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Unveiling Angkasa Pura Airport's Economic Efficiency Through DEA Analysis

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Abstract: This study aims to analyze the economic efficiency of airports in Angkasa Pura I, especially since the formation of the Tourism SOE holding in 2022 which changes airport operations. This study examines efficiency during the COVID-19 pandemic by introducing Air Traffic Movement (ATM), Air Passenger Movement (APM), and Air Cargo Movement (ACM) variables as output variables, which provide new insights that have not been explored before, especially the study in all Angkasa Pura I airports. This study uses quantitative research methods with non-parametric techniques to analyze efficiency and economies of scale in the aviation industry. The analytical tool used is Data Envelopment Analysis (DEA) using STATA 17 software as the main tool to evaluate efficiency and economies of scale at 16 airports. The results revealed variations in the level of efficiency of economies of scale among airports, with some airports improving their efficiency in response to the pandemic. The study confirms the importance of effective management strategies, transparency in information dissemination, and continuous monitoring in shaping airports' economic efficiency.

Keywords: Airport, Data Envelopment Analysis, Efficiency, Economies of Scale.

INTRODUCTION

The concept of economies of scale is crucial for businesses aiming to gain a competitive advantage by reducing production costs per unit as output increases. This strategy hinges on operational efficiency across various company departments and the expansion of production scale. (Carpenter & Sanders, 2007). Returns to scale, which describe how average costs change with output, are classified into three scenarios: economies of scale, diseconomies of scale, and constant returns to scale. Economies of scale occur when average costs decrease as output expands, indicating that a company can produce more at a lower cost per unit. On the other hand, diseconomies of scale involve rising average costs with increased output, suggesting that a company's production becomes less efficient at higher volumes. Constant returns to scale, as the name suggests, indicate that average costs remain constant regardless of the level of output (Besanko et al., 2020).

Companies that experience economies of scale typically exhibit efficiency in cost management, which translates into lower average costs as production increases. This efficiency is primarily due to the ability to distribute total fixed costs over a larger production output, thereby generating cost advantages per unit of product or service (Carpenter & Sanders, 2007). The practical implications of economies of scale are substantial, allowing companies to lower their average production costs as output increases. This is achieved through various strategies, including the ability to spread fixed costs over a larger production volume, negotiate better deals with suppliers due to bulk purchasing, and optimize resource utilization through improved processes and technologies.

Economies of scale can be quantified using the output elasticity of total cost ($\epsilon TC,Q$), representing the percentage change in total costs per one percent change in output (Besanko et al., 2020). This measurement, derived from comparing marginal cost (MC) with average cost (AC), provides insights into production efficiencies and cost optimization strategies.

In airport management, economies of scale is crucial, particularly with the growth of passenger and cargo traffic managed by companies like Angkasa Pura I. As airport capacity expands, it poses challenges that require optimizing infrastructure usage and strategic route development. To manage economies of scale effectively, airport companies may consider corporate mergers as a strategy, although this approach is complicated by government policies and regulations (Ülkü, 2009).

Research on economies of scale in the aviation sector significantly contributes to understanding the efficiency factors that impact airport operations and their effectiveness. Studies have shown varying economies of scale across different airport sizes, providing valuable insights for managing airport infrastructure and operations effectively. (Doganis & Thompson, 1974; Jeong, 2005; Main et al., 2003; Martín et al., 2011; Martín & Dorta, 2008; Tolofari et al., 1990; Walters, 1978). This research contributes significantly to aviation industry knowledge, particularly in optimizing operational efficiency and developing airport infrastructure.

The objective of this research is to analyze and understand the economic scale of airports managed by Angkasa Pura I in Indonesia, aiming to provide insights into managing economies of scale within airport operations, thus contributing to national economic development and efficient airport management.

METHOD

This research adopts non-parametric techniques to analyze efficiency and economies of scale in the aviation industry. One of the advantages of non-parametric techniques is their ability to overcome assumptions about the exact functional form of a production or cost function, thereby allowing a more flexible and realistic analysis. In this context, the research uses Data Envelopment Analysis (DEA) as the main tool to measure the relative efficiency and economies of scale of 16 airports that are decision-making units (DMUs) under the auspices of Angkasa Pura I. For example, Ferro et al. (2020) conducted an empirical study of Argentinian airport analysis using the DEA approach, with input variables such as the number of employees, runway surface, and passenger terminal, and output variables including the number of aircraft, passengers, and total cargo. Ennen & Batool (2018) analyzed airport efficiency in Pakistan with input variables including the number of workers, runways, airport area, labor costs, other operational costs, and Angkasa Pura I stock, and output variables including the number of passengers, flights, cargo, and airline revenue. Meanwhile, Olariaga & Moreno (2019) utilized the DEA approach with input variables such as the number of runways, runway length, aircraft parking stands on the apron, passenger terminal, and apron area, and output variables including aircraft operations (takeoffs/landings), passenger transit, and transit cargo.

DEA is a non-parametric method widely used in evaluating the performance of institutions such as education, hospitals, banking, and manufacturing industries. This method employs a Linear Programming approach, unlike the Stochastic Frontier Analysis (SFA) method that utilizes a production function approach. The DEA method was chosen for its ability to consider multiple inputs and outputs simultaneously and identify relatively efficient units within a given dataset (Coelli et al., 2005). The methodological steps include several stages. Firstly, the research identifies input and output variables using simple statistical analysis methods like Simple Linear Regression (SLR) to ensure the selection of appropriate and relevant variables. Secondly, secondary data about various aspects of airport operations are collected from reliable sources. After identifying input and output variables and collecting data, an analysis of efficiency and economies of scale is conducted using the DEA approach. DEA also allows researchers to assess the relative efficiency of each DMU in utilizing its inputs to produce output and measure the level of economies of scale possessed by each DMU (Coelli et al., 2005). This method provides a comprehensive overview of the relative performance of each airport and enables the identification of areas where efficiency can be enhanced or economies of scale better utilized.

Efficiency can be measured in two orientations: input orientation and output orientation. Input orientation indicates how much input can be reduced without decreasing the amount of output produced, while output orientation shows how much output can be increased without increasing the amount of input used (Coelli et al., 2005).

DEA as a non-parametric approach does not require assumptions about the relationship between input and output variables (Christianti, 2021). Measuring efficiency with DEA yields three benefits: serving as a benchmark for obtaining relative efficiency, identifying factors that cause variations in efficiency, and determining policy implications for increasing efficiency levels (Sutawijaya & Lestari, 2009).

The analysis in this research will use the BCC (Banker, Charnes, and Cooper) or VRS (Variable Return to Scale) DEA model approach, which is oriented towards input and output. The basic DEA formula will be applied to evaluate the efficiency of the units that are the object of research.

RESULTS AND DISCUSSION

Results

This research aims to analyze the fundamental concept of economies of scale, with the objective of providing insight to evaluate its application within the airport industry in Indonesia. The study observes that the airport business has evolved from merely serving as a landing and takeoff field for planes to becoming a diversified multi-service business.

Several studies have investigated economies of scale within the airport industry, yielding varying conclusions despite their focus on the same sector. Results range from no observed economies of scale at all. To measure economies of scale across 16 airports in Indonesia included within the operational areas of Angkasa Pura I, this research utilizes Data Envelopment Analysis (DEA) over three periods: pre-COVID (2018 and 2019), COVID (2020-2021), and post-COVID (2022) to examine efficiency variations in each period.

By employing input and output variables identified from a previous Systematic Literature Review (SLR) analysis, the study obtains airport efficiency scores using the DEA analytical tool. Efficiency in this context refers to Return to Scale (RtS), indicating the degree to which an organization or system leverages its production scale to achieve optimal output levels. Three primary Return to Scale categories are utilized in this study: Constant Returns to Scale (CRS), Decreasing Returns to Scale (DRS), and Increasing Returns to Scale (IRS).

Constant Returns to Scale (CRS) efficiency occurs when a proportional increase in inputs (production factors) results in a proportional increase in output, allowing production scale adjustments without impacting cost per unit. Decreasing Returns to Scale (DRS)

efficiency arises when a proportional input increase yields a proportionally smaller output increase, suggesting diminishing returns with larger production scales. Conversely, Increasing Returns to Scale (IRS) efficiency occurs when a proportional input increase leads to a proportionally greater output increase, showcasing heightened production output with scale expansion. These categories reflect how the relationship between input and output changes as production scale varies, pivotal for efficiency analysis within organizations seeking optimal resource utilization. These results are presented in Table 1 below.

Table 1. Angkasa Pura I Airport Efficiency Performance Values

DMUs	Efficiency Score					RTS				
	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
DPS	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
SUB	0.00	0.00	0.00	0.00	0.00	Constant	Constant	Constant	Constant	Constant
UPG	0.00	0.00	0.00	0.00	0.00	Constant	Constant	Constant	Constant	Constant
BPN	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
BIK	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
MDC	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
BDJ	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
SRG	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
JOG	0.00	0.00	1.00	1.00	1.00	Constant	Constant	Increasing	Increasing	Increasing
SOC	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
LOP	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
AMQ	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
KOE	1.00	1.00	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
YIA	1.00 *	1.00 *	1.00	1.00	1.00	Increasing	Increasing	Increasing	Increasing	Increasing
DJJ	0.00 *	0.00 *	0.00	0.00	0.00	Constant	Constant	Constant	Constant	Constant

Notes: *Assumed data using the moving average method, some of the input data is empty because there are several airports operating in 2020.
*YIA was newly built and inaugurated by President on August 28 2020.
*DJJ is still managed by the Ministry of Transportation as UPBU, and AP 1 manages DJJ airport starting January 1 2020.

Source: Data Envelopment Analysis (DEA) processing using STATA17

The Data Envelopment Analysis (DEA) conducted above illustrates the changes in airport efficiency performance in Indonesia under Angkasa Pura I from 2018 to 2022, focusing on efficiency distribution based on return to scale. Before the COVID-19 pandemic, most airports maintained consistent efficiency levels, with one airport experiencing an increase in efficiency. Despite the onset of the pandemic in late 2019, the shift in efficiency patterns at these airports was not significant enough to alter their return to scale.

In 2020, the impact of the COVID-19 pandemic was pronounced, yet surprisingly positive for one airport, as it experienced an increase in efficiency (increasing return to scale). While many airports remained consistent in their efficiency, the notable increase in efficiency at one airport indicates positive growth and development in airport operations. In this case, the airport may have adopted more efficient strategies compared to previous years, leveraging economies of scale to reduce costs per unit and increase output proportionally more than the increase in costs. This also demonstrates the airport's ability to adapt to larger scales and may be indicative of healthy growth within the aviation industry.

The year 2021 was marked by a surge in COVID-19 cases in Indonesia, resulting in the implementation of Community Activity Restrictions (PPKM). In this scenario, the pandemic did not significantly impact the efficiency of Angkasa Pura I airports, with most airports able to maintain their efficiency levels.

Entering 2022, several airports still maintain consistent or increased efficiency levels. This demonstrates the adaptability and resilience of airports in facing dynamic market

conditions. Although there are differences among the airports under Angkasa Pura I, this recovery marks a positive achievement for Indonesia's aviation industry overall.

Analyzing the efficiency performance of Angkasa Pura I based on the above analysis indicates that Angkasa Pura I has achieved decent efficiency performance. To enhance efficiency, Angkasa Pura I can adopt specific strategic measures. Firstly, transitioning to a more specialized management approach akin to Angkasa Pura II, focusing on developing expertise within each operational unit to enhance operational efficiency and goal achievement. Additionally, Angkasa Pura I should evaluate its organizational structure, identifying opportunities to streamline processes to boost efficiency and responsiveness to operational demands. By reducing excessive bureaucracy and strengthening inter-unit coordination, Angkasa Pura I can enhance flexibility and responsiveness to market dynamics and customer needs. Furthermore, investing in technology and innovation is crucial for Angkasa Pura I. Integrating cutting-edge technology across operational aspects, such as air traffic management, terminal operations, and human resources, can enhance overall operational efficiency. Innovating airport services and facilities will also enhance airport attractiveness and revenue. These initiatives should be complemented by robust cost and revenue management efforts. Angkasa Pura I must conduct comprehensive assessments of operational costs to identify areas for improvement. Implementing strategies to boost revenue, such as expanding flight routes, enhancing passenger services, and forging partnerships with airlines and stakeholders, can help Angkasa Pura I increase its revenue.

By strategically integrating these measures, Angkasa Pura I can enhance efficiency and strengthen its position in the Indonesian aviation industry. In addition to the efficiency calculations using the aforementioned DEA analysis, Table 2 below provides a more detailed depiction of the efficiency performance values of Angkasa Pura I airports during different periods (pre-COVID, COVID, and post-COVID), facilitating a better understanding of the earlier analysis outcomes.

Table 2. Angkasa Pura I Airport Efficiency Performance Values Per Period

DMUs	Efficiency Score			RTS		
	Pre Covid	Covid	Post Covid	Pre Covid	Covid	Post Covid
DPS	1.00	1.00	1.00	Increasing	Increasing	Increasing
SUB	0.00	0.00	0.00	Constant	Constant	Constant
UPG	0.00	0.00	0.00	Constant	Constant	Constant
BPN	1.00	1.00	1.00	Increasing	Increasing	Increasing
BIK	0.00	1.00	1.00	Increasing	Increasing	Increasing
MDC	1.00	1.00	1.00	Increasing	Increasing	Increasing
BDJ	1.00	1.00	1.00	Increasing	Increasing	Increasing
SRG	1.00	1.00	1.00	Increasing	Increasing	Increasing
JOG	0.00	1.00	1.00	Increasing	Increasing	Increasing
SOC	1.00	1.00	1.00	Increasing	Increasing	Increasing
LOP	1.00	1.00	1.00	Increasing	Increasing	Increasing
AMQ	1.00	1.00	1.00	Increasing	Increasing	Increasing
KOE	1.00	1.00	1.00	Increasing	Increasing	Increasing
YIA	1.00*	1.00	1.00	Increasing	Increasing	Increasing
DJJ	0.00*	0.00	0.00	Constant	Constant	Constant

Notes: *Assumed data using the moving average method, some of the input data is empty because there are several airports operating in 2020.
* YIA was newly built and inaugurated by President on August 28 2020.
* DJJ is still managed by the Ministry of Transportation as UPBU, and AP 1 manages DJJ airport starting January 1 2020.

Source: Data Envelopment Analysis (DEA) processing using STATA17.

After being classified based on three time periods (pre-COVID, COVID, and post-COVID), the return to scale for Angkasa Pura I airports becomes increasingly clear that the

presence of COVID-19 did not significantly impact the efficiency of these airports. The impact of the COVID-19 pandemic on airport efficiency can be observed through several significant changes in airport operations and business conditions.

Furthermore, this study will present a more in-depth analysis regarding the justification of economies of scale that apply to 16 airports under Angkasa Pura I. This step is consistent with our research objective, which aims to investigate the impact of the COVID-19 pandemic on the operational efficiency of Angkasa Pura I airports. This analysis will specifically highlight significant changes in the production scale of these airports, carefully considering the concept of economies of scale. This concept refers to the profits that a company can obtain when it increases its production scale. In the economic framework, there are three main aspects relevant to economies of scale as previously explained by Besanko et al. (2020), namely constant economies of scale, diseconomies of scale, and economies of scale.

Constant economies of scale indicate that the airport will continue to experience additional efficiency and profits when the production scale is increased (MC = AC or efficiency value = 1). Conversely, diseconomies of scale reflect a situation where profits and efficiency decrease as the scale of production increases (MC > AC or efficiency value > 1). Economies of scale create conditions where increasing the scale of production results in a decrease in the average production cost per unit of output, allowing airports to produce goods or services at lower costs (MC < AC or efficiency value < 1). Through this analysis, it is hoped that this research will provide a deeper understanding of the dynamics of economic scale that may occur in the Indonesian aviation sector due to the significant changes that occurred before, during, and after the pandemic. This analysis can be seen in Table 3 below.

Table 3. Economies of Scale Angkasa Pura I Airports 2019 – 2022

DMUs	Elasticity of Total Cost				Economies of Scale			
	2019	2020	2021	2022	2019	2020	2021	2022
DPS	-0.42	0.09	0.99	-0.32	EOS	EOS	EOS	EOS
SUB	0.08	0.13	1.02	0.05	EOS	EOS	DOS	EOS
UPG	-0.06	0.17	-1.27	-0.32	EOS	EOS	EOS	EOS
BPN	0.05	0.19	6.78	-0.29	EOS	EOS	DOS	EOS
BIK	-0.11	0.10	0.19	-0.37	EOS	EOS	EOS	EOS
MDC	-0.11	0.07	-244.20	0.35	EOS	EOS	EOS	EOS
BDJ	-0.30	-0.42	0.72	-0.12	EOS	EOS	EOS	EOS
SRG	-0.97	-0.01	0.49	-0.07	EOS	EOS	EOS	EOS
JOG	-0.32	0.29	0.05	1.41	EOS	EOS	EOS	DOS
SOC	-0.21	0.08	0.45	0.07	EOS	EOS	EOS	EOS
LOP	-0.59	0.34	-0.35	0.14	EOS	EOS	EOS	EOS
AMQ	0.30	0.17	0.67	-0.49	EOS	EOS	EOS	EOS
KOE	-0.29	0.03	2.73	0.14	EOS	EOS	DOS	EOS
YIA	0.00	1.12	3.61	-0.21	EOS	DOS	DOS	EOS
DJJ	1.75	0.63	-0.21	0.83	DOS	EOS	EOS	EOS
Average	-0.08	0.20	-15.22	0.05	EOS	EOS	EOS	EOS

Notes: *EOS stands for Economies of Scale.
*DOS stands for Diseconomies of Scale.

Source: Data processing using Microsoft Excel.

The analysis of economies of scale at Angkasa Pura I airports presents a complex and varied picture. In conducting this research, economies of scale were evaluated at 16 airports to understand their response to significant operational changes, particularly due to the COVID-19 pandemic. Based on this data, it can be concluded that during the periods before, during, and after the pandemic, airports in Angkasa Pura I's operational areas continued to experience economies of scale. However, upon analyzing each airport, some show patterns of diseconomies of scale, where airports such as Juanda Airport (SUB), Sepinggan Airport (BPN), Adisutjipto Airport (JOG), El Tari Airport (KOE), Yogyakarta Kulon Progo Airport (YIA), and Sentani Airport (DJJ), especially post-COVID, experienced decreased efficiency

and profits as their operational scale increased. This occurred when fixed costs were challenging to allocate efficiently between increasing variable costs and decreasing passenger volumes. In other words, as the operational scale expanded, the additional costs faced by airports exceeded the additional profits gained from increased production. These diseconomies of scale reflect the airports' limited ability to manage operational scale increases efficiently, ultimately affecting overall profitability and efficiency. However, several airports also managed to achieve economies of scale, where increasing operational scale benefited by reducing the average production cost per unit output.

Further analysis of specific airports can provide deeper insights into the strategies and factors influencing success or challenges in achieving economies of scale. Thus, understanding of the economic dynamics in the Indonesian aviation sector can be enhanced, providing a foundation for better decision-making in the future.

Discussion

Since the 1970s, there have been remarkable changes in the airport production process worldwide, particularly in business expansion. Doganis & Thompson (1974) divided airport functions into operational services and facilities, traffic handling services, and commercial activities. Despite the fundamental elements of airports, such as runways, being relatively stable, non-aviation businesses have grown rapidly, contributing up to 50% of total revenue at some airports in Europe (Graham, 2018). Current airport business attention is more focused on commercializing and expanding non-aviation activities (Freathy, 2004), transforming airports into multi-product companies serving as consumption centers (Fuerst et al., 2011).

This development highlights the important role of economies of scale in optimizing airport operational performance and efficiency. Economies of scale refer to the benefits gained from increasing production scale, resulting in efficiency and lower production costs per unit of output (Pindyck & Rubinfeld, 2013).

In the context of the Indonesian airport industry, DEA analysis measuring scale efficiency over three periods shows variations from constant returns to scale to increasing and decreasing returns to scale (Mankiw, 2014). Based on the analysis of Angkasa Pura I's operational areas, differences in performance are evident, with relatively good efficiency in Angkasa Pura I influenced by policy and infrastructure.

However, significant impacts have also been observed due to the COVID-19 pandemic. This is evident in the DEA analysis focusing on returns to scale. Some airports initially managed to rapidly increase their efficiency, thanks to their ability to adjust operational scale and implement crisis policies. As they enter the post-COVID-19 recovery phase, all airports are showing increased efficiency, marking a positive sign for overall industry recovery (Gudmundsson et al., 2021).

From examining airport efficiency over these three periods, variations appear to reflect changes in measures of economic production. Some airports maintain stable efficiency over time, while others experience declining efficiency. Therefore, a deeper understanding of these economic concepts can provide valuable guidance for future decision-making, especially considering the continuous changes in the Indonesian aviation industry. In this context, economic concepts such as constant economies of scale and diseconomies of scale are also used to explain changes in efficiency. Airports achieving constant economies of scale demonstrate their ability to maintain high efficiency levels throughout the analyzed period. Conversely, airports experiencing diseconomies of scale face declining efficiency over time.

The importance of understanding these economic concepts is emphasized as a guide for future decision-making. This analysis aims to provide insights into the dynamics of the Indonesian aviation industry and how airports can adapt their operational strategies to continuous change. By understanding economic concepts like economies of scale, decision-

makers can better prepare responsive strategies to adapt to changes in the business environment.

CONCLUSION

Based on the research findings discussed earlier, it can be concluded that the analysis of economies of scale efficiency at airports managed by Angkasa Pura I reveals varying levels of efficiency performance across these airports. The COVID-19 pandemic has also played a significant role in influencing returns to scale, with certain airports managing to enhance their efficiency amidst the crisis. Shifting travel patterns and a decline in overall passenger numbers have posed notable challenges for the aviation industry during this period; however, some airports have responded swiftly by adapting and optimizing their operations to achieve higher efficiency. It's important to note, though, that not all airports have seen improvements in efficiency, and some may be experiencing declines or stagnation in their performance even though they are consistent in figures. Therefore, conducting comprehensive analysis and implementing appropriate adaptive strategies are crucial to ensuring the continuity of airport operations amid evolving market dynamics.

From these research outcomes, several practical and theoretical benefits can be identified. Empirically, the analysis of economies of scale efficiency at Indonesian airports offers deeper insights into their operational performance amid environmental changes, including the impact of the COVID-19 pandemic. By understanding the varying efficiency patterns among airports, decision-makers in the aviation sector can pinpoint the factors affecting operational performance and develop tailored strategies to enhance efficiency. Theoretically, this study provides additional perspectives on the concept of economies of scale and its application within the aviation industry context. By exploring the factors influencing airport efficiency in depth, this research contributes to the development of operational management theories within the aviation sector. Economically, this study enhances understanding of the economic implications of airport efficiency. Improved efficiency can lead to cost savings and increased revenue for airports, thereby positively impacting the overall economy through increased investment and economic growth around airports, as well as contributing to the growth of the national aviation sector.

Furthermore, this research has uncovered novel findings that can inform policies and practices related to airport operations management. For example, it can unveil strategies or best practices adopted by airports that have successfully enhanced their efficiency during specific periods, serving as examples for other airports. These new insights can assist decision-makers in formulating strategies to improve airport efficiency and competitiveness moving forward.

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