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Jakarta Veterans National Development University, Indonesia

*CORRESPONDENCE
Faik Fahmi
✉ faikfahmiii@gmail.com

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Corporate agility and government regulation as drivers of airport performance and airport sustainability: an SEM-based study in Indonesian airports

Faik Fahmi[1]*, M. Al Musadieq[2], Cacik Rut Damayanti[2] and Edriana Pangestuti[2]

[1]Doctoral Student, Faculty of Administrative Science, Brawijaya University, Malang, Indonesia, [2]Lecturer, Doctoral Program, Faculty of Administrative Sciences, Brawijaya University, East Java, Indonesia

Introduction: This study examines the effect of Corporate Agility and Government Regulation on Airport Performance and Airport Sustainability, with Airport Performance acting as a mediating variable.
Methods: This study utilized Structural Equation Modeling (SEM) to analyze data obtained from an Indonesian airport managed by PT Angkasa Pura Indonesia.
Results: The result indicate that Responsiveness is the strongest indicator of Corporate Agility (loading = 0.830), followed by Workplace & People, Technology, Quality, Process Planning, and Competency. The Regulator indicator contributes the most to the Government Regulation variable (loading = 0.875), followed by Catalyst and Facilitator. In terms of Airport Sustainability, Environmental factors emerge as the most dominant (loading = 0.884), followed by Social and Economic aspects. Among five tested direct relationships between variables, four are statistically significant. However, one of the two indirect effects from Government Regulation to Airport Sustainability via Airport Performance is not significant. Overall, the structural model explains 57.1% of the variance in the observed phenomena.
Discussion: These findings offer useful insights for airport policymakers and managers to improve sustainability performance through targeted agility initiatives and regulatory alignment. The study contributes to strategic airport management by identifying key levers that drive both operational performance and environmental responsibility.

KEYWORDS

airport performance, airport sustainability, corporate agility, government regulation, SEM

1 Introduction

The aviation industry has become one of the fastest growing transportation sectors in recent decades, creating unprecedented global connectivity (Vasigh and Gorjidooz, 2016). The liberalization of the aviation market has created more competitive competition and provided consumers with more choices in terms of routes and prices (Zhang et al., 2024). The positive growth of the aviation industry is reflected in the growth in the number of passengers globally which generally increases until 2043 (IATA, 2024). However, behind the growing potential, there are challenges that can disrupt this growth such as global pandemics such as Covid-19, fuel prices, geopolitical conditions and flight operational regulations in each country. Digital transformation is one of the important solutions to overcome these challenges, especially in the context of Corporate Agility. The use of technologies such as digital twins and real-time analytics allows airports to monitor operational conditions comprehensively, detect potential disruptions earlier, and make more accurate decisions (Newbold, 2020). This not only improves operational efficiency but also supports long-term sustainability by optimizing resources and reducing the risk of errors. For example, the COVID-19 pandemic caused a drastic decrease in passenger numbers at Hartsfield-Jackson Atlanta International Airport by 95% in April 2020 compared to the previous year, as well as a decrease in flight operations by 73%. This fact shows the vulnerability of the aviation industry to external crises, so that rapid adaptation steps are needed to maintain operational sustainability (Ayers and Crawley, 2020). In addition, the demand for participation in environmental sustainability aspects is a concern for all industries, including the aviation industry. This condition requires the ability to adapt from industry players in order to survive and maintain performance for the sustainability of the company.

Agility refers to the ability to survive and thrive despite being in a situation full of change and uncertainty (Dove, 2001). In an increasingly complex and dynamic world, companies that have a high level of agility can be more effective in facing challenges and taking advantage of emerging opportunities. Corporate Agility is the ability of an organization to adapt and respond to changes in the business environment by involving the use of technology, adaptive organizational structures, and a collaborative work culture so that the company can respond to challenges and opportunities responsively. Holloway (2024) states that by applying the principles of agility throughout the organization, companies can increase their responsiveness to market changes and improve services. This advantage is becoming increasingly important in the digital era, where changes can occur suddenly and have a significant impact. This is in accordance with research by Fitrianto et al. (2024) whichshows the importance of quality infrastructure and superstructure that not only support operational efficiency but also long-term sustainability. This finding is relevant to be applied to the aviation sector, especially through the application of corporate agility principles that allow adaptation to regulatory changes.

Corporate agility is very important for companies because it allows them to quickly adapt to changing market conditions and customer demands, thereby increasing competitive advantage. Organizations or companies that implement agility by building a culture of innovation and responsiveness can significantly reduce the time to launch new products and services, allowing them to more effectively take advantage of emerging opportunities (Amajuoyi et al., 2024). Organizations with high agility can better align their resources and strategies, leading to increased resilience and long-term sustainability. As an illustration, organizational agility in a crisis situation is reflected in Hartsfield-Jackson Atlanta International Airport's strategy during the pandemic, such as the use of a phased approach to restore operations, the implementation of additional sanitation measures, and intensive communication with stakeholders through online forums and daily reports. This strategy ensures that operations continue safely and are adaptive to changing conditions (Ayers and Crawley, 2020). Company operations that are efficiently organized and equipped with adequate facilities will provide benefits for industry and trade (Fitrianto et al., 2024). Furthermore, agile practices can improve operational efficiency by streamlining processes and reducing waste, which contributes to overall organizational effectiveness (Kolasani, 2023).

Corporate performance reflects the extent to which an organization is able to achieve its stated goals by using its resources effectively and efficiently. One way to improve corporate performance is through corporate agility, which is the ability to respond to market and environmental changes quickly and efficiently, and to take advantage of emerging opportunities (Rehman and Khatoon, 2022). In a dynamic sector such as airport management, corporate agility is an important factor in maintaining high performance and achieving sustainability. For PT Angkasa Pura Indonesia, optimal infrastructure not only improves air accessibility, but also the efficiency of ground logistics, having a major impact on productivity, especially in the industrial sector (Lopes, 2008). The synergy between corporate agility and government regulations can create an adaptive and sustainable operational ecosystem.

Corporate Sustainability (CS) in the context of airports is a strategic approach that integrates economic, social, and environmental aspects in airport operations to achieve sustainable performance. The implementation of CS at airports such as PT Angkasa Pura Indonesia focuses on increasing energy efficiency, reducing carbon emissions, and engaging with local communities to minimize environmental impacts while driving economic growth (Yusliza et al., 2019). CS is considered an important foundation in ensuring that airports are able to face increasingly complex operational and regulatory challenges. With government regulations as a moderating factor, airport companies are expected to not only improve performance but also achieve long-term sustainability standards that advance social and economic welfare. This approach is in line with the principle of Corporate Agility, which allows airports to adapt more quickly to changes in policies and market needs, and maintain operational sustainability in the future. This is important, considering that global challenges in implementing CS in the aviation sector continue to increase, so that responsive and innovative strategies are needed (Rajnoha and Lesníková, 2016). Thus, CS is not only a determining factor in performance, but also a pillar in maintaining the company's competitiveness in a sustainable industry.

In the business and organizational world, Government Regulation plays an important role in influencing the strategy and performance of a company or airport. Government regulations can have a significant impact on Corporate Agility efforts undertaken by a company or airport, which will ultimately affect their performance and sustainability. A study conducted shows that compliance with government regulations is a key factor in implementing effective risk management practices. Furthermore, research by Prakash and Potoski (2016) revealed that strict government regulations can encourage companies to adopt better sustainability practices. Thus, understanding the role of Government Regulation in the relationship between corporate agility, performance, and sustainability of a company or airport is important to discuss further.

The increasingly complex and uncertain dynamics of the aviation industry require airports as vital infrastructure for air transportation to develop organizational agility (corporate agility) in facing rapid changes in the business environment. PT Angkasa Pura Indonesia, as the manager of 37 airports in Indonesia, faces significant challenges in maintaining airport performance and sustainability amidst global competition and increasing service demands. Evolving government regulations play an important role in shaping airport strategy and operations, but often create additional complexity in the organizational adaptation process. A case study of Hartsfield-Jackson Atlanta International Airport shows that effective government regulation can support sustainability by encouraging the adoption of higher safety standards and operational efficiency during the pandemic (Ayers and Crawley, 2020). Despite the growing interest in airport sustainability and organizational agility, previous studies have tended to examine these aspects in isolation. Many studies have focused only on the role of agility in private sector firms, or on regulatory impacts without considering internal adaptability. Futhermore, research integrating Corporate Agility, Government Regulation, Airport Regulation, Airport Performance, and Airport Sustainability in a unified empirical model, particularly in the context of Indonesian airport management is still scarce. This theoretical gap highlights the need to understand the strategic interplay between internal organizational flexibility and external regulatory forces in achieving sustainable airport performance. Research on the relationship between corporate agility, airport performance, and airport sustainability is very important considering the limited comprehensive studies that integrate these three aspects in the context of airport management in Indonesia. The urgency of this research is further strengthened by the need to understand how government regulations moderate the relationship between organizational agility and airport performance and sustainability. A deep understanding of these dynamics will provide a significant contribution to the development of more adaptive and sustainable airport management strategies in the future.

Public interest in corporate agility and sustainability issues is increasing, but there is still a lack of empirical research that integrates Corporate Agility, Government Regulation, Airport Performance, and Airport Sustainability, especially in the context of airport management in Indonesia. This study seeks to fill this gap by analyzing how Corporate Agility and Government Regulation affect Airport Performance and Airport Sustainability with Airport Performance as a mediating variable. The results showed that the Responsiveness indicator was the strongest reflection of the Corporate Agility variable (loading = 0.830), the Regulator indicator was the most dominant in the Government Regulation variable (loading = 0.875), and the Environmental aspect was the strongest indicator of the Airport Sustainability variable (loading = 0.884). Among the five direct relationships between the variables tested, four were statistically significant. Meanwhile, of the two indirect influences, only one is insignificant, namely the path from Government Regulation to Airport Sustainability mediated by Bandara Performance. Overall, this research model can explain 57.1% of the observed variation in empirical phenomena. This research can make an important contribution in understanding the strategic linkages between organizational agility, regulation, and sustainability in Indonesia's airport sector, as well as show empirical evidence that supports the development of a more adaptive, responsive, and sustainable airport management strategy.

2 Literature review

2.1 Corporate agility

The concept of corporate agility evolved from the concept of Agile Manufacturing which emphasizes the ability to harmonize the three main components of a company, namely organization, personnel, and technology to overcome a competitive business environment with a planned and efficient strategy. This harmonization requires strong structural support in several sectors such as manufacturing, marketing activities, HR management, and information system development (Tsourveloudis and Valavanis, 2002). The birth of this organizational agility concept is a response to the characteristics of dynamic global competition, which requires comprehensive insight into the aspects that make an organization more agile. Thus, corporate agility can be understood as the capacity of a company to excel in a competitive atmosphere, where the company is able to provide responsive responses to market changes and trends, and produce valuable products and services that focus on customer satisfaction, regardless of ongoing changes (Qin and Nembhard, 2010). The implementation of appropriate corporate agility not only enables the company to survive, but also builds sustainable competitiveness in the face of various market disruptions and uncertainties.

Corporate agility in the context of airport management is an essential ability to adapt and respond quickly to dynamic changes in the aviation industry, including fluctuations in passenger demand, safety regulations, and new technology trends (Durak and Sengur, 2024). The implementation of corporate agility in the airport environment includes seamless integration between operational systems, digital technology, and human resources to create efficient and responsive services to customer needs. The success of implementing Corporate Agility at airports can be measured by increasing customer satisfaction, operational efficiency, quality of infrastructure and superstructure, and the ability to maintain competitive advantage in the highly dynamic aviation industry (Fitrianto et al., 2024). Brueckner et al. (2020) stated in their research that by adopting corporate agility, airports can take advantage of emerging opportunities more effectively while reducing risks in the increasingly competitive global aviation market, especially in the post-pandemic era where flexibility and adaptability are key to sustainable growth and operational resilience.

2.2 Airport performance/corporate performance

Corporate performance can also be improved through corporate agility, which is the ability of an organization to respond to changes quickly and efficiently, while taking advantage of emerging opportunities (Rehman and Khatoon, 2022). In a dynamic environment such as airport management, agility is essential to maintaining high performance and achieving long-term sustainability. Changes in regulations, market needs, and environmental risks require companies to be more agile in adjusting their operations. Corporate agility can be a key driver in optimizing airport performance and ensuring the continuity of PT Angkasa Pura Indonesia's operations, with government regulations as a moderation that affects the effectiveness and flexibility of the company (Abbas et al., 2020).

Airport performance refers to how effectively an airport handles passenger traffic, ensures safety, and operates efficiently within a framework of economic and environmental sustainability. Airport infrastructure development plays a strategic role in driving optimal airport operational performance while also being a catalyst for regional economic growth. Adequate infrastructure, such as modern terminals, quality runways, and efficient supporting facilities, can increase the capacity and quality of airport services, thereby accelerating the mobility of people, goods, and services. This is especially relevant for industries related to human travel, especially tourism, where good accessibility is a key factor for success. With airports that are able to accommodate more tourists and provide a comfortable travel experience, the tourism sector can grow rapidly, create jobs, increase local incomes, and stimulate the development of supporting sectors such as hospitality, transportation, and culinary. Overall, airport infrastructure development not only increases the efficiency of air transportation, but also strengthens the economic competitiveness of a region.

Good infrastructure allows companies to reduce logistics costs and increase competitiveness. Furthermore, while improved air access contributes, the greater impact on economic performance comes from reduced ground travel time, demonstrating the importance of strategic location in airport planning. This synergy plays a role in supporting sustainable growth in industrial-oriented regions (Gibbons and Wu, 2020). Improving airport performance requires a balance between operational efficiency and environmental sustainability, where factors such as infrastructure quality, technology adoption, and regulatory frameworks play critical roles (Serio et al., 2022).

2.3 Airport sustainability/corporate sustainability

Corporate Sustainability (CS) theory describes a company's strategic approach that combines environmental, social, and economic dimensions into all aspects of the company's operations, with the main goal of achieving long-term sustainability and creating value for stakeholders (Ashrafi et al., 2020). This approach emphasizes that sustainability is not just about fulfilling social responsibilities, but also optimizing business performance by reducing negative impacts on the environment and society. Through the implementation of CS, companies are expected to be able to increase resource efficiency, such as energy savings and waste management, as well as build stronger relationships with local communities and other stakeholders. In addition, the integration of these three aspects is believed to mitigate business risks, improve the company's image, and support financial stability in the future.

In the context of large companies, especially in industries with significant environmental impacts such as airports, the implementation of Corporate Sustainability (CS) is essential to maintain long-term sustainability and ensure compliance with increasingly stringent environmental and social regulations. This is because airport operations generally produce high carbon emissions and waste, so responsible management is an urgent need in achieving sustainability standards. In addition to operational efficiency, CS theory also emphasizes the importance of innovation to help companies adapt quickly to changes in the business and social environment, which ultimately provides a competitive advantage in the market (Schaltegger et al., 2012). The CS approach allows companies to proactively reduce negative impacts, such as reducing carbon footprints and increasing energy efficiency, while still paying attention to the welfare of the surrounding community. Thus, companies are expected to not only be able to meet stakeholder expectations but also strengthen the company's image as a socially responsible and sustainable entity.

2.4 Government regulation

Government regulations play a significant role in influencing a company or airport's strategy and performance. Showed that compliance with government regulations is a key factor in implementing effective risk management practices. The study revealed that companies that comply with government regulations tend to have better risk management practices, which in turn can improve organizational performance. Furthermore, Prakash and Potoski (2016) explored how stringent government regulations can encourage companies to adopt better sustainability practices. They found that effective regulations can encourage companies to invest in greener technologies and processes, thereby improving organizational sustainability in the long term.

2.5 Digital twin and predictive maintenance

In the context of operational corporate agility, the implementation of digital twin and predictive maintenance technology has become a significant strategic step. Digital twin technology creates a virtual model of the airport that allows real-time data collection and comprehensive monitoring of operational conditions. This technology helps detect potential problems earlier, respond to disruptions faster, and optimize resource allocation to maintain smooth airport operations (Newbold, 2020). In addition, predictive maintenance allows prediction of airport asset damage before it occurs, through historical data analysis and equipment condition monitoring. This approach not only minimizes the risk of sudden damage but also increases operational efficiency by reducing unplanned downtime and extending asset life (Newbold, 2020).

In relation to previous literature on risk management, Flanagan and Norman (1993) explained that corporate agility strategies include proactive measures such as risk reduction and risk avoidance aimed at minimizing the impact of disruptions on the organization. Digital twin and predictive maintenance technologies represent concrete implementations of risk reduction in the context of airport operations. By adopting this technology, airports can carry out better preventive planning and reduce uncertainty in risk management decision making. In the long term, the integration of digital twin and predictive maintenance technologies supports the improvement of airport performance by ensuring operations run more efficiently, safely and sustainably. Thus, this technology becomes an integral part of modern risk management in the aviation industry.

3 Research methods

This study uses the Structural Equation Modeling (SEM) method to analyze the relationship between corporate agility and government regulation in improving airport performance and airport sustainability in the work environment. SEM is a multivariate analysis that combines factor analysis and multiple regression to test and estimate complex relationships between variables in a structural model (Solimun et al., 2017). SEM focuses on the covariance analysis of these variables and begins by calculating the covariance matrix so it is often called covariance-based SEM. By using SEM, all relationships between variables can be analyzed simultaneously in a comprehensive structural model. This model is especially useful in research that involves latent variables constructs that cannot be measured directly but are reflected through multiple observable indicators or items. This technique is used to analyze various relationships at one time, both direct and indirect relationships, and is suitable for research that has latent variables or constructs that cannot be measured directly.

In SEM there are two models, namely the measurement model and the structural model (Hair et al., 2019).

3.1 Measurement model

Measurement model describes the relationship of latent variables with indicators. The following is a measurement model for exogenous and endogenous variables.

$$x = \wedge_x \xi + \delta$$

Information:

x: Vector of exogenous observation variables.

$\wedge_x$: Factor loadings matrix for exogenous variables.

ξ : Vector of exogenous latent variables.

δ : Vector of measurement errors of exogenous variables

$$y = \wedge_y \eta + \varepsilon$$

Information:

y: Vector of endogenous observation variables.

$\wedge_y$: Factor loadings matrix for endogenous variables.

η : Vector of endogenous latent variables.

ε : Vector of measurement errors of endogenous variables.

3.2 Structural model

Structural models describe the relationship between latent variables in the model, both exogenous and endogenous variables.

$$\eta = B\eta + \Gamma\xi + \zeta$$

Information:

η : Vector of endogenous latent variables.

B: Regression coefficient matrix showing the relationship between endogenous latent variables.

Γ: Regression coefficient matrix showing the relationship between exogenous and endogenous latent variables.

ξ : Vector of exogenous latent variables.

ζ : Structural error vector (residual).

The use of SEM in this study aims to identify the influence of corporate agility and government regulation on airport performance and sustainability, capturing the overall interaction and causal pathways among the studied constructs. Through this approach, the study also determines which indicators most significantly refrelct each construh, and which pathways are statistically significant in shaping airport performance and sustainability. The indicator used in this study were selected based on established theories and prior empirical studies.

Corporate Agility can be measured using indicators such as responsiveness, technology, process planning, workplace & people, quality, and competence. This is in line with the proposed framework by Doz and Kosonen (2010) and validated in studies on organizational dynamic capabilities and agility (Tallon et al., 2019; Nijssen and Paauwe, 2012), emphasizing flexibility, adaptability, and speed in responding to change. Government regulation can be measured by the role of catalyst, facilitator, and regulator. The aforementioned role is the basis of public policy theory and regulatory governance literature (Baldwin et al., 2012; Scott, 2001), who stated that the government not only implements rules but also encourages and enables industrial adaptation and innovation. Airport performance includes indicators of operational efficiency, passenger service, and volume. This is in line with standard airport performance metrics from the literature (Graham, 2013; Forsyth et al., 2010), which are used to examine the service delivery and effectiveness of airport operations. Airport sustainability can be assessed through social, economic, and environmental dimensions. This is based on the framework introduced by Elkington (1997), namely the Triple Bottom Line (TBL), which is generally applied to sustainable airport development studies (ACI, 2020). Indonesia is the country that is the focus of this study because Indonesia is an archipelagic country, where air transportation plays an important role in establishing connectivity between islands. Airports in Indonesia, especially those managed by PT Angkasa Pura, are under increasing pressure to be agile in responding to rapid environmental and regulatory changes, while pursuing sustainability goals. However, empirical research integrating corporate agility, regulatory frameworks, and sustainability outcomes in the management of Indonesian airports is still scarce, thus justifying the state as a relevant and important case study.

The population of this study was all employees working at PT Angkasa Pura Indonesia. The sample was taken using a purposive sampling technique, which was selected based on certain and relevant criteria from employees at the airport, as many as 148 respondents were selected to participate in the survey, which was considered sufficient to meet the minimum sample size requirements in SEM analysis (Hair et al., 2019). This study employs a complex structural model within the SEM framework, involving multiple constructs and both direct and indirect relationships. Unlike a simple or single path model, this research includes Corporate Agility and Government Regulation as exogenous variables, Airport Performance as a mediating variable, and Airport Sustainability as the final endogenous outcome. The model is classified as complex because it simultaneously examines multiple latent construct, includes a mediating pathway, and tests several causal relationships in a unified structure. This complexity allows for a more comprehensive understanding of how internal agility and external regulation influence airport performance and long term sustainability outcomes. This study uses the Partial Least Squares SEM (PLS-SEM) method by utilizing the WarpPLS device. This method is sorted because it is appropriate in predictive and exploratory studies that include complex models with latent variables, especially

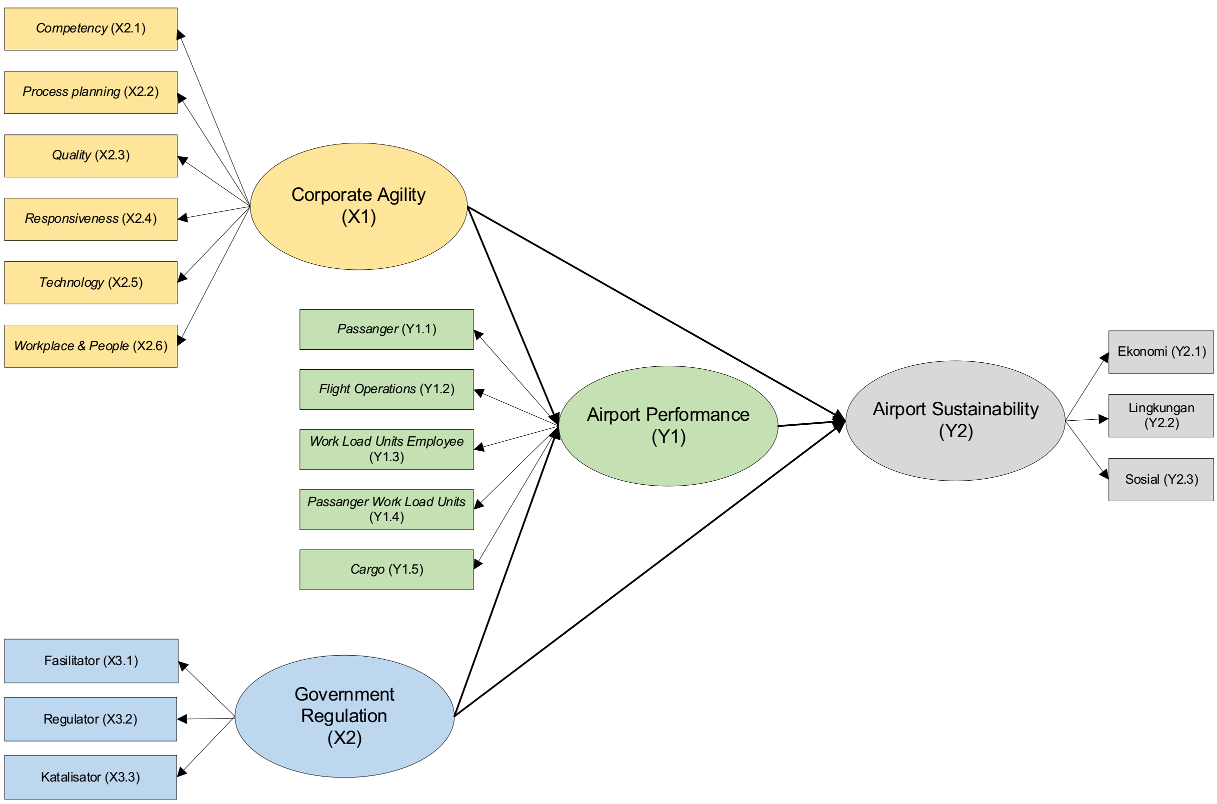

FIGURE 1
Conceptual research model.

TABLE 1 Research variables and indicators.

Variables	Indicator
Corporate agility (X1)	Competence (X1.1)
	Process Planning (X1.2)
	Quality (X1.3)
	Responsiveness (X1.4)
	Technology (X1.5)
	Workplace and People (X1.6)
Government regulation (X2)	Facilitator (X2.1)
	Regulator (X2.2)
	Catalyst (X2.3)
Airport performance (Y1)	Passenger (Y1.1)
	Flight Operations (Y1.2)
	Work Load Units - Employees (Y1.3)
	Passenger Work Load Units (Y1.4)
	Cargo (Y1.5)
Airport sustainability (Y2)	Economy (Y2.1)
	Environment (Y2.2)
	Social (Y2.3)

when the sample size is relatively small to medium (Hair et al., 2019). The research model is shown in Figure 1. The variables and indicators used in this study are also presented in Table 1.

4 Results and discussion

4.1 Descriptive analysis

On September 9, 2024, the minister of SOEs officially merged PT Angkasa Pura I (AP I) and PT Angkasa Pura II (AP II) into a sigle entity, PT Angkasa Pura Indonesia (API) or Injourney Airports, which now manages 37 commercial airports in Indonesia (ANTARA News, 2024). Before the merger, AP I oversaw 17 airports, while AP II managed 20. In comparison, the Ministry of Transportation's UPT continues to operate 216 airports, bringing the national total to 251. From 2017 to 2019, before the Covid-19 pandemic, passenger traffic across all three airport operators remained relatively stable. These trends are illustrated in Figure 2.

Figure 2 shows an imbalance in passenger traffic among airports managed by PT Angkasa Pura I, PT Angkasa Pura II, and the Ministry of Transportation's UPT. This imbalance is mainly due to domestic traffic being concentrated at Soekarno Hatta (CGK), followed by Juanda (SUB) and Ngurah Rai (DPS), which remain the busiest domestic airports. In the eastern region, air traffic is dominated by charter flights, as the need for air connectivity is higher due to limited land access, unlike in the western region, which benefits from infrastructure such as Trans Sumatra and Trans Java. Additionally, many pioneer routes remain underutilized, partly due to the dominance of point to point flights from CGK. PT Angkasa Pura Indonesia generates the highest operating income compared to UPT-managed airports, as shown in Figure 3.

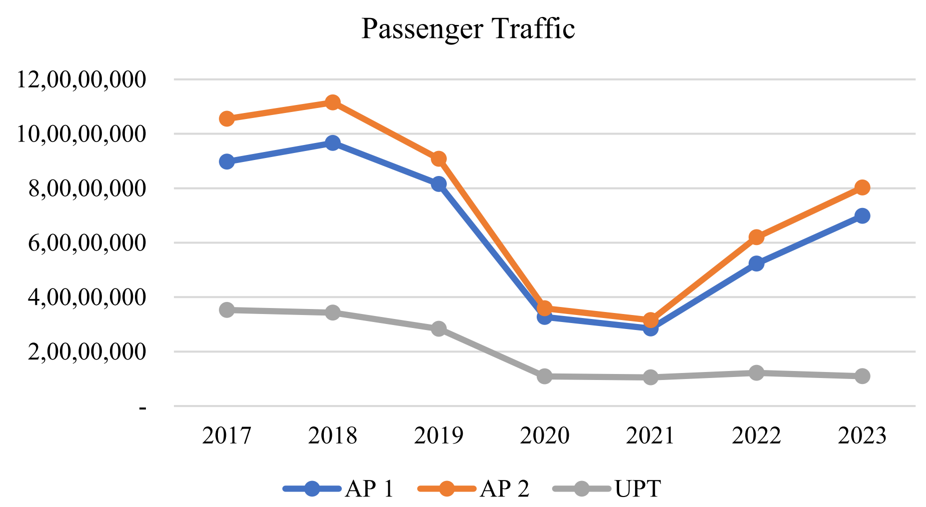

FIGURE 2
Airport passenger traffic in 2017–2023.

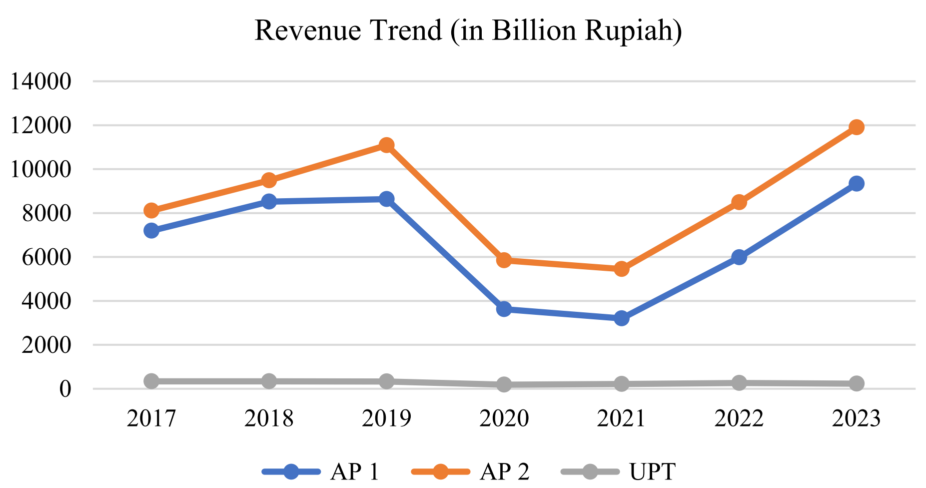

FIGURE 3
Total airport operating revenue in 2017–2023.

Figure 3 illustrates that from 2017 to 2019, operating income at airports managed by PT Angkasa Pura Indonesia increased, while income at UPT-managed airport declined. In 2020, all airport operators experienced a sharp drop in income due to the Covid-19 pandemic, which severely restricted air travel and passenger movement. This decline in traffic directly impacted airport revenues. According to Saputra et al. (2021), the pandemic reflrects a VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) situation that disrupted both daily life and business operations.

4.2 Construct reliability and validity

Reliability test or instrument reliability test is a test intended to show the extent to which a measurement can provide consistent results when re-measured against the same symptoms with the same measuring device (Sugiyono, 2013). Reliability testing is done by testing question items or statements. It can be said to be reliable if it gives a Cronbach Alpha (α) value > 0.60 (Solimun et al., 2017). Reliability testing using the Cronbach Alpha test using WarpPLS software. The results of the reliability test are presented in Table 2.

TABLE 2 Questionnaire reliability test results.

Variabel	Alpha cronbach	Conclusion
Corporate Agility (X1)	0.84	Reliabel
Government Regulation (X2)	0.87	Reliabel
Airport Performance (Y1)	0.80	Reliabel
Airport Sustainability (Y2)	0.84	Reliabel

Table 2 shows that the Alpha Cronbach values of the four study variables were worth more than 0.6. Based on the above examination, the research instrument can be declared valid and reliable.

The following is a table of Discriminant Validity using the Fornell-Larcker Criterion. Discriminant validity is declared adequate if the square root of the AVE (Average Variance Extracted) for each construct shown diagonally will be greater than the correlation between constructs or non-diagonal elements in rows/columns. The results of Discriminant Validity can be seen in Table 3.

Based on Table 3 using the Fornell-Larcker Criterion, all constructs in the model have met the discriminat validity requirement. This is shown from the square root value of the average variance extracted of each construct which has a higher value compared to the correlation value with other constructs. Konstruk Risk Management (RM) has a $\sqrt{AVE}$ of 0.854, higher than its highest correlation with Airport Sustainability (US) at 0.551. Corporate Agility (CA) has a $\sqrt{AVE}$ of 0.726, above its correlation with Government Regulation (GR) at 0.597. Airport Performance (AP) has a $\sqrt{AVE}$ of 0.760, higher than its correlation with a GR at 0.484. US has a $\sqrt{AVE}$ of 0.857, exceeding its correlation with the RM at 0.551. GR has an $\sqrt{AVE}$ of 0.853, above its correlation with a CA of 0.597. Meanwhile, for the interaction constructs of GR × RM and GR × CA, each have a $\sqrt{AVE}$ of 1.000, also higher than their respective correlations with other constructs (−0.166 and 0.113). These results confirm that all constructs in the model are distinct and reliably measure different concepts.

4.3 Goodness of fit WarpPLS

R-squared adjusted used to evaluate how well the model is able to explain the variability of the observed data by taking into account the number of independent variables and sample size. In SEM, goodness of fit is measured by the Q^2 value. The Q^2 value is used to assess the extent to which the observations made support the results of the research model. If $Q^2 > 0$, then the model has predictive relevance. The higher the Q^2 value, the better the performance of the model. The Q^2 result from this study is 0.571 or 57.1%. Based on these results, this research model can explain the empirical phenomenon (system) studied by 57.1%. Thus, this research model has relatively good predictive relevance. 57.1% is the contribution of other variables that have not been included in the model and error.

4.4 Measurement model

The variables used in the study are included in latent variables that cannot be measured directly so that several indicators are needed to measure the variables in the study. Therefore, data from factor analysis processed based on secondary data is needed. The results of Confirmatory Factor Analysis (CFA) will form data based on research variables.

4.4.1 Corporate agility variable measurement model (X_1)

The Corporate Agility (X_1) variable is a latent variable that has six reflective indicators. Briefly, the calculation of the measurement weight value and *p*-value of each indicator of the Corporate Agility (X_1) variable can be seen in Table 4.

Based on Table 4, the outer loading value of the Corporate Agility variable indicator (X_1) can be presented in Figure 4.

Figure 4 shows that Responsiveness ($X_{1.4}$) is the strongest indicator of Corporate Agility (X_1), with an outer loading of 0.830. This is followed by Workplace & People ($X_{1.6}$) at 0.782 and Technology ($X_{1.5}$) at 0.765. The remaining indicators are Quality ($X_{1.3}$) at 0.680, Process Planning ($X_{1.2}$) at 0.648, and Competency ($X_{1.1}$) at 0.631. The high value for Responsiveness emphasizes the importance of an airport's ability to adapt quickly to regulatory changes, market demand, and operational disruptions. Such agility enhances efiiciency and reduces costs linked to delays or capacity issues. The consistently volatile nature of the aviation industry makes responsiveness a key competitive factor. Additionally, the strength of Workplace & People and Technology indicates that investment in human resources and digital infrastructure supports real time decision making and process optimization, ultimately driving cost efficiency, service quality, and innovation.

4.4.2 Measurement model of government regulation variable (X_2)

The Corporate Agility variable (X_2) is a latent variable that has three reflective indicators. Briefly, the calculation of the measurement weight value and *p*-value of each indicator of the Corporate Agility variable (X_2) can be seen in Table 5.

Based on Table 5, the outer loading value of the Government Regulation variable indicator (X_2) can be presented in Figure 5.

Figure 5 shows that Reguler ($X_{2.2}$) is the strongest indicator of Government Regulation (X_2), with an outer loading of 0.875. This is followed by Catalyst ($X_{2.3}$) at 0.849 and Facilitator ($X_{2.1}$) at 0.835. The dominance of the Regulator indicator highlights the importance of government oversight in ensuring compliance and setting industry standards, which helps reduce uncertainty, maintain safety, and build investor confidence. Meanwhile, the strong values for Catalyst and Facilitator reflect the government's role in promoting innovation, collaboration, and institutional support, such as through policy

TABLE 3 Fornell-Larcker (discriminant validity) result.

Konstruk	RM	CA	AP	AS	GR	GR × RM	GR × CA
RM	0.854	0.190	0.087	0.551	−0.196	−0.166	−0.039
CA	0.190	0.726	0.076	0.528	0.597	−0.048	0.113
AP	0.087	0.076	0.760	0.471	0.484	−0.227	0.016
AS	0.551	0.528	0.471	0.857	0.398	−0.074	0.053
GR	−0.196	0.597	0.484	0.398	0.853	−0.016	0.037
GR × RM	−0.166	−0.048	−0.227	−0.074	−0.016	1.000	0.041
GR × CA	−0.039	0.113	0.016	0.053	0.037	0.041	1.000

TABLE 4 Results of outer loading corporate agility variable (Y_1).

Indicator	Outer loading	*p*-value
Competence ($X_{1.1}$)	0.631	<0.001
Process planning ($X_{1.2}$)	0.648	<0.001
Quality ($X_{1.3}$)	0.680	<0.001
Responsiveness ($X_{1.4}$)	0.830	<0.001
Technology ($X_{1.5}$)	0.765	<0.001
Workplace and people ($X_{1.6}$)	0.782	<0.001

coordination and capacity building, that strengthen economic resilience and sustainability in the airport sector.

4.4.3 Measurement model of airport performance variable (Y_1)

The Airport Performance variable (Y_1) is a latent variable that has five reflective indicators. Briefly, the calculation of the measurement weight value and *p*-value of each indicator of the Airport Performance variable (Y_1) can be seen in Table 6.

Based on Table 6, the outer loading value of the Airport Performance variable indicator (Y_1) can be presented in Figure 6.

4.4.4 Measurement model of airport sustainability variable (Y_2)

The Airport Sustainability (Y_2) variable is a latent variable that has three reflective indicators. Briefly, the calculation of the measurement weight value and p-value of each indicator of the Airport Sustainability (Y_2) variable can be seen in Table 7.

Based on Table 7, the outer loading value of the Airport Sustainability variable indicator (Y_2) can be presented in Figure 7.

Figure 7 shows that the strongest indicator in the Airport Sustainability variable (Y_2) is Environmental ($Y_{2.2}$) with an outer loading value of 0.884. The second strongest indicator is Social ($Y_{2.3}$) with an outer loading value of 0.868, followed by the indicator in third position, namely Economic ($Y_{2.1}$) with an outer loading value of 0.817. The superiority of the environmental dimension on the sustainability of airports illustrates the increased pressure for airports to lower their ecological footprint. High performance on environmental conservation, such as efficient use of energy, emission control, and waste reduction, is increasingly related to long-term cost savings and compliance in regulations. Strong social and economic indicators also emphasize that a sustainable airport must ensure how people's well-being and financial viability are. Social initiatives like local workforce development or noise mitigation enhance social license to operate, while strong economic outcomes ensure the airport's ability to reinvest in future infrastructure and innovation (Figure 8).

4.5 Structural model

The WarpPLS model provides information on the coefficient of determination (R^2), the calculation of the R^2 of the Airport Performance (Y_1) variable model obtained an R^2 of 0.34, the Airport Sustainability (Y_2) variable model obtained an R^2 of 0.82. Based on the R^2 value for Airport Performance (Y_1) is 34% (0.34) which means that Corporate Agility (X_1) and Government Regulation (X_2) are able to explain the Airport Performance (Y_1) variable by 34%. While the Airport Sustainability (Y_2) variable can be explained by Corporate Agility (X_1), Government Regulation (X_2) and Airport Performance (Y_1) by 82%. Based on the previously available R^2 value, the Q^2 value can be calculated. The Q^2 value is a measure of how well the observations made provide results for the research model. With $Q^2 > 0$, it can be concluded that the model has predictive relevance. The greater the Q^2 value, the better the model. The following is the calculation formula and the results of the Q^2 calculation for this research model.

$$Q^2 = 1 - \left(\left(1 - R^2{}_{Y1}R^2{}_{Y1}\right)\left(1 - R^2{}_{Y2}R^2{}_{Y2}\right)\right)$$

$$= 1 - \left(\left(1 - 0.34\right)\left(1 - 0.82\right)\right)$$

$$= 0.8812$$

Based on the calculation results, this research model can explain the empirical phenomenon (system) studied by 88.12%. Thus, this research model has relatively good predictive relevance. 11.88% is the contribution of other variables that have not been included in the model and error.

An overview of the direct relationships between Corporate Agility, Government Regulation, Airport Performance, and Airport Sustainability is presented in Table 8.

This study adopts a 5% significance level ($\alpha = 0.05$) as the standard threshold for determining the statistical significance of relationships between variables. This approach aligns with widely accepted practices in quantitative research within the fields of management and social sciences (Hair et al., 2019) and is intended to minimize the risk of Type I errors while maintaining methodological rigor. In SEM analysis with WarpPLS approach. The following hypothesis testing results were obtained.

The analysis shows that Corporate Agility (X_1) has a positive but not significant effect on Airport Performance (Y_1), with path coefficient of 0.130 and *p*-value of 0.053. Although the relationship is positive, it is not significant, suggesting that agility has not yet been fully integrated into core operations or aligned with key performance metrics.

The analysis shows that Corporate Agility (X_1) has a positive and significant effect on Airport Sustainability (Y_2), with a path coefficient of 0.636 and a p-value <0.001. This means that stronger agility supports long term airport sustainability. The positive relationship suggests that effective implementation of corporate agility enhances an airport's ability to adapt to environmental and regulatory demands, contributing to sustainable operations.

The analysis shows that Government Regulation (X_2) has a positive and significant influence on Airport Performance (Y_1), with a path coefficient of 0.596 and a p-value <0.001. This indicates that clear and well enforced regulations play a key role in enhancing airport operations. Supportive policies such as security standards, environmental guidelines, and operational procedures can improve the efficiency and effectiveness of airport performance.

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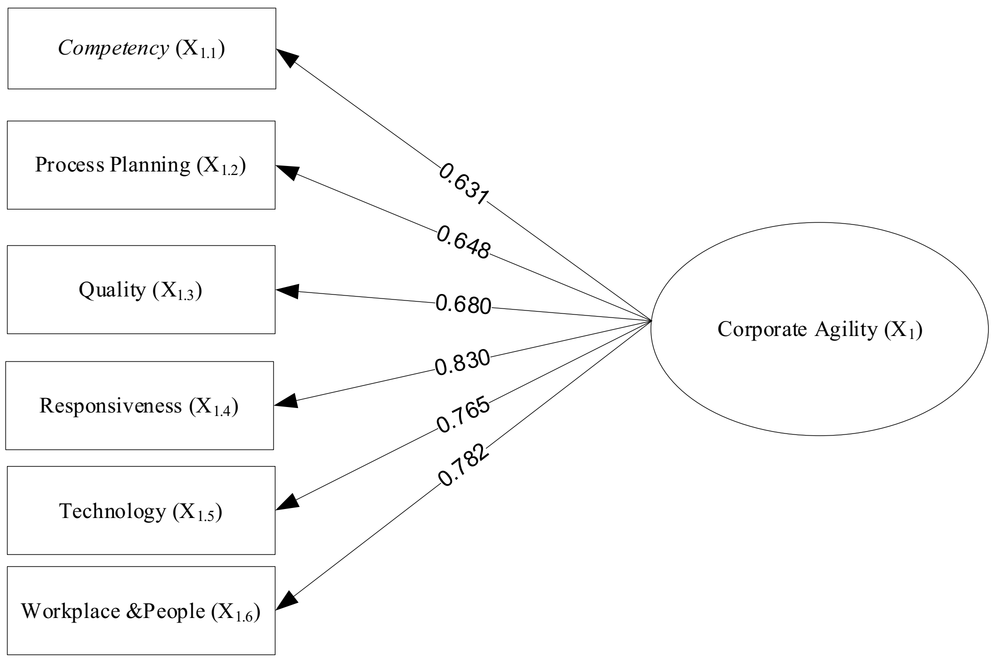

FIGURE 4
Results of outer loading corporate agility variable (Y_1).

TABLE 5 Results of outer loading variable government regulation (X_2).

Indicator	Outer loading	*p*-value
Facilitator ($X_{2.1}$)	0.835	<0.001
Regulator ($X_{2.2}$)	0.875	<0.001
Catalyst ($X_{2.3}$)	0.849	<0.001

The analysis shows that Government Regulation (X_2) has a positive and significant effect on Airport Sustainability (Y_2), with a path coefficient of 0.325 and a *p*-value <0.001. This underscores the regulatory role in supporting both operational performance and long term sustainability. Policies promoting sustainability such as emission controls or resource management help strengthen airport resilience against future challenges.

The results of the analysis show that Airport Performance (Y_1) has a positive and significant influence on Airport Sustainability (Y_2), with a path coefficient of 0.638 and a p-value <0.001. This indicates that improvements in logistics, service quality, and efficiency directly enhance sustainability outcomes. Better performance leads to greater operational sustainability and strengthens the airport's overall reputation.

Indirect influence is an influence that occurs through one or more mediating variables. The results of the indirect influence test with one mediating variable are presented in Table 9.

The result show that the indirect effect of Corporate Agility (X_1) on Airport Sustainability (Y_2) through Airport Performance (Y_1) is not significant (path coefficient = 0.083, $p = 0.074$). This suggests that agility alone is not sufficient to enhance sustainability via performance improvements, possibly due to limited implementation in core operational areas. In contrast, Government Regulation (X_2) has a significant indirect effect on Airport Sustainability (Y_2) through Airport Performance (Y_1), with a path coefficient of 0.380 and a p-value <0.001. This indicates that effective regulation supports better airport performance, which in turn promotes sustainability. These findings emphasize the key role of external regulation in driving airport sustainability, while internal capabilities like agility still require fusther development to have a meaningful impact.

The role of government regulation as a key driver of airport sustainability highlights the importance of clear policies and consistent implementation. Meanwhile, the limited impact of corporate agility does not mean it is unimportant, but rather indicates the need for further development to strengthen its role. Corporate agility can enhance an airport adaptability to regulatory changes, technological shifts, and evolving consumer demands. Therefore, a more structured analysis is needed to determine whether its limited effect stems from weak implementation or contextual misalignment. Ultimately, airport sustainability should be seen as the result of synergy between strong external regulation and robust internal capabilities, both of which require balanced and complementary attention.

The study shows that Corporate Agility (X_1) has a positive but insignificant effect on Airport Performance (Y_1). This suggests that while agility can improve operational efficiency, other factors such as regulations, infrastructure, and workforce readiness also play key roles. According to Organizational Agility Theory (Dove, 2001), agile organizations respond well to change. However, in aviation, strict regulations and standardized procedures may limit this flexibility. To increase its impact, corporate agility should be supported by adaptive management and better technology integration.

The study finds that Corporate Agility (X_1) has a positive and significant effect on Airport Sustainability (Y_2). This suggests that

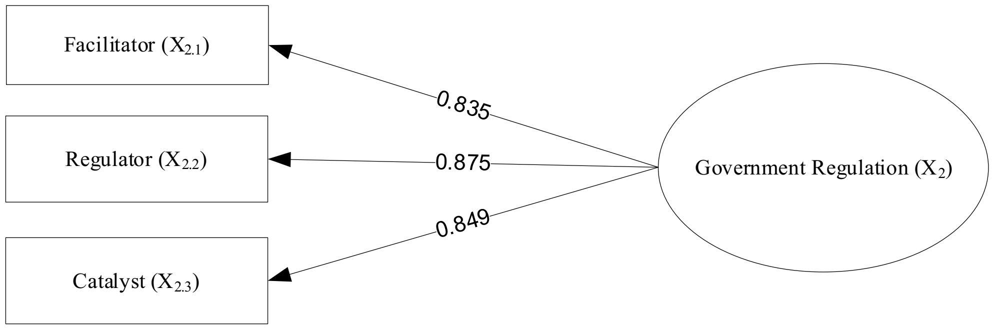

FIGURE 5
Results of outer loading variable government regulation (X_2).

TABLE 6 Outer loading results of airport performance variables (Y_1).

Indicator	Outer loading	*p*-value
Passenger ($Y_{1.1}$)	0.756	<0.001
Flight operations ($Y_{1.2}$)	0.725	<0.001
Work load units –employee ($Y_{1.3}$)	0.747	<0.001
Passenger work load units ($Y_{1.4}$)	0.754	<0.001
Cargo ($Y_{1.5}$)	0.784	<0.001

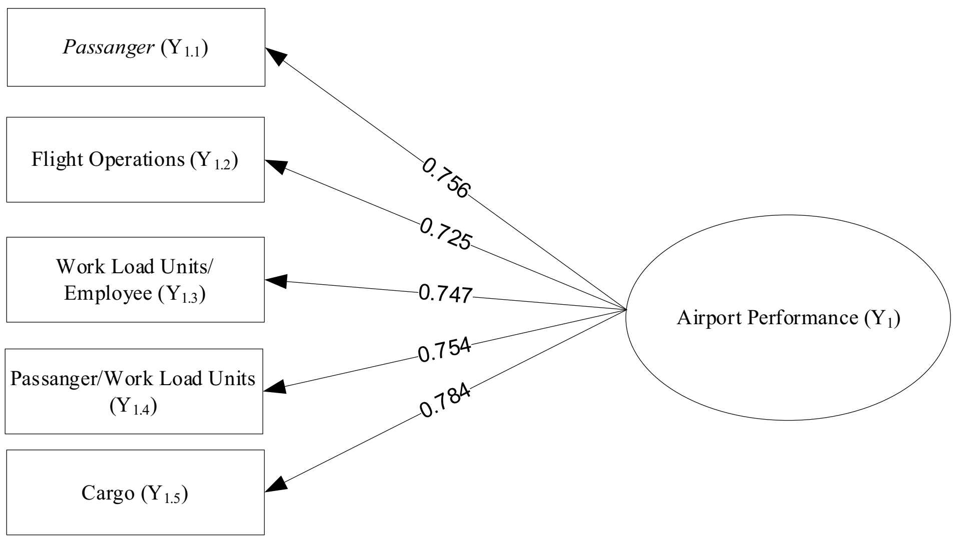

FIGURE 6
Outer loading results of airport performance variables (Y_1).

organizations with greater adaptability and innovation are more likely to adopt sustainable practices. According to Resource Based View (RBV) Theory (Barney, 1991), agility acts as a strategic resource that enhances competitiveness through energy efficiency, operational optimization, and environmental management. Meanwhile, Government Regulation (X_2) also shows a positive and significant effect on Airport Performance (Y_1), supporting findings. Regulations related to safety, the environment, and traffic management improve operational efficiency and service quality, while strengthening competitiveness.

Government Regulation (X_2) further exerts a positive and significant effect on Airport Sustainability (Y_2). This highlights the role of policies promoting emission reduction and sustainable resource use. In line with the Triple Bottom Line Theory (Elkington, 1998), these regulations encourage economic, social, and environmental improvements. In addition, Airport Performance (Y_1) has a positive and significant effect on Airport Sustainability (Y_2). Improved operations, such as optimized traffic management and digital innovation contribute directly to sustainability. According to Operational Excellence Theory (Porter, 1985), efficient operations support long-term competitiveness and sustainability. However, the indirect effect of Corporate Agility (X_1) on Airport Sustainability (Y_2) is not significantn. This implies that agility strategies may not yet be fully integrated into operational systems. As noted in Organizational Adaption Theory (Burns and Stalker, 1961), flexibility alone is insufficient without strategic alignment and execution. On the other hand, Government Regulation (X_2) has a significant indirect effect on Airport Sustainability (Y_2) via Airport Performance (Y_1). Based on Institutional Theory (DiMaggio and Powell, 1983), external regulations shape organizational practices and drive sustainability efforts. Effective policies promote efficiency, environmental stewardship, and social responsibility, leading to long term airport sustainability.

4.6 Implications for airport sustainability and policy recommendations

The findings of this study not only shed light on the statistical results but also offer useful insights for sustainability-driven airport management. The strongest indicator of Company Agility is responsiveness with loading = 0.830 emphasizing the importance of adaptive skills in dealing with operational, market, and regulatory uncertainties. In the context of airports in Indonesia, this emphasizes the urgency of management to strengthen internal agility, particularly in improving rapid decision-making and the ability to adapt to the workforce to address environmental and service-related challenges.

Similarly, Cargo is the most influential indicator of Airport Performance, showing that the center of operational success depends not only on passenger service, but also on how well the airport handles logistics. This is in line with the function of airports that are logistics centers, especially in archipelagic countries such as Indonesia, where e-commerce trade between islands is growing. Efficient cargo handling contributes not only to the competitiveness of airports but also to economic resilience and wider regional development.

The dominance of the Regulator indicator (loading = 0.875) in the construction of Government Regulations illustrates the need for strong supervision and clearer policies. This is in line with Baldwin et al. (2012), who affirm the importance of regulation in reducing ambiguity and guiding strategic alignment in high-risk sectors such as aviation. An effective regulatory framework can directly improve airport performance through clearer compliance standards and indirectly drive sustainability by driving the adoption of green infrastructure, safety protocols, and carbon reduction initiatives. The Environmental Indicator in Airport Sustainability has the highest load of 0.884, which reaffirms the priority placed on mitigating ecological impacts. However, this does not limit the importance of economic and social aspects. Instead, it illustrates the growing expectations for airports in serving sustainable growth, waste management, and community well-being.

The results of the structural model show that government regulations have a significant effect on the performance and sustainability of airports, both directly and indirectly through performance. This confirms that policies not only function as a control mechanism, but also as a driver of efficiency and innovation, for example through green technology incentives, bureaucratic simplification, and public-private collaboration. Conversely, the indirect influence of Corporate Agility on sustainability through performance is insignificant, indicating that the integration of agile practices in operational processes is still limited or not aligned with sustainability goals. To overcome this, airport authorities need to internalize the principle of agility in daily operations, supported by the development of human resources and digital infrastructure. These findings resulted in three key recommendations: strengthening agility capabilities, especially in terms of responsiveness through continuous training, digital transformation, and cross-unit coordination; reform policies to balance control and empowerment and align with the sustainability agenda; as well as redefining performance metrics that emphasize not only operational efficiency, but also environmental and social value. With these measures, airports in Indonesia will be more adaptive, efficient, and sustainable in the long term.

TABLE 7 Outer loading results of airport sustainability variables (Y_2).

Indicator	Outer loading	*p*-value
Economy ($Y_{2.1}$)	0.817	<0.001
Environment ($Y_{2.2}$)	0.884	<0.001
Social ($Y_{2.3}$)	0.868	<0.001

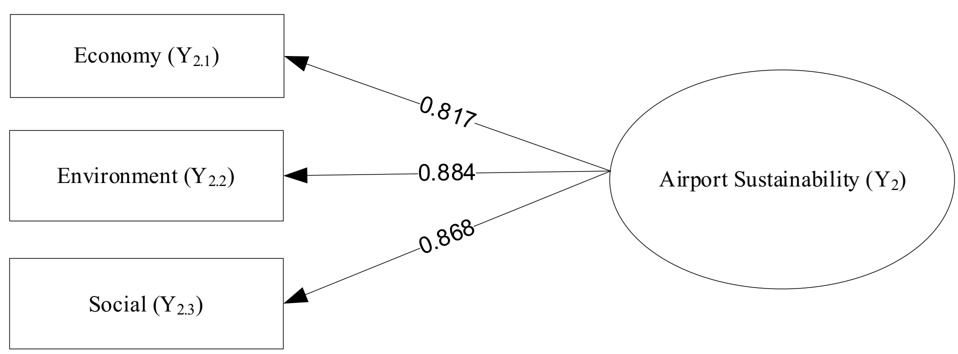

FIGURE 7
Outer loading results of airport sustainability variables (Y_2).

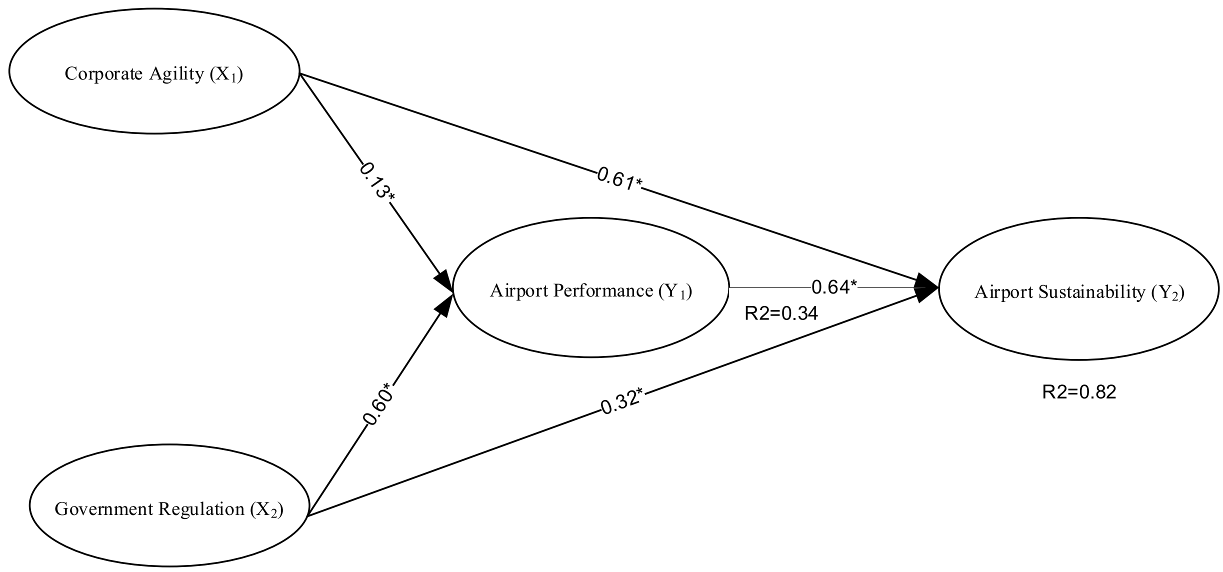

FIGURE 8
Structural model.

TABLE 8 Direct influence between variables.

Influence of variables	Path coefficient	*p*-value	Conclusion
Corporate agility (X_1) to airport performance (Y_1)	0.130	0.053	Not Significant
Corporate agility (X_1) to airport sustainability (Y_2)	0.636	<0.001	Significant
Government regulation (X_2) on airport performance (Y_1)	0.596	<0.001	Significant
Government regulation (X_2) on Airport sustainability (Y_2)	0.325	<0.001	Significant
Airport performance (Y_1) to Airport sustainability (Y_2)	0.638	<0.001	Significant

Source: Processed data (2024).

TABLE 9 Indirect effect test results.

Variables			Path coefficient	*p*-value	Conclusion
Predictor	Mediation	Response			
Corporate Agility (X_1)	Airport Performance (Y_1)	Airport Sustainability (Y_2)	0.083	0.074	Not significant
Government Regulation (X_2)	Airport Performance (Y_1)	Airport Sustainability (Y_2)	0.380	<0.001	Significant

Source: Processed data (2024).

5 Conclusion and suggestion

From the results of the analysis that has been carried out, the following conclusions were obtained.

The measurement model test shows that the outer loading value of each indicator is significant, so that all indicators successfully represent their respective latent variables in the study. The outer loading results found that Responsiveness ($X_{1.4}$), Regulator ($X_{2.2}$), Cargo ($Y_{1.5}$), and Environment ($Y_{2.2}$) were the strongest indicators for each variable.

The results of the structural model test obtained the results that of the 5 direct relationships between variables, 4 of them have a significant direct influence. Meanwhile, from the 2 indirect relationships between research variables, one indirect influence was obtained that was not significant, namely the relationship between Government Regulation and Airport Sustainability through (mediated by) Airport Performance. Thus, it can be seen that the Airport Performance variable $\left(Y_1\right)$ can mediate between the Government Regulation variable (X_2) and Airport Sustainability $\left(Y_2\right)$.

The research model can explain the empirical phenomena studied by 57.1%. Thus, this research model has quite good predictive relevance.

To improve corporate agility, performance and sustainability of airports, the integration of real-time technologies such as digital twins and operational automation is a new and very strategic approach. Digital twins technology enables comprehensive operational monitoring through virtual models, so that potential disruptions can be detected and resolved early. Meanwhile, operational automation helps improve efficiency by reducing manual intervention and minimizing the risk of errors, supporting the smooth operation of airports in the long term.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

FF: Writing – original draft. MA: Data curation, Conceptualization, Formal analysis, Writing – review & editing. CD: Validation, Resources, Software, Writing – review & editing. EP: Methodology, Investigation, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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