

The Future of Suvarnabhumi Airport as an Air Logistics Hub in Southeast Asia

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Abstract – This study examines the strategic potential and limitations of Suvarnabhumi Airport in its development as a leading air logistics hub in Southeast Asia. Employing a mixed-methods approach comprising document analysis, field surveys, in-depth interviews, focus group discussions, and a comprehensive industry stakeholder survey (n=169), the research presents a multidimensional analysis of infrastructure requirements, regulatory frameworks, information technology integration, and human capital development needs. Findings indicate that Suvarnabhumi Airport possesses significant strengths in its strategic location and modern infrastructure but faces substantial challenges in regulatory barriers, human resource limitations, and incomplete information technology integration. Quantitative analysis of cargo volumes and performance metrics reveals that Suvarnabhumi substantially underperforms compared to leading regional competitors despite comparable capacity. The survey identifies critical gaps in specialized facilities for e-commerce and digital technology expertise as key areas requiring improvement, while cost competitiveness as Suvarnabhumi's primary advantage relative to competitors.

The study proposes a strategic development framework encompassing four key strategies, eight tactics, and 26 action plans prioritized according to stakeholder assessments, with an estimated implementation cost of \$2.5 billion over nine years. This research contributes to the understanding of air cargo hub development in emerging economies and provides empirically supported recommendations for policymakers and airport authorities seeking to improve their global logistics positioning.

Keywords – Air cargo hub, strategic development, regulatory framework, human capital, Southeast Asia.

1. Introduction

Air cargo transportation constitutes a vital component of global supply chains, enabling the rapid movement of high-value and time-sensitive goods across international borders. The significance of air cargo has been further emphasized in recent years due to the expansion of e-commerce, increasing demand for pharmaceuticals and perishable goods, and the need for resilient supply chains in the wake of global disruptions [1]. The Asia-Pacific region, with its robust economic growth and increasing intra-regional trade, has emerged as a key driver of global air cargo demand, accounting for approximately 35% of global air cargo traffic [2].

Within this dynamic regional context, Thailand's Suvarnabhumi Airport has positioned itself as an aspiring air logistics hub, seeking to leverage its strategic geographical location at the center of Southeast Asia. Since its opening in 2006, Suvarnabhumi Airport has undergone continuous development to enhance its cargo handling capabilities and establish itself as a competitive player in the regional air cargo market. However, it faces significant competition from established hubs such as Singapore's Changi Airport and Hong Kong International Airport, which benefit from comprehensive infrastructure, efficient regulatory frameworks, and strategic government support.

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This integrated study aims to comprehensively analyze the potential and limitations of Suvarnabhumi Airport's development as a regional air logistics hub by addressing the following research objectives:

1. To evaluate the current infrastructure and technological capabilities of Suvarnabhumi Airport in comparison with leading regional air cargo hubs.
2. To assess the regulatory framework governing air cargo operations at Suvarnabhumi Airport and identify areas for improvement.
3. To examine the human capital development needs for enhancing Suvarnabhumi's competitiveness as an air logistics hub
4. To develop a strategic framework for transforming Suvarnabhumi Airport into a leading air logistics hub in Southeast Asia.

The significance of this research lies in its potential to inform policy decisions and strategic planning for Suvarnabhumi Airport's development, with implications for Thailand's broader economic growth and regional connectivity. By providing a comprehensive analysis of the key factors influencing air cargo hub development, this study contributes to the academic understanding of airport competitiveness and offers practical insights for stakeholders involved in air logistics development.

2. Research Methods

Conceptual Framework of Air Cargo Hub Development: The concept of air cargo hubs has evolved significantly in academic literature, with various perspectives on the defining characteristics and development factors. Moreover, [3] define an air cargo hub as an airport that facilitates the consolidation and distribution of freight, often serving as a transfer point between long-haul and short-haul flights. As [4] elaborate on this concept, introducing the "aerotropolis" model that emphasizes the integration of airport infrastructure with surrounding business districts to create a comprehensive logistics ecosystem.

The theoretical underpinnings of air cargo hub development draw from multiple disciplines, including transport economics, supply chain management, and economic geography. Furthermore, [5] that the success of an air cargo hub depends on a complex interplay of factors, including geographical location, infrastructure quality, regulatory environment, operational efficiency, and connectivity to global markets. This multi-dimensional perspective provides a useful framework for analyzing the development potential of airports aspiring to become regional or global cargo hubs.

Determinants of Air Cargo Hub Competitiveness: Empirical research has identified several key determinants of air cargo hub competitiveness. A comparative analysis of major Asian airports [6], states that airport charges, handling capacity, and service quality significantly influence cargo transshipment decisions. Their research suggests that price competitiveness remains a critical factor, particularly in regions with multiple competing hubs.

Infrastructure quality has been consistently identified as a fundamental determinant of cargo hub performance. The importance of specialized cargo facilities, advanced handling equipment, and intermodal connectivity in enhancing an airport's attractiveness to cargo operators [7]. More recently, technological capabilities have gained prominence as a competitive factor, [8] of e-freight initiatives and digital integration on operational efficiency, while [9] explore the potential of blockchain technology in improving supply chain visibility and security in air cargo operations.

Human capital has emerged as an increasingly important dimension of competitive advantage. Key skill shortages in the logistics sector and emphasize the need for specialized training programs to develop expertise in air cargo logistics [10]. Their research suggests that investment in human resources can yield significant returns in terms of operational efficiency and service quality.

Air Cargo Industry in Southeast Asia: The Southeast Asian air cargo market presents both significant opportunities and challenges. The region has experienced robust economic growth, increasing intra-regional trade, and rapid expansion of e-commerce, driving demand for efficient air cargo services [11]. The implementation of the ASEAN Single Aviation Market (ASAM) initiative has further emphasized the importance of enhancing air transport capabilities, including cargo operations, among member countries [12].

However, the region also faces challenges such as infrastructure constraints, regulatory disparities among countries, and intense competition among airports seeking to establish themselves as dominant cargo centers [13]. As examined by [14], the Thai air cargo industry, highlighting both opportunities for growth and obstacles such as regulatory barriers and human resource limitations.

Research Gap and Contribution: While existing literature provides valuable insights into various aspects of air cargo hub development, there remains a gap in comprehensive studies that integrate multiple dimensions of analysis specific to emerging hubs in Southeast Asia.

This study addresses this gap by providing a holistic analysis of Suvarnabhumi Airport's development potential, combining infrastructure assessment, regulatory analysis, and human capital considerations within a strategic framework.

The research also contributes to the literature by incorporating quantitative benchmarking data that allows for direct comparison with leading regional hubs, providing empirical evidence to support strategic recommendations.

3. Methodology

This chapter presents the research methodology adopted in examining the prospective role of Suvarnabhumi Airport as a strategic air logistics hub within the Southeast Asian region. The chapter encompasses a systematic description of the research design, data collection procedures, sampling framework, research instruments, and analytical techniques applied throughout the course of this study. The methodological approach was carefully structured to uphold the principles of reliability, validity, and analytical comprehensiveness by means of integrating both qualitative and quantitative research paradigms, thereby enabling a holistic understanding of the subject under investigation.

3.1. Research Design

This study employed a mixed-methods research design, combining qualitative and quantitative approaches to provide a comprehensive analysis of Suvarnabhumi Airport's potential as an air logistics hub. The research was conducted between January 2022 and June 2023, incorporating multiple data collection methods to ensure methodological triangulation and enhance the validity of findings.

3.2. Data Collection Methods

Document Analysis: A comprehensive review of official reports, master plans, industry publications, and academic literature related to Suvarnabhumi Airport's development and air cargo industry trends was conducted. Key documents included Airports of [15], Suvarnabhumi Airport Master Plan (2021-2030), IATA e-freight Monthly Reports, and publications from the Civil Aviation Authority of Thailand.

Field Surveys: On-site assessments of current infrastructure and operations at Suvarnabhumi Airport's cargo facilities were conducted through scheduled visits between February and April 2023. These surveys included structured observations of cargo handling processes, assessment of facility utilization, and documentation of technological implementations at the airport.

Stakeholder Interviews: Semi-structured interviews were conducted with 40 key stakeholders, including:

- Senior management from Airports of Thailand Public Company Limited (AOT) (n=5)
- Officials from the Customs Department and Civil Aviation Authority of Thailand (n=8)
- Executives from cargo airlines and ground handlers (n=7)
- Representatives from freight forwarders and logistics providers (n=10)
- Industry experts and academics (n=7)
- Representatives from industry associations (n=3)

Interviews lasted approximately 60-90 minutes and focused on perceptions of current challenges, opportunities, and future directions for Suvarnabhumi's development as an air logistics hub.

Focus Group Discussions: Four focus group discussions were organized, each comprising 8-10 participants representing various sectors of the air cargo industry. The discussions were structured around key themes identified from the literature and preliminary interview findings, allowing for in-depth exploration of specific issues and collaborative generation of potential solutions.

Benchmarking Analysis: Quantitative data on key performance indicators was collected to enable comparative analysis between Suvarnabhumi Airport and leading regional air cargo hubs. Data sources included [16]. ACI World Airport Traffic Reports, IATA World Air Transport Statistics, and individual airport annual reports. Key metrics included cargo volume, capacity, on-time performance, connectivity indices, and operational costs.

Survey Research: A comprehensive survey was administered to stakeholders across the air cargo ecosystem to quantitatively assess perceptions of Suvarnabhumi Airport's current capabilities and future potential. The survey was developed based on preliminary findings from literature review, document analysis, and initial stakeholder interviews.

Survey Design and Instrument: The survey instrument consisted of 42 items organized into five main sections:

- Infrastructure adequacy (9 items)
- Technological readiness (8 items)
- Regulatory environment (8 items)
- Human resource capabilities (7 items)
- Strategic priorities (10 items)

Most items utilized a 5-point Likert scale (1=strongly disagree to 5=strongly agree), with additional ranking questions for prioritization of strategic initiatives and comparative assessment questions using a 7-point scale (-3 to +3) to evaluate Suvarnabhumi's position relative to competitor airports.

The survey instrument was initially developed in English and then translated into Thai using a forward-backward translation procedure to ensure conceptual equivalence. The instrument was pilot-tested with 12 industry experts to assess clarity, comprehensiveness, and validity before finalization. Cronbach's alpha coefficients for the five main sections ranged from 0.79 to 0.88, indicating good internal consistency reliability.

Sampling and Administration: The sampling frame was constructed to ensure representation across the entire air cargo value chain. Stratified purposive sampling was employed to select participants from the following stakeholder groups:

- Airport operators and ground handlers,
- Airlines and cargo carriers,
- Freight forwarders and logistics providers,
- Government agencies and regulators,
- Shippers and manufacturers,
- Industry associations and consultants.

A total of 215 potential respondents were identified through industry databases, professional networks, and recommendations from initial interview participants. The survey was administered through multiple channels:

- Online distribution via Qualtrics (primary method)
- Paper-based distribution during industry events
- In-person administration during field visits

Data collection occurred between March 10 and May 22, 2023. Two follow-up reminders were sent to non-respondents at two-week intervals to maximize response rate. The final response rate was 78.6% (n=169), with representation across all targeted stakeholder groups.

Data Analysis: Qualitative data from interviews and focus groups were analyzed using thematic analysis techniques, with NVivo software employed to facilitate coding and theme identification. Document analysis findings were synthesized using content analysis methods to identify recurring themes and strategic priorities.

Quantitative data from the benchmarking analysis were analyzed using descriptive statistics to establish comparative performance metrics. Statistical analysis was performed using SPSS software, with radar charts and comparative tables created to visualize performance differences across airports.

A comprehensive SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis was conducted based on the integrated findings from all data sources, providing a structured framework for strategic planning.

The preliminary findings and strategic recommendations were validated through two strategic planning workshops with key stakeholders to ensure practical relevance and feasibility.

Survey data were analyzed using SPSS version 27.0. Analysis techniques included:

- Descriptive statistics (frequency distributions, measures of central tendency, and dispersion)
- Exploratory factor analysis to identify underlying constructs.
- Reliability analysis using Cronbach's alpha coefficients.
- Gap analysis comparing current state with industry benchmarks.
- Chi-square tests to examine differences across stakeholder groups.
- Multiple regression analysis to identify predictors of perceived competitiveness.
- Cluster analysis to identify distinct perception patterns among respondents.

Non-response bias was assessed by comparing early and late respondents across key variables, with no significant differences detected ($p > 0.05$). Missing data (less than 3% per variable) were addressed using multiple imputation techniques.

Ethical Considerations: This research was conducted in accordance with established ethical guidelines. All participants provided informed consent before interviews or focus group participation, and confidentiality was maintained throughout the data collection and analysis process. Organizational permissions were obtained for site visits and data collection at airport facilities. The research protocols were reviewed and approved by the institutional research ethics committee prior to commencement of the study.

4. Results

This chapter presents the findings derived from the comprehensive analysis of Suvarnabhumi Airport's air logistics operations, stakeholder perceptions, and competitive positioning within the Southeast Asian aviation landscape. The results are organized in accordance with the research objectives, commencing with an assessment of the airport's current operational status, followed by a comparative benchmarking analysis against regional counterparts, and concluding with the consolidated strategic insights obtained through SWOT analysis and stakeholder validation. The findings collectively serve as an empirical foundation upon which strategic recommendations for enhancing Suvarnabhumi Airport's role as a regional air logistics hub are subsequently formulated.

4.1. Current Status of Suvarnabhumi Airport's Air Cargo Operations

Infrastructure and Capacity: Suvarnabhumi Airport currently operates with a cargo handling capacity of 3.0 million tons per year, supported by cargo terminals covering approximately 570,000 square meters. As shown in Table 1, the airport handled 1.41 million tons of cargo in 2019 (pre-pandemic), utilizing approximately 47% of its designed capacity. This represents a significant gap between capacity and utilization compared to regional competitors such as Hong Kong International Airport (65% utilization) and Singapore Changi Airport (67% utilization).

Table 1. Cargo volume and capacity utilization (2019)

Airport	Cargo Volume (million tons)	Cargo Capacity (million tons)	Utilization Rate (%)
Suvarnabhumi (BKK)	1.41	3.00	47.0
Hong Kong (HKG)	4.81	7.40	65.0
Singapore (SIN)	2.01	3.00	67.0
Incheon (ICN)	2.76	5.00	55.2

Sources: [17], Individual airport reports

The field surveys revealed that Suvarnabhumi Airport has made significant investments in cargo infrastructure, including:

Modern cargo terminals with temperature-controlled facilities

- Free zone areas designated for value-added activities.
- Dedicated areas for specialized cargo such as perishables and pharmaceuticals.
- Customs clearance facilities operating 24/7.

However, stakeholder interviews highlighted several infrastructure limitations:

- Incomplete automation in certain cargo handling processes.
- Limited specialized facilities for emerging cargo segments such as e-commerce.
- Constraints in intermodal connectivity, particularly rail connections.
- Aging equipment in some sections of the cargo terminals.

Technology Implementation: Assessment of technological capabilities revealed varying levels of implementation across different systems at Suvarnabhumi Airport.

The analysis presented in Figure 1 revealed that Suvarnabhumi Airport has made progress in implementing basic technological systems but lags behind regional competitors in advanced technology adoption.

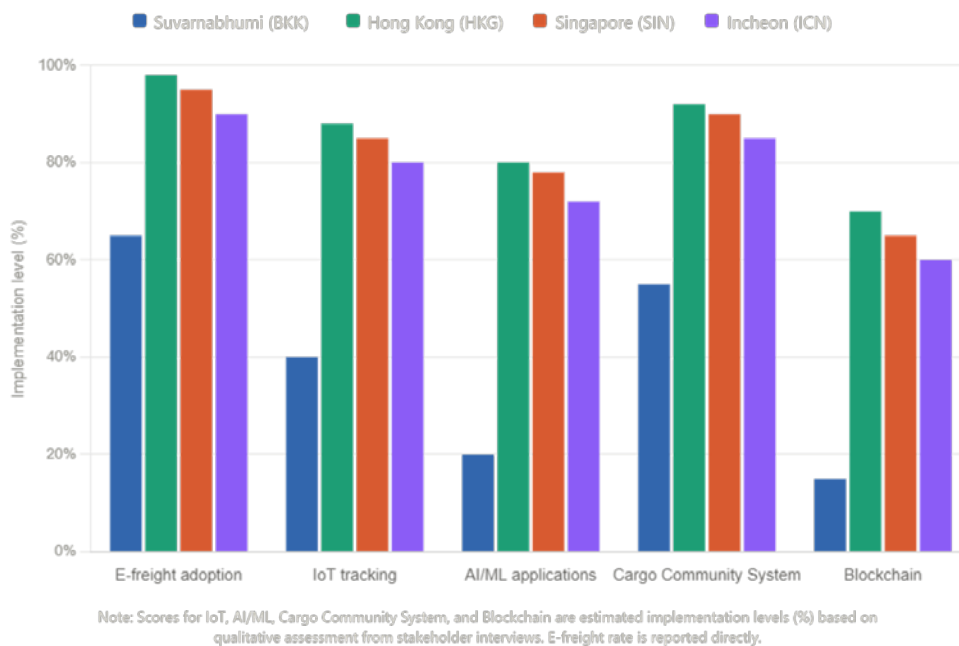


Figure 1. Comparative analysis of key technological implementations between Suvarnabhumi and benchmark airports

Specifically:

- E-freight adoption rate stands at 65% compared to 90-98% at benchmark airports.
- IoT-enabled tracking systems remain limited in scope and implementation.
- AI and machine learning applications are mostly in pilot stages.
- The Cargo Community System is partially implemented with incomplete stakeholder integration.
- Blockchain applications for cargo security and traceability are in planning stages.

Regulatory Framework:

Document analysis and stakeholder interviews revealed several key issues in the regulatory framework governing air cargo operations at Suvarnabhumi Airport:

1. **Customs procedures:** While 24/7 customs services are available, documentation requirements remain more complex compared to benchmark airports, with electronic processing not fully implemented for all cargo types.
2. **Free zone regulations:** Current regulations limit certain value-added activities within the free zone, reducing the airport's attractiveness for logistics companies seeking to establish regional distribution operations.
3. **Air service agreements:** Thailand has restrictions in some air service agreements that limit fifth freedom rights for cargo operations, potentially constraining connectivity.
4. **Agency coordination:** Multiple government agencies involved in cargo clearance operate with varying levels of integration, leading to procedural inefficiencies.
5. **Investment incentives:** Tax and non-tax incentives for cargo-related investments are less comprehensive compared to competing hubs like Singapore and Hong Kong.

Human Capital: Survey results from industry stakeholders (n=169, from a pool of 215 potential respondents, 78.6% response rate) working in various roles within the air cargo industry revealed significant skills gaps in key areas at Suvarnabhumi Airport:

- **Technical expertise:** 72% of respondents identified a shortage of personnel with specialized knowledge in advanced cargo handling technologies.
- **Regulatory knowledge:** 65% noted insufficient expertise in international trade regulations and compliance requirements.
- **Supply chain management:** 58% highlighted gaps in holistic supply chain understanding and optimization skills.
- **Language proficiency:** 47% mentioned limitations in English language skills among operational staff.
- **Leadership capabilities:** 54% identified deficiencies in managerial and leadership skills required for complex logistics operations.

Focus group discussions further elaborated on these findings, noting that while Thailand has a strong workforce in general logistics, specialized air cargo knowledge remains limited. Participants emphasized the need for structured training programs focused specifically in air cargo operations, regulatory compliance, and advanced technology applications.

Comparative Analysis with Regional Competitors:

Performance Metrics: Table 2 presents a comparative analysis of key performance indicators between Suvarnabhumi Airport and leading regional air cargo hubs based on 2019 (pre-pandemic) data.

Table 2. Comparison of key performance indicators (2019)

Indicator	Suvarnabhumi (BKK)	Hong Kong (HKG)	Singapore (SIN)	Incheon (ICN)
Cargo Volume (million tons)	1.41	4.81	2.01	2.76
On-time Performance (%)	83	87	85	88
Connectivity Index	142	333	340	268
Average Dwell Time (hours)	14.2	5.8	6.3	7.1
E-freight Adoption (%)	65	95	90	84
Cargo Revenue (USD/ton)	115	132	127	121

Sources: [17], Individual airport reports

The analysis reveals that Suvarnabhumi Airport underperforms across multiple metrics compared to its regional competitors.

Particularly notable are the significantly longer average dwell times for cargo and substantially lower connectivity indices, both of which directly impact the airport's attractiveness as a cargo hub.

Cost Competitiveness:

Analysis of operational costs revealed a mixed competitive position for Suvarnabhumi Airport:

- **Land rental rates:** Higher than Incheon but lower than Hong Kong and Singapore.
- **Handling charges:** Competitive, with rates approximately 15% lower than Singapore and 8% lower than Hong Kong.
- **Warehouse operating costs:** Higher than regional competitors due to energy costs and less efficient operations.
- **Labor costs:** Lower than all benchmark airports, providing a potential competitive advantage.

The total cost structure analysis indicates that while Suvarnabhumi offers competitive handling charges and labor costs, these advantages are partially offset by higher facility costs and operational inefficiencies that increase overall logistics costs.

Strategic Positioning

Document analysis and stakeholder interviews revealed distinct strategic positions among the airports:

- **Hong Kong:** Positioned as a premium global cargo hub with extensive intermodal connections to the Greater Bay Area.
- **Singapore:** Focused on high-value, specialized cargo with emphasis on pharmaceutical and aerospace logistics.
- **Incheon:** Developed as a manufacturing-connected cargo hub with strong integration with nearby industrial zones.
- **Suvarnabhumi:** Currently positioned as a regional gateway with limited differentiation in specialized services.

This analysis suggests that Suvarnabhumi Airport has not yet established a clearly differentiated strategic position in the regional cargo market, potentially limiting its ability to attract specialized cargo flows despite its geographical advantages.

SWOT Analysis: Based on the comprehensive data collection and analysis, a SWOT analysis was conducted to identify the strategic position of Suvarnabhumi Airport. The key findings are summarized below:

Strengths

1. Strategic geographical location at the center of Southeast Asia.
2. Modern infrastructure with capacity for expansion.
3. 24/7 customs clearance services.
4. Competitive handling charges compared to regional hubs.
5. Strong government commitment to logistics development.
6. Presence of international standard cargo operators adhering to global benchmarks.

Weaknesses

1. Shortage of specialized personnel in air cargo logistics.
2. Incomplete integration of information technology systems.
3. Higher dwell times compared to regional competitors.
4. Limited specialized facilities for emerging cargo segments.
5. Regulatory constraints on value-added activities in the free zone.
6. Lower connectivity index compared to competing hubs.
7. Outdated IT infrastructure in some areas.

Opportunities

1. Growing e-commerce market in Southeast Asia (projected 22% CAGR 2022-2027) [18].
2. Increasing trade volumes in high-value sectors like electronics and pharmaceuticals.
3. Emerging technologies for cargo handling and tracking.
4. Government policies promoting Thailand as a trade and logistics hub.
5. Potential for enhanced regional connectivity through ASEAN integration.
6. Growing demand for specialized cargo handling (e.g., cold chain).

Threats

1. Intense competition from established regional hubs with strong government backing.
2. Regulatory constraints on air services liberalization.
3. Economic uncertainties affecting global trade volumes.
4. Shifting trade patterns due to geopolitical factors.
5. Rapid technological advancements requiring significant investment.
6. Environmental regulations increasing operational costs.
7. Talent attraction competition from competing hubs.

Strategic Development Framework: Based on the comprehensive analysis, a strategic development framework was formulated to address the identified challenges and leverage opportunities. The framework consists of four main strategies, eight tactics, and 26 action plans, as outlined below:

Strategy 1: Regulatory Enhancement:

Tactic 1.1: Streamline regulatory processes

- Action Plan 1.1.1: Implement a comprehensive Single Window system for cargo clearance.
- Action Plan 1.1.2: Amend free zone regulations to allow expanded value-added activities.
- Action Plan 1.1.3: Harmonize documentation requirements with international standards.

Tactic 1.2: Enhance incentive structures

- Action Plan 1.2.1: Develop targeted tax incentives for cargo operators and logistics providers.
- Action Plan 1.2.2: Create performance-based incentives for air cargo volume and efficiency.
- Action Plan 1.2.3: Establish special benefits for operators of specialized cargo facilities.

Strategy 2: Infrastructure and Technology Development:

Tactic 2.1: Enhance physical infrastructure

- Action Plan 2.1.1: Construct specialized facilities for e-commerce handling.
- Action Plan 2.1.2: Develop advanced pharmaceutical handling centers.
- Action Plan 2.1.3: Expand intermodal connectivity, particularly rail connections.
- Action Plan 2.1.4: Implement automated storage and retrieval systems (AS/RS).

Tactic 2.2: Advance digital capabilities

- Action Plan 2.2.1: Implement a comprehensive Cargo Community System with full stakeholder integration.
- Action Plan 2.2.2: Achieve 100% e-freight adoption across all cargo operations.
- Action Plan 2.2.3: Deploy IoT-enabled tracking throughout the cargo handling process.
- Action Plan 2.2.4: Implement AI and predictive analytics for demand forecasting and capacity planning.
- Action Plan 2.2.5: Develop blockchain applications for cargo security and traceability.

Strategy 3: Human Capital Development

Tactic 3.1: Establish specialized education programs:

- Action Plan 3.1.1: Create an Air Logistics Academy at Suvarnabhumi Airport.
- Action Plan 3.1.2: Develop industry-academia partnerships for curriculum alignment.
- Action Plan 3.1.3: Implement apprenticeship programs for practical skills development.

Tactic 3.2: Enhance professional development

- Action Plan 3.2.1: Establish mandatory continuing professional development requirements.
- Action Plan 3.2.2: Create international exchange programs with leading cargo hubs.
- Action Plan 3.2.3: Develop specialized certification programs for air cargo professionals.

Strategy 4: Strategic Positioning and Marketing

Tactic 4.1: Develop specialized service offerings:

- Action Plan 4.1.1: Establish centers of excellence for high-value cargo segments.
- Action Plan 4.1.2: Create integrated logistics solutions for key industry verticals.
- Action Plan 4.1.3: Develop value-added services for cargo in transit.

Tactic 4.2: Enhance global awareness and perception

- Action Plan 4.2.1: Implement targeted marketing campaigns in key international markets.
- Action Plan 4.2.2: Develop competitive pricing strategies for transit cargo.
- Action Plan 4.2.3: Create an air cargo excellence awards program to recognize best practices.

Survey Analysis Results: This section presents the findings derived from a structured survey administered to key stakeholders across the air cargo ecosystem. The analysis encompasses five principal dimensions infrastructure, adequacy, technological readiness, regulatory environment, human resource capabilities, and strategic priorities providing quantitative evidence to complement and validate the qualitative insights obtained through interviews and focus group discussions.

Survey Methodology: To supplement the qualitative findings from interviews and focus groups, a structured survey was administered to 215 stakeholders in the air cargo industry between March and May 2023. The survey achieved a response rate of 78.6% (n=169), with respondents representing various sectors within the air cargo ecosystem:

- Airport operators and ground handlers (18.3%).
- Airlines and cargo carriers (14.2%).
- Freight forwarders and logistics providers (32.5%).
- Government agencies and regulators (12.4%).
- Shippers and manufacturers (15.4%).
- Industry associations and consultants (7.2%).

The survey instrument contained 42 items covering five main dimensions: infrastructure adequacy, technological readiness, regulatory environment, human resource capabilities, and strategic priorities. Items were measured on a 5-point Likert scale (1=strongly disagree to 5=strongly agree). Statistical analysis was performed using SPSS version 27.0, with descriptive statistics, factor analysis, and multiple regression analysis conducted to identify key relationships between variables.

Infrastructure Assessment: Respondents' assessment of Suvarnabhumi Airport's infrastructure revealed varying perceptions across different facility types (Table 3).

While general cargo handling facilities were rated relatively favorably (mean=3.68, SD=0.72), specialized facilities for emerging cargo segments received lower ratings, particularly for e-commerce handling (mean=2.46, SD=0.83) and pharmaceutical logistics (mean=2.73, SD=0.91).

Table 3. Assessment of infrastructure adequacy at Suvarnabhumi Airport

Infrastructure Component	Mean	Standard Deviation	Adequacy Rating*
General cargo facilities	3.68	0.72	Moderately adequate
Perishable cargo facilities	3.21	0.88	Somewhat adequate
Express/courier facilities	3.04	0.79	Somewhat adequate
E-commerce handling facilities	2.46	0.83	Inadequate
Pharmaceutical logistics facilities	2.73	0.91	Somewhat inadequate
Dangerous goods handling facilities	3.42	0.76	Somewhat adequate
Ground transportation connectivity	3.51	0.85	Moderately adequate
Rail connectivity	2.12	0.96	Inadequate
Warehouse automation systems	2.87	0.82	Somewhat inadequate

*Adequacy Rating: 1.00-1.80 (Highly inadequate), 1.81-2.60 (Inadequate), 2.61-3.40 (Somewhat adequate), 3.41-4.20 (Moderately adequate), 4.21-5.00 (Highly adequate)

Factor analysis revealed that infrastructure adequacy items loaded onto three main factors: core facilities (explaining 32.7% of variance), specialized facilities (28.4% of variance), and connectivity infrastructure (18.2% of variance). Regression analysis showed that perceived adequacy of specialized facilities was the strongest predictor of overall satisfaction with Suvarnabhumi's cargo capabilities ($\beta=0.48$, $p<0.001$).

Technological Readiness: Survey respondents indicated significant gaps in Suvarnabhumi Airport's technological implementation compared to perceived industry standards (Figure 2). The largest gaps were observed in blockchain implementation (gap=2.31), AI/ML applications (gap=2.17), and IoT-enabled tracking (gap=1.86), while the smallest gap was in basic IT infrastructure (gap=0.72).

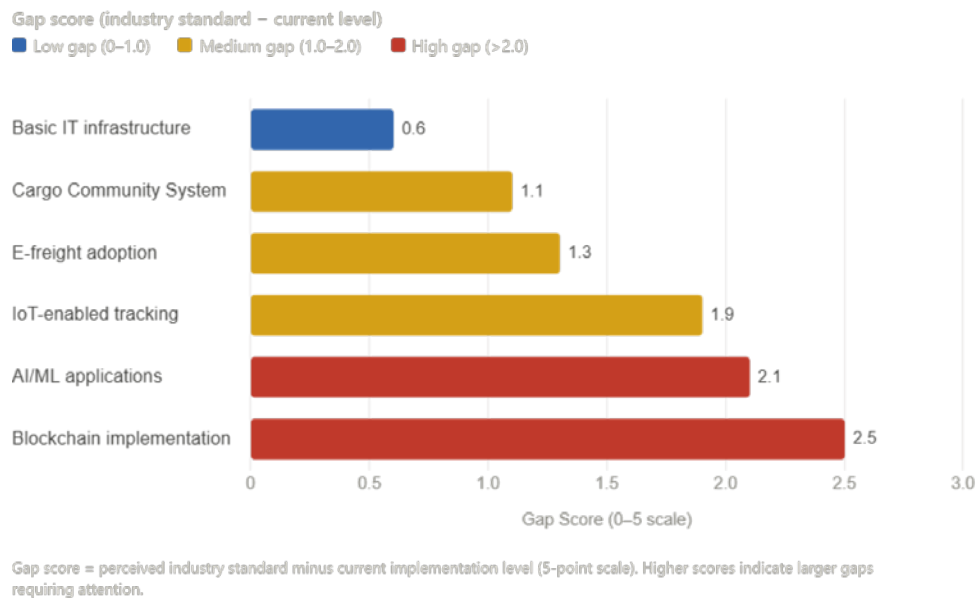


Figure 2. Technology implementation gap analysis

Figure 2 would display a radar chart showing the gap between current implementation level and perceived industry standard across multiple technology categories.

Respondents also identified priority areas for technological investment, with Cargo Community System implementation ranking highest (86.4% of respondents rating it as "high priority"), followed by e-freight adoption (78.9%) and track-and-trace capabilities (74.3%).

Correlation analysis revealed a strong relationship between perceived technological readiness and overall competitiveness ratings ($r=0.67$, $p<0.001$), suggesting that technological capabilities are viewed as a critical factor in Suvarnabhumi's competitive positioning.

Regulatory Environment: The regulatory environment was assessed through multiple items measuring clarity, efficiency, and supportiveness of regulations for air cargo operations. The mean scores across all regulatory dimensions were consistently below the midpoint of the scale (Table 4), indicating respondent dissatisfaction with the current regulatory framework.

Table 4. Assessment of regulatory environment

Regulatory Dimension	Mean	Standard Deviation	Satisfaction Rating*
Clarity of customs procedures	2.84	0.93	Somewhat dissatisfied
Efficiency of documentation processing	2.62	0.87	Somewhat dissatisfied
Supportiveness for e-freight implementation	2.53	0.95	Dissatisfied
Free zone regulations flexibility	2.21	1.02	Dissatisfied
Air service agreement liberalization	2.48	0.89	Dissatisfied
Inter-agency coordination	2.37	0.92	Dissatisfied
Implementation of international standards	2.91	0.84	Somewhat dissatisfied
Investment incentives	2.58	1.06	Somewhat dissatisfied

*Satisfaction Rating: 1.00-1.80 (Highly dissatisfied), 1.81-2.60 (Dissatisfied), 2.61-3.40 (Somewhat dissatisfied), 3.41-4.20 (Somewhat satisfied), 4.21-5.00 (Highly satisfied)

Open-ended responses highlighted specific regulatory challenges, with the most frequently mentioned issues being:

1. Overlapping jurisdiction among government agencies (mentioned by 76.3% of respondents).
2. Inconsistent interpretation of regulations by different officials (68.7%).
3. Lengthy approval processes for specialized cargo handling (62.1%).
4. Limited provisions for value-added activities in the free zone (59.8%).
5. Outdated regulations not aligned with technological advancements (57.4%).

Human Resource Capabilities: Survey findings on human resource capabilities revealed significant gaps across various skill areas (Figure 3). The largest skills gaps were identified in digital technology expertise (gap=2.43), specialized cargo handling knowledge (gap=2.18), and global supply chain understanding (gap=1.97).

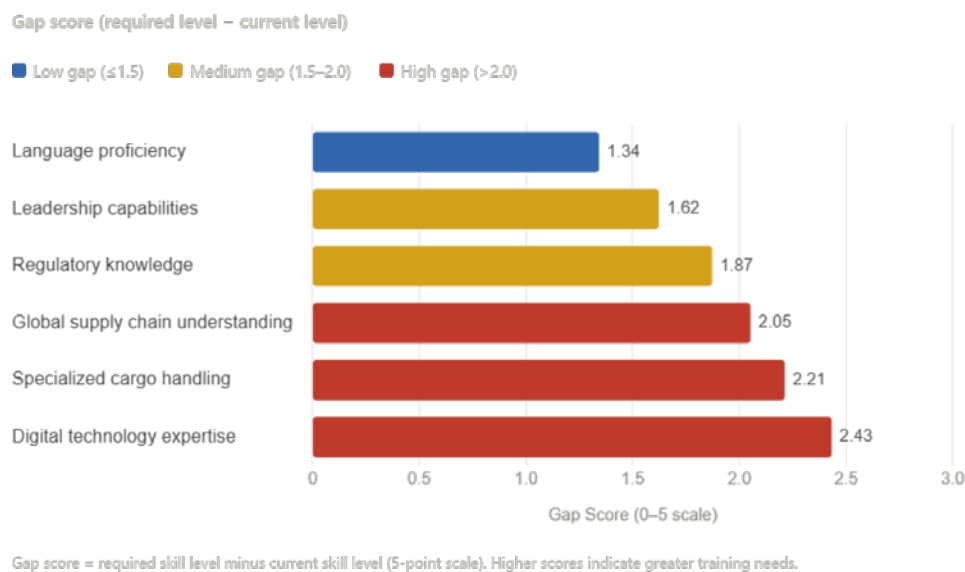


Figure 3. Air cargo skills gap analysis

Figure 3 would display a bar chart showing the gap between current skill levels and required skill levels across multiple skill categories.

Respondents also evaluated the effectiveness of current training programs for air cargo professionals, with only 23.7% rating existing programs as "effective" or "very effective." The majority (58.6%) rated current training as "somewhat ineffective" or "ineffective," highlighting a critical area for improvement.

Cross-tabulation analysis revealed significant differences in skills gap perception based on respondent sector, with freight forwarders and logistics providers reporting larger skills gaps than airport operators and airlines ($\chi^2=18.72$, $p<0.01$).

Strategic Priorities: Respondents were asked to rank potential strategic initiatives for enhancing Suvarnabhumi Airport's competitiveness as an air cargo hub. The weighted ranking scores (maximum possible score=100) are presented in Table 5.

Table 5. Ranking of strategic priorities

Strategic Initiative	Weighted Score	Rank
Implementing a comprehensive Cargo Community System	87.3	1
Streamlining customs procedures	83.2	2
Developing specialized e-commerce facilities	79.8	3
Enhancing intermodal connectivity	77.1	4
Establishing an Air Logistics Academy	72.6	5
Expanding pharmaceutical handling capabilities	68.9	6
Implementing advanced automation systems	65.4	7
Developing value-added services in the free zone	63.8	8
Creating targeted marketing incentives	58.7	9
Implementing blockchain for cargo security	56.4	10

Multiple regression analysis was conducted to identify factors predicting respondents' optimism about Suvarnabhumi's future competitiveness. The analysis revealed that regulatory environment perception ($\beta=0.42$, $p<0.001$), technology implementation plans ($\beta=0.38$, $p<0.001$), and human resource development strategies ($\beta=0.29$, $p<0.01$) were significant predictors, together explaining 63.7% of the variance in competitiveness outlook.

Comparative Positioning: The survey included items assessing Suvarnabhumi Airport's comparative position against regional competitors across key performance dimensions (Table 6). Respondents rated Suvarnabhumi's performance relative to Hong Kong, Singapore, and Incheon airports on a scale from -3 (significantly worse) to +3 (significantly better).

Table 6. Comparative performance assessment

Performance Dimension	vs Hong Kong	vs Singapore	vs Incheon
Infrastructure quality	-1.87	-1.62	-0.93
Technological integration	-2.34	-2.15	-1.58
Regulatory efficiency	-2.28	-2.41	-1.26
Human resource expertise	-1.96	-1.83	-1.42
Cost competitiveness	+0.92	+0.75	+0.23
Overall competitiveness	-1.87	-1.76	-1.24

The findings indicate that Suvarnabhumi is perceived to lag behind all three benchmark airports across most dimensions, with the exception of cost competitiveness. The largest performance gaps were observed in technological integration and regulatory efficiency, while the smallest gaps were in basic infrastructure quality.

Cluster analysis of respondent perceptions identified three distinct perspectives on Suvarnabhumi's competitive position:

- Optimistic (22.5% of respondents): Viewing current gaps as moderate and readily addressable.
- Realistic (54.3% of respondents): Acknowledging significant gaps but seeing potential for improvement.
- Pessimistic (23.2% of respondents): Perceiving fundamental structural challenges difficult to overcome.

These findings provide quantitative validation of the qualitative insights gathered through interviews and focus groups, highlighting the multidimensional nature of the challenges facing Suvarnabhumi Airport in its development as a regional air cargo hub.

Implementation Roadmap: The strategic framework is supported by a phased implementation roadmap divided into three periods:

Phase 1 (2024-2026): Foundation Building

- Focus on regulatory reforms and basic infrastructure improvements.
- Implementation of the Cargo Community System.
- Establishment of the Air Logistics Academy.
- Estimated investment: \$350 million.

Phase 2 (2027-2029): Capability Enhancement

- Development of specialized facilities for e-commerce and pharmaceuticals
- Expansion of intermodal connections
- Implementation of advanced technology solutions
- Estimated investment: \$950 million

Phase 3 (2030-2032): Strategic Differentiation

- Development of an integrated logistics park adjacent to the airport.
- Implementation of next-generation cargo handling technologies.
- Establishment of centers of excellence for specialized cargo.
- Estimated investment: \$1.2 billion.

The total estimated investment for the complete implementation is \$2.5 billion over the nine-year period, with projected returns based on increased cargo volumes and value-added services.

5. Discussion

Comparative Advantages and Challenges: The findings of this study highlight both the potential advantages and significant challenges facing Suvarnabhumi Airport in its aspiration to become a leading air logistics hub in Southeast Asia. The airport's strategic location at the center of the region provides a natural geographic advantage, particularly for intra-regional distribution networks. This advantage is complemented by modern infrastructure with capacity for expansion and strong government commitment to logistics development.

However, the comparative analysis reveals that Suvarnabhumi significantly lags behind established regional hubs across multiple performance metrics. Particularly concerning are the substantially longer cargo dwell times (14.2 hours compared to 5.8-7.1 hours at competitor airports) and lower connectivity indices (142 compared to 268-340 at competitors). These metrics directly impact the airport's attractiveness for time-sensitive cargo and network-dependent operations.

The survey results provide quantitative validation of these performance gaps, with respondents consistently rating Suvarnabhumi's performance below that of regional competitors across most dimensions.

The most significant perceived gaps were identified in technological integration, where Suvarnabhumi scored -2.34 relative to Hong Kong and -2.15 relative to Singapore, and in regulatory efficiency, with comparative scores of -2.28 and -2.41 respectively. Notably, the only dimension in which Suvarnabhumi demonstrated a competitive advantage was cost competitiveness, recording positive differentials of +0.92 against Hong Kong and +0.75 against Singapore, thereby suggesting a viable strategic positioning as a cost-effective alternative to premium regional hubs.

The infrastructure assessment from the survey further clarifies specific facility inadequacies, with e-commerce handling facilities (mean=2.46, SD=0.83) and rail connectivity (mean=2.12, SD=0.96) receiving the lowest adequacy ratings. These findings align with the qualitative insights from stakeholder interviews, which highlighted the need for specialized facilities to accommodate emerging cargo segments.

The performance gap can be attributed to several interrelated factors. The regulatory environment, while improving, still imposes constraints that limit operational efficiency and value-added activities. This aligns with findings [5], who emphasized the impact of regulatory frameworks on air cargo competitiveness. Survey respondents corroborated this assessment, with all regulatory dimensions scoring below the midpoint of the satisfaction scale. The most problematic areas identified were free zone regulations flexibility (mean=2.21, SD=1.02) and inter-agency coordination (mean=2.37, SD=0.92).

Similarly, the incomplete integration of information technology systems hampers seamless information flow, a critical factor identified by [8] in their research on air cargo efficiency. The technology implementation gap analysis from the survey revealed significant deficiencies in blockchain implementation (gap=2.31), AI/ML applications (gap=2.17), and IoT-enabled tracking (gap=1.86). These gaps are particularly concerning given the strong correlation between perceived technological readiness and overall competitiveness ratings ($r=0.67$, $p<0.001$) identified in the survey analysis.

Human capital limitations represent another significant challenge, with the survey results indicating substantial skills gaps across technical, regulatory, and managerial domains. The largest skills gaps were identified in digital technology expertise (gap=2.43), specialized cargo handling knowledge (gap=2.18), and global supply chain understanding (gap=1.97). This finding resonates with [10] research highlighting the importance of specialized skills in logistics competitiveness. The shortage of personnel with expertise in emerging technologies and international trade regulations represents a particular constraint on Suvarnabhumi's development potential.

Strategic Positioning Considerations: The SWOT analysis and comparative benchmarking suggest that Suvarnabhumi Airport has not yet established a clearly differentiated strategic position in the regional air cargo market. Unlike Hong Kong's premium global hub positioning or Singapore's focus on high-value specialized cargo, Suvarnabhumi currently operates primarily as a regional gateway without distinct specialization or competitive advantage beyond its geographical location.

The cluster analysis from the survey provides additional nuance to this assessment, identifying three distinct perspectives on Suvarnabhumi's competitive position: optimistic (22.5% of respondents), realistic (54.3%), and pessimistic (23.2%). The predominance of the "realistic" perspective, acknowledging significant gaps but seeing potential for improvement, suggests a pragmatic stakeholder outlook that recognizes both challenges and opportunities.

This lack of clear positioning presents both a challenge and an opportunity. While it may limit current attractiveness to certain cargo segments, it also provides flexibility to develop a strategic positioning that capitalizes on emerging trends and market gaps. The growing e-commerce market in Southeast Asia, with its projected 22% CAGR between 2022-2027, represents a particularly promising opportunity for specialization.

This potential is reflected in the strategic priorities identified by survey respondents, who ranked developing specialized e-commerce facilities as the third highest priority (weighted score=79.8), following the implementation of a comprehensive Cargo Community System (score=87.3) and streamlining customs procedures (score=83.2). This ranking indicates stakeholder recognition of e-commerce as a key opportunity for differentiation.

The proposed strategic framework addresses this positioning challenge through actions focused on developing specialized service offerings and centers of excellence for high-value cargo segments. This approach aligns with research by [19], who found that specialized capabilities can significantly enhance an airport's attractiveness to specific cargo flows. By developing expertise in emerging segments such as e-commerce logistics or pharmaceutical handling, Suvarnabhumi can potentially establish a differentiated position in the regional market.

Implementation Considerations: The successful implementation of the proposed strategic framework faces several potential challenges that merit consideration. First, the estimated investment of \$2.5 billion over nine years represents a substantial financial commitment that will require creative funding approaches beyond traditional public financing. Public-private partnerships, as suggested by [20], may offer a viable approach to mobilizing the necessary capital while ensuring operational efficiency.

Second, the regulatory reforms proposed in the framework will require coordination across multiple government agencies with potentially divergent priorities and institutional interests. The establishment of an integrated development agency, as proposed in the action plans, could help address this challenge by providing a centralized coordination mechanism, but its effectiveness will depend on the political support and authority granted to such an entity. The survey findings underscore this challenge, with 76.3% of respondents identifying overlapping jurisdiction among government agencies as a key regulatory issue.

Third, the human capital development strategy, while comprehensive, will face implementation challenges related to the time required to develop specialized skills and the competition for talent from established hubs with higher compensation levels. The survey evaluation of current training programs for air cargo professionals found that only 23.7% of respondents rated existing programs as "effective" or "very effective," highlighting the substantial improvements needed in this area. Strategic partnerships with international training providers and incentive schemes for returning Thai professionals with international experience may help address this challenge.

Finally, the phased implementation approach, while necessary for fiscal and operational reasons, creates risks related to maintaining momentum and stakeholder commitment throughout the nine-year timeline. Regular monitoring, transparent progress reporting, and early demonstration projects that deliver visible improvements could help sustain support for the longer-term transformation process.

Multiple regression analysis from the survey provides guidance on implementation priorities, indicating that regulatory environment perception ($\beta=0.42$, $p<0.001$), technology implementation plans ($\beta=0.38$, $p<0.001$), and human resource development strategies ($\beta=0.29$, $p<0.01$) were significant predictors of stakeholder optimism about future competitiveness, together explaining 63.7% of the variance. This suggests that demonstrating early progress in these areas could be particularly important for building and maintaining stakeholder confidence in the overall development program.

Theoretical and Practical Implications: This research contributes to both theoretical understanding and practical knowledge in several ways. From a theoretical perspective, it provides empirical support for the multi-dimensional nature of air cargo hub competitiveness, demonstrating the interconnection between infrastructure, regulatory frameworks, technology, and human capital in determining hub performance. The factor analysis of infrastructure adequacy items, which identified three distinct factors (core facilities, specialized facilities, and connectivity infrastructure), exemplifies this multi-dimensional structure.

Moreover, the finding that perceived adequacy of specialized facilities was the strongest predictor of overall satisfaction ($\beta=0.48$, $p<0.001$) highlights the differential importance of these dimensions.

This integrative perspective extends beyond traditional infrastructure-focused studies to incorporate institutional and human dimensions of competitiveness. The findings also offer insights into the development challenges facing emerging air cargo hubs in middle-income economies, highlighting the particular importance of institutional capacity and human capital as potential constraints. This extends the applicability of air cargo hub development theories beyond the context of advanced economies where much of the existing research has been conducted.

From a practical perspective, the study provides actionable recommendations for policymakers and airport authorities seeking to enhance their competitive position in the global air cargo market. The prioritized ranking of strategic initiatives derived from the survey (Table 5) offers specific guidance on stakeholder preferences and perceived importance. The phased implementation roadmap offers a structured approach to development that balances immediate improvements with longer-term strategic initiatives. The emphasis on quantitative benchmarking also provides a practical framework for ongoing performance monitoring and competitive assessment.

6. Conclusion

This comprehensive study has analyzed the strategic potential and limitations of Suvarnabhumi Airport's development as a leading air logistics hub in Southeast Asia. The findings reveal that while Suvarnabhumi possesses significant advantages in terms of geographical location and infrastructure capacity, it faces substantial challenges related to regulatory frameworks, technological integration, and human capital development. These challenges are reflected in performance metrics that currently lag behind established regional hubs across multiple dimensions, with survey respondents consistently rating Suvarnabhumi below regional competitors except in cost competitiveness.

The proposed strategic development framework addresses these challenges through an integrated approach encompassing regulatory enhancements, infrastructure and technology development, human capital development, and strategic positioning initiatives. The phased implementation roadmap provides a structured path forward, balancing immediate improvements with longer-term transformational changes.

Several key implications emerge from this research. First, the development of Suvarnabhumi as a competitive air logistics hub will require sustained commitment and substantial investment from both public and private stakeholders over an extended period. Second, while infrastructure improvements are necessary, they are not sufficient; equal attention must be given to regulatory reforms, technological integration, and human capital development. This is evidenced by the multiple regression analysis showing that regulatory environment perception, technology implementation plans, and human resource development strategies were significant predictors of stakeholder optimism about future competitiveness.

Third, establishing a differentiated strategic position in the competitive regional market will be essential for long-term success, potentially focusing on emerging segments such as e-commerce or specialized high-value cargo. The survey results support this direction, with developing specialized e-commerce facilities ranking as the third highest priority among stakeholders.

This study has several limitations that should be acknowledged. The comparative benchmarking data primarily reflects pre-pandemic performance (2019), and the air cargo landscape has evolved considerably since then. While efforts were made to incorporate recent trends, the full impact of these changes may not be fully captured in the analysis.

Additionally, although the stakeholder survey achieved a high response rate (78.6%) and included representatives from across the air cargo ecosystem, the sample size ($n=169$) may limit the generalizability of some statistical analyses, particularly for smaller stakeholder subgroups. Furthermore, the cross-sectional nature of the survey provides a snapshot of perceptions at a single point in time, which may evolve as the implementation of strategic initiatives progresses.

The economic projections underlying the implementation roadmap are subject to considerable uncertainty given the volatile nature of global trade and technological change. Finally, while the study proposes a comprehensive strategic framework, the detailed operational planning required for implementation lies beyond its scope.

Several promising directions for future research emerge from this study. Quantitative modeling of the economic impact of the proposed strategic initiatives would provide valuable insights for investment prioritization and policy development. Longitudinal studies tracking the implementation and impact of specific interventions would contribute to understanding the effectiveness of different approaches to air cargo hub development.

Cross-national comparative studies examining the development trajectories of multiple emerging hubs could identify common success factors and challenges. The cluster analysis identifying three distinct perspectives on Suvarnabhumi's competitive position (optimistic, realistic, and pessimistic) suggests that a more detailed exploration of these stakeholder segments and their underlying assumptions could inform more effective engagement strategies.

Finally, in-depth analysis of specific cargo segments, such as e-commerce logistics or pharmaceutical handling, could inform more targeted development strategies for specialized capabilities. The survey finding that specialized facilities were the strongest predictor of overall satisfaction with Suvarnabhumi's cargo capabilities underscores the potential value of such segment-specific research.

In conclusion, while Suvarnabhumi Airport faces significant challenges in its aspiration to become a leading air logistics hub in Southeast Asia, the strategic framework developed through this research provides a viable pathway forward. With sustained commitment, strategic investment, and effective implementation, Suvarnabhumi has the potential to significantly enhance its competitive position in the regional and global air cargo market, contributing to Thailand's economic development and regional connectivity.

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