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Navigating operational excellence: A strategic framework for enhancing sustainable logistics performance at Indonesian International Airport

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A B S T R A C T

Research on measuring airport operational performance has predominantly focused on technical aspects. However, there is still a need for studies to be conducted on measuring sustainable logistics and operational performance at international airports. The objective of this study is to develop a comprehensive measurement system for the Airport Operations Division in Indonesia that incorporates both operational and sustainable logistics performance. This will be achieved by integrating the company's vision, mission, and strategy into various performance measures using the Balanced Scorecard concept. The research methodology employed quantitative research methods, including primary data collection through observation and questionnaires. These questionnaires were developed using a pairwise comparison matrix derived from the Analytical Hierarchy Process (AHP). Data was collected from five international airports in Indonesia. The findings of the study demonstrate that the application of the Balanced Scorecard, coupled with the Objective Matrix method for setting performance targets and enriched with the AHP approach, enables the identification of priorities and assessment of performance. The research emphasizes the significance of considering non-financial aspects when measuring airport performance. This is crucial for supporting strategic decision-making and promoting sustainable performance improvement.

1. Introduction

Airports function as crucial hubs in the aviation industry, offering an array of services to both passengers and aircraft. They act as gateways and transportation facilities, facilitating the movement of passengers to and from other airports (Menteri Perhubungan, 2013). When compared to other modes of transportation, airport operations possess distinctive characteristics. Aviation can be examined as a two-fold process: gate-to-gate and air-to-air. The gate-to-gate perspective solely centers on the actual flight, while the air-to-air approach encompasses the ground operations that ensure smooth transitions from arrival to departure, adhering to dependable departure times. Throughout airport operations, various stakeholders are involved in delivering different types of services. Despite the intricacy of these operations, airport managers must prioritize safety, security, and customer satisfaction. In order to meet these expectations, airports must

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comply with service standards that align with national and international regulations. Errors, malfunctions, and delays in airport operations can disrupt flight schedules and are therefore deemed unacceptable (Garg, 2020).

In the realm of public services, airports are obligated to prioritize optimal performance, thereby becoming a paramount concern for the government. The fulfillment of predefined standards is integral to the satisfaction of service users (Pabedinskaitė & Akstinaitė, 2014). In order to accomplish this, airport management must deliver services that conform to safety, security, efficiency, and comfort benchmarks (Wang et al., 2022). To delineate airport operational performance, four perspectives are employed: Financial Perspectives, Passenger-Related Operations, Flight-Related Operations, and Social Considerations (Adler & Berechman, 2001). The financial perspective assumes great significance, as it takes into account key performance indicators such as aircraft landing fees, business fees, passenger fees, and aircraft parking fees, all of which are tied to sources of revenue and expenditure for the airport (Mańkowska et al., 2023).

International airports play a crucial role as central nodes in promoting sustainable logistics. They facilitate the smooth flow of global trade and ensure supply chain continuity by efficiently and timely moving goods (Purnomo & Syafrianita, 2024a). Operating as connecting gateways between air, land, and sea transportation modes, international airports enable the seamless movement of goods (Modarress Fathi et al., 2023; Caldeirinha et al., 2023). Moreover, well-managed international airports have the ability to minimize carbon emissions and mitigate environmental impacts through the implementation of environmentally friendly operational practices (L'Abate et al., 2023; Su et al., 2022). Recent research on CO2 emissions standards highlights the significant role of international airports in promoting sustainable logistics and addressing climate change on a global scale (Dmytro et al., 2022). Additionally, international airports, serving as vital logistics facilities, are instrumental in building resilient and future-oriented logistics systems. Therefore, it is crucial to optimize the performance of international airports in managing sustainable logistics to achieve sustainable economic development (EC, 2020).

Although extensive research has been conducted in the literature on the measurement of airlines' operational performance as a mode of transportation, there has been a lack of academic research on the measurement of airports' operational and logistical performance, despite their role as primary service providers for airlines (Sarkis & Talluri, 2004). It should be noted, however, that previous airport research has primarily focused on technical areas such as planning, design, construction, and legal and environmental issues (Inamete, 1993). Research in aviation and airport operations has confidently addressed economic and ecological efficiency and the estimation of Air Traffic Management system resilience and its impact on airport operational performance (Rosenow, 2018; Schumann et al., 2011; Kaiser et al., 2012). Measurement of operational and sustainable logistics performance in international airports is crucial given their role in improving the country's economy and local government (Graham, 2023). Despite the complexity of the task due to the involvement of various processes across different companies and regulatory regulations (Fasone & Zapata-Aguirre, 2016), ensuring accurate and reliable measurements is essential. With a confident approach, we can achieve this goal and make informed decisions to enhance international airport performance.

The observations at the Indonesian international airport clearly indicate a lack of research in designing airport operational and sustainable logistical performance that aligns with the company's vision, mission, and strategy and integrates it into various airport operational performance measures using the Balanced Scorecard concept. This research aims to design operational and sustainable logistical performance measures for the Indonesian Airport Operations Services Division. Through this study, we will determine the most appropriate measures and develop a performance measurement system to enhance the division's overall performance.

This research presents several important novelties and justifications that enhance the significance of contributions within the realm of enhancing operational excellence and sustainable logistics performance at the Indonesian International Airport. The comprehensive strategic framework, which combines the Balanced Scorecard (BSC), Analytical Hierarchy Process (AHP), and Objective Matrix (OMAX), provides strong justification for the value of these contributions. Our research offers new insights and improved management practices for the airport industry. The methods employed in this research enhance operational excellence and logistics performance. The BSC identifies and evaluates the performance of various operational aspects, including security, efficiency, and customer service. AHP and OMAX are indispensable tools for decision-making and designing airport sustainable logistics performance measures. AHP is utilized to assign weights to critical factors that impact operational performance, while OMAX tailors' performance measures to address specific goals and requirements. Our research significantly contributes to bridging the gap in the literature on operations and logistics management at international airports by integrating these three methods. The findings will provide fresh perspectives, strategic recommendations, and practical solutions for the management of the Indonesian International Airport. This will enhance efficiency, service quality, and competitiveness in the ever-evolving aviation market.

2. Theoretical framework

2.1 Balanced Scorecard

The BSC was introduced in 1992 by Robert S. Kaplan and David Norton as a framework for performance measurement that aligns with corporate strategy (Tawse & Tabesh, 2023). The BSC incorporates four perspectives - financial, customer, business process, and learning and growth to offer managers comprehensive control over improving organizational performance (Elbanna et al., 2022). While the BSC can be implemented at both the corporate and business unit levels, it can also be applied at divisional and functional levels (Suárez-Gargallo & Zaragoza-Sáez, 2023). The adoption of the BSC as a tool for assessing company operational performance has been empirically demonstrated to contribute to a substantial enhancement of overall organizational performance

(Al-Mawali, 2023; Abdallah et al., 2018; Davis & Albright, 2004; Hoque & James, 2000). Moreover, the BSC approach facilitates the harmonization of multiple pertinent performance indicators, thereby ensuring that managers direct their attention towards the critical factors that are vital for the long-term success of the organization (Saleheen & Habib 2023; Malina & Selto, 2001).

The use of BSC in measuring Sustainable Logistics performance has become a new trend in a business era that increasingly emphasizes sustainability (Trisyulianti et al., 2023; Garcia-Buendia et al., 2024). BSC offers a holistic approach to measuring performance by including non-financial perspectives, such as environmental and social, in addition to traditional financial perspectives (Agarwal et al., 2022; Bhagwat & Sharma, 2007). This allows companies to integrate aspects of sustainability into their logistics strategies and operations and measure performance in a balanced manner between economic, environmental and social objectives (Kumar et al., 2023; Brewer & Speh, 2000). Thus, BSC can help companies achieve Sustainable Logistics goals, such as reducing carbon footprints, optimizing resource use, and fulfilling social responsibilities (Garcia-Buendia et al., 2024; Bhagwat & Sharma, 2007).

2.2 Analytical Hierarchy Process

AHP technique, introduced by Saaty, is a method used for multi-criteria decision making in various fields such as economics, politics, and engineering (Dožić et al., 2023). AHP involves the use of expert opinions to construct a functional hierarchy, which helps in the classification and selection of alternatives based on their level of preference compared to other options (Dhingra et al., 2022). The AHP is extensively utilized in the assessment of Sustainable Logistics performance due to its ability to address complex multi-criteria issues (Stofkova et al., 2022; Ortega et al., 2020). This technique enables decision-makers to prioritize various criteria and sub-criteria that are relevant to Sustainable Logistics, including cost, delivery time, carbon emissions, and social impact (Kumar & Singh, 2012; Gupta et al., 2022). In addition, AHP facilitates the integration of qualitative and quantitative assessments in the decision-making process, which is particularly valuable in Sustainable Logistics where economic, environmental, and social considerations are involved (Stofkova et al., 2022). Furthermore, AHP can be combined with other methods, such as fuzzy logic, TOPSIS, and DEMATEL, to enhance the accuracy and flexibility of evaluating Sustainable Logistics performance (Guo & Wu, 2023; de Souza et al., 2022; Yontar, 2022).

The AHP method follows the following decision-making process (Terzi, 2019):
1) Define the research problem, objectives, criteria, sub-criteria, and alternatives for decision making, and represent them in a decision hierarchy.
2) Design a questionnaire based on the determined hierarchy and administer it to the selected experts.
3) Create a pairwise comparison matrix based on expert judgment, indicating the relative importance of each level in the hierarchy. The matrix has a size of k x k.
4) Use the formula k (k-1) to construct a pairwise comparison matrix as described in step 3. The values in the matrix are determined using a formula derived from the values in the pairwise comparison matrix.

$$d[g,h] = \frac{1}{d[h,g]}, \text{ for } g \neq h \text{ and } d[h,h] = 1 \quad (1)$$

5) Calculate the hierarchical synthesis value to determine the eigenvector weight for each criterion and sub-criterion. The eigenvalue is calculated from the priority vector value of the criteria matrix. The calculation involves adding the values in each column of the matrix, dividing each cell value by the total number of values in the column to obtain a normalized matrix, and then adding the values in each row and dividing by the number of criteria, k.
6) Calculate the Consistency Index (KI) using the formula:

$$KI = \frac{(\lambda max - k)}{k - 1} \quad (2)$$

7) Check the Consistency Ratio (KR) with a criterion of KR<1 to assess the validity of the experts' answers. The Consistency Index is divided by the Random Index (IR) to determine the KR.

$$KR = \frac{KI}{IR} \quad (3)$$

2.3 Objective Matrix

The OMAX model is utilized to oversee each performance indicator within the target achievement value group. This approach falls under the category of partial productivity measurement models. A matrix is employed to combine various group performance criteria that consist of target criteria, with the objective of making improvements in accordance with the set targets. Each criterion is assigned a value based on its significance in achieving the target goal. This value reflects the level of success of the work group in attaining productivity goals (Felix, 1985). The OMAX is a multi-criteria decision-making method that effectively measures the performance of Sustainable Logistics. OMAX enables companies to assess various logistics alternatives based on economic, environmental, and social criteria that are relevant to sustainability principles (Atapattu et al., 2024; Abonyi et al., 2023). By integrating a comprehensive set of criteria, OMAX facilitates informed decision-making that balances economic viability with environmental and social impacts, aligning with the goals of sustainable logistics practices. This methodological approach enhances the decision-making process by providing a structured framework for evaluating logistics alternatives based on their overall sustainability performance, thereby contributing to the advancement of sustainable practices in the logistics industry (Guerrero-Martin et al., 2023; Nandi, 2023). This method combines criteria weights obtained through techniques like AHP or ANP with alternative performance rankings for each (Wang & Liao, 2023). Consequently, OMAX aids companies in identifying the most sustainable logistics solutions based on the preferences and priorities established by decision-makers (Mohammadkhani & Mousavi, 2023). Furthermore, OMAX allows for sensitivity analysis to evaluate the impact of changes in criteria weights on alternative rankings, thereby providing decision-making flexibility (Cheng et al., 2022; Deveci et al., 2022).

Meanwhile, the format or procedure of the OMAX method developed by (Felix, 1985) is as follows:

1) Defining performance determinants as a measure of a work unit's performance and accomplishments over a specific time period.
2) Quantifying the level of achievement for each criterion using a scale of 0-10, following these conditions:
a. Level 0 scale: represents the lowest level that a criterion has ever reached within a given time period.
b. Level 3 scale: signifies the performance achievement for each criterion during the initiation phase, or the creation of this rating scale.
c. Level 10 scale: provides a realistic estimation of what each criterion can accomplish in the future.
Scale values of 0 and 3 are used as benchmarks, while a scale value of 10 indicates the challenge of attaining performance values between the scales, which are obtained through interpolation.
3) Monitoring two primary aspects:
a. Weighting the performance scale values, which indicates the scale at which the performance value falls. The performance score is obtained by multiplying the scale value by its weight. This demonstrates the relative impact of each indicator on the work unit's performance measurement objectives.
b. Calculating the index involves assigning an overall performance value to the performance measurement, which is the sum of each performance score.

3. Method

3.1 Methods of Data Collection

Quantitative research is a research methodology that focuses on gathering numerical data and generalizing it to a larger population using computational techniques, statistical analysis, and mathematics. This data is collected through various means such as observations, interviews, questionnaires, and surveys (Survey Research Methods, 2012). The survey method is employed to collect data from a representative sample group that accurately represents the population being studied. The total population of international airports in Indonesia is 17. The research sample comprises five international airports in Indonesia, namely Kualanamu (North Sumatra), Hang Nadim (Riau Islands), Soekarno-Hatta (Banten), Kertajati (West Java), and Juanda (East Java). This sample was selected based on various criteria, such as passenger volume, number and frequency of flights, connectivity and intercountry relations, facilities and infrastructure, strategic position, security and safety, and cargo capacity (Adisasmita & Caroles, 2021). The collected primary data will then be further analyzed. Problem-solving in this study is conducted using the BSC framework, which evaluates airport operations from four perspectives: internal business, customers, finance, and growth and learning. The primary data required for this research is gathered through the following methods:

1) Observation: This involves observing the research object to gather the necessary data for the predetermined research objectives. In this case, data source documents at Indonesian Airport are examined as secondary data.

2) Questionnaire: A series of written questions is designed based on the four perspectives of the BSC. This questionnaire is developed using a pairwise comparison matrix from the AHP. The aim is to collect primary data from respondents who are experts in their respective fields, specifically from the Operations Services Division, Airport Operations Services Section, and Air Traffic Services Section. Figure 1 outlines the different stages involved in processing research data using a quantitative approach. This serves as a helpful guide for researchers in undertaking their study.

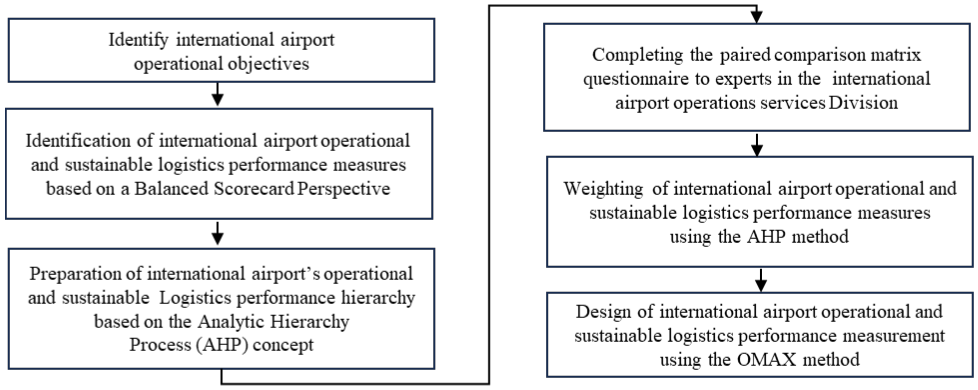

Fig. 1. Research framework

3.2 Operational and logistics performance measures

Indonesian airport identified its operational performance measures using the perspective relationship framework in the BSC (Brewer & Speh, 2000). Table 1 outlines the identified operational performance measures, their descriptions, and the references used. This text outlines the operational and sustainable logistics performance measures for Indonesian airport, providing clear descriptions and references to support their implementation.

Table 1
Identify operational and sustainable logistics performance measures

BSC Perspectives	Operational & sustainable logistics performance measures	Description	References
Financial	Operating ratio	Total operating expenses/total operating revenue	(Melly Anne Dharasta et al., 2022)
	Earning-price ratio	Total operating revenue/total operating cost	(Chakraborty et al., 2020); (Lu et al., 2018); (Cantarelli et al., 2018)
	Absorption of investment for sustainability	The level of realization of the investment program set out in the budget plan	(Melly Anne Dharasta et al., 2022)
Customer	Navigation equipment	Non Directional Beacon Localizer, DME Instrument Landing System, & DVOR.	(Chakraborty et al., 2020); (Lu et al., 2018); (Cantarelli et al., 2018)
	Safety	Security measures according to ICAO standards	(Melly Anne Dharasta et al., 2022)
	Waiting time	Waiting time for chek-in service	(Chakraborty et al., 2020) - (Cantarelli et al., 2018)
	Terminal facility capacity	Available space divided by passengers during peak hours	(Melly Anne Dharasta et al., 2022); (Cantarelli et al., 2018)
	Apron	Apron capacity is able to accommodate the number of aircraft during peak hours	(Melly Anne Dharasta et al., 2022)
Internal business processes	Airplane arrival & departure	Average monthly Airplane arrivals & departures	(Chakraborty et al., 2020); (Lu et al., 2018); (Cantarelli et al., 2018)
	Facility readiness	Level of runway, apron, and facility readiness	(Melly Anne Dharasta et al., 2022)
	Operating hours	Average operating hours to serve airlines	(Chakraborty et al., 2020); (Lu et al., 2018); (Cantarelli et al., 2018)
Learning and growth	Quality & quantity of employees	Number of employees with education levels that are in accordance with their fields	(Chakraborty et al., 2020); (Lu et al., 2018); (Cantarelli et al., 2018)
	Employee training	Number of employees who participated in training in one year	(Melly Anne Dharasta et al., 2022)
	Green certification for employees	Number of employees who meet certification according to Directorate General of Air rules	(Melly Anne Dharasta et al., 2022)

3.3 Operational Hierarchy Structure of Indonesian Airport

The operational hierarchy structure in the AHP is utilized to provide a clearer and more measurable definition of complex and unstructured problems (Leal, 2020). The construction of this hierarchy commences with the identification of components associated with the company's strategy. These components are derived from an analysis tailored to address the company's specific challenges (Nazim et al., 2022). To determine the selected elements within the hierarchy, interviews are conducted with company personnel to identify the elements that have the greatest impact on operational performance. Subsequently, a hierarchy of problems, commonly referred to as a hierarchical structure, is organized. In order to identify the components that exert the most significant influence on operational performance, a survey was conducted among employees to establish the hierarchical structure. Fig. 2 illustrates the Operational Hierarchy Structure of Indonesian Airport based on the BSC and AHP concepts.

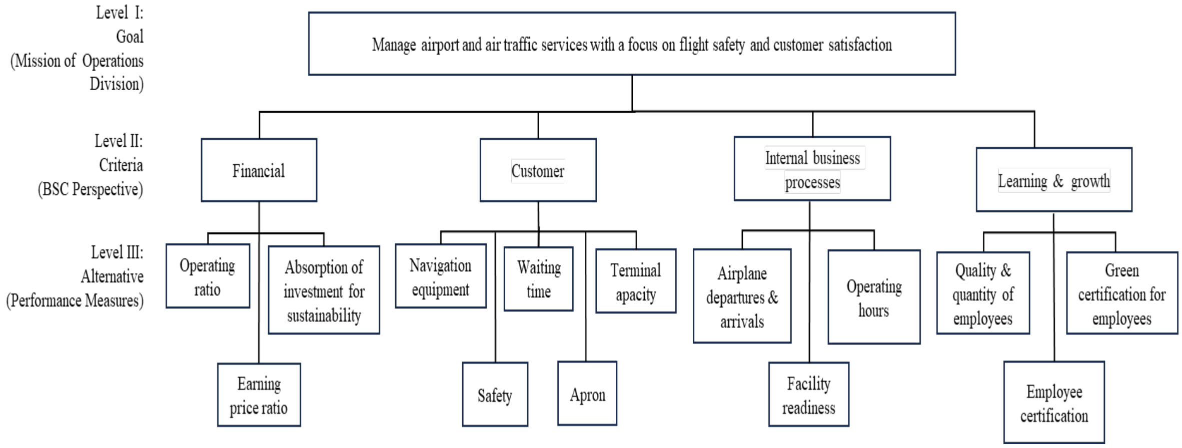

Fig. 2. Indonesian Airport Operational Hierarchy Structure

4. Results

4.1 Research Results

The data obtained from direct observation of the research object consists of documents that contain the vision, mission, and strategy, as well as job descriptions, organizational structure, and the role of Indonesian airport in measuring operational performance. Based on the relationship framework from the perspective of the BSC, a hierarchical structure using the AHP method can be created, as explained in Fig. 2. Next, we will provide an overview of the process involved in designing the Operational Performance Measurement System for Indonesian airport.

4.2 Weighting of Indonesian Airport Operational Performance Measures using AHP

Each priority performance measure for important operational performance elements is identified by assigning a weight to it based on expert considerations. This allows the measures to be used in achieving the objective of improving Indonesian airport's operational performance. The AHP method follows the following procedure for weighting:

1) Creating a Pairwise Comparison Matrix: Based on the AHP hierarchy in Fig. 2, a Pairwise Comparison Matrix was created. This matrix served as a questionnaire filled out by three expert respondents, one from each of the Operations Services Division, Airport Operations Services Section, and Air Traffic Services Section. AHP calculations were performed using Expert Choice 11 software.

2) Calculation of Eigen Vector, Eigen Value, Index Consistency, and Ratio Consistency: Based on the considerations provided by the expert sources in the Pairwise Comparison Matrix, the Eigen Vector, Eigen Value, Index Consistency, and Ratio Consistency are calculated. To ensure that the expert responses are unbiased and consistent in assessing the level of importance of all criteria and alternatives, the overall pairwise comparison matrix needs to be tested for consistency. The Consistency Ratio (CR) is used as the parameter for this test. A maximum CR of 0.1 is used as the threshold to determine whether the pairwise comparison matrix is unbiased and consistent.

Table 2
Priority Global Weight Values for Levels II and III

Levels	Element	Global Weight	Priority
2	Customer	0.571	1
2	Financial	0.189	2
2	Learning and growth	0.178	3
2	Internal business processes	0.062	4
3	Safety	0.264	1
3	Navigation equipment	0.222	2
3	Absorption of investment for sustainability	0.087	3
3	Green certification for employees	0.082	4
3	Waiting time	0.074	5
3	Quality & quantity of employees	0.069	6
3	Apron	0.600	7
3	Earning-price ratio	0.036	8
3	Terminal facility capacity	0.030	9
3	Facility readiness	0,028	10
3	Employee training	0.018	11
3	Operating Ratio	0.017	12
3	Airplane arrival & departure	0.011	13
3	Operating hours	0.004	14

3) Determination of Global Priorities (Overall): Calculation of the global (overall) priority weight value is performed to determine the weight of each criterion and alternative in the entire hierarchy. The calculated values of the Global weights can be ranked from highest to lowest for Level III with an inconsistency of only 0.04. Therefore, the respondents' answers are considered consistent, and the priority weights can be used. Based on the Local and Global weight values, the Global weight priorities can be ranked for both Level II of the BSC Perspective and Level III of the Operational Performance Measures, as presented in Table 2.

4.3 Designing Indonesian Airport Operational Performance Measures using OMAX

To ensure the effective implementation of performance measurements, it is crucial to have a clear and detailed design of the Indonesian Airport operational performance measurement system. Each operational performance measure possesses a unique unit value, thus necessitating the equalization of these values through the utilization of the OMAX model. This equalization process involves normalizing various units of performance measurement into a standardized unit of measurement. The following outlines the stages involved in designing the operational performance measurement for Indonesian Airport using the OMAX method.

1) Determination of Performance Values for each Operational Performance Measure: Performance Value refers to the desired value to be achieved during the current period. For instance, the performance value set for the Absorption of investment for sustainability performance measure is 80%.
2) Determination of the Performance Scale, starting from 0, 3, and 10: During this stage, the Indonesian Airport Operational Services Division defines the scope for each measure by assigning a performance scale value.
a. Scale_0: Represents the lowest categorization of operational performance achievements, indicating dissatisfaction compared to previous achievements by the Indonesian Airport Operational Services Division in the period ending in 2023.
b. Scale_3: Indicates the average value of operational performance achievements at the time of measuring operational performance in the first quarter of 2024.
c. Scale_10: Reflects the target to be achieved within a future time period, specifically by the end of 2024.

Calculation Example:

Scale 0 = 55% (lowest performance achievement, ranging from 1 to 100%)
Scale 3 = 35% (average of current work achievements compared to the previous period)
Scale 10 = 10% (obtained from interviews with top management regarding the achievement of performance measurement targets in the future). For performance scale assessment between scale 1-2 and scale 4-9, interpolation is employed. The results of performance scale interpolation can be found in Table 3. An example of determining scale values is provided below:
The calculation example above for the performance scale value on scale 2 employs an interpolation formula. Thus, for the 0-3 scale, the following formula is used:

$$\frac{(X_i - X_3)}{(X_3 - X_0)} = \frac{(Y_i - Y_0)}{(Y_3 - Y_0)} \quad (4)$$

X_i = Performance value on scale I; X_3 = Performance value on scale 3

X_0 = Performance value on a scale of 0; X_{10} = Performance value on a scale of 10

i = Scale to be determined for an operational performance value

The calculation results on other scales are presented in Table 3.

3) In this step, the determination of the operational performance scale measure is conducted, which is subsequently converted into a scale value ranging from one to ten. This conversion is based on the rule that the largest value of the performance measure represents the scale value. Furthermore, evaluation is performed based on the determined operational performance scale, following the following guidelines:

a. If the performance scale falls within the range of zero to three, it can be inferred that there has been a decline in performance within the Indonesian Airport Operational Services Division.

b. If the performance scale is exactly three, it can be inferred that the performance within the Indonesian Airport Operational Services Division is constant.

c. If the performance scale falls within the range of four to ten, it can be inferred that performance has improved within the Indonesian Airport Operational Services Division.

d. If the performance scale is exactly ten, the Indonesian Airport Operational Services Division's performance has achieved the established targets.

4) In this step, the performance measure score is calculated by multiplying the performance measure scale by the weight obtained during the AHP calculation process.

5) In this final step, the total performance score is calculated by combining all the performance measure scores. This score demonstrates the overall operational performance of the Indonesian Airport Operational Services Division, based on the results obtained from determining the value of the operational performance scale measurement in step three.

Table 3
Performance Scale Interpolation Results

No	BSC Perspectives	Operational & Logistics Performance Measures	unit	Performance Scale										
				0	1	2	3	4	5	6	7	8	9	10
1	Financial	Operating ratio	%	64.25	63.00	62.58	60.50	59.71	58.93	58.14	57.36	56.57	55.79	55.00
		Earning-price ratio	%	56.00	57.33	57.78	60.00	63.57	67.14	70.71	74.29	77.86	81.43	85.00
		Investment absorption	%	80.00	80.67	80.89	82.00	83.14	84.29	85.43	86.57	87.71	88.86	90.00
2	Customer	Navigation equipment	%	95.00	95.33	95.44	96.00	96.29	96.57	96.86	97.14	97.43	97.71	98.00
		Safety	%	92.00	93.00	93.33	95.00	95.43	95.86	96.29	96.71	97.14	97.57	98.00
		Waiting time	minute	22.00	21.33	21.11	20.00	19.86	19.71	19.57	19.43	19.29	19.14	19.00
		Terminal facility capacity	meters	0.96	1.04	1.07	1.20	1.23	1.26	1.29	1.31	1.34	1.37	1.40
		Apron	%	99.00	99.00	99.00	99.00	99.14	99.29	99.43	99.57	99.71	99.86	100.00
3	Internal business processes	Airplan arrival & departure	freq.	300,00	327,33	336,44	382.00	386.86	391.71	396.57	401.43	406.29	411.14	416.00
		Facility readiness	%	94.00	94.67	94.89	96.00	96.57	97.14	97.71	98.29	98.86	99.43	100.00
		Operating hours	hours	12.00	12.00	12.00	12.00	12.29	12.57	12.86	13.14	13.43	13.71	14.00
4	Learning and growth	Quality & quantity of employees	man	41.00	41.33	41.44	42.00	42.43	42.86	43.29	43.71	44.14	44.57	45.00
		Employee training	man	20.00	21.33	21.78	24.00	25.14	26.29	27.43	28.57	29.71	30.86	32.00
		Green certification for employees	man	18.00	19.33	19.78	22.00	23.14	24.29	25.43	26.57	27.71	28.86	30.00

5. Discussion

This research demonstrates that the utilization of the BSC Model has successfully translated the vision and strategy of Indonesian Airport into specific metrics and objectives for measuring airport operational performance at the division level. These findings are consistent with previous research (Tawse & Tabesh, 2023; Elbanna et al., 2022; Suárez-Gargallo & Zaragoza-Sáez, 2023), which suggests that the BSC is a valuable tool in assessing the performance of influential companies and divisions over the past 75 years. The use of the BSC in this study also offers the advantage of capturing the operational performance measures of Indonesian Airport not only from a financial standpoint, but also by incorporating other perspectives such as growth and learning, internal business, and customer satisfaction. The identification of performance metrics was based on a comprehensive review of literature, documents on airport operations, and interviews with Indonesian Airport management. Consequently, this research further solidifies earlier studies (Hansen & Schaltegger, 2018; Dudic et al., 2020) that highlight the BSC's ability to combine both financial and non-financial variables, making it a well-rounded tool for measuring operational performance.

The application of the AHP method in this study proved to be valuable in determining the validity of expert responses to various criteria and alternatives derived from the BSC method. This enabled the establishment of a priority ranking for performance measures. These findings align with previous research (Purnomo & Syafrianita, 2024b; Chai et al., 2013; Ahn, 2017) that have leveraged the AHP in combination with other methodologies to establish priorities as a foundation for decision making. According to the AHP results, Green certification for employees emerged as a critical factor in achieving the objectives of the growth and learning perspective, while Absorption of investment for sustainability played a crucial role in improving financial performance. In terms of the internal business perspective, facility readiness demonstrated the highest local weight, thus making a substantial contribution to overall internal performance. From a customer perspective, Safety was prioritized in effort to meet customer needs and attain performance targets. The determination of global weight for performance measures took into consideration the linear (hierarchical) relationship between performance measures and strategic objectives, as well as the non-linear (network) relationships among performance measures. At the third level of the hierarchical structure, Safety exhibited the highest global weight value, indicating its significant influence on other performance measures.

As a result of assigning weights to performance measures, the customer perspective has the highest weight (57.10%), followed by the financial perspective (18.90%), the the learning growth perspective (17.80%), and Internal business processes perspective (6.20%). This indicates that the Indonesian Airport Operations Services Division needs to prioritize customers to improve performance, keeping in mind that customers consist of passengers and airline customers. Meeting customer needs, such as providing navigation equipment, may incur high costs but significantly impact all aspects of airport operations. Efforts to enhance performance from a customer perspective can contribute to achieving Indonesian Airport's mission, which is to manage airport and air traffic services while prioritizing flight safety and customer satisfaction. The financial aspect is integral to airport operational activities as it is crucial for meeting customer satisfaction. Even though the internal perspective and learning growth have lower overall weights compared to the customer and financial perspectives, they support all aspects outlined in airport operations, contributing to the continuous improvement of managing the airport and air traffic services. To support this, it is necessary to increase the number of human resources according to their respective fields, considering the annual increase in the number of passengers.

The global weights of operational performance measures reflect the level of importance (priority) and the magnitude of contribution in achieving problem-solving goals aligned with the mission of Indonesian Airport. The higher the global weight value of a performance measure, the greater its contribution to the goal of the problem model. Based on the global weighting value, four operational performance measures have significant global weights: security performance measures (26.40%), navigation equipment performance measures (22.22%), Green certification for employees performance measures (8.70%), and facility readiness performance measures (8.20%). This indicates that these four performance measures play a crucial role in achieving the mission of the Indonesian Airport Operations Services Division and require significant attention from top management in the field of airport operations services. Security performance measurement is a critical consideration, as it pertains not only to the safety of passengers but also to the security of cargo. Furthermore, as a member of the International Civil Aviation Organization (ICAO), Indonesian airports are mandated to adhere to established security provisions and to implement appropriate security measures in their operational activities. The measurement of navigation equipment performance constitutes a second vital factor, given its direct correlation with safety considerations and the responsibility of Indonesian airports in managing airport services and air traffic for a diverse range of customers. Absorption of investment for sustainability performance measures play a crucial role in airport operational processes. Achieving investments as per the investment program benefits management and also influences customer satisfaction. It is imperative to consider performance measures related to facility readiness as they pertain to the arrival and departure of aircraft, including runway, aerodrome, and apron facilities. However, this does not imply that other performance measures can be disregarded. Performance measures related to employee training should not be overlooked as employees are responsible for the technical implementation of routine airport operations activities. Running an airport necessitates well-trained employees due to the numerous regulations that must be complied with, both national and international.

The OMAX method, however, exhibits greater flexibility as it incorporates management considerations in determining weights and permits the normalization of measurement elements to establish operational performance measurement guidelines for Indonesian Airport. This entails four perspectives, fourteen performance measures derived from literature research and interviews, as well as performance measurement standards utilizing the OMAX method and performance measurement formats/sheets. The enhancement of each operational indicator (performance measure) at Indonesian Airport is guided by the performance measurement score and the overall performance score. The level 3 scale represents the initial performance achievement of each criterion, which was established in the first quarter of 2023. By multiplying the scale value with the global weight, the performance score is obtained. The importance of the weight assigned to each indicator demonstrates its relative impact on the objectives of measuring the performance of work units. The calculation of performance scores and weights enables the monitoring of logistics and operational performance achievements at Indonesian Airport. Notably, this indicator can effectively track operational performance achievements due to the high-performance measure scores of navigation equipment. Table 4 depicts the simulation results of performance values for each indicator on a three-point scale.

In an academic context, these findings provide empirical evidence that supports the effectiveness of the BSC in measuring and improving operational performance in the public sector, particularly in airport management. From a practical standpoint, these results demonstrate that the utilization of BSC can aid airport management in Indonesia in formulating a more comprehensive strategy to tackle operational challenges and global competition by prioritizing customer satisfaction and aviation safety.

Table 4
Simulation of Performance Measure Scores on Level 3 Scale Values

No	BSC Perspectives	OLPM	unit	Performance Scale											SSP	GWM	PMS
				0	1	2	3	4	5	6	7	8	9	10			
1	Financial	OPR	%	64.25	63.00	62.58	60.50	59.71	58.93	58.14	57.36	56.57	55.79	55.00	3	0.017	5.1%
		EPR	%	56.00	57.33	57.78	60.00	63.57	67.14	70.71	74.29	77.86	81.43	85.00	3	0.036	10.8%
		AIS	%	80.00	80.67	80.89	82.00	83.14	84.29	85.43	86.57	87.71	88.86	90.00	3	0.087	26.1%
2	Customer	NE	%	95.00	95.33	95.44	96.00	96.29	96.57	96.86	97.14	97.43	97.71	98.00	3	0.222	66.6%
		Safety	%	92.00	93.00	93.33	95.00	95.43	95.86	96.29	96.71	97.14	97.57	98.00	3	0.264	79.2%
		WT	minute	22.00	21.33	21.11	20.00	19.86	19.71	19.57	19.43	19.29	19.14	19.00	3	0.074	22.2%
		TFC	meters	0.96	1.04	1.07	1.20	1.23	1.26	1.29	1.31	1.34	1.37	1.40	3	0.03	9.0%
		Apron	%	99.00	99.00	99.00	99.00	99.14	99.29	99.43	99.57	99.71	99.86	100.00	3	0.6	180.0%
3	Internal business processes	AAD	freq.	300,00	327,33	336,44	382.00	386.86	391.71	396.57	401.43	406.29	411.14	416.00	3	0.011	3.3%
		FR	%	94.00	94.67	94.89	96.00	96.57	97.14	97.71	98.29	98.86	99.43	100.00	3	0.028	8.4%
		OH	hours	12.00	12.00	12.00	12.00	12.29	12.57	12.86	13.14	13.43	13.71	14.00	3	0.004	1.2%
4	Learning and growth	QQE	man	41.00	41.33	41.44	42.00	42.43	42.86	43.29	43.71	44.14	44.57	45.00	3	0.069	20.7%
		ET	man	20.00	21.33	21.78	24.00	25.14	26.29	27.43	28.57	29.71	30.86	32.00	3	0.018	5.4%
		GCE	man	18.00	19.33	19.78	22.00	23.14	24.29	25.43	26.57	27.71	28.86	30.00	3	0.082	24.6%

OLPM:Operational & Logistics Performance Measures SCP: Size Scale Performance GWM: Global Weight Measure PMS: Performance Measure Scores OPR: Operating ratio EPR: Earning-price ratio AIS: Absorption of investment for sustainability NE: Navigation equipment WT: Waiting time TFC: Terminal facility capacity AAD: Airplan arrival & departure FR: Facility readiness OH: Operating hours QQE: Quality & quantity of employees ET: Employee training GCE: Green certification for employees

Additionally, this study reaffirms and reinforces the BSC theory by integrating the Analytical Hierarchy Process) and OMAX methods, thereby allowing for more accurate validation and weighing of criteria when determining priorities. These findings contribute to the existing literature by illustrating how the amalgamation of BSC, AHP, and OMAX can effectively address the complexity of airport operations, encompassing not only conventional performance measures but also factors such as security, sustainability, and facility readiness.

6. Conclusion

This study has effectively demonstrated the efficacy of combining the BSC model with the AHP method to measure and enhance operational performance in five international airports in Indonesia. The BSC facilitates the measurement of financial performance and enables integration across growth and learning, internal business, and customer satisfaction perspectives. These findings confirm that prioritizing customer satisfaction is paramount in airport operations as it heavily influences all aspects of airport functioning. Moreover, the application of AHP strengthens the decision-making process in terms of prioritization and performance assessment, thereby allowing airport management to develop more suitable strategies and concentrate on the most critical areas. Subsequent research could delve deeper into understanding customer satisfaction by utilizing more advanced data analysis techniques, such as structural equation modeling, to uncover the factors that have the greatest impact on customer satisfaction at airports. Additionally, given the frequent changes in aviation sector policies, future research could explore how regulatory changes affect airport operational performance and how the BSC can adapt to accommodate these changes.

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