ISSN: 2941-198X
JATRS
Journal of the Air Transport Research Society Volume 1, Issue 1, June 2023

Airport Performance – a multifarious review of literature

Chunyan Yu[1]

[1]*David B. O'Maley College of Business, Embry-Riddle Aeronautical University, Daytona Beach, FL, USA*

Abstract: This paper reviews literature covering three broad categories of airport performance: productivity and efficiency, financial performance, and service quality and passenger satisfaction. Data Envelopment Analysis (DEA) has become the overwhelmingly dominant method for airport productivity and efficiency studies, in large part due to the lack of publicly accessible data. The effects of ownership and regulations on airport efficiency appear to be of the most interest to researchers. However, sustainability has increasingly become one of the top priorities for many airports, thus we start to see more research incorporate environmental factors in evaluating airport productivity and efficiency. In contrast to the vast volume of literature on airport productivity and efficiency, published works on airport financial performance are scarce with most simply comparing various ratios reflecting unit revenues, unit cost and some forms of profitability, which indicates an indisputable need for more research in the area. There has been a rapid growth in literature on airport service quality over the last decade, mostly focusing on examining drivers for passenger satisfaction. Advancements in data mining and text mining techniques have led to increasing use of user generated contents from web-based platforms instead of traditional questionnaire surveys as data sources by studies of airport service quality and passenger satisfaction.
Keywords: *Airport performance;Efficiency;Productivity;Financial performance;Airport service quality;Passenger satisfaction;Literature review*
Citation: *Yu, C. (2023). Airport Performance – a multifarious review of literature. Journal of the Air Transport Research Society 1(1): 22-39*
DOI: https://dx.doi.org/10.59521/E7E8098D7A835864

1. Introduction

Every flight starts and ends at an airport. As critical infrastructure, airports are essential for the success of the aviation industry. Airports were traditionally owned and operated by government entities, but there has been a worldwide trend of airports being privatized and/or commercialized since the mid-1980s. As airports continue to evolve from public utilities to commercially oriented business entities, studies on airport performance have flourished and resulted in a broad range of literature reflecting diverse interests by academic researchers, industry analysts and practitioners, investors as well as policy makers. These studies can be classified into three general categories: productivity and efficiency, financial performance, and service quality and customer satisfaction. The academic research on airport performance tend to focus on productivity and efficiency, applying various methodologies to different groups of airports, as evidenced by multiple survey articles on the topic over the last two decades including Graham (2005), Merkert et al. (2012), Liebert and Niemeier (2013), Iyer and Jain (2019), See et al. (2023), and Adler and Kumar (2023). While investors and airport managers are understandably more interested in financial performance, published academic works on airport financial performance have been relatively scarce. In the meantime, there has been a growing volume of works on airport service quality and customer satisfaction.

This paper aims to provide a multifarious review of literature on airport performance including productivity and efficiency, financial performance and service quality. Specifically, the review consists of three parts. The first part discusses the evolution of literature on airport productivity and efficiency. Since there have been several well received survey articles on this topic, the discussions will be drawn mostly through a perusal of these survey articles with respects to research methodologies, empirical findings on various issues, and challenges researchers have encountered. The second part of the review is about airport financial performance. As pointed out by Raghavan and Yu (2021), rapid growth of airline industry and the intense competition among airlines have created tremendous challenges for airports to meet the growing demand for significant infrastructure expansion and improvement with limited ability to increase aeronautical charges. Therefore, financial viability and strength are imperative for airports to be successful, especially in light of the devasting impacts of the COVID-19 pandemic on airlines and airports. This paper reviews different financial performance metrics that have been used to measure airport financial performance, and discusses their applicability to airports under various ownership and government forms. Complications in financial performance analysis arising from the increasing presence of global airport operators are also discussed. Finally, the third part examines the airport service quality and customer satisfaction. Studies in this area transcend multiple disciplines. The paper reviews various methodologies used and attempts to provide an interpretative overview of the empirical results.

This paper contributes to the literature by providing a synthesis of existent surveys of the literature on airport productivity and efficiency, and offers interpretative reviews of the literature on airport financial performance and airport service quality and passenger satisfaction.

2. Airport Productivity and Efficiency

Productivity is defined as the ratio of output to input. It would be easy and straightforward to measure and compare productivity if a firm produces one output from one input. When multiple inputs are employed to produce multiple outputs, it becomes necessary to aggregate the outputs and inputs. Consequently, different methodologies have been developed to measure and compare productivity in the presence of multiple inputs and multiple outputs, especially when these outputs and inputs are measured in different units. *Productivity* itself does not tell how well (efficiently) a firm performs without having best practice as reference point. *Efficiency* measures how well a firm performs relative to the best practice or the most output obtainable from a given input level with the given production technology.

2.1. Inputs and Outputs

One of the critical elements of productivity and efficiency analysis is to identify and define inputs and outputs. Given the complex nature of airport business, definition and quantification of consistent and comparable inputs and outputs are not a simple task, especially for comparisons between airports. The fundamental difficulties associated with inter-airport comparison arise largely from the diversity of inputs and outputs (Graham, 2005), and from the fact that some of the inputs are often supplied by different stakeholders at various degrees. Nevertheless, as noted by Liebert and Niemeier (2013), there has been a broad census among the studies on airport productivity and efficiency that “capital, labour, materials and other external services” are generally considered as inputs, whereas “traffic volume and selling non-aeronautical products” are considered as outputs. Both physical and monetary measures of inputs and outputs have been used, mostly depending on data availability. Liebert and Niemeier (2013) provide a comprehensive list of inputs and outputs. For example, number of employees and staff cost have been used as labor inputs; airport area, number of gates, runway area, and capital stock or capital value have been used as capital inputs. Liebert and Niemeier (2013) divide outputs into desirable outputs versus undesirable outputs. Number of passengers, aircraft movements, work load units (WLU), aeronautical revenues, and non-aeronautical revenues are considered as desirable outputs, whereas delays and noise are considered as un-desirable outputs.

There are a number of issues with airport input and output measures, albeit these issues are often due to lack of consistent data. On the output side, number of passengers and aircraft movements[1] are generally accepted as airport output measures with little disagreements other than aircraft movements not differentiating between different aircraft size (Graham, 2005). On the other hand, not all the studies include freight or cargo tonnage as an airport output as some argue that freight/cargo is generally handled by airlines or 3rd party handling companies, not airport operators (Graham, 2005). Workload unit (WLU) originated from airlines. Although WLU has been commonly used as an overall airport output measure, its pertinence has been questioned (Humphreys and Francis, 2000). One of the main criticisms is that it is computed using an arbitrary method to combine passengers and cargo (Hooper and Hensher, 1997). It is interesting to note that Graham (2005) states that WLU is “the most popular measure” of outputs, as many of the earlier academic studies and industry reports reviewed by Graham (2005) use partial productivity measures that often include WLU as an aggregate output. Less than 8 years later, many of the studies reviewed by Liebert and Niemeier (2013) employ methodologies that can incorporate multiple inputs and multiple outputs to estimate overall productivity or efficiency, thus do not use WLU as output.

The direct use of monetary value (various revenue values) as outputs are problematic, as revenue values are affected by “output prices” that are affected by the local overall price level, regulatory policy, nature of air transport traffic, competition with other airports, and market power of airlines serving the airport. An acceptable way to use revenues as outputs is to deflate revenues to form an output quantity index as argued by Hooper and Hensher (1997) and Oum et al. (2003). This issue is not discussed in any of the survey articles. Non-aeronautical revenue is discussed in the context of revenue generation indicators in Graham (2005), but is considered as an output measure in Liebert and Niemeier (2013), which reflects the changes in how researchers view the production process of airports with the increasing importance of non-aeronautical revenues for airports.

Another noticeable difference between Liebert and Niemeier (2013) and Graham (2005) with respect to outputs is the emergence of “Undesirable or negative output” that formally recognizes the fact that airport production process yields side products in the form of delays, noise and pollution that are not desirable. Liebert and Niemeier (2013) include three studies that incorporate delays and noise as undesirable or negative outputs in their review. Since then, there have been a few

[1] Aircraft movements are also referred to as air transport movements or airport operations, representing the number of takeoffs and landings at an airport.

more studies that consider undesirable or negative outputs including Fan etl al. (2013), Lozano, et al. (2013), Martini et al (2013), Scotti, et al. (2014), Zou et al (2015), Shamohammadi et al (2022), etc., reflecting the increasing awareness of airports' impacts on the environment, as noted by See et al. (2023) in their bibliometric analysis of airport productivity and efficiency studies over the last two decades.

The complexity of airport output measures is nothing compared to the intricacy of inputs. Airports are composed of a tangled collection of immense infrastructure, costly facilities and myriad equipment built and operated by various stakeholders including airport operators, airlines, and others. Number of employees as a commonly used labor input measure may seem to be a straightforward measure, it is not always comparable between airports as pointed by Liebert and Niemeier (2013). First, the number of employees often does not distinguish between full time and part-time employees or between annual average and end of year. Second, the operational responsibilities of airport operators vary greatly from airport to airport, thus the number of employees may bias the performance results (Tretheway, 1995). For example, some European and Asian airports provide employee extensive ground handling services whereas airport operators in North America generally are not involved in ground handling. Adjustment is needed to make the numbers comparable. The use of staff costs as labor input is subject to similar problems as those when revenues are used as outputs as they do not account for the differences in labor prices as well as differences in accounting systems.

Airports are capital intensive business, thus capital inputs are very important in evaluating airport productivity and efficiency. Ideally, capital input measures should reflect the opportunity costs of the capital inputs consumed in the relevant period. However, it is difficult, if not impossible, to construct consistently comparable measures of capital inputs, as airports have very different ownership and governance structures with respect to the funding (and accounting) and operations of infrastructure and facilities. Most studies use some physical measures as capital inputs, such as number of gates, terminal area, number of runways. Fansone and Zapata-Aguirre (2016) review 60 peer-reviewed published articles on airport performance using DEA, 46 of these studies use physical measures as capital inputs. The main problem with using physical capital input measures is that these physical capital inputs (such as airport area, runway length, number of gates) are generally "fixed" in the short and medium term, but few studies distinguish between fixed and variable inputs when performance analysis is conducted based on annual or quarterly data. Moreover, the fact that airlines or other stakeholders may have invested and operate some of the facilities are not considered, such as Lufthansa's role as both investor and operator of Terminal 2 at Munich Airport. Because of the difficulties of constructing meaningful capital input measures, and the fact that airports make managerial and operational decisions within the given state of their infrastructure and facilities in the short and medium term, Oum and Yu (2004) argue for the use of variable factor productivity instead of total factor productivity. There are some studies, such as Hooper and Hensher (1997), Parker (1999), Martin and Roman (2001), Curi et al. (2010), Coto-Millan et al. (2014), that use capital stock or invested capital as capital inputs. It is noted that these studies include only airports located in the same country.

A notable omission in most of the studies that use physical capital input measures is non-labor non-capital expenses (such as materials, utilities, outsourcing, etc) airports employ (Fansone and Zapata-Aguirre, 2016). Such omission could potentially bias the performance results significantly as these expenses account for 23.7% ~ 94.7% of airports' non-capital expenses in 2019 (ATRS, 2021). Oum et al. (2003) construct a soft cost input index to account for the non-labor non-capital expenses as the second variable input.

2.2. Methodologies for measuring airport productivity and efficiency

2.2.1. Partial Performance Measures

Airports, trade associations and industry analyst reports make extensive use of various partial performance measures or key performance indicators (KPIs) as discussed by Graham (2005) and Merket et al. (2012). In fact, Airport Council International (ACI) has published a guide for airport managers to assess airport performance in six key performance areas (ACI, 2012). The U.S. Federal Aviation Administration (FAA) sponsored Airport Cooperative Research Program (ACRP) have published three guidebooks associated with airport performance measurements (ACRP, 2010; ACRP, 2011; ACRP. 2018). These guidebooks provide comprehensive lists of performance metrics for different performance areas including productivity and efficiency. Merket et al (2012) provide a list of partial airport performance indicators compiled from both academic articles and industry reports. These partial performance measures are easy to compute and intuitively easy to understand and interpret. Partial productivity measures relate an airport's output to a single input, and can be misleading when being used alone. For example, airports that outsource certain activities may appear to have lower labor productivity when compared to airports that do everything in house, as labor productivity in insolation does not reflect the expenses airports pay to the contractors. This limitation is discussed by Graham (2005), Liebert and Niemeier (2013), and Merket et al. (2012).

2.2.2. Index Number Method – Total Factor Productivity

Total factor productivity (TFP) uses pre-determined sets of weights, generally revenue shares and expenses shares, to aggregate outputs and inputs, and the ratio of aggregated outputs over aggregated inputs is then considered as an overall productivity measure of airports. TFP is essentially the weighted average of partial factor productivities of all inputs airports use. A commonly accepted way to aggregate outputs and inputs is the translog multilateral index procedure[2] developed by Caves et al. (1982). This translog multilateral index procedure allows researchers to compute a consistent output (input) index that provides a consistent comparison across firms and over time within a firm. The typical inputs (or outputs) aggregation formula can be specified as follows:

$$Ln\ Z_k - Ln\ Z_j = \sum_i \frac{R_{ik} + \overline{R_i}}{2} \ln \frac{Z_{ik}}{\widetilde{Z}_i} - \sum_i \frac{R_{ij} + \overline{R_i}}{2} \ln \frac{Z_{ij}}{\widetilde{Z}_i} \ (1)$$

where Z_k is the aggregate index of input (or output) for kth observation, Z_{ik} is ith input (output) for kth observation, the R_{ik} are weights, a bar over a variable indicates the arithmetic mean and a tilde over a variable indicates the geometric mean. Revenue shares are often used as the weights in output aggregation (with the assumption of constant returns to scale), while cost shares are used as weights in input aggregation. Each observation represents a specific firm at a particular time. This procedure allows transitive comparisons across all observations (across firms and over time within a firm) via a series of binary comparisons between each observation and the means of the data.

Merket et al. (2012) and Liebert and Niemeier (2013) review a number of studies that measure airports' total factor productivity using the multilateral index procedure, including Hooper and Hensher (1997), Nyshadham and Rao (2000), Martin-Cejas (2002), Vasigh and Gorjidooz (2006), Oum and Yu (2003). Researchers typically augment TFP with a second stage regression analysis to examine the factors that influence the observed or gross TFP and to estimate airport efficiency. TFP requires detailed revenues and cost data in addition to the quantifiable inputs and outputs. Access to detailed and comparable airport financial and operational data is often limited, as a result, application of the TFP method to measure airport productivity may not always be possible. With the advancement of other methods that have less data requirements, particularly Data Envelopment Analysis (DEA), TFP has not been widely applied to measure airport performance.

2.2.3. Non-Parametric Method – Data Envelopment Analysis (DEA)

In their bibliometric analysis of literature on airport productivity and efficiency during the 1999-2019 period, See et al. (2023) note that DEA has been the most commonly used method to measure airport productivity and efficiency. Data Envelopment Analysis (DEA) is a non-parametric method developed by Charnes, Cooper and Rhoades (1978) to measure productive efficiency of "decision making units" (DMUs) with multiple inputs and multiple outputs. DEA utilizes a sequence of linear programs, one for each DMU, to construct a piecewise linear production frontier, and to compute an efficiency index relative to the frontier. Observations (DMUs) that lie on the production frontier are deemed efficient, and those not on the frontier are considered as inefficient. The relative efficiency level of each observation is measured by its distance to the production frontier, and is essentially the ratio of the total weighted output to the total weighted input. The weights are determined by linear programming optimization. DEA allows each DMU to select the weights that maximize its own efficiency score. Generally, DMUs will place higher weights on the inputs that they use the least and on the outputs they produce the most. In this sense DEA shows each DMU in its best possible light. A score of 1 indicates that the DMU is efficient relative to other DMUs in the sample, and a value less than l indicates a DMU being inefficient. The original DEA model, often referred to as CCR model, assumes constant returns to scale and is either input-oriented or output-oriented. The input-oriented DEA model attempts to minimize inputs for given level of output, while output-oriented DEA model attempts to maximize output for given level of input. Since various DEA models are now well documented and widely applied to different industries, this section focuses on discussions of DEA's applications to the airport industry and not the methodology itself.

While Graham (2005), Merket et al. (2012) and Liebert and Niemeier (2013) review airport performance studies using different methodologies, Lyer and Jain (2019) and Fasone and Zapata-Aquirre (2015) focus on studies apply DEA to airport efficiency because of its popularity. In particular, Fasone and Zapata-Aquirre (2015) review 60 articles published between 1997 and July 2014, and Lyer and Jain (2019) review 61 articles published during the 2009 – 2017 period. Both reviews note that most of the studies analyzes airports in a single country, i.e., 48 out of the 60 articles reviewed by Fasone and Zaparta-Aquirre (2015) and 38 out of the 61 articles reviewed by Lyer and Jain (2019). Furthermore, Lyer and Jain (2019) point out that the published studies on airport efficiency are mostly based on large airports with little attention to small, regional airports, and based on airports in high-income and upper-middle income countries, which highlights the lack of airport data in lower middle-income and low-income countries. Lyer and Jain (2019) find that nearly half of the studies use output-oriented DEA due to the fact that inputs such as runways and terminal area cannot be minimized. Most of the studies use both constant returns to scale (CRS) and variable returns to scale (VRS) DEA models. Although the studies generally find that airports exhibit returns to scale, there is no consensus with respects to whether airports have increasing or decreasing returns to scale. They note four general themes among the studies. The most prevalent theme is the explanation of variation in airport efficiency through exogenous factors. The second theme is the examination of the change in airport efficiency over time. The other two themes are the application of network DEA to decompose efficiency into intermediate level and final, and the comparison with other methods. Examination of the factors that influence airport efficiency or

[2]There are a number of other index procedures used to measure productivity growth such as Fisher Ideal Index (Ray and Mukherjee, 1996).

drivers of efficiency is generally done through a second stage Tobit regression or Simar and Wilson bootstrapping regression (Fasone and Zparta-Aquirre, 2015). The empirical findings from the studies are discussed later in a different section.

Liebert and Niemeier (2013) and See et al. (2023) observe that a growing number of airport efficiency studies have applied various DEA extensions and derivatives to improve the discriminatory power of efficiency estimates and to decompose the efficiency at different stages of production process. For example, Barros and Dieke (2007) apply cross-efficiency DEA model and Super-Efficiency DEA model to measure financial and operational performance of 31 Italian airports during the 2001-2003 period. Lozano et al. (2013) develop a directional distance function (DDF) network DEA model and apply it to data for 39 Spanish airports in 2008. The model distinguishes airport operation into two process, movement of aircraft, and loading (and unloading) of passengers and cargo, and considers aircraft movement as an intermediate product that is an input in the second stage. Their model also includes two undesirable outputs associated with flight delays in the first stage. Wanke, et al. (2016) assess the productive efficiency of 30 Nigerian airports over the 2003-2013 period using Fuzzy-DEA that allow them to capture vagueness in input and output variables. Wang and Song (2020) apply network DEA to actual and forecasted data of 12 airports (8 Chinese and 4 other Asian airports) to evaluate operational efficiency (with passengers, cargo and aircraft movements at intermediate outputs) and financial efficiency (with total revenue and net income as outputs). Yu and Rakshit (2023) develop a so-called union dynamic network DEA model to analyze the dynamic efficiency and changes of technology gap of 50 European airports during the 2011-2017 period.

2.2.4. Index Number Method – Malmquist Productivity Index

The Malmquist productivity index was first introduced by Caves, Christensen and Diewert (1982), and is based on the concept of a distance function introduced by Malmquist (1953). It measures the productivity change of a decision-making unit (DMU) over time, and attributes the productivity change to change in efficiency and technical change. An improvement in efficiency can occur when inputs are reduced to produce a given level of outputs under given production technology (input oriented), or outputs are increased with a given level of inputs under the same technology (output oriented). Technical change can enhance productivity if new technology leads to less inputs needed to produce a given level of outputs. The Malmquist productivity index is often applied in association with Data Envelopment Analysis, with DEA identifying the efficient frontier in each period. Murillo-Melchor (1999) estimates both efficiency and productivity changes of Spanish Airports over the 1992-1994 period using DEA and Malmquist Index. Other studies apply DEA-Malmquist include Gillen and Lall (2001), Fung et al. (2008), Barros et al, (2010), De Nicola and Gitto (2013), Ahn and Min (2014), Orkcu et al. (2016), Fernandes, et al. (2019), Fragoudaki and Giokas (2020), Thomas and Jha (2022), and Chutiphongdech and Vongsaroj (2022).

2.2.5. Parametric Method – Stochastic Frontier Analysis (SFA)

The **parametric methods** generally involve the estimation of a production or cost function. The estimated production or cost function is then used to identify changes in productivity or efficiency. A time trend variable is commonly included in the production function, and the derivative of the estimated production function with respect to the time trend is used to measure the rate of technical progress that in turn indicates the rate of productivity growth. In the presence of multiple outputs, many studies estimate cost functions instead of production functions to avoid endogeneity issues that often characterize production function estimations.

Conventional econometric estimation of production and cost functions implicitly assumes that all firms are on the efficient frontier. ***Frontier production or cost functions***, on the other hand, recognize that some firms may not be on the efficient frontier, thus a firm's efficiency is measured based on its location relative to the frontier. Aigner and Chu (1968) made the first attempt to impose a parametric functional form on the production frontier within the framework provided by Farrell. In estimating the frontier production function, they force all observations to be on or beneath the frontier through the introduction of a one-sided error term. Afriat (1972) was the first to impose a statistical assumption on the one-sided errors, and to introduce the concept of "distribution of technical inefficiency", which makes statistical estimation of frontier functions possible. Within the frontier function frame, a distinction is made between two different methods: the *deterministic frontier method* and the *stochastic frontier method*. The main difference between the two methods is that the deterministic method attributes all deviations from the frontier to inefficiency while the stochastic method distinguishes the deviations into a random component capturing statistical noise and an inefficiency component. The stochastic frontier method was introduced by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). See et al. (2023) state that 23 out of the 88 articles on airport efficiency included in their analysis use stochastic frontier analysis method. Liebert and Niemeier (2013) provide a good review of the various approaches used to estimate stochastic frontiers in airport productivity and efficiency studies. They note that studies in the early 2000s tend to estimate production frontiers with physical inputs reflecting airport infrastructure, such as number of gates and terminal size. In late 2000s, however, studies often estimate cost frontiers to assess cost-efficiency. They further note that translog functions are generally preferred over Cobb-Douglas function to allow more flexibility. Exogenous factors are considered either as impacting the production technology or the inefficiency. Lin, et al. (2013) compare airport operating efficiency estimates derived from variable factor productivity (VFP), DEA and SFA based on the data for 62 major Canadian and US airports. They find that the airport efficiency rankings for both the top 15 and the bottom 15 airports are largely consistent across the three alternative methods, while significant differences exist in the mid-ranked airports. They further note that the differences are more significant between the DEA efficiency rankings and those from the other two methods.

The main issue with estimating cost functions is that it requires data on input prices that are not always readily available. Nevertheless, SFA has remained as the 2nd most commonly used method to measure and compare airport efficiency. Examples of studies applying SFA include Pels, et al. (2001), Oum, et al. (2008), Chow and Fung (2009), Martin et al. (2009), Assaf (2010), Diana (2010), Scotti et al. (2012), Kutlu and McCarthy (2016), Chen and Lai (2019), Hidalgo-Gallego and Mateo-Mantecón (2019), Gianmaria et al. (2020), Karanki and Lim (2021), and Adachi (2023).

2.3. Selected Applications of Airport Productivity and Efficiency Studies

Airport productivity and efficiency are affected by a wide range of factors, including airport size, location, ownership, regulatory environment, governance, competition, and policies/practices. It is imperative to better understand the relative importance of these factors and to identify strategies for improving airport productivity and efficiency, and to provide useful insights for airport managers, policymakers, and researchers seeking to improve airport operations and performance.

2.3.1. The Effects of Ownership on Airport Efficiency

It is not surprising to note that ownership had been the most commonly studied influential factor for airport efficiency (Lyer and Jain, 2019), as privatization and commercialization has been the ongoing trend in the airport industry over the last three decades. However, there appear to be some conflicting findings among the studies, likely due to the fact that the studies are based on data for airports in different countries and over different time periods. For example, some studies find that privatized airports tend to have higher operational efficiency (Oum et al, 2006; Vogel, 2006; Oum et al. 2008; Perelman and Serebrisky, 2012; Alder and Liebert, 2014; lo Storto, 2018; and Chutiphongdech and Vongsaroj, 2022), while other studies suggest publicly owned airports perform better than privately owned airports (D'Afonso et al, 2015; Curi et al., 2010; Martini et al. 2013; Tsui et al., 2014, Chen and Lai, 2019). Randrianarisoa et al. (2023) find that Asia Pacific airports owned/operated by public corporations appear to be the most efficient in a low corruption environment, but most likely to be subject to significant negative effect of corruption when located in countries with high corruption. Parker (1999), Ahn and Min (2014), Ablando-Rosas and Gemoets (2010), Barros and Weber (2009) do not find any significant effect of ownership on airport efficiency.

2.3.2. The Effects of Economic Regulation on Airport Efficiency

Privatized and commercialized airports are generally subject to economic regulations to safeguard the interests of airport users (Phang, 2016). Consequently, many studies have investigated the effects of various forms of economic regulations on airport efficiency. It is found that unregulated and/or deregulated airports tend to perform better than their regulated counterparts (Adler and Liebert, 2014; Barros et al. 2013). A move towards incentive regulations is associated with increased productive efficiency (Adler, et al, 2015). Oum et al. (2004) provide evidence to support the argument that dual-till regulation would be better than the single-till regulation in terms of economic efficiency, especially for large and busy airports. Assaf and Gillen (2012) argue that the impact of regulation and airport ownership structure should be investigated jointly. They find that price regulation is dominant in affecting efficiency, but the starting ownership form matters. Their results show that shifting from a regulated government enterprise to a private sector operator with no price regulation would achieve the biggest efficiency gains. Adler and Kumar (2023) find that a majority of the studies they reviewed show evidence that airport regulation encourages technical, financial and cost efficiency.

2.3.3. The Effects of Airlines on Airport Efficiency

Airlines and airports are co-dependents. Thus, airline business models and partnerships as well as competition among airlines are likely to have significant impacts on airport performance. However, the empirical results are not always in consensus. Choo and Oum (2013) find non-monotonic relationships between the level of LCC presence and airport efficiency based on 63 major US airports during the 2007-2010 period. In particular, they show that airport efficiency falls as LCC presence increases from very low level, and then rises as LCC become dominant. Based on the 24 largest UK airports during the 2002-2005, Bottasso, et al. (2013) indicate a positive relationship between the intensity of LCC's presence and airports' productivity. They also discuss the causality issue associated with the positive relationship, pointing out the possibility that the most efficient airports are likely to be more attractive to LCCs. Merket and Assaf (2015) and Coto-Millan et al. (2014) find similar results based on 33 international airports and 35 Spanish airports, respectively.

Tsui et al. (2014) find that airports with the dominant carrier being a member of global alliance tend to have higher efficiency based on data for 21 Asia-Pacific airports. However, airline mergers do not seem to have a significant correlation with productivity among Chinese airports (Yuan and Zhang, 2009). Airline hub status appears to have a significant positive effect on operational efficiency among the medium and small airports in Europe (Gutierrez and Lozano, 2016). An inverse U-Shaped relationship between airport efficiency and airlines' market concentration is observed by Ha et al. (2013) among major airports in Northeast Asia, indicating that airports with either too large or too little airline market concentration are likely to be inefficient.

3. Airport Financial Performance

In contrast to the vast volume of literature on airport productivity and efficiency, studies solely focusing on airport financial performance are few and far between (Raghavan and Yu, 2021), albeit there are studies that use financial variables (expenses and revenues) as input or output in their analysis of airport productivity or productive efficiency as discussed in Section 2.1, and there are studies that examine some financial metrics in addition to other performance indicators.

Financial performance generally refers to how well a company uses its assets to generate revenue and profits. It is the evaluation of a company's financial health and stability, and it involves analyzing various financial metrics such as revenue growth, profitability, return on investment, cash flow, and asset utilization. Financial performance is typically assessed over a period of time, such as a fiscal year or a quarter, and is compared to past performance as well as industry benchmarks to determine the company's overall financial strength and potential for growth.

Among airport performance studies, the term "financial performance" may not always be used in its conventional definition. Graham (2005) lists revenue generation indicators, such as revenue per employee and revenue per work load unit (WLU), and profitability, such as profit/total asset, under Economic performance. Cahill et al. (2017) also include a number of financial metrics in their analysis of Dublin Airport Authority's economic performance. Furthermore, as shown in Fasone and Zapata-Aguirre (2016), some studies use revenues as outputs and operating expenses as inputs in measuring airport productivity and efficiency, which is often due to the lack of data for physical inputs and outputs. For example, Bazargan and Vasigh (2003) include operating and non-operating expenses among their inputs and aeronautical and non-aeronautical revenues among their outputs in measuring the efficiency performance of a sample of U.S. commercial service airports.

There are also a few studies that attempt to construct an overall airport performance indicator to combine profitability, service quality and efficiency. For example, Merkert and Assaf (2015) include operating margin (EBITDA) as an output in their DEA model to estimate a single profitability / perceived service quality /traffic efficiency indicator. Chang et al. (2018) consider Net Operating Income as a final output in their network DEA model to generate a comprehensive performance indicator that reflects airports' commercial viability, customer satisfaction, traffic volume and bonding ratings.

3.1. Revenue Generation and Cost Effectiveness

Revenue generation is one of the most common financial performance measures used by airports and industry analysts (ACRP, 2020; ACI, 2012), and is usually measured by ratios of various revenues (such as total operating revenue, aeronautical revenue, or non-aeronautical revenue) per passenger, or per employee, or per aircraft movement, or per work load unit (WLU). Among the published academic articles, non-aeronautical revenue per passenger is used by Pagliari and Graham (2019), turnover per employee by Cahill et al. (2017), revenue per gate and revenue per runway by Vasigh and Haririan (2003), operating income per WLU by Fasone et al. (2014), revenue per WLU by Vogel and Graham (2013) and Graham and Dennis (2007). Cost Effectiveness is one of the core performance measures suggested by ACI (2012) and ACRP (2010). Common metrics used to assess cost effectiveness include operating expenses per passenger (Pagliari and Graham, 2019), and costs per WLU (Graham and Dennis, 2007; Vogel and Graham, 2013).

3.2. Profitability, Return on Investment, and Return on Asset

Profitability is usually measured by EBITDA (earnings before interest, taxes, depreciation and amortization), gross profit margin, operating profit margin, net profit margin, which measure a company's ability to generate profits relative to its revenue. Return on Investment (ROI) measures the return earned on an investment relative to its cost, often used to evaluate the effectiveness of investment decisions, whereas return on asset (ROA) measures how effectively a business uses its assets. EBITDA is used by Vogel (2006), Vogel and Graham (2013), Merkert and Assaf (2015) and Pagliari and Graham (2019) to assess airports' profitability, whereas profit margin is used by Zuidberg (2017) and Tavalaei and Santalo (2019). Graham and Dennis (2007) include both EBITDA and profit margin in their analysis.

Return on capital employed (ROCE) and Return on sales (ROS) are used by Cahill et al. (2017) to analyze Dublin Airport Authority's economic performance over the 1994-2014 period along with turnover per employee and total factor productivity (TFP) analysis. Return on Investment is one of the five financial performance indicators examined by Abbruzzo et al. (2016) in their analysis of 10 Italian airports during the 2008-2014. Vogel (2006) uses total asset turnover, EBIDTA, return on asset and return on equity among others to assess and compare the financial performance of public versus private airports in Europe during the 1990-2000 period. Return on Equity and Return on Sales are also used by Fasone et al. (2014) in their comparison of the financial performance of 14 Italian airports. Both Vogel (2006) and Fasone et al. (2014) implicitly assume profit maximization for all airports no matter whether they are private or government owned. Oum et al. (2008) measure and compare productive efficiency and profitability among airports owned and operated by government departments, 100% government-owned corporations, independent airport authorities, mixed enterprises with government majority ownership, and mixed enterprises with private majority ownership, and their results indicate that government-owned airports may not be pursuing profit-maximizing goals. Their results are consistent with credit rating agencies' practice of using different rating methodologies for private vs. public airports as private airports are led by profit maximization motive while public airports operate for the municipalities or regions' social and economic benefit (Moody's, 2017; Moody's, 2019).

Raghavan and Yu (2021) argue that traditional profitability measures and financial efficiency measures are not appropriate for the US commercial services airports that are owned and operated by various government entities. The US commercial service airports are non-profit by nature, and expected to be financially self-sufficient and raise capital funds mainly through the bond markets. They propose six pertinent financial performance metrics to measure and compare the US airports in terms of operational financial performance, leverage, and liquidity after reviewing the literature on non-profit organization and practices of credit rating agencies and government oversight bodies. Instead of the traditional profitability indicators, they use two operating financial metrics to compare the performance the US commercial services airports: namely, operating financial ratio and net take-down ratio. Operating financial ratio is defined as operating expenses/operating revenue, and net take-down ratio is defined as total revenue-operating expenses/total revenue. A high operating financial ratio suggests very little surplus revenue available for capital spending, and a low ratio indicates financial strength. The net take-down ratio is a broader measure as it includes non-operating revenues generated by an airport.

3.3. Leverage and Liquidity

Financial leverage results from using borrowed capital as a funding source when investing to expand a firm's asset base and generate returns on risk capital. There are a range of leverage metrics to measure how risky a firm's position is. Debt-to-assets and debt-to-equity are the most common leverage ratios. Other leverage measures include interest coverage ratio, debt service coverage ratio, and leverage ratio. Liquidity refers to how easy it is to turn an asset into cash without losing much value. Current ratio and quick ratio are the most common liquidity measures. Cash ratio, operating cash flow ratio and working capital ratio are also used to measure a firm's liquidity.

Airports are capital intensive industry with massive investments. Therefore, leverage and liquidity are important aspects of their financial viability and strength. However, few studies consider any leverage and liquidity measures in their analysis of airport financial performance. Fasone et al. (2014) and Abbruzzo et al. (2016) are the very few studies that take into account of leverage by including Equity/Debt ratio in their analysis. Raghavan and Yu (2021) suggest two leverage ratios (debt-to-asset ratio and debt service safety margin) and two liquidity ratios (current ratio and days cash on hand). A low debt-to-asset ratio is desirable because creditors have the assurance that asset coverage of debt is high. A high debt service safety margin, on the other hand, shows the proportion of revenues available to service new debt and the availability of a safety net for an airport when an airport faces abnormally low revenues. Days Cash on Hand (DCOH) reveals days of unrestricted cash and investments an airport has to meet its operating expenses, whereas current ratio captures whether the current assets of an airport are sufficient to meet the current liabilities of the airport. These measures are used to assess and compare the financial performance of the US commercial service airports by Raghavan and Yu (2021).

3.4. Factors affecting Airport Financial Performance

As the trend toward privatization and commercialization has continued across different regions of the world, investors and researchers alike become interested in the effects of ownership and governance on airport financial performance. Vasigh and Haririan (2003) find that public airports generate higher unit revenues (revenue per runway, revenue per gate) with lower unit cost (cost per runway and cost per gate) than private airports based on a sample of 7 airports in the UK and 8 airports in the U.S.. In contrast, based on a sample of European airports during the 1990-2000 period, Vogel (2006) find that privatized airports achieve higher returns on total assets and revenues and are more cost efficient, whereas public airports appear to have higher financial leverage. Based on a sample of major Asia-Pacific, European, and North American airports during the 2001–2003 period, Oum et al. (2008) find that airports with majority private ownership generally achieve higher operating profit margins, whereas airports with majority government ownership tend to have significantly lower operating profit margin. Fasone, et al. (2014) provide evidence that Italian airports with a majority private ownership appear to performance better in terms of operating income than their public airports. As pointed out by Fasone et al (2014), there is a need to explore the causality issue associated with the relationship between ownership and financial performance, as private stakeholders are more likely to invest in profitable and/or financially promising airports. Unfortunately, this remains a gap in the literature.

Focusing on a sample of 10 commercialized national and regional Italian airports, airports managed by private operators under "total concession" agreements with public authorities, Abbruzzo et al. (2016) investigate the effects of airports' operational indicators on their financial performance using a Gaussian graphical model. Their results suggest that increasing jointly the number of flights and number of passengers would improve revenues and profitability, which is consistent with the finding of increased passenger traffic likely leading to higher profits by Zuidberg (2017). Abbruzzo et al. (2016) further state that the effects of LCC on airport financial performance have been heterogeneous, as their results do not show any significant relationship between the degree of LCC presence and financial performance. Graham and Dennis (2007) find that airports with high proportion of low cost traffic tend to have lower unit revenues, despite the strong passenger growth and increased passenger load generated by LCCs. In the context of the U.S. airports, Tavalaei and Santalo (2019) suggest airports that are either dominated by legacy carriers or LCCs tend to have better financial performance than airports with more diversified airlines services.

Based on a sample of 23 US large hub airports, Richardson et al. (2014) find that airports with compensatory agreements perform better in terms of revenue generation, operating margin, operating liquidity (net working capital) and debt ratio than airports with residual or hybrid agreements. However, airports with residual agreements generate higher commercial revenues than airports with compensatory agreements. Raghavan and Yu (2021) show that the US large hub airports tend to perform better in terms of liquidity, whereas the medium hub airports tend to have lower leverage ratios. They further show that airports with high productive efficiency and those with a dominant carrier appear to have more surplus revenues for meeting their operational needs and capital spending. Their results also indicate that airports with larger proportion of international passengers are likely to have less surplus revenue available for capital spending, whereas airports with significant cargo operations are likely to have more surplus revenue. Furthermore, the share of non-aeronautical revenues in total operating revenues is found to have a positive association with better leverage and higher liquidity.

3.5. Growth of Global Airport Operators

The global airport operators continue to expand their portfolio, and have become a significant phenomenon in the airport industry. According to ATRS (2022), as of August 2022, VINCI Airports operates/manages 53 airports in 12 countries, not including the 13 airports under OMA (Grupo Aeroportuario del Centro Norte) that signed an agreement giving VINCI 29.99% of ownership at the beginning of August 2022. Table 1 provides some examples of major global airport operators.

Airport Operations	**Number of airports**	**Notes**
VINCI Airports	53 airports in 12 countries	VINCE Airports signed an agreement to purchase 29.99% of OMA (Grupo Aeroportuario del Centro Norte), which will add 13 airports to its portfolio (Northern and Central Mexico)
GROUPE ADP	28 airports in all continents	GROUPE ADP has strategic holdings in TAV (Turkey), AIG (Jordan) and GMR (India)
Fraport AG	31 airports worldwide	In cooperation with its partners, Fraport AG is investing in the expansion of Frankfurt Airport City
Corporacion America Airports	53 airports in 6 countries	Argentina, Armenia, Brazil, Ecuador, Italy, and Uruguay

Source: ATRS (2022).

Table 1: *Global Airport Operators.*

Asker and Kiraci (2016) conduct a trend analysis of five airport groups, AENA, Fraport, Ferrovial, TAV Airports Groupe, and Groupe ADP, using the 9 financial variables, terms of trade receivables, net sales, current assets, short term liability, long-term liabilities, tangible fixed assets, fixed assets and liabilities, and shareholders' equity, and discuss whether these ratios increased or decreased over the 2007-2014 period. However, there is no direct performance comparison between the airport groups apart from their respective trends. There is a lack of published study examining the impact of these global airport operators on the financial performance of individual airports within each group, as only consolidated financial data for the groups instead of individual airports are publicly available.

4. Airport Service quality and Customer Satisfaction

Airports provide services to airlines, passengers, shippers and other customers, therefore, service quality is essential to airport operation and management. Studies on airport service quality to airlines are very limited (Adler and Berechman, 2001; Pabedinskaitė and Akstinaitė, 2014), this paper focuses on airport service quality with respects to passengers. Airport service quality refers to the level of satisfaction that passengers have with the services and facilities provided by an airport. There are often discrepancies between passengers' expectation of service quality and their perceptions of service quality (Jiang and Zhang, 2016). Service quality is one of the most debated topics in the service marketing literature. However, the one thing researchers appear to agree on is that perceptions of service quality are based on multiple dimensions. Inherently, airport service quality is a complex and multifaceted issue that represents a broad range of passenger experiences. According to Bakir et al. (2022a), the number of publications on airport service quality start to show an increasing trend since 2014, albeit with considerable drops in 2017 and 2018. Usman et al. (2022) provide a chronicle list of the 27 top articles published between 2000 and 2020. Panouvakis and Renzi (2016) point out that there are two general tracks of airport service quality literature: (1) to identify the different dimensions or attributes of airport service quality through conceptual or empirical modeling; (2) to identify quality drivers that lead to customers' satisfaction.

4.1. Attributes of airport service quality and Service Quality Evaluation.

Airport service quality studies generally start with survey conducted in various format and/or different media, and survey results are then analyzed using different methodologies. One of the most publicized passenger satisfaction surveys is Airports Council International's (ACI) Airport Service Quality program (hereinafter ASQ), which was initiated in 2006. The ASQ program measures service quality across eight different categories: access, check-in, security, airport facilities, food and beverage, retail, airport environment, and arrival/departure. Each category is broken down into several different factors that are evaluated through a combination of surveys and on-site assessments. In total, 34 service attributes are included in the survey. Unfortunately, ASQ survey results are only accessible to participating airports. Academic researchers generally rely on surveys that are limited to a particular airport or a small number of airports.

Rhoades et al. (2000) conduct a mail questionnaire survey of 150 airport directors and consultants, and use factor analysis to analyze the survey results. They identify four dimensions that contain twelve attributes, including passenger service (food and beverage, restrooms, retail and duty free, special services), airport access (parking, rental car, ground transportation), airline-airport interface (gate boarding areas, baggage claim, information display), and the inter-terminal transportation as a single attribute dimension. Also using factor analysis, Bezerra and Gomes (2015) extract seven dimensions of airport service quality as perceived by the passengers from an extensive survey conducted in a main Brazilian international airport, and then examine how each of these dimensions affects passengers' overall satisfaction using a probabilistic model. They further emphasize the need to consider the effects of passenger characteristics on the perceived levels of service quality. Based on the same survey results, Bezerra and Gomes (2016) estimate a six-factor model to measure airport service quality (Check-in, Security, Mobility, Ambience, Basic facilities, and Convenience).

Based on 700 mail survey responses, Fodness and Murray (2007) propose that passengers' expectation of airport service quality has three key dimensions with five subdimensions including function (effectiveness, efficiency), interaction, and diversion (maintenance, productivity, decor). Pantouvakis and Renzi (2016) conducted in-terminal personal interviews at Rome Fiumicino Airport over a two month period in 2014, and collected 922 usable responses. Three "distinct, independent and invariant" service quality dimensions are identified based on the responses, namely, "Servicescape and Image," "Signage" and "Service." Their results also provide some evidence that passengers' satisfaction or dissatisfaction perception of airport service quality vary according to their nationalities. Fakfare et al. (2021) initially identify 10 dimensions and 44 airport service quality attributes. The quality attributes are then reviewed by a panel of experts, and one attribute is deleted and four attributes are added at the recommendation of the panel, resulting in 47 quality attributes to be included in an online survey of air passengers in Thailand. The study employ Impact Range Performance Analysis (IRPA) and Impact Asymmetry Analysis (IAA) based on 879 responses from the survey to investigate the asymmetric effect of attributes on passenger satisfaction. Results based on surveys at a single airport may not be generalizable to all airports as the perception of airport service quality is context dependent as pointed out by Bezerra and Gomes (2015) and Pantouvakis and Renzi (2016).

Instead of relying on surveys, Yeh and Kuo (2003) employ a panel of experts to identify six "manageable" service attributes (Comfort, Processing time, Convenience, Courtesy of staff, Information visibility, and Security). A fuzzy multi-attribute decision making (MADM) model is then applied to generate a service quality index to evaluate the comparative level of passenger service performance among 14 Asia Pacific airports. A number of studies attempt to construct airport service quality measures using different approaches. Lupo (2014) proposes a Fuzzy ServPerf model together with the multi-criteria decision making ELECTRE III method to evaluate perceived service quality and apply it to three airports in Sicily. Pandey (2016) utilizes the Fuzzy multi-criteria decision making method and importance performance analysis to measure the service quality of the two main airports in Bangkok (Thailand), Suvarnabhumi (BKK) and Don Mueang (DMK). Chonsalasin et al. (2020) use confirmatory factor analysis to identify passengers' expectations of airport services and measure airport service quality based on a sample of 1037 randomly selected passengers flying on domestic Thai airlines. Their resulting model consists of seven dimensions of service quality: security, check-in, wayfinding, airport environment, access, arrival services, and airport facilities.

Antwi et al. (2020) propose the so-called Airport Indicators of Passenger Experience (AIPEX) model to measure airport service quality, and apply it to Shanghai Pudong International Airport as an illustration. The study also conducts a second stage analysis to examine the relationship between airport service quality, passenger affective image and passenger satisfaction. Nwaogbe, et al. (2021) adopt the SERVQUAL model to assess the overall service quality and passenger satisfaction for airlines and airports in Nigeria. Their study is based on 150 questionnaire responses collected at four airports in Nigeria over a one-week survey period. They conclude that perceived airport service quality is less than passengers' expectations for the selected airport service operations. Adeniran and Fadare (2018) also use SERVQUAL model to assess passenger satisfaction and airport service quality at the domestic terminal of Murtala Muhammed Airport in Nigeria.

4.2. Drivers for Passenger Satisfaction of Airport Service Quality

Based on a survey of 201 airports worldwide, Advani and Borins (2001) find that private airports appear to provide better services. Suarez-Aleman and Jimenez (2016) investigate the effects of airport management and characteristics on passenger satisfaction based on 111 international airports worldwide. Their results indicate that airports in countries with higher levels of competition and with private participation tend to have higher perceived service quality. Allen et al. (2020) use Principal Component Analysis to investigate the factors that influence airport service quality at Lamezia Terme International Airport in Italy. They find that accessibility (e.g., flight information, signposting, etc), control operations (e.g., waiting time at check-in, security, etc) and environment (cleanliness, air conditioning) in the terminal have significant effect on air service quality.

Brida et al. (2016) examine the effects of information and communication technologies (ICT) on passengers' perception of airport service quality using a mixed generalized ordered logit analysis based on data from a survey conducted by Chilean Aviation Authority at Santiago International Airport (SCL) in 2013, they find that factors related to flights and airport information have an important impact on the passengers' perception of airport services. In particular, their results indicate that passengers appreciate "good quality" in information screen, and value terminal signage that makes it easy to move in the airport. Furthermore, speaker sound quality appear to have a significant positive impact on overall perception of airport service quality. Rubio-Andrada et al. (2023) attempt to examine the degree of passenger satisfaction derived from information and communication technologies from a gender perspective and conclude that women give higher value to the use of technologies and technology-based services at airports. Antwi et al. (2021) show a significant positive association between airport self-service technology (SST) performance and passenger satisfaction with SST, and the spillover effects of satisfaction with technology on passengers' overall satisfaction with airport service quality.

Gkritza et al. (2006) explore factors that affect passenger satisfaction with airport security check points by using multinomial logit models. It is not surprising that their results show that wait times is the most significant determinant of passenger satisfaction. They further show that passenger satisfaction varies among different age groups, education levels, trip purposes, etc. Moreover, the study find that the determinants of customer satisfaction are not stable over time. Sakano, et al. (2016) show that passengers who show a greater level of satisfaction with the airport security screening process perceive higher level of airport safety. Ceccato and Masci (2017) use Chi-square analysis and binary logistic regression to examine passengers' satisfaction with their perceived safety at an international airport in Europe. Their results show that passengers' perceived safety is affected by their perception of airport environment (e.g., elevators, overall maintenance, etc) for both arrival and departing passengers.

de Barros et al. (2007) study the airport service quality from the perspective of transfer passengers. They conduct a regression analysis based on survey responses collected at Bandaranaike International Airport in Sri Lanka, and show that courtesy of the security check staff and the quality of the Flight Information Display are among the most valued service attributes by transfer passengers at that airport. Park and Jung (2011) examine transfer passengers' perception of airport service quality and its effects on passenger satisfaction and airport image, etc based on survey of 331 transfer passengers at Incheon International Airport (S. Korea). Airport service quality is measured in terms of 22 service attributes. Chang and Chen (2011) apply importance-performance analysis (IPA) to examine the perceived satisfaction of passengers based on a sample of 130 respondents with mobility disability. Their analysis suggests barrier-free ramp and slip resistant floors in the airports are important to the satisfaction of disabled passengers.

Based on 377 survey responses collected at Kuala Lumpur International Airport, Batouei et al. (2020) assess the effects of airport experience on travelers' overall satisfaction as well as their intention to revisit an airport. Airport experience is assessed through three perspectives each consisting of multiple dimensions, namely sociological, psychological, and service marketing. Their results reveal that service fairness, servicescape, service encounter, and self-service technologies have significant effects on satisfaction, which is the driver of intention to revisit an airport. The two sociological dimensions (sense of place and social interaction), airport anxiety, and retail experience do not seem to have any significant influence on travelers' satisfaction. Isa et al. (2020) use the PLS-SEM method to analyze the 2016 ACI-ASQ survey data for Kuala Lumpur International Airport Terminal 2 (KLIA2) that is predominantly used by LCCs. Their analysis indicates that there is a significant positive relationship between most of the ACI-ASQ dimensions and passenger overall satisfaction at KLIA2, with the airport environment dimension as the best predictor for the overall passenger satisfaction.

Martín et al. (2019) apply a hybrid-fuzzy TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) method to analyze airport duty-free shopper' satisfaction through a six-attribute construct. The analysis is based on questionnaire responses collected at the international terminal of a regional airport in Australia. Their results indicate that place of residence and destination of the passengers have important impact on customers' satisfaction with duty free shopping at the airport. Australian residents travelling short haul appear to be more likely to be satisfied with the duty free shops than non-residents and those traveling long haul. Freitas, el al, (2021) estimate a logit discrete choice model based on the Permanent Passenger Survey data collected by Brazilian National Civil Aviation Secretariat to evaluate Customer Experience in the airport commercial areas of 20 main Brazilian airports during the 2016-2018 period. Their analysis indicates that passengers traveling alone are more likely to be satisfied with airport cafeterias and restaurants, while frequent flyers tend to have lower level of satisfaction with airport commercial services.

Li et al. (2022) show that passengers at US airports appear to have higher satisfaction after the COVID-19 outbreak than pre-COVID period based on their analysis of Google Map reviews of 98 US airports. Their results also indicate that environment (cleanliness and hygiene conditions) and personnel have stronger influence on passenger satisfaction during the COVID-19 Pandemic period than the pre-COVID period. Similarly, Lopez-Valpuesta and Casas-Albala (2023) find that cleanliness and comfort is the most important factor for passenger satisfaction during the COVID pandemic period. They further show that the actions taken by the airports during the early months of the Pandemic (in 2020) appear to be positively associated with passenger satisfaction, however, passengers became less satisfied in 2021.

Bezerra and Gomes (2020) examine the relationship between the antecedents and consequences of passenger satisfaction, taking into account the effects of switching costs for changing airports within a multi-airport region. It is a little surprising to note that their analysis indicates that passenger expectations do not influence their perception of service value and their satisfaction level. On the other hand, airport service quality is shown to have a strong effect on perceived value and passenger satisfaction.

Hong et al. (2020) distinguish airport users' service quality satisfaction between passengers and service providers. They apply exploratory factor analysis and reliability test as well as confirmatory factor analysis to survey responses collected from 138 passengers and 110 employees of service providers that provide direct services to passengers at Incheon International Airport. Their results suggest that interactional service quality (courtesy and attitude of employees) are drivers for overall satisfaction of both passengers and service providers. Furthermore, physical environment quality (restrooms, lighting, humidity and temperature) are drivers for service providers' satisfaction, whereas passengers' satisfaction is driven by convenience and easy to find signs and flight information, baggage, and access to the gate.

4.3. Content and Sentiment Analysis based on User Generated Content

Web-based opinion platforms have become popular venues for passengers to offer voluntary reviews of airport services. These platforms let passengers rate services with stars along with comments and reviews, which are great sources of information for both passengers and service providers. The rapid advancement in data mining (i.e., techniques of discovering patterns and trends from a large data set) (Larose, 2005) and text mining (i.e., a subset of data mining that aims at extracting information from texts) (Zhong et al., 2012) provides various means to analyze these rating and reviews, offering new sources of data to capture passengers' perception and expectations of airport service quality on a broader scale than the traditional questionnaire surveys.

There has been an increasing number of studies utilizing the ever growing online resources to investigate travel and transport related issues. For example, Bogicevic et al. (2013) conduct content analysis of 1095 traveler comments posted between 2010 and 2013 on www.AirlineQuality.com. Their analysis indicate that cleanliness and shopping options, WIFI and adequate seating are among the main drivers of passengers satisfaction, and on the other hand, security check location and procedure, poor signage and long waiting lines associated with passenger dissatisfaction. Yavuz el al. (2020) also that find queuing time is the main influencing factor for passenger satisfaction at European airports based on analysis of Skytrax reviews. Gitto and Mancuso (2017) use sentiment analysis based on comments posted on SKYTRAX website to investigate passenger satisfaction levels at five major European airports. Their analysis suggests that food & beverage and the shopping area are passengers' main concerns about airport non aeronautical services, whereas check-in, baggage claim and security control procedures dominate passengers' concern about aviation services. Nghiem-Phu and Suter (2018) analyze 427 passenger reviews of Harry Reid International Airport (formerly Las Vegas McCarran International Airport) posted on TripAdvisor to identify the attributes that are associated with the image of the airport. The study suggests that Harry Reid International Airport shares most of the common airport service attributes identified by earlier studies, but also has several attributes unique to its host city, Las Vegas.

Lee and Yu (2018) apply sentiment analysis and topic modeling technique to 42,137 reviews collected from Google Maps. The sentiment scores computed from the textual Google reviews are very good predictors of the associated Google stars. Both the sentiment scores and Google star ratings are found to have a fairly strong association with the ACI ASQ ratings, indicating that the online reviews provide a good proxy for airport service quality ratings and an effective means to cross-validate the conventional industry standard survey results. Furthermore, the topic modelling analysis extracts 25 latent topics from the Google reviews that show good correspondence with the ASQ service attributes, suggesting that the ASQ program effectively covers all the service quality attributes of airport users. Li et al. (2022) use Google Map reviews to investigate the factors that influence passenger satisfaction at 86 US airports before and during the COVID-19 pandemic. Martin-Domingo et al. (2019) apply the sentiment analysis technique to measure airport service quality based on 4392 tweets collected from London Heathrow Airport's twitter account. The study identifies 23 attributes and finds that these attributes are similar to the ACI-ASQ service attributes. The authors point out some potential issues with applying sentiment analysis, for example, the misclassification of false positives associated with sarcastic comments.

Bae and Chi (2021) conduct content analysis based on 1341 comments posted on Skytrax website to explore passengers' perception of airport service quality at Honolulu International Airport and five other international airports. Their analysis reveals that security, check, flight, line, and staff are the most frequently occurring words used by dissatisfied passengers, whereas staff, terminal, clean, time, immigration, and free are the most common words mentioned by satisfied passengers. Bakır et al. (2022b) use multiple regression analysis to examine the effects of eight airport service attributes on passenger satisfaction, and use necessary condition analysis to dissect the necessary conditions and level of necessity to achieve passenger satisfaction based on 1463 valid online reviews of the top 50 busiest airports in Europe posted on Skytrax.

5. Summary and Concluding Remarks

Airport productivity and efficiency has attracted substantial interests among scholars, practitioners, industry analysts and government regulators, resulting in a vast volume of literature. There have been several surveys and reviews of literature on the topic. This paper attempts to synthesize these survey articles with respects to research methodologies, empirical findings on various issues, and challenges researchers have encountered. Quantifiable inputs and outputs are essential to any productivity and efficiency studies, one of the main challengers for airport productivity and efficiency studies is lack of data to generate meaningful input and output measures that are comparable across airports and over time, especially with respects to inputs. Consequently, researchers have often replied on some physical measures, such as number of gates, number of runways, etc, that are "fixed" in the short and medium term, or monetary values, such as expenses or revenues, without considering the implication of different input or output prices. The lack of data is also at least partially the driver for DEA becoming the dominant methodology being used for airport productivity and efficiency studies, as it has less data requirement than stochastic frontier analysis method and various multilateral index methods.

As airport privatization and commercialization actuated researchers' interests in airport performance in the 1980s, it is not surprising to see many of the published articles focusing on effects of airport ownership on airport productivity and efficiency. Various regulatory policies have been imposed on privatized or commercialized airports, naturally policy makers and academic researchers have strong interests on the effects of regulations on airport performance, leading to numerous publications on the topic. Airports and airlines are partners and co-dependents, thus airline strategies and market structure inherently affect performance of airports, which has become another "popular" research topic. Sustainability has increasingly become one of the top priorities for many airports, thus we start to see more research incorporate environmental factors in evaluating airport productivity and efficiency. We expect to see more efforts in this regard, and go beyond the simple inclusion of negative outputs.

Escalating needs for significant infrastructure improvement and expansion is one of the main challenges for many airports, thus financial viability and strength of airports are imperative. However, literature on airport financial performance are limited. Most of the studies on airport financial performance often involve comparison of various ratios representing unit revenues or unit costs, and some profitability metrics. Profitability analysis is generally based on the traditional framework for for-profit firms, despite the presence of different ownership forms and government structures. The increasing presence of global airport operators further complicates the study of airport financial performance. In view of the devasting financial impacts of the COVID-19 pandemic, there is a need for more works that would help understand and improve airport financial health and stability. Similar to other service industries, airports have made tremendous efforts to improve service quality and customer satisfaction, which are reflected in the fast growing volume of literature on the topic. Although early work on airport service quality tend to focus on identifying different service attributes, more recent works tend to focus on investigating factors that influence passengers' satisfaction. Traditional airport service quality are generally based in in-person or mail questionnaire surveys, user generated contents on web based platforms (Skytrax, Google maps, TripAdvisor, Twitters) have become a valuable source of data for studies on airport passenger satisfactions. With the continuing advancement of sentiment and content analysis techniques, we expect to see more studies to explore the vast data generated by users.

References

Abbott, M., (2015), Reform and efficiency of New Zealand's airports, Utilities Policy, Volume 36, Pages 1-9, https://doi.org/10.1016/j.jup.2015.05.001.

Ablanedo-Rosas, J.H. & Gemoets, L.A., (2010), Measuring the efficiency of Mexican airports, Journal of Air Transport Management, Volume 16, Issue 6, Pages 343-345, https://doi.org/10.1016/j.jairtraman.2010.05.003

ACI (2012), Guide to Airport Performance Measures, February, 2012, Airport Council International (ACI) World, Montreal, Canada, https://store.aci.aero/product/a-guide-to-airport-performance-measures/

ACRP (2010), ACRP Report 19: Developing an Airport Performance-Measurement System, Washington, DC: The National Academies Press. https://doi.org/10.17226/14428.

ACRP (2011), ACRP Report 19A: Resource Guide to Airport Performance Indicators. Washington, DC: The National Academies Press. https://doi.org/10.17226/17645

ACRP (2018), ACRP Report 190: Common Performance Metrics for Airport Infrastructure and Operational Planning. Washington, DC: The National Academies Press. https://doi.org/10.17226/25306

Adachi, K. (2023). The Impact of Airport Concession on Technical Efficiency: Evidence from Major Airports in Japan. In: Mizutani, F., Urakami, T., Nakamura, E. (eds) Current Issues in Public Utilities and Public Policy. Kobe University Monograph Series in Social Science Research. Springer, Singapore. https://doi.org/10.1007/978-981-19-7489-2_7

Adeniran, A.O. & Fadare, S. O. (2018), Assessment of Passengers' Satisfaction and Service Quality in Murtala Muhammed Airport (MMA2), Lagos, Nigeria: Application of SERVQUAL Model, Journal of Hotel & Business Management, 7:2, DOI: 10.4172/2169-0286.1000188

Adler, N. & Berechman, J. (2001), Measuring airport quality from the airlines' viewpoint: an application of data envelopment analysis, Transport Policy, Volume 8, Issue 3, Pages 171-181, https://doi.org/10.1016/S0967-070X(01)00011-7

Adler, N., Forsyth, P., Mueller, J. & Niemeier, H.-M., (2015), An economic assessment of airport incentive regulation, Transport Policy,

Volume 41, Pages 5-15, https://doi.org/10.1016/j.tranpol.2015.03.008
Adler, N.& Kumar, S. (2023). Efficiency Assessment of Airports and the Impact of Regulation on Performance. In: Forsyth, P., Müller, J., Niemeier, HM., Pels, E. (eds) Economic Regulation of Urban and Regional Airports. Advances in Spatial Science. Springer, Cham. https://doi.org/10.1007/978-3-031-20341-1_10
Adler, N. & Liebert, V. (2014), Joint impact of competition, ownership form and economic regulation on airport performance and pricing, Transportation Research Part A: Policy and Practice, Volume 64, Pages 92-109, https://doi.org/10.1016/j.tra.2014.03.008
Advani, A. & Borins, S. (2001), Managing airports: a test of the new public management, International Public Management Journal, Volume 4, Issue 1, Pages 91-107, https://doi.org/10.1016/S1096-7494(01)00045-9
Afriat, S. N. (1972), Efficiency Estimation of Production Functions, International Economic Review 13(3), Pages 568-598, https://doi.org/10.2307/25258
Ahn, Y.-H. & Min, H., (2014), Evaluating the multi-period operating efficiency of international airports using data envelopment analysis and the Malmquist productivity index, Journal of Air Transport Management, Volume 39, Pages 12-22, https://doi.org/10.1016/j.jairtraman.2014.03.005
Aigner, D.J. & Chu, S.F. (1968), On Estimating the Industry Production Function, American Economic Review, 58, Pages 826-839, http://www.jstor.org/stable/1815535
Aigner, D., Lovell, C.A.K. & Schmidt, P. (1977), Formulation and Estimation of Stochastic Frontier Production Function Models, Journal of Econometrics Volume 6, Issue 1, Pages 21-37, https://doi.org/10.1016/0304-4076(77)90052-5
Allen, J., Bellizzi, M.G., Eboli, L., Forciniti, C. & Mazzulla, G. (2020), Latent factors on the assessment of service quality in an Italian peripheral airport, Transportation Research Procedia, Volume 47, Pages 91-98, https://doi.org/10.1016/j.trpro.2020.03.083
Antwi, C. O., Fan, C.-J., Ihnatushchenko, N., Aboagye, M.O. & Xu, H. (2020), Does the nature of airport terminal service activities matter? Processing and non-processing service quality, passenger affective image and satisfaction, Journal of Air Transport Management, Volume 89, 101869, https://doi.org/10.1016/j.jairtraman.2020.101869
Antwi, C. O., Ren, J., Owusu-Ansah, W., Mensah, H. K., & Aboagye, M. O. (2021). Airport Self-Service Technologies, Passenger Self-Concept, and Behavior: An Attributional View. Sustainability, 13(6), 3134. MDPI AG. Retrieved from http://dx.doi.org/10.3390/su13063134
Asker, V., & Kiracı, K. (2016). A RESEARCH ON REVIEW OF FINANCIAL PERFORMANCE: AIRPORT GROUPS SAMPLE. *The International Journal of Transport & Logistics*, 16(38), 1-9.
Assaf, A. (2010), The cost efficiency of Australian airports post privatisation: A Bayesian methodology, Tourism Management, Volume 31, Issue 2, Pages 267-273, https://doi.org/10.1016/j.tourman.2009.03.005
Assaf, A.G. & Gillen, D., (2012), Measuring the joint impact of governance form and economic regulation on airport efficiency, European Journal of Operational Research, Volume 220, Issue 1, Pages 187-198, https://doi.org/10.1016/j.ejor.2012.01.038
ATRS (2021), Airport Benchmarking Report – 2021: Global Standards for Airport Excellence, Air Transport Research Society (ATRS), August, 2021. https://www.atrsworld.org/airport-benchmarking
ATRS (2022), Airport Benchmarking Report – 2022: Global Standards for Airport Excellence, Air Transport Research Society (ATRS), August, 2022. https://www.atrsworld.org/airport-benchmarking
Bae, W. & Chi, J. (2021), Content Analysis of Passengers' Perceptions of Airport Service Quality: The Case of Honolulu, International Airport Journal of Risk and Financial Management 15 (5) http://dx.doi.org/10.3390/jrfm15010005
Bakır, M., Özdemir, E., Akan, S. & Atalık,O., (2022a), A bibliometric analysis of airport service quality, Journal of Air Transport Management, Volume 104, 102273, https://doi.org/10.1016/j.jairtraman.2022.102273
Bakır M, Akan Ş, Özdemir E, Nguyen P-H, Tsai J-F & Pham H-A. (2022b), How to Achieve Passenger Satisfaction in the Airport? Findings from Regression Analysis and Necessary Condition Analysis Approaches through Online Airport Reviews. *Sustainability,* 14(4):2151. https://doi.org/10.3390/su14042151
Barros, C.P., (2008), Technical efficiency of UK airports, Journal of Air Transport Management, Volume 14, Issue 4, Pages 175-178, https://doi.org/10.1016/j.jairtraman.2008.04.002
Barros, C.P. & Dieke, P.U.C. (2007), Performance evaluation of Italian airports: A data envelopment analysis, Journal of Air Transport Management, Volume 13, Issue 4, Pages 184-191, https://doi.org/10.1016/j.jairtraman.2007.03.001
Barros, C.P., Liang, Q.B. & Peypoch, N., (2013), The efficiency of French regional airports: An inverse B-convex analysis, International Journal of Production Economics, Volume 141, Issue 2, Pages 668-674, https://doi.org/10.1016/j.ijpe.2012.10.007
Barros, C.P., Managi, S. & Yoshida, Y., (2010), Productivity growth and biased technological change in Japanese airports, Transport Policy, Volume 17, Issue 4, Pages 259-265, https://doi.org/10.1016/j.tranpol.2010.01.009
Barros, C.P. & Weber, W.L., (2009), Productivity growth and biased technological change in UK airports, Transportation Research Part E: Logistics and Transportation Review, Volume 45, Issue 4, Pages 642-653, https://doi.org/10.1016/j.tre.2009.01.004
Batouei, A., Iranmanesh, M., Mustafa, H., Nikbin, D. & Ping, T.A. (2020), Components of airport experience and their roles in eliciting passengers' satisfaction and behavioural intentions, Research in Transportation Business & Management, Volume 37, 100585, https://doi.org/10.1016/j.rtbm.2020.100585
Bazargan, M., & Vasigh, B. (2003). Size versus efficiency: a case study of U.S. commercial airports. *Journal of Air Transport Management, 9*(3), 187-193.
Bezerra, G.C.L. and Gomes, C.F. (2015), "The effects of service quality dimensions and passenger characteristics on passenger's overall satisfaction with an airport", *Journal of Air Transport Management*, Vol. 44, pp. 77–81
Bezerra, G.C.L. and Gomes, C.F. (2016), "Measuring airport service quality: A multidimensional approach", *Journal of Air Transport Management*, Vol. 53, pp. 85–93.
Bezerra, G.C.L. & Gomes, C.F. (2020), Antecedents and consequences of passenger satisfaction with the airport, Journal of Air Transport Management, Volume 83, 101766, https://doi.org/10.1016/j.jairtraman.2020.101766
Bogicevic, V., Yang, W., Bilgihan, A. & Bujisic, M. (2013), "Airport service quality drivers of passenger satisfaction", Tourism Review, Vol. 68 No. 4, pp. 3-18. https://doi.org/10.1108/TR-09-2013-0047

Cahill, C., Palcic, D., & Reeves, E. (2017). Commercialisation and airport performance: The case of Ireland's DAA. *Journal of Air Transport Management, 59*, 155-163.

Caves, D. W., Christensen, L. R. and Diewert, W. E. (1982) Multilateral comparisons of output, input, and productivity using superlative index numbers. The Economic Journal 92(March), Pages 73-86.

Ceccato, V. & Masci, S. (2017) Airport Environment and Passengers' Satisfaction with Safety, Journal of Applied Security Research, 12:3, 356-373, DOI: 10.1080/19361610.2017.1315696

Chang, Y.C. & Chen, C.-F. (2011), Identifying mobility service needs for disabled air passengers, Tourism Management, Volume 32, Issue 5, Pages 1214-1217, https://doi.org/10.1016/j.tourman.2010.11.001

Chang, YT, Yu, C., Lee, K. & Lee S.Y., (2018), Passenger Satisfaction, Efficiency, Delays, and Bond Ratings: an Application of Network DEA to Evaluate the Performance of US Airports, a paper presented at the 21st Air Transport Research Society World Conference, July 2018, Seoul, Korea

Charnes, A., Cooper, W., and Rhodes, E. (1978), "Measuring the Efficiency of Decision Making Units", European Journal of Operational Research, Volume 2, Issue 6, pp 429-444

Chen,Y.-H. & Lai, P.-L., (2019), Determining the relationship between ownership and technical efficiency by using a dynamic stochastic production frontier approach, Journal of Air Transport Management, Volume 75, Pages 61-67, https://doi.org/10.1016/j.jairtraman.2018.12.001

Chonsalasin, D., Jomnonkwao, S. & Ratanavaraha, V. (2021), Measurement model of passengers' Expectations of airport service quality, International Journal of Transportation Science and Technology, Volume 10, Issue 4, Pages 342-352, https://doi.org/10.1016/j.ijtst.2020.11.001

Chow, C.K.W. & Fung, M.K.Y. (2009), Efficiencies and scope economies of Chinese airports in moving passengers and cargo, Journal of Air Transport Management, Volume 15, Issue 6, Pages 324-329, https://doi.org/10.1016/j.jairtraman.2009.05.002

Chutiphongdech, T. & Vongsaroj, R. (2022), Technical efficiency and productivity change analysis: A case study of the regional and local airports in Thailand, Case Studies on Transport Policy, Volume 10, Issue 2, Pages 870-890, https://doi.org/10.1016/j.cstp.2022.03.001

Coto-Millán, P., Casares-Hontañón, P., Inglada, V., Agüeros, M., Pesquera, M.A. & Badiola, A., (2014), Small is beautiful? The impact of economic crisis, low cost carriers, and size on efficiency in Spanish airports (2009–2011), Journal of Air Transport Management, Volume 40, Pages 34-41, https://doi.org/10.1016/j.jairtraman.2014.05.006

Coto-Millán, P., Inglada, V., Fernández, X.L., Inglada-Pérez, L. & Pesquera, M.A., (2016), The "effect procargo" on technical and scale efficiency at airports: The case of Spanish airports (2009–2011), Utilities Policy, Volume 39, Pages 29-35, https://doi.org/10.1016/j.jup.2016.01.004

Curi, C., Gitto, S. & Mancuso, P., (2010), The Italian airport industry in transition: a performance analysis, Journal of Air Transport Management, Volume 16, Issue 4, Pages 218-221, https://doi.org/10.1016/j.jairtraman.2009.11.001

Curi, C., Gitto, S. & Mancuso, P. (2014), The Italian airport industry in transition: a performance analysis, Journal of Air Transport Management, Volume 16, Issue 4, Pages 218-221, https://doi.org/10.1016/j.jairtraman.2009.11.001

D'Alfonso, T., Daraio, C. & Nastasi,A., (2015), Competition and efficiency in the Italian airport system: new insights from a conditional nonparametric frontier analysis, Transportation Research Part E: Logistics and Transportation Review, Volume 80, Pages 20-38, https://doi.org/10.1016/j.tre.2015.05.003

de Barros, A.G., Somasundaraswaran, A.K. & Wirasinghe, S.C. (2007), Evaluation of level of service for transfer passengers at airports, Journal of Air Transport Management, Volume 13, Issue 5, Pages 293-298, https://doi.org/10.1016/j.jairtraman.2007.04.004

De Nicola, A., Gitto,S. & Mancuso, P., (2013), Airport quality and productivity changes: A Malmquist index decomposition assessment, Transportation Research Part E: Logistics and Transportation Review, Volume 58,Pages 67-75, https://doi.org/10.1016/j.tre.2013.07.001

Diana, T. (2010), Can we explain airport performance? A case study of selected New York airports using a stochastic frontier model, Journal of Air Transport Management, Volume 16, Issue 6, Pages 310-314, https://doi.org/10.1016/j.jairtraman.2010.03.006

Doganis, R. and Graham, A. (1987) Airport Management: The Role of Performance Indicators. Transport Studies Group, Polytechnic of Central London, London.

Fakfare, P., Wattanacharoensil, W. & Graham, A. (2021), Exploring multi-quality attributes of airports and the asymmetric effects on air traveller satisfaction: The case of Thai International Airports, Research in Transportation Business & Management, Volume 41, 100648, https://doi.org/10.1016/j.rtbm.2021.100648

Fan, L.W.,Wu,F. & Zhou, P., (2014), Efficiency measurement of Chinese airports with flight delays by directional distance function, Journal of Air Transport Management, Volume 34, Pages 140-145, https://doi.org/10.1016/j.jairtraman.2013.10.002.

Fasone, V., Maggiore, P., & Scuderi, R. (2014). Airport ownership and financial performance: Evidence from Italy. *Journal of Air Transport Management, 40*, 163-168.

Fasone, V., & Zapata-Aguirre, S. (2016). Measuring business performance in the airport context: a critical review of literature. International Journal of Productivity and Performance Management., Volume 65 No. 8, pp. 1137-1158. https://doi.org/10.1108/IJPPM-06-2015-0090

Fernandes, V.A, Pacheco, R.R., Fernandes, E. & da Silva, W.R., (2019), Regional change in the hierarchy of Brazilian airports 2007–2016, Journal of Transport Geography, Volume 79, 102467, https://doi.org/10.1016/j.jtrangeo.2019.102467

Fodness, D. and Murray, B. (2007), Passengers' expectations of airport service quality, Journal of Services Marketing, Vol. 21 No. 7, Pages 492–506. https://doi.org/10.1108/08876040710824852.

Fragoudaki, A. & Giokas, D. (2020), Airport efficiency in the dawn of privatization: The case of Greece, Journal of Air Transport Management, Volume 86, 101821, https://doi.org/10.1016/j.jairtraman.2020.101821

Freitas, P.T.C., Silva, L.M., Nascimento, M.V. & Borille, G. M.R., (2021), Passenger profile and its effects on satisfaction level in food and beverage establishments: Case study of major Brazilian airports, Case Studies on Transport Policy, Volume 9, Issue 3, Pages

1219-1224, https://doi.org/10.1016/j.cstp.2021.06.009

Fung, M.K.Y., Wan, K. K. H., Hui, Y.V. & Law, J. S. (2008), Productivity changes in Chinese airports 1995–2004, Transportation Research Part E: Logistics and Transportation Review, Volume 44, Issue 3, Pages 521-542, https://doi.org/10.1016/j.tre.2007.01.003

Gillen, D. & Lall, A. (1997), Developing measures of airport productivity and performance: an application of data envelopment analysis, Transportation Research Part E: Logistics and Transportation Review, Volume 33, Issue 4, Pages 261-273, https://doi.org/10.1016/S1366-5545(97)00028-8.

Gillen, D. & Lall, A. (2001). Non-Parametric Measures of Efficiency of U.S. Airports, International Journal of Transport Economics / Rivista Internazionale Di Economia Dei Trasporti, 28(3), 283–306. http://www.jstor.org/stable/42748269

Gitto, S. & Mancuso, P. (2017), Improving airport services using sentiment analysis of the websites, Tourism Management Perspectives, Volume 22, Pages 132-136, https://doi.org/10.1016/j.tmp.2017.03.008

Gkritza,K., Niemeier, D. & Mannering, F. (2006), Airport security screening and changing passenger satisfaction: An exploratory assessment, Journal of Air Transport Management, Volume 12, Issue 5, Pages 213-219, https://doi.org/10.1016/j.jairtraman.2006.03.001

Graham, A., & Dennis, N. (2007). Airport traffic and financial performance: a UK and Ireland case study. *Journal of Transport Geography*, *15*(3), 161-171.

Hidalgo-Gallego, S. & Mateo-Mantecón, I., (2019), Effect of concentration in airline market on Spanish airport technical efficiency, Journal of Air Transport Management, Volume 76, Pages 56-66, https://doi.org/10.1016/j.jairtraman.2019.02.003

Hong, S.-J., Choi, D. & Chae, J., (2020), Exploring different airport users' service quality satisfaction between service providers and air travelers, Journal of Retailing and Consumer Services, Volume 52, 101917, https://doi.org/10.1016/j.jretconser.2019.101917

Hooper, P.G. & Hensher, D.A. (1997), Measuring total factor productivity of airports— an index number approach, Transportation Research Part E: Logistics and Transportation Review, Volume 33, Issue 4, Pages 249-259, https://doi.org/10.1016/S1366-5545(97)00033-1.

Humphreys, I., & Francis, G. (2000). Traditional Airport Performance Indicators: A Critical Perspective. Transportation Research Record, 1703(1), Pages 24–30. https://doi.org/10.3141/1703-04

Isa, N. A. Mohd., Ghaus, H., Hamid, N. A. & Tan, P.-L. (2020), Key drivers of passengers' overall satisfaction at klia2 terminal, Journal of Air Transport Management, Volume 87, 101859, https://doi.org/10.1016/j.jairtraman.2020.101859

Jiang, H. & Zhang, Y. (2016), An assessment of passenger experience at Melbourne Airport, Journal of Air Transport Management, Volume 54, Pages 88-92, https://doi.org/10.1016/j.jairtraman.2016.04.002

Karanki, F. & Lim, S.H., (2021), Airport use agreements and cost efficiency of U.S. airports, Transport Policy, Volume 114, Pages 68-77, https://doi.org/10.1016/j.tranpol.2021.09.006

Kutlu, L. & McCarthy, P. (2016), US airport ownership, efficiency, and heterogeneity, Transportation Research Part E: Logistics and Transportation Review, Volume 89, Pages 117-132, https://doi.org/10.1016/j.tre.2016.03.003

Larose, D.T. (2005), Introduction to Data Mining, Wiley Online Library.

Lee, K. & Yu, C. (2018), Assessment of airport service quality: A complementary approach to measure perceived service quality based on Google reviews, Journal of Air Transport Management, Volume 71, Pages 28-44, https://doi.org/10.1016/j.jairtraman.2018.05.004

Li, L, Mao, Y., Wang, Y. & Ma, Z. (2022), How has airport service qality changed in the context of COVID-19: A data-driven crowdsourcing approach based on sentiment analysis, Journal of Air Transport Management, Volume 105, 102298, https://doi.org/10.1016/j.jairtraman.2022.102298

Liebert, V., & Niemeier, H.-M. (2013). A Survey of Empirical Research on the Productivity and Efficiency Measurement of Airports. Journal of Transport Economics and Policy, 47(2), 157–189. http://www.jstor.org/stable/24396267

Lin, Z., Choo, Y.Y. & Oum, T.H. (2013), Efficiency Benchmarking of North American Airports: Comparative Results of Productivity Index, Data Envelopment Analysis and Stochastic Frontier Analysis, Journal of the Transportation Research Forum, Volume 52, Issue 1, pages 47-67

lo Storto, C., (2018), Ownership structure and the technical, cost, and revenue efficiency of Italian airports, Utilities Policy, Volume 50, Pages 175-193, https://doi.org/10.1016/j.jup.2018.01.003

Lopez-Valpuesta, L. & Casas-Albala, D. (2023), Has passenger satisfaction at airports changed with the onset of COVID-19? The case of Seville Airport (Spain), Journal of Air Transport Management, Volume 108, 102361, https://doi.org/10.1016/j.jairtraman.2023.102361

Lozano,S., Gutiérrez,E. & Moreno, P., (2013), Network DEA approach to airports performance assessment considering undesirable outputs, Applied Mathematical Modelling, Volume 37, Issue 4, Pages 1665-1676, https://doi.org/10.1016/j.apm.2012.04.041

Lupo, T. (2014), Fuzzy ServPerf model combined with ELECTRE III to comparatively evaluate service quality of international airports in Sicily, Journal of Air Transport Management, Volume 42, Pages 249-259, https://doi.org/10.1016/j.jairtraman.2014.11.006

Lyer,K.C. & Jain,S. (2019), Performance measurement of airports using data envelopment analysis: A review of methods and findings, Journal of Air Transport Management, Volume 81, 101707, https://doi.org/10.1016/j.jairtraman.2019.101707

Malmquist, S. (1953), Index Numbers and Indifference Surfaces, Trabajos de Estatistica, 4, pp. 209-242

Martin, J.C. and Roman, C. (2001), An application of DEA to measure the efficiency of Spanish airports, Journal of Air Transport Management, Vol. 7 No. 3, pages 149-157. https://doi.org/10.1016/S0969-6997(00)00044-2

Martın, J. C., Roman, C., & Voltes-Dorta, A. (2009), A stochastic frontier analysis to estimate the relative efficiency of Spanish airports, Journal of Productivity Analysis, 31(3), 163–76.

Martín, J. C., Martín-Domingo, L, Lohmann, L. & Spasojevic, B. (2019), The role of travel patterns in airport duty-free shopping satisfaction: A case study from an Australian regional airport, Journal of Air Transport Management, Volume 80, 101691, https://doi.org/10.1016/j.jairtraman.2019.101691

Martin-Domingo, L., Martín, J.C. & Mandsberg , G., (2019), Social media as a resource for sentiment analysis of Airport Service Quality

(ASQ), Journal of Air Transport Management, Volume 78, Pages 106-115, https://doi.org/10.1016/j.jairtraman.2019.01.004

Martıin-Cejas, R.R. (2002), An approximation to the productive efficiency of the Spanish airports network through a deterministic cost frontier, Journal of Air Transport Management, Volume 8, Issue 4, Pages 233-238, https://doi.org/10.1016/S0969-6997(01)00056-4

Martini, G., Manello, A. & Scotti, D. (2013), The influence of fleet mix, ownership and LCCs on airports' technical/environmental efficiency, Transportation Research Part E: Logistics and Transportation Review, Volume 50, Pages 37-52, https://doi.org/10.1016/j.tre.2012.10.005

Martini, G., Scotti, D. & Volta, N., (2013), Including local air pollution in airport efficiency assessment: A hyperbolic-stochastic approach, Transportation Research Part D: Transport and Environment, Volume 24, Pages 27-36, https://doi.org/10.1016/j.trd.2013.05.002.

Martini, G., Scotti,D., Viola,D.& Vittadini, G. (2020), Persistent and temporary inefficiency in airport cost function: An application to Italy, Transportation Research Part A: Policy and Practice, Volume 132, Pages 999-1019, https://doi.org/10.1016/j.tra.2019.12.016

Merkert, R., Odeck, J., Brathen, S. & Pagliari, R. (2012) A Review of Different Benchmarking Methods in the Context of Regional Airports, Transport Reviews, 32:3, 379-395, DOI: 10.1080/01441647.2012.662707

Merkert, R., & Assaf, A. G. (2015). Using DEA models to jointly estimate service quality perception and profitability–Evidence from international airports. *Transportation Research Part A: Policy and Practice*, *75*, 42-50.

Meeusen, W. & van den Broeck, J. (1977), Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error, International Economic Review, 8, Pages 435-444, https://doi.org/10.2307/2525757

Moody's Investor Service. (2019). *Publicly Managed Airports and Related Issuers.* New York: Moody's Investor Service.

Moody's Investor Service. (2017). *Privately Managed Airports and Related Issuers.* New York: Moody's Investor Service.

Murillo-Melchor, C. (1999). An Analysis of Technical Efficiency and Productivity Changes in Spanish Airports using the Malmquist Index, International Journal of Transport Economics / Rivista Internazionale Di Economia Dei Trasporti, 26(2), 271–292. http://www.jstor.org/stable/42747748

Nwaogbe, O. R.; Ogwude, I. C.; Ejem A.E.; & Pius, A (2021) "Service Quality and Passenger Satisfaction in Air Transportation in a Developing Economy: Evidence from Nigeria," *Journal of Aviation Technology and Engineering*: Vol. 10: Iss. 1, Article 4. https://doi.org/10.7771/2159-6670.1207

Nyshadham, E. A., & Rao, V. K. (2000). Assessing Efficiency of European Airports: A Total Factor Productivity Approach. Public Works Management & Policy, 5(2), Pages 106-114. https://doi.org/10.1177/1087724X0052004

Örkcü, H.H., Balıkçı, C. Dogan, M.I. & Genç,A. (2016), An evaluation of the operational efficiency of turkish airports using data envelopment analysis and the Malmquist productivity index: 2009–2014 case, Transport Policy, Volume 48, Pages 92-104, https://doi.org/10.1016/j.tranpol.2016.02.008

Oum,T.H., Yu,C. & Fu, X., (2003), A comparative analysis of productivity performance of the world's major airports: summary report of the ATRS global airport benchmarking research report—2002, Journal of Air Transport Management, Volume 9, Issue 5, Pages 285-297,https://doi.org/10.1016/S0969-6997(03)00037-1

Oum, T.-H. & Yu, C., (2004), Measuring airports' operating efficiency: a summary of the 2003 ATRS global airport benchmarking report, Transportation Research Part E: Logistics and Transportation Review, Volume 40, Issue 6, Pages 515-532, https://doi.org/10.1016/j.tre.2004.08.002

Oum, T.H., Adler, N. & Yu, C. (2006), Privatization, corporatization, ownership forms and their effects on the performance of the world's major airports, Journal of Air Transport Management, Volume 12, Issue 3, Pages 109-121, https://doi.org/10.1016/j.jairtraman.2005.11.003

Oum, T.H, Yan, J. & Yu, C. (2008), Ownership forms matter for airport efficiency: A stochastic frontier investigation of worldwide airports, Journal of Urban Economics, Volume 64, Issue 2, Pages 422-435, https://doi.org/10.1016/j.jue.2008.03.001.

Oum, T. H., Zhang, A. & Zhang, Y. (2004), Alternative Forms of Economic Regulation and their Efficiency Implications for Airports, Journal of Transport Economics and Policy, Volume 38, Number 2, pages 217-246

Pabedinskaitė, A. & Akstinaitė,V., (2014), Evaluation of the Airport Service Quality, Procedia - Social and Behavioral Sciences, Volume 110, Pages 398-409, https://doi.org/10.1016/j.sbspro.2013.12.884

Pagliari, R., & Graham, A. (2019). An exploratory analysis of the effects of ownership change on airport competition. *Transport Policy*, *78*, 76-85.

Pandey, M.M. (2016), Evaluating the service quality of airports in Thailand using fuzzy multi-criteria decision making method, Journal of Air Transport Management, Volume 57, Pages 241-249,https://doi.org/10.1016/j.jairtraman.2016.08.014

Pantouvakis, A. and Renzi, M.F. (2016), "Exploring different nationality perceptions of airport service quality", Journal of Air Transport Management, Vol. 52, pp. 90–98.

Park, J.-W. & Jung, S.Y., (2011), Transfer Passengers' Perceptions of Airport Service Quality: A Case Study of Incheon International Airport, International Business Research, Vol. 4, No. 3; Pages 75-82, doi:10.5539/ibr.v4n3p75

Parker, D. (1999). The Performance of BAA before and after Privatisation: A DEA Study. Journal of Transport Economics and Policy, 33(2), 133–145. http://www.jstor.org/stable/20053801

Pels, E., Nijkamp, P. & Rietveld, P., (2001), Relative efficiency of European airports, Transport Policy, Volume 8, Issue 3, Pages 183-192, https://doi.org/10.1016/S0967-070X(01)00012-9

Pels, E., Nijkamp, P. & Rietveld, P. (2003), Inefficiencies and scale economies of European airport operations, Transportation Research Part E: Logistics and Transportation Review, Volume 39, Issue 5, Pages 341-361, https://doi.org/10.1016/S1366-5545(03)00016-4

Perelman, S. & Serebrisky, T., (2012), Measuring the technical efficiency of airports in Latin America, Utilities Policy, Volume 22, Pages 1-7, https://doi.org/10.1016/j.jup.2012.02.001

Phang,S.-Y., (2016), A general framework for price regulation of airports, Journal of Air Transport Management, Volume 51, Pages 39-45, https://doi.org/10.1016/j.jairtraman.2015.11.001

Raghavan, S. & Yu, C. (2021), Evaluating financial performance of commercial service airports in the United States, Journal of Air Transport Management, Volume 96, 102111, https://doi.org/10.1016/j.jairtraman.2021.102111

Randrianarisoa, L.M., Oum, T.H. & Yu, C. (2023), Corruption and airport efficiency: A study on Asian airports, Transport Policy, Volume 130, Pages 46-54, https://doi.org/10.1016/j.tranpol.2022.11.001

Ray, S. C. and Mukherjee, K. (1996). "Decomposition of the Fisher Ideal Index of Productivity: A Non-Parametric Dual Analysis of US Airlines Data". The Economic Journal, Vol. 106, No. 439, Pp. 1659-1678.

Rhoades, D.L., Waguespack, J.B. and Young, S. (2000), "Developing a quality index for US airports", Managing Service Quality: An International Journal, Vol. 10 No. 4, pp. 257–262.

Richardson, C., Budd, L., & Pitfield, D. (2014). The impact of airline lease agreements on the financial performance of US hub airports. *Journal of Air Transport Management*, *40*, 1-15.

Rotondo, F. (2019), An explorative analysis to identify airport business models, Research in Transportation Business & Management, Volume 33, 100417, https://doi.org/10.1016/j.rtbm.2019.100417

Rubio-Andrada, L, Celemín-Pedroche, M.S., Escat-Cortés, M.-D., & Jiménez-Crisóstomo, A. (2023), Passengers satisfaction with the technologies used in smart airports: An empirical study from a gender perspective, Journal of Air Transport Management, Volume 107, 102347, https://doi.org/10.1016/j.jairtraman.2022.102347

Sakano, R., Obeng, K. & Fuller, K. (2016), Airport security and screening satisfaction: A case study of U.S., Journal of Air Transport Management, Volume 55, Pages 129-138, https://doi.org/10.1016/j.jairtraman.2016.05.007

Scotti, D., Malighetti,P., Martini, G. & Volta, N., (2012), The impact of airport competition on technical efficiency: A stochastic frontier analysis applied to Italian airport, Journal of Air Transport Management, Volume 22, Pages 9-15, https://doi.org/10.1016/j.jairtraman.2012.01.003.

Scotti, D., Dresner, M., Martini, G. & Yu, C. (2014), Incorporating negative externalities into productivity assessments of US airports, Transportation Research Part A: Policy and Practice, Volume 62, Pages 39-53, https://doi.org/10.1016/j.tra.2014.02.008

See, K. F., Ülkü, T., Forsyth, P., & Niemeier, H. M. (2023). Twenty years of airport efficiency and productivity studies: A machine learning bibliometric analysis. Research in Transportation Business & Management, 46, 100771, https://doi.org/10.1016/j.rtbm.2021.100771

Shamohammadi, M., Park, Y., Choi, J. H., & Kwon, O. K. (2022). Exploring the Performance of International Airports in the Pre- and Post-COVID-19 Era: Evidence from Incheon International Airport. Sustainability, 14(7), 4222. http://dx.doi.org/10.3390/su14074222

Suárez-Alemán, A. and Jiménez, J.L. (2016), "Quality assessment of airport performance from the passengers' perspective", *Research in Transportation Business and Management*, Vol. 20, pp. 13–19.

Tavalaei, M. M., & Santalo, J. (2019). Pure versus hybrid competitive strategies in the airport industry. *Transportation Research Part A: Policy and Practice*, *124*, 444-455.

Thomas, N. & Jha, K.N., (2022), Structural efficiency assessment of regional airports: Lessons from India, Utilities Policy, Volume 79, 101449, https://doi.org/10.1016/j.jup.2022.101449

Tretheway,M., (1995), The Economic Performance of European Airports: RS Doganis, Anne Graham and A Lobbenberg Research Report 3, Department of Air Transport, Cranfield University 106 pp £150, Journal of Air Transport Management, Volume 2, Issues 3–4, Page 207, https://doi.org/10.1016/0969-6997(96)86942-0.

Tsui, W.H.K., Gilbey, A. & Balli, H.O., (2014), Estimating airport efficiency of New Zealand airports, Journal of Air Transport Management, Volume 35, Pages 78-86, https://doi.org/10.1016/j.jairtraman.2013.11.011

Usman, A., Azis, Y., Harsanto, B., & Azis, A. M. (2022). Airport service quality dimension and measurement: a systematic literature review and future research agenda. International Journal of Quality & Reliability Management, 39(10), 2302-2322.

Vasigh, B. & Gorjidooz, J. (2006): Productivity analysis of public and private airports: a causal investigation, Journal of Air Transportation, 11(3), Pages 144–63.

Vasigh, B., & Haririan, M. (2003). An Empirical Investigation of Financial and Operational Efficiency of Private Versus Public Airports. *Journal of Air Transportation, 8*(1), 91-110.

Vogel, H. A. (2006). Impact of privatisation on the financial and economic performance of European airports. *The Aeronautical Journal, 110*(1106), 197-213.

Vogel, H. A., & Graham, A. (2013). Devising airport groupings for financial benchmarking. *Journal of Air Transport Management*, *30*, 32-38.

Wang, Z. & Song, W.-K., (2020), Sustainable airport development with performance evaluation forecasts: A case study of 12 Asian airports, Journal of Air Transport Management, Volume 89, 101925, https://doi.org/10.1016/j.jairtraman.2020.101925

Wanke, P., Barros, C.P. & Nwaogbe, O.R., (2016), Assessing productive efficiency in Nigerian airports using Fuzzy-DEA, Transport Policy, Volume 49, Pages 9-19, https://doi.org/10.1016/j.tranpol.2016.03.012

Yavuz, N., Olgaç, S., Aktaş, S.G., & Kantar, Y. M. (2020). Passenger Satisfaction in European Airports. In: Coşkun, İ., Othman, N., Aslam, M., Lew, A. (eds) Travel and Tourism: Sustainability, Economics, and Management Issues. Springer, Singapore. https://doi.org/10.1007/978-981-10-7068-6_14

Yeh, C.-H. and Kuo, Y.-L. (2003), "Evaluating passenger services of Asia-Pacific international airports", *Transportation Research Part E: Logistics and Transportation Review*, Elsevier, Vol. 39 No. 1, pp. 35–48.

Yu, M.-M. & Rakshit,I. (2023), Assessing the dynamic efficiency and technology gap of airports under different ownerships: A union dynamic NDEA approach, Omega, Volume 119, 102888, https://doi.org/10.1016/j.omega.2023.102888

Zhong, N., Li, Y. and Wu, S.-T. (2012), Effective pattern discovery for text mining, IEEE Transactions on Knowledge and Data Engineering, IEEE, Vol. 24 No. 1, Pages 30–44, http://doi.org/10.1109/TKDE.2010.211

Zou, B., Kafle,N., Chang, Y-T, & Park, K., (2015), US airport financial reform and its implications for airport efficiency: An exploratory investigation, Journal of Air Transport Management, Volume 47, Pages 66-78, https://doi.org/10.1016/j.jairtraman.2015.05.002

Zuidberg, J. (2017). Exploring the determinants for airport profitability: Traffic characteristics, low-cost carriers, seasonality and cost efficiency. *Transportation Research Part A: Policy and Practice, 101*, 61-72.