Air Navigation Service Quality and Sustainability Requirements as Drivers of Competitive Advantage in an Aviation Context

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Abstract:

This paper sets out to examine how the quality of air navigation services influences competitive advantage within Yemen's Sana'a Flight Information Region and to test whether international sustainable development requirements play a mediating role in that relationship. A quantitative, cross-sectional, descriptive-analytical design was adopted. The sample consisted of 98 employees and air traffic controllers at the Civil Aviation and Meteorology Authority (CAMA) in the Sana'a FIR, representing nearly 82 percent of the total workforce (N=120). Structural equation modeling with partial least squares (PLS-SEM) was used for hypothesis testing. The findings show that service quality has a strong and statistically significant direct effect on competitive advantage (β=0.789, $p<0.001$, f=0.667). In addition, there is a notable indirect effect operating through sustainable development practices (β=0.300 with a 95% bootstrap confidence interval ranging from 0.1642 to 0.3638), indicating partial mediation. The overall model accounts for approximately 81% of the variance in competitive advantage (R^2=0.8106). Discriminant validity was generally acceptable. Reliability and security received the highest ratings, while creativity and environmental sustainability scored low. Integrating sustainability practices amplifies service quality's impact on competitive advantage. For aviation authorities in fragile states, investing in tangible infrastructure while gradually aligning with ICAO's sustainability targets is recommended.

Keywords: *Air Navigation Service Quality; Competitive Advantage; Sustainable Development; Yemen*

1. Introduction

Aviation is not merely a means of transport; in emerging economies, it is a strategic driver of connectivity, trade, and development. The extent to which a region performs in air transport often reflects, and sometimes shapes, its broader economic competitiveness (Chung & Tan, 2022; Wu & Yang, 2021). In fragile developing contexts such as Yemen, however, flight information regions (FIRs) operate under severe constraints, including weak infrastructure, persistent security threats, and institutional fragility. Under such conditions, operational challenges are not confined to routine service delivery; they also affect the broader capacity to build and sustain competitive advantage (Bhuiyan et al., 2023). Against this backdrop, the present study examines how air navigation service quality and sustainability requirements interact to influence competitive advantage in Sana'a FIR, contributing to the ongoing debate on sustainable aviation in politically fragile economies.

Competitive advantage, in this study, is understood in line with Porter's (1985) classical formulation as the ability of an organization to create greater value for customers than its competitors. Although this idea is widely applicable across sectors, its relevance in aviation is particularly pronounced because the industry is structured around interconnected FIRs operating within sovereign territorial boundaries. For developing countries, sustaining advantage in such a system is especially difficult. In Yemen, years of conflict, political instability, and economic decline have significantly weakened air navigation services, making competitiveness both vulnerable and difficult to restore. Prior studies suggest that service quality is an important determinant of an FIR's attractiveness to airlines and overflights (Jeeradist, 2023; Carvalho & Medeiros, 2021). Yet the process through which service quality is converted into competitive advantage remains insufficiently explained, especially in fragile settings.

Evidence from developing and emerging economies consistently shows that service quality contributes to competitive positioning in aviation markets. Service quality, commonly assessed through reliability, responsiveness, assurance, empathy, and tangibles, has been linked to higher customer satisfaction, stronger loyalty, and greater repurchase intention. These outcomes, in turn, reinforce organizational competitiveness even under conditions of limited resources (Law et al., 2022; Shen & Yahya, 2021; Tahanisaz & Shokuhyar, 2020). Most of this evidence, however, is drawn from airline-focused studies. The same logic, nevertheless, applies to air navigation systems, where technical reliability, safety assurance, and operational efficiency form the foundation of perceived quality. Without these attributes, sustaining long-term competitiveness becomes highly unlikely (Rahman & Rahman, 2023; Afonso et al., 2023).

Over the past decade, the service quality literature has moved beyond traditional models such as SERVQUAL, introduced by Parasuraman, Zeithaml, and Berry (1988), toward broader frameworks that incorporate sustainability, digital transformation, pandemic responsiveness, and information systems (Kavus et al., 2022). In aviation, improvements in service quality have been associated with stronger demand and profitability, largely because better quality helps retain customers and encourages repeat use (Jeeradist, 2023). Collaborative operating models such as Airport Collaborative Decision-Making (A-CDM) have also been shown to improve service quality by strengthening coordination among airports, airlines, and air navigation service providers.

At the same time, sustainability has become a defining concern in aviation governance. This shift reflects increasing environmental pressures, changing stakeholder expectations, and the influence of international regulatory frameworks. Airports and airlines in ASEAN and other developing regions have begun embedding environmental, social, and economic sustainability into their operations through emissions management, energy efficiency, waste reduction, noise mitigation, workforce development, and community engagement (Sreenath et al., 2021; Dimitriou & Karagkouni, 2022). Empirical evidence indicates that environmental initiatives can generate long-term operational and strategic benefits while also supporting broader Sustainable Development Goals, especially those related to infrastructure, decent work, and sustainable cities (Sreenath et al., 2021). Recent syntheses of sustainable aviation strategies likewise identify environmental mitigation technologies and operational redesign as central to industry transformation (Afonso et al., 2023).

Despite growing attention to both service quality and sustainability in aviation, an important question remains underexplored: can sustainability practices mediate the relationship between service quality and competitive advantage, particularly in fragile developing contexts? Studies from Uganda and Nepal have largely examined the determinants of service quality without considering sustainability as a mediating mechanism (Wanje, 2025; Thakuri et al., 2025). Likewise, although research in other sectors has shown that corporate social responsibility and dynamic capabilities can mediate performance outcomes (Rochayatun et al., 2023; Alenazi & Alanazi, 2023), such relationships have not yet been sufficiently tested in air navigation service provision in fragile states.

This study draws on three complementary theoretical perspectives. First, the Resource-Based View (RBV) (Barney, 1991) and the Natural-Resource-Based View (NRBV) (Hart, 1995) conceptualize service quality capabilities and environmental compliance as strategic resources capable of generating sustained competitive advantage. Second, Dynamic Capabilities Theory (Teece et al., 1997) helps explain how organizations reconfigure their resources in response to institutional pressures, including sustainability requirements issued by the International Civil Aviation Organization (ICAO). Taken together, these perspectives suggest a framework in which adherence to sustainable development requirements helps translate service quality into stronger competitive positioning (Bhuiyan et al., 2023; Kılıç et al., 2019).

By examining Sana'a FIR, this study extends the literature on service quality and competitive advantage into a fragile aviation context that has received limited scholarly attention. It also offers empirically grounded implications for policymakers and aviation authorities in developing countries, particularly those operating under institutional fragility and resource constraints.
The study extends existing service-quality and competitive-advantage literature into a fragile aviation context. It also offers empirically grounded insights for policymakers and aviation authorities in developing countries – insights that might otherwise be missing from research focused on stable, high-income settings.

2. Literature Review

2.1 Conceptual Foundations of ANSQ

The concept of service quality has been extensively examined since the early 1980s. The most influential framework is the SERVQUAL model developed by Parasuraman, Zeithaml, and Berry (1988), which conceptualises service quality as the gap between customers' expectations and their perceptions of actual service performance. The SERVQUAL instrument comprises five core dimensions: tangibility (physical facilities, equipment, and appearance of personnel), reliability (ability to perform the promised service dependably and accurately), responsiveness (willingness to help customers and provide prompt service), assurance (employees' knowledge and courtesy, and their ability to inspire trust and confidence), and empathy (caring, individualised attention provided to customers).
Recent research has extended this framework to include dimensions critical to contemporary aviation. Kavus et al., (2022) proposed a three-level framework incorporating Environment, Pandemic, Digital Technology, and Information Systems, demonstrating that an extended SERVQUAL approach enables more detailed service quality measurement. In the aviation context, service quality impacts passenger demand and profitability (Jeeradist, 2023). For air navigation services specifically, quality refers to the capacity of air traffic control and navigation service providers to ensure safe, efficient, and punctual flight operations. The A-CDM network has been shown to improve aviation service quality when integrated with SERVQUAL and Kano's model (Jeeradist, 2023).

2.2 Sustainable Development in Civil Aviation

The integration of sustainable development principles into civil aviation has accelerated significantly. The International Civil Aviation Organization (ICAO), a specialized agency of the United Nations, has established that international aviation contributes to 14 of the 17 Sustainable Development Goals (SDGs) (UN, n.d.). At the 42nd session of the ICAO Assembly (23 September to 3 October 2025), Member States reaffirmed their commitment to advancing the SDGs, adopting landmark resolutions:

Resolution A42-20 on Environmental Protection: Encourages the ICAO Council to continue cooperation with international organizations to address aviation's environmental impacts and contribute to the SDGs, including goals related to plastic pollution, biodiversity loss, and waste management (ICAO, 2025a).

Resolution A42-21 on Climate Change: Reaffirms the sector's commitment to implement the long-term global aspirational goal (LTAG) of net-zero carbon emissions by 2050, alongside the ICAO Global Framework for Sustainable Aviation Fuels (SAF) and other cleaner energies (ICAO, 2025b; UN, n.d.).

Resolution A42-22 on CORSIA: Reaffirms the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) as the only global market-based measure applying to CO_2 emissions from international aviation (ICAO, 2025c).

The deployment of Sustainable Aviation Fuels (SAFs) is central to decarbonizing aviation. As Prussi et al., (2025) notes, differing greenhouse gas reduction thresholds and feedstock eligibility rules increase the compliance burden, especially for cross-regional operators. ICAO has strengthened sustainability certification requirements under CORSIA in its Fourth Edition (June 2025 update), enhancing transparency and tightening standards (ICAO, 2025d).

2.3 Service Quality and Sustainable Development in Developing Countries

Recent empirical studies from developing countries have examined service quality in civil aviation. In Uganda, Wanje (2025) found that service availability expressed the most significant positive effect on service quality, with 55.5% of the variance attributed to combined service attributes and institutional factors. In Nepal, Thakuri et al. (2025) identified 15 key determinants of passenger satisfaction using confirmatory factor analysis, highlighting infrastructure inadequacies and service inefficiencies as common challenges.

However, none of these studies examined the mediating role of international sustainable development requirements in the relationship between service quality and competitive advantage, leaving a significant gap in the literature.

2.4 Theoretical Framework

The present study integrates three complementary theoretical perspectives: the Resource-Based View (RBV), the Natural-Resource-Based View (NRBV), and Dynamic Capabilities Theory.

2.4.1 Resource-Based View (RBV)

The RBV, originally proposed by Wernerfelt (1984) and refined by Barney (1991), posits that a firm's competitive advantage is derived from resources that are valuable, rare, imperfectly imitable, and non-substitutable (VRIN). Barney (1991) argued that only resources possessing these four attributes can generate sustained competitive advantage. Applying this lens, air navigation service quality can be conceptualized as a valuable organizational resource that meets the VRIN criteria. If a FIR develops superior service quality capabilities that are rare among competitors and difficult to imitate, it can achieve a sustainable advantage.

The RBV has considerable support in the business literature (Wernerfelt, 1984; Conner, 1991; Peteraf, 1993). A major premise is that competitive advantage is a function of firm-specific resources and capabilities (Barney, 1991). Valuable resources help a firm exploit opportunities and avoid environmental threats, enabling it to improve efficiency and effectiveness (Capron & Hulland, 1999).

2.4.2 Natural-Resource-Based View (NRBV)

The NRBV extends the RBV by integrating the natural environment. Hart (1995) argued that the RBV ignored the interaction between an organization and its natural environment, proposing that pollution prevention, product stewardship, and clean technology capabilities can be sources of competitive advantage. This perspective directly supports the mediating role of ISDR. Compliance with ICAO environmental regulations is not merely a cost but a strategic capability that can differentiate a FIR, reduce risks, and attract environmentally conscious partners.

The NRBV posits four key strategic capabilities built upon different resources: pollution prevention, product stewardship, clean technology, and bottom-of-the-pyramid strategies (Hart, 1995).

2.4.3 Dynamic Capabilities Theory

Dynamic Capabilities Theory, introduced by Teece, Pisano, and Shuen (1997), addresses the limitations of the RBV's static nature. Dynamic capabilities (DCs) are higher-level competences enabling organisations to integrate, build, and reconfigure resources to address and shape dynamic environments (Teece et al., 1997). DCs operate as higher-order capabilities that govern the evolution and reconfiguration of ordinary or operational capabilities (Schriber & Löwstedt, 2020). The theory centres on a firm's ability to purposefully adapt, renew, and reconfigure its resource base to achieve sustained competitive advantage in volatile environments (Teece et al., 1997). Organisations with robust DCs can manage uncertainty and proactively shape their competitive landscape, securing long-term success (Zahra, Sapienza & Davidsson, 2006; Benner & Tushman, 2003). This framework explains the mediation hypothesis: ISDR represents a dynamic capability that enables CAMA to sense environmental changes (evolving ICAO standards), seize opportunities (integrate sustainability into operations), and transform its resource base, thereby converting service quality into enhanced competitive advantage.

2.5 The Research Gap and Hypotheses Development

The literature highlights several gaps: (1) Most service quality research in aviation has focused on airlines and airports in developed economies, neglecting fragile developing countries. (2) Limited empirical research examines how sustainable development practices function as strategic resources mediating the service quality–competitive advantage relationship. (3) The relationship between service quality and sustainable development is under-researched in the aviation sector, despite ICAO requirements.

Based on this, the following hypotheses were formulated:

H1: Air navigation service quality has a statistically significant positive effect on the competitive advantage of Sana'a FIR.

H2: Air navigation service quality has a statistically significant positive effect on compliance with international sustainable development requirements.

H3: International sustainable development requirements have a statistically significant positive effect on the competitive advantage of Sana'a FIR.

H4: International sustainable development requirements mediate the relationship between air navigation service quality and competitive advantage (partial mediation).

3. Methodology

3.1 Research Design and Setting

A quantitative, cross-sectional, descriptive-analytical design was adopted. The study was conducted at the Civil Aviation and Meteorology Authority (CAMA), which is responsible for managing the Sana’a Flight Information Region (FIR) in Yemen. This setting represents a fragile developing country context characterised by political instability, armed conflict, and severe infrastructure constraints.

3.2 Population and Sample

The target population consisted of all 120 employees and air traffic controllers working in CAMA’s air navigation sector. A complete census was performed. After data cleaning, 98 valid questionnaires were retained, yielding an effective response rate of 81.7%. Table 1 presents the demographic characteristics of the sample.

Table 1. Demographic Characteristics of the Sample (N = 98)

Characteristic	Category	Frequency	Percentage (%)
Age	20–30 years	17	17.3
	31–40 years	41	41.8
	41–50 years	34	34.7
	>50 years	6	6.1
Education	Secondary or less	11	11.2
	Bachelor	68	69.4
	Master	19	19.4
Work experience	1–5 years	13	13.3
	6–15 years	36	36.7
	16–25 years	39	39.8
	>25 years	10	10.2

3.3 Instruments

A structured questionnaire using a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree) was developed based on validated instruments from prior studies. The questionnaire comprised three main sections:

Air Navigation Service Quality (ANSQ) – 29 items measuring five dimensions: tangibility (TAN), reliability (REL), assurance (ASS), responsiveness (RES), and empathy (EMP), adapted from the SERVQUAL framework (Parasuraman et al., 1988).

Competitive Advantage (CA) – 18 items measuring three dimensions: creativity and innovation (INN), meeting customer needs (CNF), and strategic location (SL), based on Porter (1985) and subsequent adaptations.

International Sustainable Development Requirements (ISDR) – 17 items measuring three dimensions: economic (ECON), environmental (ENV), and social (SOC), aligned with ICAO sustainability standards (ICAO, 2025a, 2025b, 2025c).

Face validity was confirmed by seven academic experts from multiple Yemeni universities. Content validity was established through a systematic literature review and expert assessment. The questionnaire was pre-tested with 10 respondents prior to full distribution.

3.4 Data Analysis

Data were analysed using SPSS version 28 for descriptive statistics and preliminary analyses, and SmartPLS version 4.0.8.6 for structural equation modeling (PLS-SEM). Mediation was further tested using Hayes' PROCESS macro (Model 4) with 5,000 bootstrap samples (Hayes, 2018) as a robustness check. The measurement model was assessed using confirmatory factor analysis following the criteria of Hair et al. (2017): outer loadings > 0.70, average variance extracted (AVE) > 0.50, and composite reliability (CR) > 0.70. Discriminant validity was assessed using the Fornell-Larcker criterion and the heterotrait-monotrait (HTMT) ratio (Henseler et al., 2015). Common method bias was examined using Harman's single-factor test (Podsakoff et al., 2003) and the marker-variable technique (Lindell & Whitney, 2001).

4. Results

4.1 Assessment of Data Quality and Preliminary Analysis

Before testing the structural model, several preliminary procedures were performed to ensure data suitability.

4.1.1 Missing Values

The dataset contained no missing values because the questionnaire was distributed electronically via Google Forms with forced responses. All 98 returned questionnaires were fully completed and valid.

4.1.2 Normality Assessment

Normality was examined using skewness and kurtosis. As shown in Table 2, all skewness values were within ±2 and all kurtosis values within ±7 (Kline, 2016), indicating approximately normal distribution.

Table 2. Assessment of Data Normality (N = 98)

Variable	Skewness	Kurtosis
Air Navigation Service Quality	-1.157	1.541
Competitive Advantage	-0.050	-0.046
International Sustainable Development Requirements	0.637	-0.028

4.1.3 Outlier Assessment

Univariate outliers were screened using boxplots and Z-scores (±3.29). A few extreme values were detected in the independent variable, but they were retained because the overall distribution remained normal and their removal did not alter the results (Hair et al., 2017).

4.1.4 Non-response Bias

Following Armstrong and Overton (1977), early (first 25%) and late (last 25%) respondents were compared using Levene's test. Table 3 shows no significant differences ($p > 0.05$), confirming that non-response bias is not a concern.

Table 3. Non-response Bias Test (Early vs. Late Respondents)

Variable	Levene Statistic	Sig.
Air Navigation Service Quality	2.199	0.141
Competitive Advantage	0.547	0.461
Sustainability Requirements	0.008	0.927

4.1.5 Common Method Bias

Procedural remedies recommended by Podsakoff et al. (2003) were implemented: anonymity, reverse-coded items, separation of predictors and criterion, and pre-testing. Harman's single-factor test showed that the first factor explained 41.2% of the total variance (below the 50% threshold). In addition, the marker-variable technique (Lindell & Whitney, 2001) was used; the smallest positive correlation between the marker variable and substantive constructs was $r = 0.032$ (non-significant), and adjusting for it did not affect any significant correlations. Thus, common method bias does not threaten the validity of the findings.

4.2 Descriptive Statistics

Table 4 presents the mean scores and standard deviations for all study dimensions. Reliability (5.699) and Assurance (5.475) were the highest-rated service quality dimensions, while tangibility (3.578) received the lowest score. For competitive advantage, strategic location (4.747) and meeting customer needs (4.652) were rated moderately high, whereas creativity and innovation (3.120) was critically low. For sustainability, the economic dimension (3.963) was highest, while the environmental dimension (2.590) was critically low. It is worth noting that while Reliability and Assurance achieved the highest mean scores based on descriptive perceptions, their statistical weights within the latent construct may differ during the structural model estimation, which is standard in PLS-SEM analysis.

Table 4. Descriptive Statistics of Study Dimensions (N = 98)

Variable	Dimension	Mean	SD
ANSQ	Tangibility	3.578	1.152
	Reliability	5.699	1.082
	Assurance	5.475	1.111
	Responsiveness	5.157	1.210
	Empathy	5.311	1.193
	Overall ANSQ	5.044	0.991
CA	Creativity & Innovation	3.120	1.472
	Customer Needs Fulfillment	4.652	1.116
	Strategic Location	4.747	1.144
	Overall CA	4.173	1.096
ISDR	Economic Dimension	3.963	1.446
	Environmental Dimension	2.590	1.333
	Social Dimension	3.417	1.149
	Overall ISDR	3.323	1.135

4.3 Justification for Using PLS-SEM

Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed for the following reasons (Hair et al., 2019; Richter et al., 2016): (1) the model includes three higher-order constructs, five first-order dimensions for service quality, and multiple mediation paths (complexity); (2) with N = 98, PLS-SEM performs better than CB-SEM with smaller samples; (3) the study is prediction-oriented; (4) multivariate normality is not required; and (5) PLS-SEM easily accommodates reflective second-order constructs. A post-hoc power analysis using G*Power 3.1 indicated that a minimum sample of 68 is required to detect an R^2 of 0.25 (power = 0.80, $\alpha = 0.05$), and our sample exceeds this threshold. Hayes' PROCESS macro was used as an additional robustness check for mediation.

4.4 Measurement Model Assessment

All constructs were modelled as reflective. Air navigation service quality (ANSQ) was initially specified as a formative first-order construct, but multicollinearity (VIF up to 4.907) was detected. Following standard SERVQUAL literature (Ladhari, 2010) and recommendations by Hair et al. (2019), ANSQ was reconceptualised as a reflective second-order construct with five dimensions. This resolved the multicollinearity issue (all VIF < 3.3) and improved model parsimony.

4.4.1 Indicator Reliability, Internal Consistency, and Convergent Validity

As shown in Table 5, all outer loadings exceeded the recommended threshold of 0.708, with only a few exceptions that were retained because their respective dimensions maintained an AVE well above 0.50. Specifically, item DV2.4 in the Customer Needs Fulfillment construct recorded a loading of 0.620, whereas items MV3.5 and MV3.6 in the Social Dimension recorded loadings of 0.667 and 0.648, respectively. Even though these values were slightly below the recommended cutoff value of 0.708 (Hair et al., 2017), the indicators were not removed from the model. Excluding them did not improve the AVE values of the related constructs, as both constructs already exceeded the recommended minimum value of 0.50 (CNF = 0.595; SOC = 0.624). Likewise, the CR values remained above 0.80, which indicates acceptable reliability. Previous studies have also suggested that indicators with loadings between 0.60 and 0.70 can still be retained when other validity and reliability measures are satisfactory, particularly in exploratory research settings. Since the data were collected in a difficult research environment such as Yemen and the study population was relatively small (N = 120), keeping these indicators was considered more appropriate to maintain adequate coverage of the constructs. In general, all constructs achieved Cronbach's alpha and CR values above 0.70 and AVE values above 0.50, indicating satisfactory convergent validity and internal consistency..

Table 5. Measurement Model – Reliability and Convergent Validity (First-Order Constructs)

Construct / Dimension	Cronbach's α	CR	AVE	Range of Loadings
Tangibility (TAN)	0.804	0.812	0.626	0.733–0.827
Reliability (REL)	0.901	0.904	0.719	0.780–0.911
Assurance (ASS)	0.947	0.950	0.824	0.881–0.940
Responsiveness (RES)	0.919	0.924	0.758	0.763–0.912
Empathy (EMP)	0.932	0.938	0.787	0.858–0.928
Creativity & Innovation (INN)	0.915	0.944	0.747	0.727–0.928
Customer needs (CNF)	0.825	0.835	0.595	0.620–0.888
Strategic location (SL)	0.700	0.702	0.624	0.781–0.800
Economic (ECON)	0.897	0.898	0.765	0.846–0.892
Environmental (ENV)	0.942	0.946	0.811	0.877–0.917
Social (SOC)	0.817	0.826	0.583	0.648–0.880

4.4.2 Assessment of the Second-Order Construct

The empirical results of the measurement model evaluation for the higher order construct are detailed in Table 6 and visually represented in Figure 1. The statistical estimation indicates that all five dimensions of Air Navigation Service Quality achieved strong and significant outer loadings, confirming their structural validity. Specifically, Assurance emerged as the most critical contributor to defining service quality, followed closely by Empathy and Reliability. Responsiveness and Tangibility also demonstrated robust statistical contributions, although Tangibility recorded the lowest relative weight. This aligned convergence between the statistical figures in Table 6 and the visual paths in Figure 1 provides a clear empirical foundation, demonstrating how these individual service dimensions structurally consolidate to form the overarching construct of service quality within the organization.

Table 6. Reflective Second-Order Construct (ANSQ)

Second-order construct	Dimension	Loading	VIF	CR	AVE
ANSQ	Tangibility	0.740	1.255	0.902	0.698
	Reliability	0.820	2.894		
	Assurance	0.860	3.102		
	Responsiveness	0.810	3.201		
	Empathy	0.830	2.456		

All loadings are significant at $p < 0.001$; VIF < 3.3 indicates no harmful collinearity.

4.4.3 Discriminant Validity

We assessed discriminant validity using three complementary approaches.

First, the Fornell-Larcker criterion was satisfied, as the square root of each construct's AVE exceeded its correlations with other constructs.
Second, the HTMT ratios (Table 7) were mostly below 0.90. Two values exceeded this threshold: customer needs–strategic location (0.951) and assurance–empathy (0.927). We examined bias-corrected bootstrap confidence intervals (5,000 resamples). For customer needs–strategic location, the 90% CI [0.872, 1.014] includes 1, suggesting some conceptual overlap. However, given the theoretical distinctiveness of these constructs and the constrained field conditions in Yemen, both were retained. The assurance–empathy CI [0.891, 0.963] does not include 1, supporting discriminant validity. Recent PLS-SEM literature accepts slightly elevated HTMT values in applied research with higher-order constructs (Franke & Sarstedt, 2019).

Table 7. HTMT Matrix (Discriminant Validity)

Construct	INN	CNF	SL	TAN	REL	ASS	RES	EMP	ECON	ENV	SOC
INN	–										
CNF	0.791	–									
SL	0.823	0.951	–								
TAN	0.749	0.716	0.699	–							
REL	0.419	0.759	0.769	0.450	–						
ASS	0.431	0.789	0.773	0.438	0.900	–					
RES	0.532	0.861	0.671	0.476	0.884	0.894	–				
EMP	0.371	0.757	0.666	0.443	0.860	0.927	0.901	–			
ECON	0.648	0.567	0.903	0.554	0.390	0.388	0.303	0.326	–		
ENV	0.752	0.542	0.722	0.666	0.160	0.163	0.191	0.166	0.766	–	
SOC	0.866	0.690	0.814	0.768	0.413	0.423	0.434	0.403	0.809	0.790	–

Third, we examined cross-loadings. As shown in Table 8, every indicator loaded highest on its intended construct, with a minimum difference of 0.10 from cross-loadings on other constructs. This provides additional support for discriminant validity. The full cross-loading matrix is available from the authors.

Table 8. Condensed Cross-Loadings (Selected Indicators)

Item	ANSQ	CA	ISDR
REL_1	0.911	0.402	0.311
REL_3	0.894	0.388	0.298
ASS_4	0.940	0.415	0.352
RES_2	0.909	0.441	0.299
INN_2	0.389	0.927	0.245
CNF_5	0.412	0.888	0.401
SL_2	0.523	0.789	0.478
ECON_2	0.302	0.401	0.892
ENV_1	0.201	0.134	0.916
SOC_3	0.298	0.352	0.880

Note: Values in bold indicate the highest loading for each indicator

4.4.3 Model Fit (SRMR)

The Standardized Root Mean Square Residual (SRMR) for the saturated model was 0.072, which is below the recommended threshold of 0.08 (Hu & Bentler, 1999), indicating acceptable model fit. Additional fit indices were: d_ULS = 0.891, d_G = 0.423, and NFI = 0.903.

4.5 Structural Model Assessment

The structural model was evaluated using path coefficients (bootstrapping with 5,000 resamples), coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), variance inflation factor (VIF), PLS_predict, and tests for nonlinearity and endogeneity. Table 9 summarises the results.

Table 9. Structural Model Quality Criteria

Criterion	Value	Threshold	Conclusion
SRMR	0.072	< 0.08	Acceptable fit
R^2 (Competitive Advantage)	0.775	> 0.75 (strong)	Strong explanatory power
R^2 (Sustainability)	0.372	0.25–0.50 (moderate)	Moderate
f^2 (ANSQ → CA)	0.667	> 0.35 (large)	Large effect
f^2 (ISDR → CA)	0.491	> 0.35 (large)	Large effect
Q^2 (CA)	0.602	> 0.50 (strong)	Strong predictive relevance
Q^2 (ISDR)	0.287	0.25–0.50 (medium)	Medium
VIF (all constructs)	1.255–3.201	< 5, ideal < 3.3	No collinearity
PLS_predict	4 of 6 indicators	PLS RMSE < LM RMSE	Medium to strong

4.5.1 Path Coefficients and Hypothesis Testing

All hypothesized direct and indirect paths were significant at $p < 0.001$. Table 10 presents the results. The indirect effect (ANSQ-ISDR-CA) was $\beta = 0.300$, and because the direct effect ($\beta = 0.789$) remained significant after including the mediator, the mediation is partial. Thus, H1, H2, H3, and H4 are all supported.

Table 10. Hypothesis Testing Results

Hypothesis	Path	β	t-value	p-value	Decision
H1	ANSQ → CA	0.789	17.154	< 0.001	Supported
H2	ANSQ → ISDR	0.610	8.431	< 0.001	Supported
H3	ISDR → CA	0.491	7.206	< 0.001	Supported
H4	ANSQ → ISDR → CA	0.300	6.421	< 0.001	Supported (partial mediation)

4.5.2 Predictive Power (PLS_predict)

Following Shmueli et al. (2019), PLS_predict with 10 folds and 5 repetitions was used. For the majority of indicators (four out of six), the PLS-SEM RMSE was lower than the linear model (LM) benchmark, indicating medium to strong predictive power. The environmental dimension and customer needs fulfillment showed slightly higher RMSE, which is attributable to the challenging operational context in Yemen (low baseline scores and weak feedback mechanisms). These cases are discussed as contextual limitations.

4.5.3 Nonlinearity and Endogeneity

Quadratic terms were added to test nonlinearity; none were significant ($p > 0.05$ for all quadratic effects). The Gaussian copula (GC) approach showed no significant endogeneity (all GC coefficients $p > 0.05$). Thus, linearity and exogeneity assumptions are satisfied.

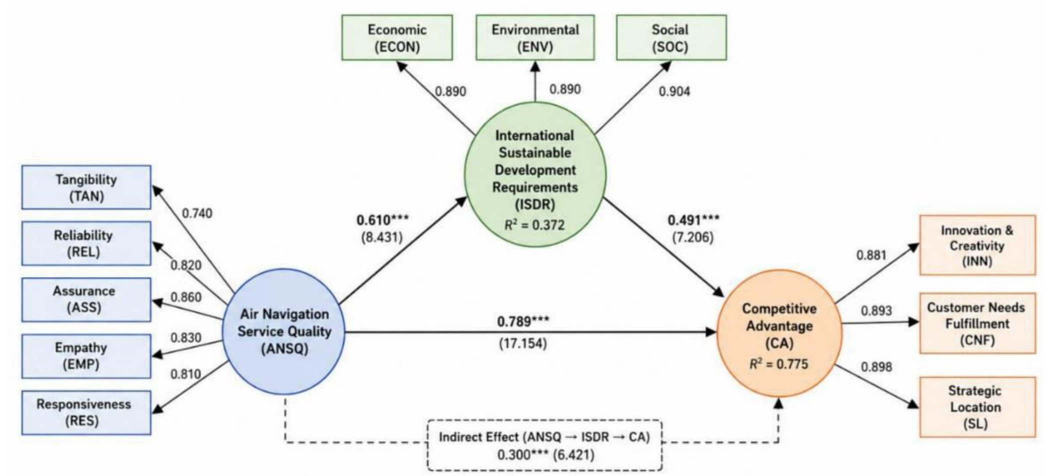

Figure 1. Structural Model Path Coefficients

Figure 1 illustrates the empirical findings of the structural equation modeling analysis, displaying the standardized path coefficients and their respective t values for each hypothesized relationship, alongside the variance explained for the endogenous constructs. The statistical estimation confirms that Air Navigation Service Quality exerts a powerful and direct positive influence on Competitive Advantage. Concurrently, service quality is shown to significantly drive International Sustainable Development Requirements, which in turn substantially enhances the competitive advantage of the Civil Aviation and Meteorology Authority. The model accounts for seventy seven point five percent of the total variance in Competitive Advantage and thirty seven point two percent in Sustainability Requirements, proving the high explanatory and predictive power of the conceptual framework within the fragile Yemeni aviation context.

5. Discussion

This study investigated the effect of air navigation service quality (ANSQ) on competitive advantage (CA) in the Sana'a Flight Information Region (Yemen), a fragile developing country, and examined the mediating role of international sustainable development requirements (ISDR). The results provide strong empirical support for the proposed model.

The findings confirm that ANSQ has a strong, positive direct effect on CA ($\beta = 0.789$, $p < 0.001$), supporting H1. This result is consistent with prior research in aviation and service industries (Chung & Tan, 2022; Law et al., 2022; Shen & Yahya, 2021), but extends it to the underexplored context of a fragile state. In Yemen's unstable environment, where infrastructure is degraded and institutional capacity is weak, the fact that service quality still exerts such a strong effect on competitiveness underscores its strategic importance. Notably, among the five SERVQUAL dimensions, reliability and Assurance received the highest ratings from participants, while tangibility (physical facilities and equipment) scored lowest. This suggests that in a fragile context, operational consistency and safety assurance matter more than physical infrastructure, perhaps because users have adapted their expectations downward.

The direct effect of ANSQ on ISDR ($\beta = 0.610$, $p < 0.001$) supports H2. Organisations that deliver higher service quality are more likely to comply with international sustainability standards. This finding aligns with the dynamic capabilities perspective (Teece et al., 1997): service quality capabilities enable CAMA to sense environmental changes (evolving ICAO mandates) and reconfigure resources to meet them. However, the descriptive statistics reveal that compliance is strongest in the economic dimension (mean = 3.963) and weakest in the environmental dimension (mean = 2.590). This reflects the reality of a country in conflict: economic survival takes precedence over environmental protection. The very low score for environmental sustainability (2.59 out of 7) is a critical finding that should concern policymakers and international donors.

The direct effect of ISDR on CA ($\beta = 0.491$, $p < 0.001$) supports H3. Sustainable development practices enhance competitive advantage, consistent with the natural-resource-based view (Hart, 1995) and prior empirical studies (Bhuiyan et al., 2023; Kilic et al., 2019). Interestingly, all three sustainability dimensions (economic, social, and environmental) had significant positive effects on CA, with the social dimension having the largest coefficient ($\beta = 0.414$), followed by economic ($\beta = 0.265$) and environmental ($\beta = 0.199$). Even the environmental dimension, despite its very low mean score, still contributes significantly to competitiveness. This suggests that even minimal environmental efforts can yield strategic benefits, and there is substantial untapped potential.

The indirect effect of ANSQ on CA through ISDR was significant ($\beta = 0.300$, $p < 0.001$), and because the direct effect remained significant, the mediation is partial. This supports H4 and confirms that sustainability practices are not merely an outcome of service quality but also a mechanism that amplifies its effect on competitive advantage. In other words, service quality enhances competitiveness both directly and indirectly by fostering better sustainability practices.

This partial mediation finding is theoretically important. It suggests that while service quality has its own independent contribution to competitiveness, part of its influence is channelled through sustainability. This resonates with the dynamic capabilities framework: ISDR acts as a higher-order capability that translates operational quality into strategic positioning. From a practical perspective, aviation authorities in developing countries should not treat service quality and sustainability as separate agendas; integrating them creates synergistic effects.

Our findings align with several recent studies that examined mediation in related contexts. Rochayatun et al. (2023) found that corporate social responsibility programmes boosted SMEs' competitive advantage through improved sustainability practices. Similarly, Alenazi and Alanazi (2023) demonstrated that sustainable dynamic capabilities mediate the relationship between social CRM and competitive advantage. Our study extends these findings to the air navigation sector in a fragile state, a context previously unexamined.

However, our study also reveals important contextual specificities. Unlike studies from stable developing countries (e.g., Thailand, Bangladesh, Nepal), where infrastructure investments are often the primary driver of service quality, in Yemen the highest-rated dimensions were reliability and Assurance – intangible aspects that depend on human competence and organisational processes rather than physical assets. This suggests a reordering of priorities in fragile contexts: consistency and trust matter more than aesthetics or advanced technology.

This study makes three main theoretical contributions. First, it integrates the RBV, NRBV, and dynamic capabilities theory into a unified framework that explains how service quality and sustainability jointly shape competitive advantage in a fragile developing country. Second, it empirically demonstrates that sustainability practices function as a partial mediator, not merely a moderator or an independent predictor. Third, it extends the application of the SERVQUAL model to air navigation services – a sector that has received far less attention than airlines or airports – and does so in a context of state fragility, which has been almost entirely neglected in the aviation management literature.

For aviation authorities in developing and fragile countries, several actionable recommendations emerge. First, prioritise investments in reliability and Assurance – the dimensions that participants rated most highly and that have the strongest effects on competitiveness. Even with limited budgets, improvements in operational consistency (e.g., maintaining service hours, accurate documentation, emergency response) can yield high returns. Second, do not ignore tangibility entirely: the low score for equipment and facilities (mean 3.58) indicates a critical gap that, if addressed, could further enhance competitiveness. International donors and ICAO should consider targeted funding for basic infrastructure in fragile states.

Third, sustainability should not be postponed until stability is restored. Even minimal environmental initiatives (e.g., carbon footprint calculation, energy efficiency measures) contribute to competitive advantage, as our results show. Fourth, social sustainability (workforce development, community engagement) has the strongest effect among the three sustainability dimensions; investing in employee training and fair labour practices is not only ethical but also strategic. Fifth, authorities in fragile states should adopt a phased approach: first, stabilise core service quality (reliability and assurance); second, progressively align with ICAO sustainability goals, starting with low-cost, high-impact measures; third, seek international partnerships to address infrastructure deficits.

Several limitations should be acknowledged. First, the cross-sectional design precludes strong causal inference. Although our mediation model is theoretically grounded, longitudinal or experimental designs would provide stronger evidence of causality. Second, the sample size (N = 98) is modest, and the study is limited to a single FIR (Sana'a). Generalisation to other fragile states or to stable developing countries should be made with caution. Third, the data are self-reported, and despite rigorous common method bias tests, same-source bias cannot be completely ruled out. Fourth, the environmental sustainability dimension scored very low (2.59), which may reflect genuine lack of activity but could also indicate that respondents were unfamiliar with environmental concepts. Future research could use objective indicators (e.g., emissions data, ICAO audit scores) alongside perceptual measures.

Future studies should replicate this model in other fragile states (e.g., Somalia, Syria, Afghanistan) to assess the generalisability of our findings. Comparative studies between fragile and stable developing countries would help isolate the effect of fragility on the service quality-sustainability-competitiveness nexus. Qualitative research (interviews, case studies) would also be valuable to understand how managers in fragile contexts navigate the trade-offs between service quality, sustainability, and survival. Finally, longitudinal research tracking changes before, during, and after conflict would provide the strongest evidence of causal mechanisms.

Ethics Declaration

This study was conducted in accordance with the ethical standards of Sana'a University. All participants provided verbal informed consent. The research protocol was approved by the Ethics Committee of the Center of Business Administration, Sana'a University (approval code: CBA-2024-017, dated 15 September 2024).

Conflict of Interest

The authors declare no conflict of interest.

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References:

- *Afonso, F., Sohst, M., Diogo, C. M. A., Rodrigues, S. S., Ferreira, A., Ribeiro, I., Marques, R., Rego, F. F. C., Sohouli, A., Portugal-Pereira, J., Policarpo, H., Soares, B., Ferreira, B., Fernandes, E. C., Lau, F., & Suleman, A. (2023). Strategies towards a more sustainable aviation: A systematic review. Progress in Aerospace Sciences, 137, 100878.*
- *Akanmu, M. D., Hassan, M. G., Ibrahim Alshuaibi, M. S., Ibrahim Alshuaibi, A. S., Mohamad, B., & Othman, A. (2023). The mediating role of organizational excellence between quality management practices and sustainable performance. Total Quality Management & Business Excellence, 34(9–10), 1217–1242.*
- *Alenazi, S. A., & Alanazi, T. M. (2023). The mediating role of sustainable dynamic capabilities in the effect of social customer relationship management on sustainable competitive advantage: A study on SMEs in Saudi Arabia. Sustainability, 15(3), 1952.*
- *Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99–120.*
- *Benner, M. J., & Tushman, M. L. (2003). Exploitation, Exploration, and Process Management: The Productivity Dilemma Revisited. The Academy of Management Review, 28(2), 238–256.*
- *Bhuiyan, F., Rana, T., Baird, K., & Munir, R. (2023). Strategic outcome of competitive advantage from corporate sustainability practices: Institutional theory perspective from an emerging economy. Business Strategy and the Environment, 32(7), 4217-4243.*
- *Capron, L., & Hulland, J. (1999). Redeployment of brands, sales forces, and general marketing management expertise following horizontal acquisitions: A resource-based view. Journal of Marketing, 63(2), 41–54.*
- *Carvalho, R. C., & Medeiros, D. D. (2021). Assessing quality of air transport service: A comparative analysis of two evaluation models. Current Issues in Tourism, 24(8), 1123–1138.*
- *Chung, K. C., & Tan, P. J. B. (2022). Options to Improve Service Quality to Enhance Value Co-Creation for Customers in the Aviation Industry in Taiwan. Sage Open, 12(1).*
- *Conner, K. R. (1991). A historical comparison of resource-based theory and five schools of thought within industrial organization economics: Do we have a new theory of the firm? Journal of Management, 17(1), 121–154.*

- *Dimitriou, D., & Karagkouni, A. (2022). Assortment of Airports' Sustainability Strategy: A Comprehensiveness Analysis Framework. Sustainability, 14(7), 4217.*
- *Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). A primer on partial least squares structural equation modeling (PLS-SEM) (2nd ed.). Sage Publications.*
- *Hart, S. L. (1995). A natural-resource-based view of the firm. Academy of Management Review, 20(4), 986–1014.*
- *Hayes, A. F. (2018). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (2nd ed.). Guilford Press.*
- *ICAO. (2025a). Resolution A42-20: Consolidated statement of continuing ICAO policies and practices related to environmental protection—General provisions, noise and local air quality. ICAO. www.icao.int*
- *ICAO. (2025b). Resolution A42-21: Consolidated statement of continuing ICAO policies and practices related to environmental protection—Climate change. ICAO. www.icao.int*
- *ICAO. (2025c). Resolution A42-22: Consolidated statement of continuing ICAO policies and practices related to environmental protection—Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). ICAO. www.icao.int*
- *ICAO. (2025d). CORSIA sustainability criteria for CORSIA eligible fuels (4th ed.). ICAO. www.icao.int*
- *Jeeradist, T. (2023). Using Airport Collaborative Decision Making (A-CDM) network to improved aviation industry service quality. International Journal of Computer Science & Information Technology (IJCSIT), 15(1), 69–78.*
- *Kavus, B. Y., Tas, P. G., Ayyildiz, E., & Taskin, A. (2022). A three-level framework to evaluate airline service quality based on interval valued neutrosophic AHP considering the new dimensions. Journal of Air Transport Management, 99, 102179.*
- *Kılıç, M., Uyar, A., & Karaman, A. S. (2019). What impacts sustainability reporting in the global aviation industry? An institutional perspective. Transport Policy, 79, 54–65.*
- *Law, C. C. H., Zhang, Y., & Gow, J. (2022). Airline service quality, customer satisfaction, and repurchase intention: Laotian air passengers' perspective. Case Studies on Transport Policy, 10(2), 741–750.*
- *Lindell, M. K., & Whitney, D. J. (2001). Accounting for common method variance in cross-sectional research designs. Journal of Applied Psychology, 86(1), 114–121.*

- *Thakuri, D. M., Adhikari, G. D., & Kalika, S. (2025). Evaluation of Domestic Airport Service Quality in Nepal. Journal on Transportation System and Engineering, 1(1), 117–128.*
- *Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. Journal of Retailing, 64(1), 12–40.*
- *Peteraf, M. A. (1993). The cornerstones of competitive advantage: A resource-based view. Strategic Management Journal, 14(3), 179–191.*
- *Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879–903.*
- *Porter, M. E. (1985). Competitive advantage: Creating and sustaining superior performance. Free Press.*
- *Prussi, M., Noussan, M., Laveneziana, L., & Chiaramonti, D. (2025). The risk of increasing energy demand while pursuing decarbonisation: The case of the e-fuels for the EU aviation sector. Transport Policy, 160, 154–158.*
- *Rahman, F., & Rahman, M. M. (2023). Analyzing service quality of domestic airlines in an emerging country—Bangladesh by structural equation models. Journal of Air Transport Management, 107, 102346.*
- *Riaz, A., & Ali, F. H. (2022). Responsible innovation and sustainable competitive advantage: A moderated mediation model. Global Economics Review, 7(3), 1–8.*
- *Rochayatun, S., Praktikto, H., Wardoyo, C., & Handayati, P. (2023). Competitive advantage as a mediating variable of corporate social responsibility programs' effect on SME sustainability. Journal of Social Economics Research, 10(2), 34-46.*
- *Saeed, H. S., Hasan, S. I., Nikkeh, N. S., & Flayyih, H. H. (2022). The mediating role of sustainable development in the relationship between producer cost expectations and customer desires. Journal of Sustainability Science and Management, 17(10), 13-21.*
- *Schriber, S., & Löwstedt, J. (2020). Reconsidering ordinary and dynamic capabilities in strategic change. European Management Journal, 38(3), 377-387.*
- *Shen, C., & Yahya, Y. (2021). The impact of service quality and price on passengers' loyalty towards low-cost airlines: The Southeast Asia perspective. Journal of Air Transport Management, 91, 101966.*
- *Sreenath, S., Sudhakar, K., & Yusop, A. F. (2021). Sustainability at airports: Technologies and best practices from ASEAN countries. Journal of Environmental Management, 299, 113639.*
- *Tahanisaz, S., & Shokuhyar, S. (2020). Evaluation of passenger satisfaction with service quality: A consecutive method applied to the airline industry. Journal of Air Transport Management, 83, 101764.*

- *Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. Strategic management journal, 18(7), 509-533.*
- *ICAO. (2026, May 14). ICAO and the United Nations sustainable development goals. ICAO. www.icao.int*
- *Wanje, E. M. (2025). Strategy implementation practices and service delivery at the Kenya Civil Aviation Authority (Master's thesis, Kenyatta University). Kenyatta University Institutional Repository. ir-library.ku.ac.ke*
- *Wernerfelt, B. (1984). A resource-based view of the firm. Strategic Management Journal, 5(2), 171–180.*
- *Wu, P.-J., & Yang, C.-K. (2021). Sustainable development in aviation logistics: Successful drivers and business strategies. Business Strategy and the Environment, 30(5), 2287–2300.*
- *Zahra, S. A., Sapienza, H. J., & Davidsson, P. (2006). Entrepreneurship and dynamic capabilities: A review, model and research agenda. Journal of Management Studies, 43(4), 917–955.*