement Context* has a medium strong positive effect (β= 0.403). Consequently, whether an airport knows about the guide, applies it or uses other guides has only a marginal, but negative impact on its total PMS value. The most important factor that influences TPMS is the Performance Measurement Context. The more an airport engages in PM activities and the more advanced the respective structures for PM are, the higher the TPMS score will be.

Surprisingly, the insignificance of H6a partially contradicts the finding of H3a. While the latter finds a significant relationship between airport size and TPMS score, the PLS calculation for H6a revealed that size, at least when it is accompanied by airport ownership and ACI membership data, is not associated with higher TPMS values. To check whether the results of H3a (Kruskal-Wallis test) are also valid when using a PLS algorithm, all other independent variables and latent constructs are temporary excluded from the model, only airport size and the construct “airport context” remain inside. In this case, the β-values increases marginally (β=0.150), however, the new t-statistics shows a 5% significance level (t= 1.986), which supports the findings of H3a. The larger the airport, the more likely is it that its organization applies a more diverse set of performance indicators. In combination with accompanying factors, the variable airport size looses some of its explanatory power, due to the influence of other variables within the model. To test whether multicollinearity is an issue, the variance inflation factor (VIF) is computed, which can be used to identify collinearity and, thus, redundancy within the data. Hair et al. (2011) and Huber (2012) suggest a critical threshold at a VIF of 5, meaning that all values below 5 indicate that multicollinearity is not present. As can be derived from appendix 7, the VIF was calculated among all variables of a specific latent construct and all values lie in the range from 0.98 to 2.94. A separate VIF, which tests for

correlation of airport size and all other variables in the overall model, also yields a VIF as low as 1.74. Hence, multicollinearity is no issue within the framework of this research.

Finally, all independent and latent variables together yield an R^2 of 0.3484 for TPMS, which means that 34.84% of the variance in TPMS is explained by the variance within the defined contexts. Although defining whether an R^2 value is high depends on the field of research (Hair et al., 2011), Hair et al. (2011) state that in the field of marketing values of 0.75, 0.50 and 0.25 are perceived as substantial, moderate and weak. In contrast to this, Chin (1998) differentiates between substantial (0.67), average (0.33), weak (0.19) and not relevant (0.19) when it comes to R^2 values in PLS models. Depending on which definition is used, the explanatory power of the model can be judged as moderate to average. In total, the collected data from the survey explain 34.84% of the variation to which extent European airports apply a diverse set of performance indicators.

5 Discussion of Findings

The following section subjectively interprets, discusses and derives conclusions from the above findings. It also connects the outlined results with the previous literature review and research expectations.

PM Characteristics

European airport´s main motivation to engage in performance measurement activities is to improve their own performance, which matches the finding of the literature review that measuring and improving of one´s own performance is a major step in the commercialization and privatization efforts of airports (Francis et al., 2001; Graham, 2005; Humphreys et al., 2002). Hence, airports view performance measurement as an essential step to be competitive in the future and as a method to adopt more business-like practices, thereby supporting the view of Boston Consulting Group (BCG, 2004). Also the finding that strategic plans, competition, senior management goals and regulation are among the most important drivers, support the view that the mentioned commercial and environmental challenges affect the performance measurement activities of airports.

The initial belief that airport size has a significant effect on TPMS in general is supported through the significance of H3a. Although the effect of airport size on the diverse set of indicators was expected, it was not obvious, since the results of the six individual hypotheses yielded a tie between dimensions for which size is an influencing factor (*Core, Financial & Commercial, Environment*) and on which it has no impact (*Safety & Security, Service Quality, Productivity & Cost*). Consequently, airport size in sum influences TPMS, while on the other hand the impact varies with respect to the specific dimension. Obviously, the three dimensions where size has no impact on TPMS represent topics that are of equal and major importance for all airports across Europe. This is in line with the generally paramount importance of safety

& security for the aviation industry and the strong commercial and cost oriented focus of the airport sector due to the outlined challenges mentioned above. The significant influence of size also serves as a justification for the division of the sample in six groups. Hence, looking at the PM characteristics of each group individually makes sense and is necessary.

In case of the dimensions *Core* (H1a) and *Productivity & Cost* (H2a) the tests revealed the opposite of what was expected. Although *Core* metrics are important for every airport and should be used similarly, differences exist within this area which indicators are applied. Most possibly this is caused by the nature of the metrics within this dimension. Unlike most other indicators, some *Core* metrics can only be monitored if the airport fulfills certain criteria. For example the KPI *Freight/Mail Loaded/Unloaded* can only be used if the airport indeed handles cargo, as well as *O&D Passengers* may only be reported if there is a differentiation between nonstop passengers and transfer passengers. Consequently, some indicators are not applicable due to the existing operational characteristics. Another possible root of this are different national regulations on which figures should be reported, which is one of the most important origins of performance measurement activities. Regarding *Productivity & Cost*, airports of various sizes apply a similar diverse set of performance metrics. Increased regulation on the airport industry as a consequence of the national efforts to privatize the aviation infrastructure, described by Georges Assaf et al. (2012) and (Graham, 2008), is one explanation for this effect. Similarly, the economic pressure resulting from the growing low cost airlines and the formation of airline alliances (Graham, 2008) might have supported an equally strong focus on productivity figures across airports of all sizes.

Since the median as well as the mean PMS and TPMS values for the groups 5 and 6 on average are considerably lower than for the other groups, the guide seems to be less useful to or less needed by smaller airports below the critical level of 1,000,000 passengers per year. The administrative costs and increased complexity of measuring a diverse set of indicators seems not to suit their business model, which is mainly driven by a cost focus (De Neufville, 2007; SEO, 2012). This is also supported by the findings of airport professional's self-perception, the number of FTE´s devoted to PM, benchmarking activities, data gathering tools and ISO-certifications. Hence, unlike expected beforehand, there is a gap between airport groups 1-4 and 5-6.

While airports above 5 million passengers per year were expected to apply a more diverse set of performance indicators, the high results for group 4 airports are surprising and indicate that performance measurement is very important for these aerodromes. They score considerably higher within the dimensions *Financial & Commercial* and *Productivity & Cost,* revealing that they have a strong focus on non-aeronautical (commercial) activities and operational efficiency. With 108 airports of this size, it is the second biggest group and, obviously, the increasing competition between European airports (ACI EUROPE, 2013b; CE, 2012) strongly affects them, leading to an increased focus on performance measurement and concentration on new areas of revenue generation.

Both, the general influence of airport size on TPMS and the clear cut between groups 1-4 and 5-6 are also supported by the identified trend in the self-perception of airport professionals and the number of FTE´s devoted to PM activities. The fact that the majority of aviation experts perceives their PM activities as rather mean seems to partially support the view of Graham (2005) that the aviation sector still lags behind compared to other industries or that at least the majority of airports lags behind their self-set claims.

A finding that is especially revealed by the constructed radar chart is that the dimension *Environment* in general lags behind all other dimensions. Airports of all sizes, besides group 1, show development potentials when it comes to this area of performance measurement. This might be due to the fact that the environmental challenges for airports have emerged relatively recent, which matches the findings from the literature review above (ACI World, 2007a, 2007b; Graham, 2008).

Another result contrasting to the initial belief is the relationship between ownership and TPMS. Unlike expected, H4a/b are not significant, implying that there is no association between ownership structure and diversity of applied indicators. This contradicts the findings of some of the reviewed literature (Barros & Dieke, 2007; Oum et al., 2006; Oum et al., 2008; Oum et al., 2003), whereas it partially supports the finding of others that ownership does not influence an airports performance (Oum et al., 2006; Oum et al., 2003; Parker, 1999), although their conclusions only relate to overall performance and efficiency values. Also the described effect of Humphreys et al. (2002) of privatized airports applying more indicators than others must be rejected based on the finding of this thesis. However, the small number of privatized airports in the sample may also cause the insignificance of H4a/b.

Although some of the above discussed results might seem intuitively, to the best of the author´s knowledge, no one has proven the existence of these relationships so far in academic literature and, surprisingly, the observed trends do not apply to all cases. There are some exemptions, where large airports have considerably low TPMS values, while very small airports have considerably high TPMS scores. Due to confidentiality, these airports cannot be outlined here, since it would allow competitive airports to gain inside knowledge about internal processes. What can be said though is that although in general big airports are the leading trendsetters in this industry, some smaller airports apply a more diverse set of metrics than some of the largest airports within this sample and, hence, their performance measurement approaches are worth studying as well.

ACI Standard

Besides aerodromes below 500,000 passengers, the *ACI Guide to Airport Performance Measures* is widely known among industry experts, although it was issued only one year ago ACI (ACI World, 2012). As H5a is significant, member airports are more likely to know the guide than others. This indicates a good promotion strategy, as well as relevance and usefulness for practitioners. Nevertheless, the gap between the high results of knowledge,

62% on average, and the low values for usage (26%) can not only be explained through the fact that is a relatively new document. What seems to be of greater influence is the fact that the guide is a product of ACI World, the global office of ACI, whereas the survey participants are members of ACI EUROPE. Unlike most organizations, where the global office rules the company, the ACI structure is different. Airports are members of the regional offices (Europe, Asia-Pacific, North America etc.) and have almost no contact to the global representation.

The insignificance of H5b implies that membership has no influence on whether an airport uses the guide or not, revealing that not every member uses the guide. However, H5c, although only significant on the 10% level due to the small number of non-members, states that there is a relationship between ACI membership and a higher TPMS value, which is also true for the association between guide usage and TPMS (H5d). Hence, if an airport is a member of ACI EUROPE this does not automatically mean, that it applies the ACI guide. However, if an airport clearly uses the guide, this application results in a more diverse set of performance indicators. Nevertheless, organizations, which do not use the guide, can reach high TPMS values as well without it, as other standards may contain the same metrics. This leads to the conclusion that the guide, or at least its proposed metrics, is more widely applied than the subjective impression of the participants suggested in the first place.

In total, 42% of all aerodromes use other standards, revealing the fact that many airports combine different guides/standards and adapt them according to their individual needs, which is fully supported by H5e: Application of other standards leads to higher TPMS values. This first of all suggests that the content of other standards and the ACI guide overlap in some areas, since application of them leads to higher TPMS. For example, the ICAO guide and the ACI guide have similar KPA´s and share some KPI´s (ACI World, 2012; ICAO, 2009b, 2013b). On the other hand, the need for additional guidelines implies that ACI should adapt its collection of KPI´s according to the actual needs of its members. In combination with the previous results, it can be concluded that the guide may especially not suit that well the needs of the largest hub airports, as half of them follow other standards. Additionally, the results suggest that the guide suits best the needs of airports between 25 and 0.5 millions of passengers. The largest airports (group 1) seem to perceive the guide as least useful, maybe due to the high complexity of their infrastructure systems and a stronger need to customize their performance measures. For the smallest airports (group 6) another effect dominates: The one airport, which knows about the guide, also states that they apply it, whereas the majority (83.3%) does not know about the guide and, consequently, does not apply it, leading again to the conclusion that stronger communication of the guide by ACI EUROPE and training will increase its spread. Thereby, the findings suggest a special focus on the application potential for smaller, regional airports in Europe.

The high usefulness scores of most of the included KPI´s illustrates that the guide suits the needs of European airports, although the mentioned scores below the threshold of four point to improvement potential. Within the dimension *Productivity & Cost* improvements are

necessary. Especially the metrics that link total and operating cost to the WLU scored low, which may be due to the fact that WLU combines two outputs (passengers & freight), although these require different inputs, like different handling equipment and different terminals (Humphreys et al., 2002). In addition, freight and passengers are difficult to compare, since freight does not move through the facilities by itself, different planes are used and freight does not spend money at the airport (Humphreys et al., 2002). Instead, like suggested by the survey participants, the operating and total costs should be linked to the separate output dimensions, e.g. operating cost per bag, per passenger and per 100kg of freight. This would also improve the comparability between airports, as some airports handle lower or even no cargo at their airports. Otherwise the influence of cargo volumes would violate the comparability between airports. Another improvement could be reached through integrating the results from the ASQ survey into the guide, as it is the most frequently added metric and a lot of airports regard this survey by ACI as useful and important. A simple way to realize this could be to monitor an airports´ ranking in the ASQ results. As ASQ and the guide are both issued by ACI, this should be no big hurdle. Within the *Financial & Cost* area, the KPI´s linked to debts are regarded as less useful as well and, hence, should be redeveloped or replaced in favor of increased consideration of EBIT and EBITDA related metrics as suggested by the airport professionals. These ratios are especially interesting for investors and other external stakeholders. Another reason for the poor results of the debt ratios could be a less developed understanding of these metrics and their application, again indicating a need for training. In terms of the environmental KPA elimination of the low scoring metrics seems to be not the right approach, given the fact that it is a topic that received attention more recently and the industry is less familiar with. Instead, additional metrics should be added to incorporate the issues of aircraft noise and public transport share. Like outlined in the literature review, in the future at least one KPI for each of the following five areas should be included in the guide to cover the environmental dimension successfully: (1) noise, (2) emissions (e.g. CO_2, $NO_{x,}$) and air quality, (3) water pollution and consumption, (4) energy management and waste, (5) wildlife protection, land usage and heritage (ACI World, 2007b; Graham, 2008).

In general, the European airport industry seems to be still very much focused on local, internal and regional standards, suggesting that there is a lot of potential to align metrics among corporations in order to enable better benchmarking in the future, which supports the view of Graham (2005). Compared to the percentages of the other standards, the *ACI Guide to Airport Performance Measures* is already widely implemented, as more than one quarter of the sample airports apply it, which is higher than any other standard mentioned in the survey. This supports the initial belief that the ACI guide is closer to being an industry standard on the European continent than any other publication so far, however, reaching the status of an universally applied standard will take some time and requires some further developments. Hence, it may be ACI EUROPE´s task in the future to incorporate the given feedback as well as to greater familiarize their members and non-members with the guide plus training them on how to use, apply and understand the metrics in it.

Looking at the expectations of airport professionals, the areas *Core* and *Safety & Security* are less expected to contain new indicators in the future, indicating that these basic categories are already on a sufficient level. In all other categories developments are widely expected, which underlines the already mentioned commercial, environmental and competitive challenges in the airport industry. Through increased and more focused performance measurement activities, Europe´s airports want to gain higher transparency of their business processes to understand their problems and face these future challenges. Noticeable is the fact that among group 1 airports in general fewer airports expect developments in the future, which suggests that the performance management activities they apply today, are already advanced and less demand for innovations exists. This matches their previous described high level of self-perception. Similarly, group 6 airports generally expect fewer future developments in most categories suggesting that there is less demand for innovations as well. However, the reasoning behind that may be different since they have no need to apply a more advance performance measurement systems due to unjustified costs that would not suit their commercial activities.

Airport Contexts

The three constructed airport contexts explain more than one third of the variation within the TPMS data and can, thus, be judged as moderate to average. Given the limited population and the small sample size and the fact that the organizations were required to give confidential information to an outsider, the computed R^2 value is regarded as satisfactory for the needs of the research project at hand. Nevertheless, roughly two-thirds of the variance remains unexplained by the chosen variables, indicating that some other factors are to be considered as well. To transfer the concept of Humphreys et al. (2002) to the area of performance measurement, only selected variables out of the proposed framework are incorporated, while new factors like FTE´s devoted to PM, Benchmarking activities etc., have been added to construct all contexts. Although this study did not aim at proving influence of individual contextual situations on the performance of airports, like Humphreys et al. (2002) suggested, it showed at least the dependence of range and quantity of KPI´s on airport´s context.

Among the three latent constructs, the PM Context is the most influencing one, indicating that the more an airport engages in all kinds of performance measurement activities (benchmarking, FTE´s etc.) the more advanced its set of KPI becomes. Whether this suits the objectives and needs of an organization depends on the individual company, but if an airport strives for better performance measurement, the independent variables listed in the model can represent starting points.

Regarding the other latent constructs in the model it must be said, that the insignificance of H6a partially contradicts the finding of H3a, for which a relationship between airport size and TPMS was found. At first sight, this seems to be caused by the fact that size is only one of three factors that form the airport context, however, removing the two insignificant variables ownership and membership from the PLS algorithm yielded no improvement. Limiting the

PLS-model to only one independent variable (airport size), one latent construct (airport context) and the TPMS variable yields a similar setting like the Kruskal-Wallis test for H3a and reveals the same result. Hence, both tests confirm the significant relationship between size and TPMS, which for the framework of this research can be regarded a sufficient proof. If the factors airport size is bundled together with other variables and other latent constructs into one more complex model, like for the test for H6a-c), its explanatory power is influenced by other variables. In combination with the fact that the one-by-one elimination of all insignificant independent variables led to no improvement, it can be concluded that this loss of significance is not solely explained by one other variable. Moreover, a cumulative effect caused by a combination of various variables seems to be the reason, while multicollinearity is not an issue, since all calculated variance inflation factors (VIF) are below 5.

Hence, size is another characteristic that influences the performance measurement approach of an airport, even though it is one than cannot be influenced by an airport directly (Oum et al., 2003). In case of the variable ownership, the PLS model supports the finding of H4a/b, as the beta value is low and the t-statistic insignificant. Ownership, another uncontrollable variable (Oum et al., 2003), is not of importance for performance measurement activities. In case of H6b, the model reveals a significant result, however, the effect is negative. Consequently, this would suggest that ACI membership, use of the guide and usage of other guides would negatively affect the TPMS score, however, previous results indicated the opposite. Nevertheless it can be summarized that although some variables are not significant, this circumstance does not harm the explanatory power of the overall system. The performance measurement activities of European airports are influenced by their individual contextual situations. Thereby, the PM context was found to be the most influential among all three modeled latent constructs. Consequently, the more FTE´s an airport devotes to PM, engages in continuous improvement and benchmarking practices and the higher it perceives its own PM system, the more advanced its performance measurement system will be. These insights support the claim of Humphreys et al. (2002) to establish contextual profiles of airports before comparing their performance and the above mentioned additional variables should be incorporated in future research papers on this topic.

In general, these findings paint a vivid picture of the status quo of the performance measurement activities of European airports and their acceptance of the ACI Guide to Airport Performance Measures. Based on the results mentioned so far, short profiles can be constructed, which give a brief overview about the main performance measurement characteristics of European airports (see Appendix 9). Resulting from those profiles, all airport categories are placed in a matrix (Figure 13) to illustrate their relative position regarding performance measurement in the airport industry.

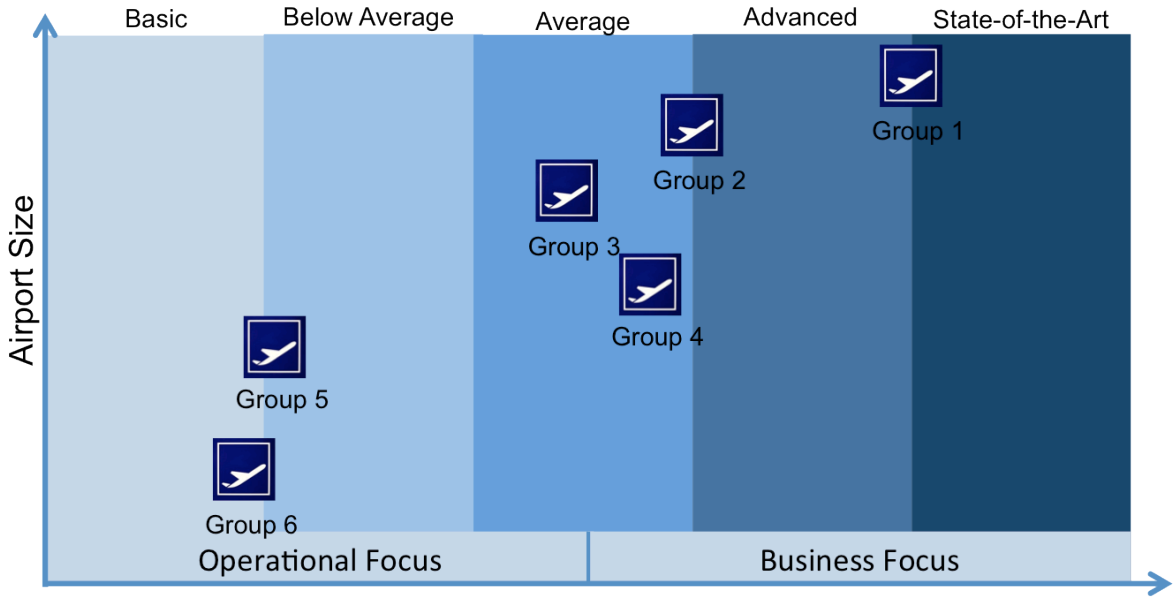


Figure 13: Performance measurement matrix

6 Conclusion

This final chapter summarizes the major research findings and highlights theoretical and practical contributions. A critical look at the limitations of this study in combination with suggestions for future research concludes the thesis.

6.1 Theoretical Implications

The research conducted in this thesis enriches the understanding of airport performance measurements by identifying major characteristics of the performance measurement activities of European airports. It is embedded within the existing stream of literature on airport performance and benchmarking, as outlined in the previous literature review. Unlike most of the articles available in academia, it concentrates not on methods to evaluate the overall efficiency of certain airports, but instead investigates the broader topic of which metrics and approaches aerodromes apply to measure their performance. To the best knowledge of the author no similar study has been conducted before. Although the research of Francis et al. (2001) chose a similar setting with a global point of view regarding airport performance measurement, the research conducted in this thesis is innovative and new as it is clearly focused on the European perspective and includes six dimensions of performance instead of three. Instead of just listing the descriptive statistics of the survey results, like Francis et al. (2001) do, within the framework of this thesis statistical test are applied to investigate underlying factors and reasons for the variations in performance measurement practices.

Value is also added to the existing airport business knowledge through referring to a specific set of indicators, which are suggested by one of the most influential organizations in the

aviation industry: Airports Council International. The incorporation of the ACI´s *Guide to Airport Performance Measures* allows to test the application of a common set of metrics across Europe and, thus, enables the author to examine to which extent the performance measurement activities of European airports are already standardized.

As it is among the first studies of this kind, one of the major theoretical implications of this project is that it serves as a basis for further research and stimulates the identification of future academic topics. In particular, this thesis contributes the following to the academic literature:

1) For the first time, the partial performance measurement activities of European airports have been analyzed and compared on the basis of six performance dimensions, which all proofed to be of importance for the industry. To actually compare the diversity of applied indicators a new metric called Total Performance Measurement Sophistication (TPMS) is introduced, which has successfully proven its usefulness and applicability. The results allow researchers new insights into the current development within the airport sector and in the future they can apply this metric to compare airports and to further investigate their PM activities. Also researchers interested in the field of overall performance values can benefit from these findings, since they illustrate the necessity to incorporate all six dimensions and not only two or three, which is the case in most of the present articles.
2) The finding that six performance dimensions are important for airports also impacts the research field of overall performance values. To create such a value, this thesis illustrates that each dimension should be incorporated td
3) The performance measurement activities of airports are dependent on the variables airport size, number of FTE´s devoted to PM, ACI membership, guide usage and other standards. This effect has not been proven before and opens a new direction for further research. Airports of different sizes etc. apply different sets of metrics and focus on different dimensions of airport performance. Hence, to compare the performance measurement activities of several airports in the future, these respective underlying factors need to be taken into account.
4) The concept of the importance of contextual situations (Humphreys et al., 2002) is transferred from the field of overall efficiency values to partial performance indicators and supported. Individual contextual situations are found to influence the diversity of metrics applied by airports to more than 34%. Therefore, the claim of Humphreys et al. (2002) to establish contextual profiles of airports before comparing their performance is supported and some new variables can be added to their proposed framework (Benchmarking activity, FTE´s devoted to PM, Self-Perception, Continuous Improvement Practices). Additionally, the constructed airport profiles in this thesis can serve as a starting point for future research in this area.
5) According to this research, airports pay large interest to performance measurement activities and benchmarking practices, which further supports the outlined process of a

change from public owned infrastructure providers to commercially orientated business (Graham, 2008, 2009).

6) This study has proven that the *ACI Guide to Airport Performance Measures* currently is widely applied in Europe and already very close to becoming an international standard in the area of airport performance measurement. Approximately 25% of all airports in Europe already use it, with airports between 1 and 25 million being the most frequent user group. Hence, future studies benefit from this insight, as they can also refer to ACI´s guide and incorporate it.
7) It has been shown that the outlined challenges like cost pressure, commercialization & privatization and environmental pressure indeed have an effect on the performance measurement practices of airports, however, various types of aerodromes are affected differently. These issues are not only of importance when it comes to partial performance measures. Also authors interested in overall performance studies should include these insights in upcoming scientific articles.

6.2 Managerial Implications

From a business or practical point of view, the research approach delivers interesting insights into the performance measurement landscape of European airports for practitioners. The described impressions and trends of the performance measurement activities of European airports will help professionals to evaluate the system in place at their organizations with regard to other airports. Airport managers will be able to identify potential starting points for improvement by comparing characteristics of their own measurement system with those of similar airports.

The results of the survey and the statistical tests can be used to develop a tool to compare the performance measurement activities of airports. All participating airports will receive a short report that puts their performance measurement approach in relation to their competitors. In these reports all individual answers and data for a specific airport will be evaluated in relation to the average airport in its group and all airports of the sample. Besides a variety of tables and the previously mentioned airport profiles, a radar chart that displays the scores on each dimension for the airport, its peers and all airports represents the main feature of the tool (see Appendix 10 for a real example of a survey airport, whose identity is not shown due to reasons of confidentiality). This enables airports to benchmark their approach against their immediate competitors and peers, as well as it allows identification of best practices from other airport categories. Thus, individual strength and weaknesses are highlighted to raise attention for improvements in the future. In addition, the reports also contain a summary of the statistical tests and findings of this research. Consequently, the proposed airport performance measurement benchmark tool provides a valuable tool to analyze airports from a new perspective.

Airports that did not participate in this study can also apply the described tool if they compute their respective PMS and TPMS score themselves. This process is relatively quick and requires the following steps:

1) Take the *ACI Guide to Airport Performance Measures* and have a look at the overview of all indicators within each performance dimension.
2) Start with the first dimension and rate all KPI´s which your organization uses on scale of 1 “not useful” to 5 “very useful”. Write down the ratings behind each KPI. Then add the values for all KPI´s that your airport uses within this dimension and you receive your Performance Measurement Sophistication (PMS) value for this dimension.
3) Repeat step 2 for all dimension.
4) Construct a radar chart that has six axes (one for each dimension) and insert the PMS values of your airport, your airport group and the average of all airports (see Figure 11).
5) Add all PMS values to generate the Total PMS (TPMS) value and compare it with the average value of your group and the average of all airports (see Figure 10).

This five-step approach enables all airports to carry out a quick self-check on their strength and weaknesses in relation to their peers. If they want to perform a more in-depth analysis, they can additionally answer the survey questions and compare their results with the average results of their group illustrated in chapter four.

Another target audience of the research outcomes is Airport Council International itself, especially its European organization ACI EUROPE. Although they are not the publisher of the *ACI Guide to Airport Performance Measures*[15], they can handover the feedback on its usefulness to their global organization to stimulate improvements and further developments. The results show that the guide is already widely applied, however, some limitations exist that hinder it from being adopted to a larger extent. Furthermore, ACI EUROPE should aim at closer collaboration with their member in the field of airport performance measurement in order to establish more common industry practices. Therefore, workshops on this particular topic with selected member airports of all sizes could be one option to stimulate discussion about performance measurement for airports. Another valuable option, together with ACI World, could be to offer trainings on how to measure airport performance and how to apply and interpret KPI´s, as well as how to derive suiting management actions from these. These training sessions should be specifically targeted at airports of a particular size. Especially the smaller airports (groups 5 and 6) show room for improvement and further standardization, which suggests that trainings should be offered to these airports in the first place. Through such practices, ACI EUROPE could significantly contribute to the further standardization of performance measurement approaches in the European airport sector and stimulate the process to close the gap between their industry and other sectors when it comes to the application of modern business practices.

[15] The *ACI Guide to Airport Performance Measures* is issued by AC World, Montreal, Canada (2012).

6.3 Limitations and Recommendations for Future Research

Regarding the influence of individual contextual situations of airports, additional data should be collected to incorporate more variables in the model and to construct additional contexts as well. Examples for this could be, amongst others, the geographical location clustered in north, west, east and south Europe, age of the organization, culture, number of total employees, revenue and profit. Besides developing new latent variable constructs, it would also be interesting whether regrouping some of the independent variables would yield any result. Additionally, the impact of moderating effects should be investigated as well. All this would contribute to further increase the coefficient of determination, thereby explaining more of the variation inside the TPMS data.

Moreover, all statistical tests in this thesis looked for linear relationships between the respective variables, however, the insignificance of some hypothesis does not automatically imply that there exist no associations. Possibly non-linear relations subsist, which require other statistical techniques to prove them.

Another drawback of this research project is the few number of non-ACI-members and privatized airports in relation to the overall of 50 respondents. In future studies, a special focus should be set on achieving a suitable balance between member and non-member airports, as well as privatized and non-privatized airports, to overcome this problem. Since small airports seem to have different needs and expectations regarding their performance measurement systems, a study that particular addresses their problems and business issues would add value to the existing literature as well.

As this study only received answers from 50 of the 338 airports that would fit the criteria of more than 100,000 passengers per year, future research ambitions could be targeted at extending the created database to further improve the validity and expressiveness of the findings. Furthermore, a similar research should be conducted on a regular basis to monitor developments and improvements within the aviation sector over time and to provide a constant stream of feedback to ACI on the application of its guide.

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Appendix

Appendix 1: Memorandum of Understanding ACI EUROPE & Swen Franken

Memorandum of Understanding between ACI EUROPE & Mr. Swen Franken Concerning Cooperation on 'Airport Performance Management' Project

Context

Mr. Swen Franken of Maastricht University approached ACI EUROPE with a proposal for cooperation on a survey concerning the practice of performance management at European airports. This is a topic also of interest to ACI EUROPE, and so it has been agreed that both parties will cooperate on collection of relevant data from member airports of ACI EUROPE.

ACI EUROPE's cooperation with Mr. Franken will primarily consist of:

- Assisting in the formulation of a questionnaire to send out to European airports.
- Availability -within reasonable limits - of the ACI EUROPE Economics Manager via telephone and mail to respond to queries concerning the thesis.
- Supplying of airport contacts to Mr. Franken, where appropriate. The supply of individual contact details will be at the discretion of ACI EUROPE.
- Supplying of 'recommendation mails' to airport members, advising airports of the relevance of Mr. Franken's work to ACI EUROPE and the European airport industry.
- Distribution of the questionnaire to contacts within the ACI EUROPE Economics Committee

Mr. Franken's cooperation with ACI EUROPE will primarily consist of:

- Allowing ACI EUROPE input into the questionnaire to ensure that the data collected suits the needs of both parties
- Leading the data collection exercise & ensuring a reasonable response.
- Choosing appropriate research methods and techniques based on the numbers of responses in cooperation with Lieven Quintens, professor at Maastricht University
- Ensuring that all collected data is available to ACI EUROPE
- Allowing ACI EUROPE visibility of the thesis to make comments if required prior to submission. This does not give ACI EUROPE any right to amend Mr. Franken's thesis, nor does it restrict Mr. Franken's academic freedom in any way.

Confidentiality

- In light of the sensitivity of the data being collected, neither Mr. Cagney nor Mr. Franken nor Maastricht University will disclose information on individual airports to any third party, nor allow third parties to infer information about individual airports, without the prior explicit consent of the airport in question.

ACI EUROPE: Signed by Dooagh Cagney, Manager Economics

6, square de meeûs,
1000 Bruxelles

Date: 12/04/13

Swen Franken:

D1.09 Tongersestraat 53,
6211 LM Maastricht
PO Box 616, 6200 MD Maastricht

Date: 15/04/13

Appendix 2: Initial Cover Letter



Covering Letter

16th April 2013

Airport Performance Measurement Survey

Dear airport professional,

We are writing to ask for your support in a study being conducted in cooperation between *Maastricht University* and *ACI EUROPE* on the topic of airport performance measurement in Europe.

As we know that those who are working within the industry provide unique and highly valuable insights into what is actually happening in the airport sector, we are looking forward to receiving your professional opinion. The purpose of the study is to get a clear picture of how the topic of airport performance measurement is addressed by European airports. Thereby, the research is not limited to large European airports, as we are also highly interested in the developments at small and medium-sized airports with either an international or regional focus. In the end, the goal is to receive a cross-section of the European airport sector in terms of performance measurement. The data will inform both a Master Thesis Project at Maastricht University and the work of the ACI EUROPE Strategy Working Group.

All collected data will be treated strictly confidential and no individual airport data will be released without prior permission. None of your data will be given to other companies. However, if you are interested in your own results, please leave a contact email address by ticking the respective check box on the last page of the survey to receive a report that offers you the generalized results of our study.

To ensure that the most value is derived from your efforts, please complete the survey by close of business on Wednesday, 8th of May.

We very much appreciate your efforts and would like to thank you in advance for your help.

Thank you very much for your participation.

Yours sincerely

Swen Franken
M.Sc. candidate
Maastricht University School of Business & Economics
swen.franken@student.maastrichtuniversity.nl

Dr. Lieven Quintens
Assistant Professor
Department of Marketing & Supply Chain Management
Maastricht University School of Business & Economics
l.quintens@maastrichtuniversity.nl

Donagh Cagney
Manager Economics
ACI Europe
donagh.cagney@aci-europe.org

Appendix 3: Performance Measurement Survey Questionnaire



Dear airport professional,

Thank you very much for supporting this research.

This questionnaire is part of a Master Thesis Project in cooperation between *Maastricht University* and *ACI Europe* on the topic of airport performance measurement in Europe.

The data will inform both the Master Thesis and the work of the ACI EUROPE Strategy Working Group.

All collected data will be treated strictly confidential and no individual airport data will be released without prior permission. None of your data will be given to other companies. However, if you are interested in your own results, please leave a contact email address and tick the respective check box on the last page of the survey. To ensure that the most value is derived from your efforts, please complete the survey by close of business on Wednesday 8 May. We very much appreciate your efforts and would like to thank you in advance for your help.

Filling out the questionnaire will take you no more than 20 minutes. When you are finished, please *save the document* and send it back to performance.management@aci-europe.org.

Thank you very much for your participation and kind regards,

Swen Franken
Student Maastricht University

Dr. Lieven Quintens
Ass. Prof. Maastricht University

Donagh Cagney
Manager Economics, ACI Europe

Airport Performance Measurement Survey

1) Please fill in your airport code (IATA): ____

2) Your organization/airport is…

☐ privately owned ☐ publically owned ☐ partially private and governmental owned

3) Respondent background: What job function do you work in?

☐ Strategy ☐ Planning ☐ other:____

☐ Finance ☐ Operations

4) Is your airport a member of Airport Council International?

☐ Yes ☐ No ☐ Don´t know

5a) Does your airport know the "*Guide to Airport Performance Measures*" developed by ACI Airport Council International?

☐ Yes ☐ No

5b) If yes, your airport knows about ACI´s "*Guide to Airport Performance Measures*", do you use it?

☐ Yes ☐ No ☐ Don´t know

6a) Does your company use another performance measurement standard or guide?

☐ Yes ☐ No ☐ Don´t know

6b) If yes, which standard/guide are you using? ____

7) Does your airport use performance indicators for benchmarking purposes?

☐ Yes, external benchmarking ☐ Yes, internal benchmarking ☐ Yes, external & internal benchmarking ☐ No, no kind of benchmarking

8) Please indicate which performance indicators your airport monitors in each category **(A)**, rate how useful you perceive them **(B)** (on a scale from 1 to 5) and indicate your target value **(C)** inclusive the respective unit. If you use other indicators than the ones listed here, please mention them, too.
Individual definitions of the listed metrics can be found in the *Guide to Airport Performance Measures*.

A) Performance Indicator	**B) Usefulness**					**C) Target**
A. Core	**(1) Not useful**	**(2)**	**(3) Average**	**(4)**	**(5) Very useful**	**Target for 2013 + unit**
☐ No. of Passengers	☐	☐	☐	☐	☐	____
☐ O&D* Passengers	☐	☐	☐	☐	☐	____
☐ Aircraft Movement	☐	☐	☐	☐	☐	____
☐ Freight/Mail Loaded/Unloaded	☐	☐	☐	☐	☐	____
☐ Destinations, nonstop	☐	☐	☐	☐	☐	____
☐ other:_____	☐	☐	☐	☐	☐	____
☐ other:_____	☐	☐	☐	☐	☐	____
B. Safety and Security						
☐ Runway Incursions	☐	☐	☐	☐	☐	____
☐ Runway Accidents	☐	☐	☐	☐	☐	____
☐ Bird Strikes	☐	☐	☐	☐	☐	____
☐ Public Injuries	☐	☐	☐	☐	☐	____
☐ Occupational Injuries	☐	☐	☐	☐	☐	____
☐ other:_____	☐	☐	☐	☐	☐	____
☐ other:_____	☐	☐	☐	☐	☐	____
C. Service Quality						
☐ Practical Hourly Capacity	☐	☐	☐	☐	☐	____
☐ Gate Departure Delay	☐	☐	☐	☐	☐	____
☐ Taxi Departure Delay	☐	☐	☐	☐	☐	____
☐ Customer Satisfaction	☐	☐	☐	☐	☐	____
☐ Baggage Delivery Time	☐	☐	☐	☐	☐	____
☐ Security Control Clearing Time	☐	☐	☐	☐	☐	____
☐ Check-In to Gate Time	☐	☐	☐	☐	☐	____
☐ other:_____	☐	☐	☐	☐	☐	____
☐ other:_____	☐	☐	☐	☐	☐	____
D. Productivity & Cost Effectiveness						
☐ Passengers per Employee	☐	☐	☐	☐	☐	____
☐ Aircraft Movements per Employee	☐	☐	☐	☐	☐	____
☐ Total Cost per Passenger	☐	☐	☐	☐	☐	____
☐ Aircraft Movements per Gate	☐	☐	☐	☐	☐	____
☐ Total Cost per Movement	☐	☐	☐	☐	☐	____
☐ Total Cost per WLU**	☐	☐	☐	☐	☐	____
☐ Operating Cost per Passenger	☐	☐	☐	☐	☐	____
☐ Operating Cost per Movement	☐	☐	☐	☐	☐	____
☐ Operating Cost per WLU**	☐	☐	☐	☐	☐	____
☐ other:_____	☐	☐	☐	☐	☐	____
☐ other:_____	☐	☐	☐	☐	☐	____

Airport Performance Measurement Survey 2013 2

* **O&D:** Origin and Destination, direct flight between two airports
** **WLU:** Work Load Unit (1 passenger or 100kg of cargo)

E. Financial & Commercial	(1) Not useful	(2)	(3)	(4)	(5) Very useful	Target for 2013 + unit
☐ Aeronautical Revenue per Passenger	☐	☐	☐	☐	☐	____
☐ Aeronautical Revenue per Movement	☐	☐	☐	☐	☐	____
☐ Non-Aeronautial Operating Revenue as % of Total Operating Revenue	☐	☐	☐	☐	☐	____
☐ Non-Aeronautical Operating Revenue per Passenger	☐	☐	☐	☐	☐	____
☐ Debt Service as Percentage of Operating Revenue	☐	☐	☐	☐	☐	____
☐ Long-Term Debt per Passenger	☐	☐	☐	☐	☐	____
☐ Debt to EBITDA	☐	☐	☐	☐	☐	____
☐ EBITDA per Passenger	☐	☐	☐	☐	☐	____
☐ other:____	☐	☐	☐	☐	☐	____
☐ other:____	☐	☐	☐	☐	☐	____
F. Environmental						
☐ Carbon Footprint	☐	☐	☐	☐	☐	____
☐ Waste Recycling	☐	☐	☐	☐	☐	____
☐ Waste Reduction Percentage	☐	☐	☐	☐	☐	____
☐ Renewable Energy Purchased by the Airport (Percent)	☐	☐	☐	☐	☐	____
☐ Utilities/Energy Usage per Square	☐	☐	☐	☐	☐	____
☐ Water Consumption per Passenger	☐	☐	☐	☐	☐	____
☐ other:____	☐	☐	☐	☐	☐	____
☐ other:____	☐	☐	☐	☐	☐	____

9) What is your airports´ motivation to measure the metrics indicated above? (Multiple answer possible)

☐ Regulatory/legal requirement
☐ Benchmark purposes
☐ Improve performance
☐ Performance related payment
☐ other: ____

10) How do you choose the metrics? (Multiple answers possible)

☐ Strategic plan/vision
☐ Regulatory/legal requirement
☐ Comparisons with competitors / comparable airports
☐ Board/Senior Management driven
☐ Based on operational needs (bottom-up)
☐ Consumer demands (airline or passengers)
☐ Other: ____

11) How do you choose the targets? (Multiple answers possible)

☐ Strategic plan/vision
☐ Regulatory/legal requirement
☐ Comparisons with competitors / comparable airports
☐ Board/Senior Management driven
☐ Based on operational needs (bottom-up)
☐ Consumer demands (airline or passengers)
☐ Other: ____

12) How many resources are devoted to the performance measurement process (Core personnel devoted to ensuring metrics and targets exist and are disseminated around your organization)?

☐ <1 FTE ☐ 1 FTE ☐ 2-5 FTEs ☐ 6-10 FTEs ☐ 10 < FTEs

13) How is the information to inform the metrics gathered? (Multiple answers possible)

☐ ACI ASQ (Airport Service Quality)
☐ Internal surveys
☐ External surveys
☐ Internal Audits
☐ External Audits
☐ Equipment specifically designed to gather data (e.g. Bluetooth monitoring at security queues)
☐ Equipment which passively gathers data (e.g. system reporting from baggage system)
☐ Partner information (e.g. data from airlines, air traffic control, police, customes,)
☐ Other: ____

14) What approach (if any) do you use to ensure the organization is working towards these metrics/targets?

☐ Balanced scorecard approach
☐ Total Quality Management
☐ Value Based Management
☐ Activity Based Costing
☐ Quality Management Systems (e.g. ISO9000)
☐ Environmental Management System (e.g. ISO 14000)
☐ Other: ____
☐ None
☐ Don´t know.

15) Does your airport use continuous improvement when setting metrics and targets?

☐ Yes ☐ No

☐ Other (Please describe): ____

16) What is your own overall perception of the sophistication of the performance measurement system at your airport? On a scale of 1 to 5, please indicate as how advanced you perceive the system at your organization compared to other airports with respect to…

a) …the design of the system (e.g. number of metrics, data collection, etc.)?

Basic	Below Average	Average	Advanced	State-of-the-Art
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

b)… the outcomes of the system (e.g. support of management decisions etc.)?

Basic	Below Average	Average	Advanced	State-of-the-Art
☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

17) In which of the areas (A-F) mentioned in question 8 are you expecting the development of new performance indicators? (Multiple answers possible)

☐ A. Core
☐ B. Safety and Security
☐ C. Service Quality
☐ D. Productivity & Cost Effectiveness
☐ E. Financial & Commercial
☐ F. Environmental
☐ None of these areas
☐ Don´t know

18) In your opinion, what are the future trends in airport performance management (e.g. new metrics/indicators, need for research, business developments, etc.)? Please elaborate.

____

☐ Yes, I am interested in the results of my airport and would like to receive a short report.

Contact e-mail address: _____
Please, *save the file* and use the link to *send it to*: performance.management@aci-europe.org

Thank you very much for supporting this research.

Appendix 4: Participating Airports

Airport Name	Country	IATA Code	ICAO Code	Passengers 2011
LONDON HEATHROW airport	UK	LHR	EGLL	69,475,746
FRANKFURT/MAIN airport	Germany	Frau	EDDF	56,561,629
AMSTERDAM/SCHIPHOL airport	Netherlands	AMS	EHAM	49,838,392
ANTALYA Int. Airport (Fraport)	Turkey	AYT	LTAI	25,113,635
ZURICH airport	Switzerland	ZRH	LSZH	24,376,142
OSLO/GARDERMOEN airport	Norway	OSL	ENGM	21,109,086
STOCKHOLM/ARLANDA airport	Sweden	ARN	ESSA	19,097,851
BRUXELLES/NATIONAL airport	Belgium	BRU	EBBR	18,901,917
DUBLIN airport	Ireland	DUB	EIDW	18,758,105
HELSINKI-VANTAA airport	Finland	HEL	EFHK	14,891,185
ATHENS INTL (ELEFTHERIOS VENIZELOS) airport	Greece	ATH	LGAV	14,422,831
GENEVE airport	Switzerland	GVA	LSGG	13,048,960
BEN GURION AIRPORT Tel Aviv	Israel	TLV	LLBG	12,978,605
PRAHA/RUZYNE airport	Czech Republic	PRG	LKPR	11,780,323
PULKOVO airport Saint Petersburg	Russia	LED	ULLI	9,610,767
WARSZAWA/OKECIE airport	Poland	WAW	EPWA	9,352,979
BIRMINGHAM airport	UK	BHX	EGBB	8,622,832
LYON SAINT-EXUPERY airport	France	LYS	LFLL	8,556,699
BERGAMO/ORIO AL SERIO airport	Italy	BGY	LIME	8,423,238
BOLOGNA/BORGO PANIGALE airport	Italy	BLQ	LIPE	5,943,835
NAPOLI/CAPODICHINO airport	Italy	NAP	LIRN	5,784,798
IBIZA airport	Spain	IBZ	LEIB	5,626,908
NURNBERG airport	Germany	NUE	EDDN	3,979,304
TRONDHEIM/VAERNES airport	Norway	TRD	ENVA	3,914,943
SOFIA airport	Bulgaria	SOF	LBSF	3,469,633
KRAKOW/BALICE airport	Poland	KRK	EPKK	3,006,503
LONDON/CITY airport	UK	LCY	EGLC	2,941,864
CORK airport	Ireland	ORK	EICK	2,358,904
BURGAS airport	Bulgaria	BOJ	LBBG	2,243,108
BODO airport	Norway	BOO	ENBO	1,904,513
BRATISLAVA/IVANKA airport	Slovakia	BTS	LZIB	1,580,642
TRAPANI/BIRGI airport	Italy	TPS	LICT	1,470,024
LJUBLJANA JOZE PUCNIK airport	Slovenia	LJU	LJLJ	1,359,646
DUBROVNIK/CILIPI airport	Croatia	DBV	LDDU	1,356,036
VARNA airport	Bulgaria	VAR	LBWN	1,181,313
KRISTIANSAND/KJEVIK airport	Norway	KRS	ENCN	946,718
ALESUND/VIGRA airport	Norway	AES	ENAL	936,110
KAUNAS airport	Lithuania	KUN	EYKA	870,817
MEMMINGEN/ALLGAU airport	Germany	FMM	EDJA	756,016
TIVAT airport	Montenegro	TIV	LYTV	647,169
PODGORICA airport	Montenegro	TGD	LYPG	611,666
EVENES airport	Norway	EVE	ENEV	603,696
AARHUS airport	Denmark	AAR	EKAH	588,698
FRIEDRICHSHAFEN airport	Germany	FDH	EDNY	539,376
MAASTRICHT AACHEN airport	Netherlands	MST	EHBK	367,643
KIRKENES/HOYBUKTMOEN airport	Norway	KKN	ENKR	304,978
LIEGE/BIERSET airport	Belgium	LGG	EBLG	302,979
PARMA airport	Italy	PMF	LIMP	268,784
ANTWERPEN/DEURNE airport	Belgium	ANR	EBAW	115,339
ANCENIS Airport	France		LFFI	11,000
Total				**470,913,885**

Appendix 5: Geographical Coverage and Airports per Country

Country Perspective	Airports per country	% of Population	# Responses per Country	% of Responded Airports/Country	% of Sample
Albania	1	0.3%	0	0.0%	0.0%
Austria	6	1.8%	0	0.0%	0.0%
Belgium *	5	1.5%	3	60.0%	6.0%
Bulgaria *	3	0.9%	3	100.0%	6.0%
Croatia	5	1.5%	1	20.0%	2.0%
Cyprus	1	0.3%	0	0.0%	0.0%
France **	3	0.9%	1	33.3%	2.0%
Denmark	6	1.8%	1	16.7%	2.0%
Estonia	1	0.3%	0	0.0%	0.0%
Finland	10	3.0%	1	10.0%	2.0%
France	50	14.8%	2	4.0%	4.0%
Germany	27	8.0%	4	14.8%	8.0%
Greece	23	6.8%	1	4.3%	2.0%
Hungary	1	0.3%	0	0.0%	0.0%
Iceland	1	0.3%	0	0.0%	0.0%
Ireland	4	1.2%	2	50.0%	4.0%
Israel	1	0.3%	1	100.0%	2.0%
Italy	34	10.1%	5	14.7%	10.0%
Latvia	1	0.3%	0	0.0%	0.0%
Lithuania	3	0.9%	1	33.3%	2.0%
Luxemburg	1	0.3%	0	0.0%	0.0%
Malta	1	0.3%	0	0.0%	0.0%
Montenegro	2	0.6%	2	100.0%	4.0%
Netherlands	5	1.5%	2	40.0%	4.0%
Norway *	18	5.3%	7	38.9%	14.0%
Poland	10	3.0%	2	20.0%	4.0%
Portugal	8	2.4%	0	0.0%	0.0%
Romania	7	2.1%	0	0.0%	0.0%
Russia	3	0.9%	1	33.3%	2.0%
Slovakia	2	0.6%	1	50.0%	2.0%
Slovenia	1	0.3%	1	100.0%	2.0%
Spain **	34	10.1%	1	2.9%	2.0%
Sweden	19	5.6%	1	5.3%	2.0%
Switzerland	4	1.2%	2	50.0%	4.0%
Turkey	2	0.6%	1	50.0%	2.0%
UK**	35	10.4%	3	8.6%	6.0%
TOTAL	**338**	**100.0%**	**50**	**14.8%**	**100.0%**

Comment: Comparing the columns “% of Population” with “% of Sample” indicates, whether a certain country is over- or under-represented within this study. In the table above, the largest deviations are marked in the following way:

- * = over-represented
- ** = under-represented

Appendix 6: Usage & Usefulness of all KPI´s in the Guide

A) Core	Times Used	% (Total Airports)	Avg. Usefulness
No. Of Passengers	50	100.0%	4.76
O&D pax	39	78.0%	4.41
aircraft movements	50	100.0%	4.62
Freight/Mail loaded/Unloaded	38	76.0%	4.00
Destinations. nonstop	41	82.0%	4.07
other	9	18.0%	4.22
other	3	6.0%	4.67
B) S & S			
Runway Incursions	47	94.0%	4.62
Runway Accidents	44	88.0%	4.55
Bird Strikes	47	94.0%	4.62
Public Injuries	35	70.0%	4.20
Occupational Injuries	40	80.0%	4.38
Other	12	24.0%	4.42
Other	6	12.0%	4.67
C) Service Q.			
Practical Hr. Cap.	31	62.0%	4.26
Gate Dep. Delay	33	66.0%	4.06
Taxi Dep. Delay	23	46.0%	3.78
Customer Satisfaction	42	84.0%	4.69
Baggage Delivery T.	38	76.0%	4.32
Security Contr. Cl. T.	36	72.0%	4.42
Check-In to Gate T.	23	46.0%	4.26
Other	12	24.0%	4.83
Other	8	16.0%	4.75
D) Productivity			
Passengers p. Employee	35	70.0%	4.11
AC Movements p. E.	27	54.0%	3.74
TC p. Pax	36	72.0%	4.33
AC Movements p. Gate	25	50.0%	3.40
TC p. Movement	30	60.0%	4.13
TC per WLU	20	40.0%	3.60
OC per pax	36	72.0%	4.36
OC per Movement	29	58.0%	4.00
OC per WLU	22	44.0%	3.59
Other	5	10.0%	4.40
Other	2	4.0%	4.50
E) Financial & C			
AR per Pax	40	80.0%	4.45
AR per Movement	29	58.0%	4.00
Non-AOR as % of TOR	36	72.0%	4.42
Non-AOR per Pax	37	74.0%	4.68
Debt Service as % of OR	15	30.0%	3.67
Long-term debt p.Pax	14	28.0%	2.79
Debt to EBITDA	21	42.0%	3.81
EBITDA p. Pax	25	50.0%	4.08
Other	12	24.0%	4.25
Other	6	12.0%	4.17
F) Environment			
Carbon Footprint	27	54.0%	4.15
Waste Recycling *	32	64.0%	3.94*
Waste Reduction % *	27	54.0%	3.96*
Renewable Energy. Purchased	23	46.0%	3.52
Ut./En. use per m2	22	44.0%	4.05
Water con. p. Pax	24	48.0%	3.54
Other	8	16.0%	4.63
Other	3	6.0%	4.67

Comment: Indicators marked in orange scored below “4” and show room for improvement.
* values scored so close to 4 that they can be regarded as useful too

Appendix 7: Other Statistics

Q10) How do you choose the metrics	# of Airports	Strategic plan/vision	Regulatory/ legal requirement	Comparisons with competitors	Board/ Senior Management driven	Based on operational needs	Consumer demands	Other
Group 1	4	100.0%	75.0%	25.0%	75.0%	100.0%	50.0%	0.0%
Group 2	10	80.0%	70.0%	70.0%	80.0%	70.0%	40.0%	0.0%
Group 3	8	87.5%	75.0%	62.5%	37.5%	12.5%	37.5%	0.0%
Group 4	13	76.9%	38.5%	61.5%	76.9%	69.2%	46.2%	0.0%
Group 5	9	44.4%	22.2%	33.3%	22.2%	11.1%	11.1%	0.0%
Group 6	6	33.3%	0.0%	33.3%	16.7%	33.3%	16.7%	0.0%
Total	**50**	**72.0%**	**46.0%**	**52.0%**	**54.0%**	**48.0%**	**34.0%**	**0.0%**

Q7) Benchmarking activity	# of Airports	External B.	Internal B.	Both	No Benchmarking
Group 1	4	50.0%	25.0%	25.0%	0.0%
Group 2	10	10.0%	10.0%	80.0%	0.0%
Group 3	8	0.0%	25.0%	75.0%	0.0%
Group 4	13	23.1%	0.0%	61.5%	15.4%
Group 5	9	11.1%	33.3%	33.3%	22.2%
Group 6	6	0.0%	33.3%	50.0%	16.7%
Total	**50**	**14.0%**	**18.0%**	**58.0%**	**10.0%**

Test for Multicollinearity

No.	Dependent V.	Independent V.	adj. R-square	VIF
1)	Airport Size	2,3	0,010	1,01010101
2)	Ownership	1,3	-0,016	0,984251969
3)	ACI Membership	1,2	0,033	1,034126163
4)	Guide Knowledge	5,6	0,648	2,840909091
5)	Guide Usage	4,6	0,647	2,83286119
6)	Other Standards	4,5	-0,012	0,988142292
7)	Benchmarking Activity	8,9,10,11	-0,023	0,977517107
8)	FTE´s	7,9,10,11	0,260	1,351351351
9)	Continouus Improvement	7,8,10,11	0,151	1,177856302
10)	Self Perception (Design)	7,8,9,11	0,655	2,898550725
11)	Self Perception (Outcome)	7,8,9,10	0,660	2,941176471
	Airport Size	All Variables	0,426	1,742160279

Appendix 8: Additional metrics proposed by participants

A) Core

- 3x Seat load factor
- 2x No. of transfer passengers
- Landings in tons of MTOW
- Punctuality
- Airport throughput
- No. of baggage
- Fuel delivery

B) **Safety & Security**

- 3x FOD (Foreign Object Damage)
- 2x Airside safety incidents
- Ramp incidents
- Runway overhaul fulfillment
- Apron accidents
- CAT A Safety
- CAT A Security
- Emergencies
- Incidents with/without damage to aircraft
- Alert on aeronautical events
- Collision aircraft and vehicles
- Vehicle accident apron
- Disturbance of aircraft movements

C) **Service Quality**

- 2x Cleanliness & comfort of facilities
- 2 x ASQ Ranking (Airport Service Quality)
- 2x Border control clearing time
- 2x Check-In queuing waiting time
- IRR rate
- Length of passport control Arr-Dep
- Visa control time
- Docking satisfaction
- Delayed flights
- EU vs. Non-EU passenger split
- Way finding and FIDS
- Airline Satisfaction
- Take-Off- Punctuality
- Baggage misconnect rate
- Cancelled flights/ No. of total aircrafts
- No. & type of complaints
- Customer feedback

D) **Productivity & Cost**

- 2x Personnel costs as % of operating revenue
- Operating cost per bag
- Staff absence rate
- Added value per employee
- Passengers per hours of work at check-in
- Movements per hour of work (airside ramp agent)

E) **Financial & Commercial**

- 2x EBIT per passenger
- Duty free revenue per pax
- Food & beverage revenue per pax
- Personnel costs per FTE
- EBITDA margin
- Sales/spending per pax
- EBIT per flight movement
- Airside retail participation
- EBIT/DEBT Service
- EBIT per passenger
- Non-aeronautical revenue per square meter
- Utilization of parking space
- Ratio: EBITDA/Revenues
- RATIO: DEBT/EBITDA

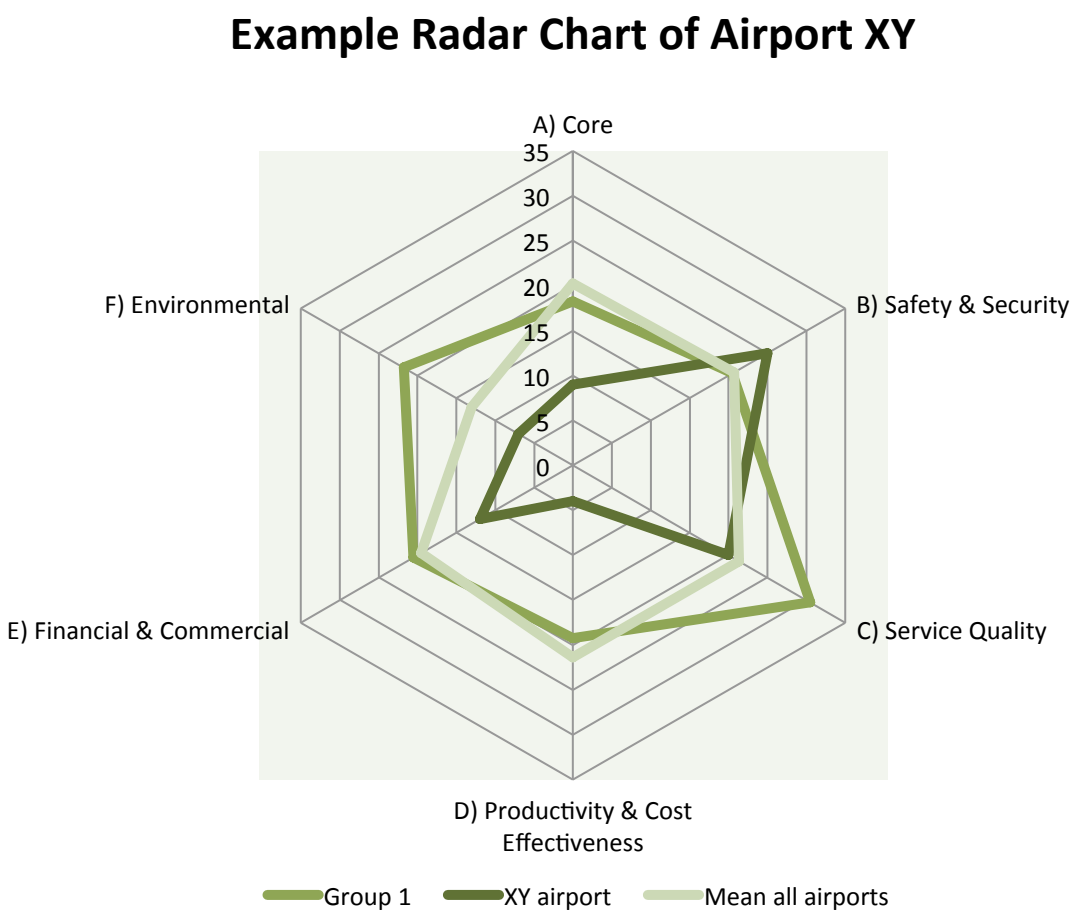
F) Environment

- 2x Aircraft noise measuring system
- 2x Public transport share (passengers & staff)
- ISO 140001 certification
- C02 emissions
- Energy used per cube meter
- N0x emissions
- Waste water quality
- Usage of runway de-icing agents

Appendix 9: Short airport profiles

	Performance Measurement					ACI Guide			
	Ø passengers	ownership	benchmarking	FTE´s	self perception	other standards	knowledge	Ø TPMS	focus dimension
Group 1	41.959.877	full or partial privatization	External & Internal	10+	Advanced	yes	100,0%	130.75	Service & Environment
	Comments:	-strong focus on internal standards, adopt metrics according to their individual needs, focus on customer service to differentiate from competitors				-strong commercial and business orientation, all airports are aware of the ACI guide, but not all use it			
Group 2	17.258.786	public	External & Internal	2 to 5	Average/Advanced	No	70,0%	136.1	Core & Service
	Comments:	-highest TPMS scores of all groups, guides suits their needs, knowledge about guide is high, but lower than for group 1							
Group 3	7.121.711	partial & public	External & Internal	2 to 5	Average	Yes	62.5%	120.75	none
	Comments:	-average PMS scores for all dimensions, guide suits their needs as they pick only the necessary KPI´s of each dimension							
Group 4	2.343.982	public	External & Internal	2 to 5	Average	Yes	61.5%	133.69	Productivity & Financial
	Comments:	-unexpected high TPMS values, 2nd largest group (108 airports), indicating increased competition among airports of this size				-strong focus on productivity and striving for additional sources of income			
Group 5	756.476	public	External & Internal	>1	Basic/below average	No	66.7%	88.67	none
	Comments:	- more liekly to be non-member of ACI; score below average on all performance dimensions, guide suits their need only partial				-increased complexit and costs are hurdles to engage in more sophisticated Pm activities			
Group 6	253.813	public	External & Internal	>1 to 5	Basic/below average	No	16.7%	71.50	none
	Comments:	-more likely to be non-member of ACI and low knowledge about ACI guide - score below average on all performance dimensions, guide suits their need only partial				-increased complexit and costs are hurdles to engage in more sophisticated PM activities			

Appendix 10: Example radar chart for performance measurement benchmark tool



Comment: The axes show PMS values for each performance dimension.