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Role of Technological Innovation and Operational Efficiency in Competitive Advantage at Soekarno Hatta International Airport

Charles An¹, Cecep Pahrudin², Arty Zykra Pratiwi³, Syahranny Anzelie Shadewi Naila Syamsuri⁴

¹Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia, bimbinganst1862@gmail.com

²Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia.

³Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia.

⁴Institut Transportasi dan Logistik Trisakti, Jakarta, Indonesia.

Corresponding Author: bimbinganst1862@gmail.com¹

Abstract: This research aims to assess the impact of technological innovation and operational efficiency on competitive advantage at Soekarno Hatta International Airport. In the digitalization era, the implementation of technologies such as self check-in services and the Internet of Things (IoT) is crucial for enhancing efficiency and customer satisfaction. Data were collected from 100 airport users using random sampling techniques, with a quantitative analysis conducted through linear regression using SPSS. Validity, reliability, normality, regression, determination (r^2), t-test, and f-test were employed in this study. The results of this study show that technological innovation and operational efficiency have a significant impact on competitive advantage, contributing 56.9% to the competitive advantage variable. The combination of technological innovation and operational efficiency plays an important role in enhancing the competitiveness of Soekarno-Hatta International Airport in both domestic and international markets.

Keyword: Technological Innovation, Operational Efficiency, Competitive Advantage, Soekarno-Hatta Airport, Digital Technology.

INTRODUCTION

Soekarno Hatta International Airport, opened on 1 January 1985, replaced Kemayoran and Halim Perdanakusuma airports. Soekarno Hatta International Airport plays an important role in the national economy and transportation infrastructure, serving domestic and international flights. The era of digitalization and globalization has brought significant transformations to the aviation industry, including Soekarno Hatta International Airport, which is the busiest airport in Indonesia. Driven by rapid technological advances, the industry is experiencing rapid growth and demand for faster and more efficient connectivity (Biringkanae & Bunahri, 2023). Digitalization facilitates access to information and services,

by encouraging user engagement, as well as operational efficiency and customer experience through technological innovation.

On the other hand, digitization also presents new challenges, especially in the aspects of customer satisfaction and environmental sustainability. The integration of digital services such as self-check-in into airline operations must be done effectively to improve customer satisfaction and operational efficiency (Yuliana et al., 2020). Factors such as ease-of-use, system reliability, and the impact of technology on operational processes must be considered to ensure the service can meet customer expectations.

The global aviation industry has sought to adopt various technological innovations to improve its services and operational efficiency. Competition between airports in the Southeast Asian region is getting tougher, prompting Soekarno-Hatta International Airport to continue to innovate in improving its services and operational efficiency the implementation of self check-in services is one of the significant steps taken by many airlines. Information and communication technology plays an important role in improving the efficiency and effectiveness of the company's operations. The implementation of digitization at Soekarno-Hatta International Airport is inevitable according to President Director of PT Angkasa Pura II Muhammad Awaluddin (21/6/2021). IoT (Internet of Things) facilities are now being implemented at Soekarno-Hatta International Airport (Soeta) IoT using beacon technology on golf carts at terminal 3. Through AI, it can further optimize facilities and increase efficiency in maintenance, energy use and also provide more personalized services according to Executive General Manager of Soekarno Hatta Dwi Ananda International Airport (8/9/2023).

However, behind the rapid growth, the aviation industry is also on a variety of challenges such as fierce competition and high operating costs. To remain competitive, airlines need to create unique airport experiences and improve operational efficiency. Technological innovation also plays an important role in improving the competitive advantage of air transportation. Digitalization plays an important role in improving operational efficiency and customer experience through various technological innovations. One example is the implementation of self check-in technology at the airport which can facilitate and shorten users in carrying out their activities when at the airport (Anggela, 2023). Airline mobile apps make it easy for passengers to book tickets, check-in online, and get real-time flight information. This service also supports more personalized and responsive customer service. Digital technology has revolutionized the tourism and hospitality industry, including the aviation sector, by providing a more integrated and efficient platform (Komalasari et al., 2020). Operational efficiency is another important factor in the competitive aviation industry. One example is RFID-based baggage tracking systems that allow passengers and airlines to track baggage status in real-time, thereby reducing incidents of baggage loss and improving baggage handling efficiency (Yuliana et al., 2020).

The purpose of this study was to determine the effect of technological innovation on the implementation of competitive advantages at Soekarno Hatta International Airport, to analyze the effect of operational efficiency on the implementation of competitive advantages at Soekarno-Hatta International Airport, and to identify the simultaneous influence of technological innovation and operational efficiency on competitive advantages at Soekarno Hatta International Airport.

This research has two main benefits. First, theoretical benefits aimed at enriching the literature on technological innovation and operational efficiency in airport management, as well as developing or expanding existing models and theories. The research also provides an in-depth understanding of the relationship between technological innovation and competitive advantage, which can form the basis for subsequent research in this area. Second, the expected practical benefits can provide recommendations for Soekarno-Hatta airport management in improving operational performance and efficiency through the application of

technological innovation. This step is expected to reduce costs, improve service to passengers, and strengthen the airport's competitiveness in the international market.

Literature Review

1. Technology Innovation

Technological innovation has significantly changed the processes and practices associated with aviation security, providing many benefits in terms of more efficient and effective security (Callander & Kaunert, 2022). This process is designed to improve the efficiency and competitiveness of Soekarno Hata International Airport, enabling them to remain ahead in a competitive environment. With a structured approach, organizations can maximize the potential of technology to achieve optimal results and create sustainable added value. (Tidd, Joe; R. Bessant, 2020) explain that technological innovation as a systematic process that aims to identify, develop, and implement new or existing technologies innovatively. Technological innovation as the ability of organizations to explore and exploit new technologies in a flexible and adaptive way, in order to achieve competitive advantages and survive in a dynamic business environment (Tushman and O'Reilly, 2021). Indicators of technological innovation according to (Jim, 2020) includes:

a) Innovative Features

Addition or improvement of features in products that utilize new technology. New technologies allow companies to design features that are more advanced, intuitive, and responsive to market trends, making products more competitive and relevant.

b) Process Efficiency

Increased efficiency in the production process or product development thanks to innovative technologies contributes to the optimization of workflow and saving resources. New technologies such as automation, robotics or process management software allow companies to reduce cycle times, improve quality consistency and reduce human error.

c) Market Success

The extent to which new products driven by innovative technologies are accepted and successful in the market. This success is not only measured by sales and market share, but also by how well the product meets customer expectations, creates loyalty and leads in relevant market categories.

d) Performance and function

Improved product performance, including functionality and durability, caused by the implementation of new technologies. More reliable and high-performance products not only attract more customers but also improve brand reputation. New technologies allow improvements in aspects such as speed, energy efficiency and resistance to long-term use, all of which contribute to the success of the product in the market.

e) Competitive Differentiation

How new technologies help products differentiate themselves from competitors and create a market advantage. By utilizing advanced technology, companies can create unique features or services that are not easily replicated by competitors.

2. Operational Efficiency

According to (De Oliveira et al., 2024) the improvement of operational efficiency in the aviation industry is one of the main results of the application of new technologies. This technology not only reduces operating time and costs but also improves passenger safety and comfort. (Osterwalder et al., 2020) operational efficiency is concerned with optimizing an organization's business model to ensure that every process runs effectively and provides added value with minimal use of resources. (Womack et al., 2020) operational efficiency is defined as the application of Lean principles that focus on eliminating activities that do not provide added value in the value chain, thereby enabling the organization to increase output

with the same or fewer inputs. By adopting a Lean approach, organizations can identify and eliminate waste at every stage of the process, allowing for increased output with the same or even fewer inputs. Efficiency indicators according to (Andrew, 2019) includes:

a) Use Of Resources

This indicator measures the extent to which a company can optimize the use of existing resources, such as raw materials, labor and energy. Operational efficiency is achieved when a company is able to minimize waste and maximize results from the resources used

b) Increased Productivity

Increased productivity reflects the company's ability to produce more output with the same or fewer inputs

c) Environmental Footprint Reduction

Environmental footprint reduction refers to a company's efforts to reduce negative impacts on the environment, such as greenhouse gas emissions, waste, and energy consumption. Operational efficiency is achieved when companies implement more sustainable and environmentally sound practices, which not only reduce environmental impact but also often reduce operational costs

d) Speed Adaptation

Speed of adaptation refers to the company's ability to quickly adapt to changing market conditions or operational environment

e) Continuous Innovation

Continuous innovation in the context of operational efficiency means constantly updating and improving processes, products or technologies to improve efficiency.

3. Competitive Advantage

According to (Jeswal et al., 2022) competitive advantage in the aviation industry can be achieved through effective talent management. Good talent management not only involves managing existing employees but also includes hiring and developing relevant skills to meet industry challenges. By building competent teams and adapting quickly to market changes, airlines can improve operational performance and innovation, which in turn strengthens their position in the market. According to (Rothaermel, 2021) competitive advantage is the result of a strategy that consistently enables a company to create value for customers in a way that competitors cannot replicate, whether through operational efficiency, innovation, or a combination of both. This can be achieved through operational efficiencies that optimize the use of resources or through innovation that creates exciting new products or services. According to (Tushman and O'Reilly, 2021) that competitive advantage is achieved when companies successfully manage exploration and exploitation simultaneously, that is, continuous innovation while remaining efficient in existing operations, thus creating sustainable value and overcoming competitive pressures. Indicators used in measuring competitive advantage by (Lei & Slocum, 2020) is:

a) Competitive Price

The company's ability to adjust the price of its products to the general market price

b) Product Uniqueness

The uniqueness of the company's products that combine artistic value with customer taste

c) Not Easy To Replace

Do not have the same substitute from the results of the explanation of the above indicators, the author chose it as.

4. Relevant Research

Table 1. Relevant Research

No	Title	Study	Research Purposes	Results of Previous Research Studies	Conclusion
1	Harnessing Technological Innovation for Competitive Advantage: A Strategic Framework	(Sun, 2024)	This study aims to analyze the influence of technological innovation and operational efficiency on competitive advantage at Soekarno-Hatta International Airport.	Previous research has shown a significant relationship between technological innovation and competitive advantage. This innovation also drives the creation of new business models that strengthen a company's position in competitive markets.	technological innovation and operational efficiency have a positive and significant impact on the competitive advantage of Soekarno-Hatta Airport. Improvements in both aspects help the airport compete better in the international market, improve services to users, and create sustainable efficiency.
2	KPI-Driven Decision Marking For Lounge Managers Enhancing Customer Experience and Efficiency	(Moghadasnian & Moghadasnian, 2024)	This study aims to explore the important role of operational efficiency in airline lounge management. The focus of the study is to analyze how increased efficiency can improve service quality, speed up operational processes, and increase customer satisfaction in airline lounges.	Previous research has shown a significant relationship between the implementation of technological innovation and the improvement of operational efficiency and customer experience in the aviation industry.	Improving operational efficiency in airline lounges significantly improves customer satisfaction and overall performance. Implementing the right digital technologies and operational strategies helps optimize time and resources, leading to better customer experience and reduced operational costs.
3	Competitive Strategies in the Airline Industry	(Sengur et al., 2022)	This study aims to understand the strategies used by airlines to compete and survive in the market.	Previous studies have shown a significant relationship between the implementation of competitive strategies and the success of airlines in maintaining their market position. Strategies such as cost leadership, differentiation, and focus provide competitive advantages in facing industry challenges.	The right competitive strategies, such as cost reduction and offering differentiated services, help airlines survive in a competitive environment.
4	An Evaluation of Air Transport Sector Operational Efficiency in China based on a Three-Stage DEA Analysis	(Song et al., 2020)	This study aims to evaluate the operational efficiency of air transport in China using a three-stage DEA (Data Envelopment Analysis) method.	Previous studies have shown a significant relationship between economic and social factors and the operational efficiency of the air transport sector. Factors such as GDP per capita, foreign direct investment, and household spending significantly influence the operational efficiency of air transport.	After accounting for external factors, the operational efficiency of air transport varies across provinces, with some regions showing potential for improvement.

Research Framework

Based on the development of the above hypothesis, the research framework can be described as follows:

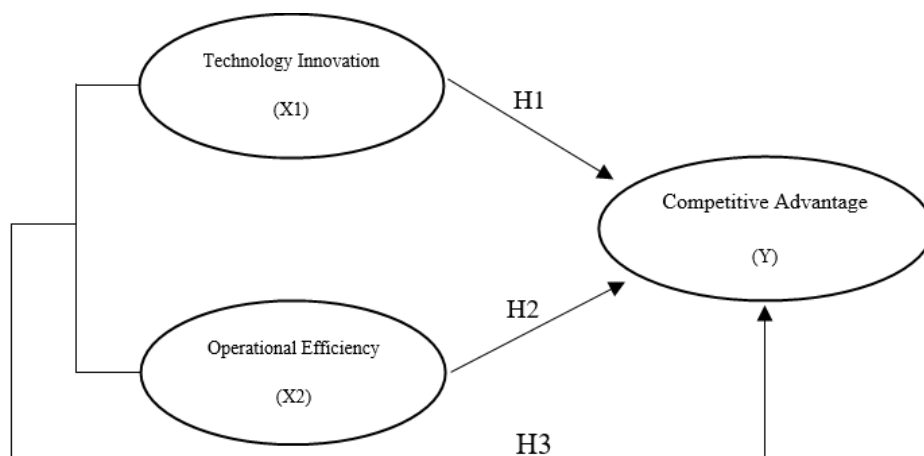


Figure 1. Research Model

Hypothesis

Departing from the basic thinking and framework described, the hypothesis put forward by this researcher is:

- H1: Technological innovations affect the implementation of competitive advantages at Soekarno Hatta International Airport
- H2: Operational efficiency affects the implementation of competitive advantages at Soekarno Hatta International Airport
- H3: Technological innovation and operational efficiency affect the implementation of competitive advantages at Soekarno Hatta International Airport

METHOD

The main focus of this study was to determine the effect of the impact of technological innovation and operational efficiency in improving competitive advantage at Soekarno Hatta International airport Soekarno Hatta International Airport. So this study uses numerical data to get a more measured and objective understanding of certain phenomena because it uses quantitative methods (Djaali, 2021).

This study collected data from the population of consumers or airport users who fly at Soekarno-Hatta International Airport. Therefore, the sample size of this survey is determined using the slovin formula. Researchers use SPSS software to manage and analyze research data.

$$n = \frac{N}{1 + N e^2}$$

Description:

- n : size of sample
- N : size of the population
- e : maximum tolerated error limit in the sample or significance level

Based on the formula described above is a sample calculation as follows:

$$n = \frac{12.682.395}{1 + 12.682.395 (0,1)^2}$$

$$n = \frac{12.682.395}{126.823,96}$$

$$n = 99,99$$

$$n = 100$$

RESULTS AND DISCUSSION

The purpose of this data study was to assess the effects of technological innovation, operational efficiency, and competitive advantages at Soekarno Hatta International Airport.

Table 2. Frequency of Users at Soekarno-Hatta International Airport

Charcteristics	Category	Frequency (N)	Percentage
Gender	Male	39	39%
	Female	61	61%
Age (year)	<17	2	2%
	18-25	53	53%
	26-35	9	9%
	36-50	28	28%
	>50	9	9%
Job	Student	29	29%
	Private Employee	23	23%
	Civil Servant	13	13%
	Entrepreneur	16	16%
	Housewife	16	16%
Frequency	Honorary Employee	4	4%
	<2 times	33	33%
	2 times	24	24%
	3-5 times	27	27%
	6-10 times	6	6%
>10 times	11	11%	

Source: data processed using SPSS

Based on the table above, there are a total of 100 respondents, with a gender percentage of 39% male and 61% female. The age distribution shows 2% are under 17 years old, 53% are aged 18-25, 9% are aged 26-35, 28% are aged 36-50, and 9% are over 50 years old. The occupational percentages include 29% students, 23% private employees, 13% civil servants, 16% entrepreneurs, 16% housewives, and 4% honorarium employees. The results of the data analysis will be used to test hypotheses one to three by applying traditional normality tests (Kolmogorov-Smirnov, multicollinearity), heteroscedasticity tests (scatterplot), followed by linear regression analysis, the coefficient of determination test, and the "f" test (simulation).

Table 3. Data Validity Test Results

Variable	R Calculate	R Table	Description
X1.1	0,707	0,1966	Valid
X1.2	0,725	0,1966	Valid
X1.3	0,733	0,1966	Valid
X1.4	0,792	0,1966	Valid
X1.5	0,82	0,1966	Valid
X2.1	0,811	0,1966	Valid
X2.2	0,719	0,1966	Valid
X2.3	0,758	0,1966	Valid
X2.4	0,802	0,1966	Valid
X2.5	0,808	0,1966	Valid
Y.1	0,744	0,1966	Valid
Y.2	0,762	0,1966	Valid
Y.3	0,768	0,1966	Valid
Y.4	0,852	0,1966	Valid
Y.5	0,731	0,1966	Valid

Source: data processed using SPSS

Based on the results of the data validity test presented in Table 3, it can be concluded that all items in the variables X1, X2, and Y have a calculated R value greater than the R value of the table by 0.1966. Thus, each item in all three variables is declared valid. This shows that the items have a strong correlation with the total score of each variable, so they can be relied upon for use in further research analysis. This validity indicates that the instruments used are capable of measuring the intended construction well, and the results can be considered credible in the context of the research carried out.

Table 4. Data Reliability Test Results

Variable	Nilai Cronbach's Alpha	Status
Technological Innovation (X1)	0,812	Reliable
Operational Efficiency (X2)	0,838	Reliable
Competitive Advantage (Y)	0,830	Reliable

Source: data processed using SPSS

Based on the results of the test validity of the data presented in Table 4, showing technological innovation that has a value of Cronbach's Alpha of 0.812, operational efficiency that has a value of Cronbach's alpha of 0.838. A competitive advantage that has a Cronbach's alpha value of 0.830. This means that the entire value of the variable is more than 0.60. With these values, it can be concluded that the instruments used in this study have a high level of reliability and can be trusted for further analysis.

Table 5. Data Normality Test Results

One-Sample Kolmogorov-Smirnov Test				
		Technological Innovation (X1)	Operational Efficiency (X2)	Competitive Advantage (Y)
N		100	100	100
Normal Parameters ^{a,b}	Mean	21,6300	21,2400	20,2800
	Std. Deviation	2,38537	2,52311	2,93044
Most Extreme Differences	Absolute	0,123	0,148	0,108
	Positive	0,123	0,148	0,108
	Negative	-0,110	-0,132	-0,092
Test Statistic		0,123	0,148	0,108
Asymp. Sig. (2-tailed) ^c		0,001	0,000	0,006
a. Test distribution is Normal.				
b. Calculated from data.				
c. Lilliefors Significance Correction.				

Source: data processed using SPSS

Based on the results in Table 5, the normality test was performed using the Kolmogorov-Smirnov test to test whether the data were normally distributed. The test results showed a significance value of 0.001 for technological innovation variables, 0.000 for operational efficiency, and 0.006 for Competitive Advantage. Since all significance values are less than 0.05, it can be concluded that the data are not normally distributed.

Table 6. Multicollinearity Test Results Data

Model	Collinearity Statistics	
	Tolerance	VIF
1	Technological Innovation	0,452
	Operational Efficiency	2,210

a. Dependent Variable: Competitive Advantage

Source: data processed using SPSS

Based on the results in Table 6, there are no symptoms of multicoline. Can be derived from the value of technological innovation $0.452 > 0.10$ and the value of operational efficiency of $0.452 > 0.10$. While technological innovation is $< 2,210$. Vif operational efficiency score of $2,502 < 10$. Showed that the independent variables do not have a high correlation with each other and can be used in regression models to predict the dependent variable of competitive advantage.

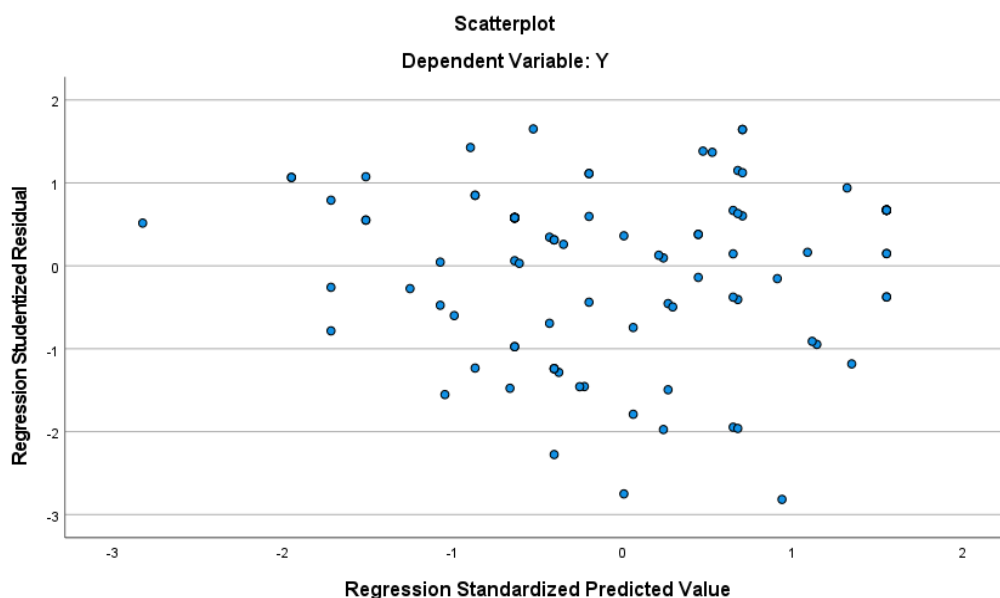


Figure 2. Heteroscedasticity Test Results

Figure 2 shows the results of heteroscedasticity test conducted to see if there is a variance that is not the same from the residual in the regression model. Based on the scatterplot of heteroscedasticity test results, there is no specific pattern in the spread of data, which indicates that heteroscedasticity does not occur. In the context of regression analysis, the absence of heteroscedasticity is a good thing because it means that assumptions about the similarity of the residual variance have been met. In other words, these results indicate that the regression model used in this study is stable.

Table 7. Multiple Linear Regression Testing Results

Model	Coefficients ^a		t	Sig.	
	Unstandardized Coefficients	Standardized Coefficients			
	B	Std. Error			Beta
(Constant)	-0,465	1,850	-0,251	0,802	
1 Technology Innovation	0,514	0,122	0,418	4,222	0,000
Operational Efficiency	0,453	0,115	0,390	3,939	0,000

a. Dependent Variable: Competitive Advantage

Source: data processed using SPSS

Based on Table 7 above which shows the value of the multiregression linear constant of -0.465, which means that both linear independent variables are 0.802. In addition, the dependent variable has a constant value of -0.465 which means competitive advantage without technological innovation and operational efficiency is equal to -0.466. Coefficients

Regression variable of technological innovation of 0.514 means that every addition of technological innovation then the competitive advantage has increased by 0.514 which is able to explain the competitive advantage at the airport. Variable regression coefficient of

operational efficiency of 0.463 means that each increase in operational efficiency by one unit, then the competitive advantage increased by 0.463 units or operational efficiency is able to explain the competitive advantages of the airport.

Based on the test results showed that technological innovation has a positive and significant effect on competitive advantage with a coefficient value of 0.514 ($p < 0.05$). Likewise, operational efficiency also has a positive and significant effect on competitive advantage with a coefficient value of 0.453 ($p < 0.05$).

Table 8. Coefficient Of Determination (R^2)

Model Summary ^b					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.754 ^a	0,569	0,560	1,94363	1,919

a. Predictors: (Constant), Technology Innovation, Operational Efficiency.
 b. Dependent Variable: Competitive Advantage

Source: data processed using SPSS

Based on the results in table 8, the coefficient of determination (r^2) of 0.560 indicates that the regression model is able to explain 56% variation in competitive advantage influenced by technological innovation and operational efficiency. The remaining 44% are explained by other variables not included in the model.

Table 9. T Testing Results

Coefficients ^a					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-0,465	1,850		-0,251	0,802
1 Technology Innovation	0,514	0,122	0,418	4,222	0,000
Operational Efficiency	0,453	0,115	0,390	3,939	0,000

a. Dependent Variable: Competitive Rivalry

Source: data processed using SPSS

Based on table 9 above, technological innovation has a T test results count 4.222 more than 1.660 (standard T table), in addition to the signya value of 0.000 and less than 0.05 of the standard value of alpha. It can be concluded that the variable of technological innovation is very influential on the variable of competitive advantage.

Table 10. F Testing Results

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	483,722	2	241,861	64,023	.000 ^b
	Residual	366,438	97	3,778		
	Total	850,160	99			

a. Dependent Variable: Competitive Advantage
 b. Predictors: (Constant), Technology Innovation, Operational Efficiency.

Source: data processed using SPSS

Based on Table 10 above independent variables have test results F count of 65.023 more than the standard F table of 3.09. and both have a sig value of 0.000, smaller than the alpha value of 0.05. It can be concluded that the regression model used has a significant influence on competitive advantage. In other words, technological innovation and operational efficiency together contribute significantly in determining competitive advantages.

H1: Technological Innovation Affects Competitive Advantage

The first hypothesis, technological innovation has a significant impact on the implementation of competitive advantage at Soekarno-Hatta International Airport. The adoption of cutting-edge technology, such as automation systems and digital services, has proven capable of enhancing service efficiency and accelerating operational processes. For example, the presence of automated check-in systems and mobile applications for passenger services has improved user experience, thereby increasing passenger satisfaction. This advantage not only simplifies the travel process but also strengthens Soekarno-Hatta Airport's position in competition with other airports at both the regional and international levels. In other words, technological innovation plays a crucial role in creating added value that differentiates Soekarno-Hatta International Airport from other airports.

H2: Operational Efficiency Affects Competitive Advantage

The second hypothesis, operational efficiency significantly influences the implementation of competitive advantage at Soekarno-Hatta International Airport. By employing various strategies to enhance efficiency, such as optimizing flight routes, effective time management, and good resource management, the airport has successfully reduced operational costs and increased productivity. With this efficiency, Soekarno-Hatta International Airport can offer high-quality services at lower costs, thereby enhancing its competitiveness in a highly competitive market. Therefore, operational efficiency becomes a key factor in achieving sustainable competitive advantage.

H3: Technological Innovation and Operational Efficiency Simultaneously Affect Competitive Advantage

The third hypothesis, combination of technological innovation and operational efficiency has a highly significant impact on the competitive advantage of Soekarno-Hatta International Airport. The synergy between these two factors creates a stronger competitive advantage compared to when only one factor is implemented. For instance, when technological innovation is applied alongside efficient processes, the airport can provide faster and more responsive services while enhancing its operational capacity. This results in better passenger experience and a stronger reputation in the market, thereby improving Soekarno-Hatta International Airport's position as one of the leading airports in Asia.

CONCLUSION

Based on the results of the study, it can be concluded that:

- 1) Technological innovation significantly influences the enhancement of airport competitiveness. The implementation of technology provides faster and more efficient services, thereby improving the passenger experience and creating differentiation that is difficult for competitors to imitate. This directly contributes to an increase in competitive advantage.
- 2) Operational efficiency has also been shown to positively affect competitiveness. Faster and cost-effective operational processes, such as more efficient baggage management and more responsive services, not only improve customer satisfaction but also lower operational costs. This efficiency enables the airport to compete more effectively in the global market.
- 3) Technological innovation and operational efficiency have a significant impact on airport competitiveness. These two factors complement each other, where technological innovation creates superior services, and operational efficiency ensures that these services operate optimally.

Overall, the results of this study confirm that increasing technological innovation and operational efficiency is an effective strategy in strengthening the competitiveness of Soekarno-Hatta International Airport in a competitive market

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