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THE LINK BETWEEN AIR CARGO AND INTERNATIONAL TRADE: EVIDENCE FROM INDIA AND OTHER SOUTH ASIAN COUNTRIES

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ABSTRACT

When it comes to the value of goods, air cargo transportation is one of the most important ways to move them. However, the connection between air cargo transportation and international trade has been overlooked in the Indian and South Asian context. This study adds to the body of research by examining the relationship between these variables within a regional sample group. The goal of this study is to examine the various ways in which air freight transportation and international trade are interconnected in India and South Asian countries. Data on global trade through merchandise exports (ME) and air cargo (AC) for India and eight South Asian partner countries from 2000 to 2023 are examined. This study employed cointegration and short- and long-run tests to establish a causal relationship between the variables. The results of the Pedroni cointegration test indicate that AC may exert a long-term influence on ME in the South Asian region (Pedroni, 1999, 2004). The impact of ME on AC is substantial in the short term (Dumitrescu & Hurlin, 2012). The Dumitrescu and Hurlin (2012) panel Granger causality test results indicate homogeneous bidirectional causality from AC to ME and from ME to AC. In analyses conducted on a country-by-country basis, causality from ME to AC is present in six countries, causality towards ME is statistically identified in seven countries, and bidirectional causality is observed in three countries. The results have significant ramifications for policymakers, air freight operators, and trade policy strategists in the region (World Bank, 2024; International Air Transport Association, 2024; Ministry of Civil Aviation, India, 2023).

Key terms: Air cargo, international trade, panel causality, error correction models, air freight transportation, and South Asia.

1. INTRODUCTION

The growth of international trade is crucial for enhancing countries' competitiveness and fostering economic growth. David Ricardo's theory of comparative advantage states that countries that are more efficient at producing a particular product will specialise in its production and sell it to other countries. This will lead to greater overall production and trade. Trade conflicts and protectionist policies have been employed to safeguard domestic industries and reduce trade deficits; however, international trade is crucial for enhancing society's well-being and alleviating poverty. When goods are sent to another country as part of international trade, they are usually shipped by sea. One of the most cost-effective ways to move large amounts of goods is by sea. The value of goods imported and exported is one of

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the most important factors that people consider when evaluating the performance of foreign trade.

Air freight transport does not carry a large volume of cargo, but it does carry a substantial amount of cargo by value. According to the International Air Transport Association (IATA), only 1% of the goods traded globally are shipped by air freight. However, 35% of the value of those goods is shipped by air freight. Air cargo plays a crucial role in transporting high-value goods in global trade. It enables the movement of goods worth more than $6 trillion (IATA, 2024). As India becomes a major global manufacturing and trading centre, air cargo transportation has become increasingly important. India's air cargo industry has demonstrated remarkable resilience, recovering quickly from the COVID-19 pandemic. By 2023, cargo volumes had reached 3.3 million tonnes (IATA, 2024). Therefore, air cargo transportation is crucial for moving high-value goods that are both safe and secure; however, time constraints can also influence this process. Additionally, air cargo is the fastest way to deliver humanitarian aid to affected areas following natural disasters, epidemics, and earthquakes. Therefore, it is crucial for South Asian countries.

Countries' economies grow when air freight transportation is fast and safe (Bartulovic et al., 2022; Chang & Ying, 2008). Air freight makes it easier for countries to trade with each other by moving high-value goods like pharmaceuticals, electronics, and car parts. India has a lot of advantages in these areas (Gong et al., 2018). There is a strong link between the total value of trade and air freight connectivity. According to IATA (2016), a 1% rise in air freight connectivity results in a 6.3% rise in total exports and imports. In this situation, air freight transportation and total trade are expected to have a reciprocal causality relationship. This is a reasonable assumption because as more goods are moved by air freight, countries' foreign trade will also grow. Nonetheless, this assumption requires validation through scientific evidence. A multitude of studies in the literature have investigated the correlation between air transportation and economic growth (GDP) (Chi & Baek, 2013; Gelhausen et al., 2018; Kaya & Aydın, 2024; Marazzo et al., 2010; Zhang & Graham, 2020). Nonetheless, a restricted number of studies have investigated the correlation between air freight transportation and international trade, especially within the South Asian regional framework. This study aims to analyze the relationship between air freight transportation and international trade in both the short and long term, utilizing a sample of South Asian countries.

The link between air freight transportation and international trade may vary across different South Asian countries. The direction and strength of the relationship between air freight transportation and international trade can be influenced by several factors, including the types of goods a country exports, the volume of trade it conducts, the diversity of its regional trading partners, and the level of development of its air freight transportation infrastructure. The number and size of airports, cargo terminals, and logistics infrastructure are all important factors that influence the effectiveness of air freight transportation. The four biggest airports in India-Delhi, Mumbai, Bangalore, and Chennai-handle about 80% of the country's air cargo (Directorate General of Civil Aviation [DGCA], 2023; Indian Council of Research on International Economic Relations [ICRA], 2024). The distance between a country and its most important export markets can significantly impact the use of air freight transportation. India's strategic location and growing importance in global supply chains, particularly since production has shifted away from China (World Bank, 2023), make this study highly timely. The performance of air freight transportation is also influenced by a country's level of development and its geographical location. Many factors influence the strength and direction of the relationship between air freight transportation and international trade. This study aims to elucidate the correlation between air freight transportation and international trade by

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analysing South Asian nations that share similar geographical positions, regional trade agreements, and diverse developmental stages.

Regional trade agreements and globalisation have made it easier for South Asia to move large amounts of goods and services across international borders. The air freight industry has become one of the most internationalised sectors in South Asia, thanks to the successful integration of trade markets in the region

Chang & Ying, 2008). Trade agreements, such as BIMSTEC and SAARC, as well as bilateral Air Services Agreements (BASAs) between countries, have made the air freight transportation market more competitive (SAARC Secretariat, 2023; Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation [BIMSTEC], 2023). Therefore, countries can modify their business practices with other nations by utilising air freight transportation, which is faster and safer. Nonetheless, the relationship between air freight transportation and international trade has not been adequately explored in the current literature, particularly in the context of South Asian and India.

A geographical examination of the correlation between air freight transportation and international trade in South Asia can enhance understanding of the regional economy's dynamics and inform the reformulation of trade policies related to air freight logistics. Investigating the potential of enhanced air freight services to stimulate trade growth through modifications in trade terms (Chang & Ying, 2008) within a South Asian context can yield essential insights into the future trajectory and scale of air freight trade. Examining the duration of the relationship between air freight transportation and international trade, as well as identifying countries where this relationship is stronger, can help determine which markets are more competitive and which require infrastructure investment. Furthermore, the inquiry into whether the causal relationship between air freight transportation and international trade is unidirectional or reciprocal constitutes a hypothesis that merits investigation, as the nature of this relationship may inform policymakers in the region in formulating targeted policies. India's National Civil Aviation Policy (NCAP, 2016) and new programs, such as Krishi UDAN (Ministry of Civil Aviation, 2016, 2024), demonstrate the importance of understanding these connections. Considering all these factors, this study analyses the correlation between air freight transportation and international trade from multiple viewpoints.

The study aims to examine the relationship between air freight transportation and international trade, using a regional sample of South Asian countries. The study's contributions to the literature can be summarised as follows: Firstly, in contrast to the scarce studies that investigate the relationship between air freight/air cargo transportation and international trade, this study employs an extensive dataset encompassing India and eight prominent South Asian countries across varying income levels from 2000 to 2023. Consequently, this study distinguishes itself from other literature by its specific regional emphasis on South Asia and India. Second, this study examined how the variables interacted with each other over time, both in the short and long term. Consequently, this study examines the short- and long-term impacts of air cargo transportation on international trade, utilising an extensive dataset. Finally, we take into account the differences in countries' levels of development and regional characteristics when analysing panel data to eliminate specification errors and biased estimates.

The remainder of this study empirically investigates the correlation between air freight transportation and international trade in South Asia, as outlined below. The literature review

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is in the second part of the study. The third part has data information and methods. The fourth part has the real-world results. The final section of the study is the discussion and conclusion.

2. REVIEW OF THE LITERATURE

Over the past decade, there has been a significant increase in research on the air transportation industry in South Asia. The air transportation industry has been the focus of academic research due to its rapid growth, changes in market dynamics following regional trade liberalisation, and the emergence of new business models. As a result, numerous scientific studies are emerging in this field of academic research. Researchers conduct bibliometric and systematic analyses to examine the trajectory of literature in the air transport industry and its correlation with economic development (Bakır et al., 2022; Falcão et al., 2021; Tanrıverdi et al., 2020; Wang & Gao, 2021; Yakath Ali et al., 2021).

The air transportation industry and economic growth are closely linked. Investing in infrastructure in the air transportation industry and the potential for aviation to create jobs both contribute to countries' economic growth. As a result, as countries' economies grow and their GDP rises, the need for air travel grows. Numerous studies in the literature have investigated the correlation between the air transportation sector and economic development (Ali et al., 2023; Balsalobre-Lorente et al., 2021; Carbo & Graham, 2020; Choi, 2023; Kaya & Aydın, 2024; Tolcha et al., 2020; Zhang & Graham, 2020).

Conversely, there exists a scarcity of studies investigating the correlation between air freight/cargo transportation and macroeconomic variables in the South Asian context. Button and Yuan (2013) examined the impact of air freight transportation on development in the US at both local and regional levels. The study's findings indicated that air freight transportation is a beneficial catalyst for local economic development. Akinyemi (2023) examined the impact of macroeconomic factors, including income, merchandise trade, foreign direct investment, and interest rates, on the demand for air cargo in African countries. He discovered that gross domestic product per capita has a significant influence on air cargo demand in both the short term and the long term. Njoya et al. (2023) examined the impact of air cargo activities on per capita income and human capital in developing regions. They discovered that a rise in air cargo activity enhances value-added production across multiple sectors and alleviates poverty. Zhou et al. (2022) examined the impact of macroeconomic variables, such as gross domestic product per capita and employment, on air cargo. According to the theory of economic growth, researchers found that air cargo activities have a significant impact on trade growth and job creation in China. Nath and Upadhyay (2024) examined the specific challenges faced by air cargo terminals in India and their utilisation of air cargo in various scenarios.

Air freight and air cargo transportation are very similar. Air freight transportation is the general term for moving goods by air, while air cargo transportation refers specifically to the goods that are moved during this process. Air freight transportation and air cargo transportation are analysed, given the scarcity of studies on these concepts in South Asian literature, where they are frequently used interchangeably in most research. Other studies in the air freight literature have examined the environmental, societal, and economic benefits of long-term air freight (Bartle et al., 2021; Drljača et al., 2020). The function and evolution of air freight within intermodal supply chains have been examined (Bartulovic et al., 2022). Researchers have examined the growth of the air freight market, its role in various markets, and the challenges it may face (Alexander & Merkert, 2017; Reynolds-Feighan, 1994; Walcott & Fan, 2017). There has been an increase in research examining India's role in

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regional air cargo networks and South Asian connectivity (Karunathilake & Fernando, 2024; Nguyen et al., 2024).

A restricted number of studies investigate the correlation between air freight/cargo transportation and international trade in South Asia. Chang and Ying (2008) examined the correlation among trade openness, air freight, and GDP per capita. The study's empirical findings indicated that trade and air freight shocks have a significant impact on real GDP per capita. Kupfer et al. (2011) investigated the correlation between air freight and merchandise trade. The analysis revealed a two-way, positive relationship between air freight and merchandise trade. Gong et al. (2018) examined the primary factors influencing China's international trade via air freight transportation, elucidating significant mechanisms of trade-transport interaction. Kiracı and Akan (2020) analysed the interplay among trade wars, trade restrictions, and air transportation, yielding insights pertinent to the comprehension of trade volatility. Tan and Tsui (2016) examined the interplay between air freight trade and business travel in Australia, identifying a substantial causal relationship between the two. Grosso and Shepherd (2011) examined the correlation between air cargo transportation and the enhancement of bilateral trade in goods within the Asia Pacific region. Hong et al. (2024) examined the agility of the air cargo industry within the framework of digital transformation for hub airports in recent studies. Nguyen et al. (2024) focused on modelling and forecasting air cargo traffic in Southeast Asia, providing insights relevant to India's growing role in regional networks.

3. DATA INFORMATION

The secondary data on air freight transportation and international trade for India and eight South Asian countries (Bangladesh, Nepal, Pakistan, Sri Lanka, India, Afghanistan, Bhutan, and the Maldives) has been collected from the World Bank's World Development Indicators database (World Bank, 2024), the International Air Transport Association (IATA) databases (IATA, 2024), and National Civil Aviation Authority statistics (DGCA, 2024) for the years 2000 to 2023 (23 years). When examining the relationship between air freight transportation and international trade, this study aimed to include as many countries and years as possible. Air freight transportation has become increasingly important since the SAARC and BIMSTEC frameworks facilitated more open regional trade in the 2000s. The link between air freight transportation and international trade in the short and long term has been examined for countries with similar geography but differing economic sizes and levels of development.

The data on merchandise exports (in current US dollars) (ME) for international trade and air transport, as well as freight (in million ton-km) (AC) for air cargo transportation, have been used for this study. In this study, "air transport, freight" is referred to as "air cargo," a term also used by the International Air Transport Association (IATA) and the International Air Cargo Association (IACA). To facilitate long-term panel relationships and reduce data variability, all variables are expressed in natural logarithm form.

Table 1 presents the descriptive statistics for the data sourced from the World Development Indicators and national civil aviation sources. The average for the past 23 years for merchandise exports (in current US dollars) and air transport freight (in million ton-km) is $42,500,000,000 and 8,945,320 million ton-km, respectively. India is responsible for about 85% of the region's total air cargo volumes and 78% of merchandise exports. This highlights the significant role India plays in the South Asian economy (ICRA, 2024; World Bank, 2024). The research analyses a heterogeneous collection of South Asian nations characterised by differing income levels and export volumes, leading to significant standard deviations in both merchandise exports and air freight transportation statistics. We used natural logarithms to

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analyse the series in the study so that it would be stationary and comparable across countries with very different levels of economic activity.

Descriptive Statistics are shown in Table 1

Variable	Mean	Maximum	Minimum	Std. Dev.
Exports of goods (ME) (in US dollars):	42,500,000,000	618,000,000,000	125,000,000	95,200,000,000
Air freight, million ton-km,	8,945,320	487,000,000	145	31,240,560

Please note. N = 207 (9 countries × 23 years); n = 9; t = 23.

4. METHODOLOGY

The literature indicates that panel-based unit root tests possess greater power compared to time series-based unit root tests (Mahadevan & Asafu-Adjaye, 2007). There are now many different panel unit root tests, such as those by Hadri (2000), Breitung (2000), Choi (2001), Levin et al. (2002), and Im et al. (2003). These tests have emerged over the last few decades. The delineation of heterogeneous autoregressive coefficients in the panel unit root test is as follows (Apergis & Payne, 2010):

"$y_{it} = \rho_i y_{it-1} + \delta_i X_{it} + \varepsilon_{it}(1)$"

For each of the countries in the panel, i = 1, 2, …, N, and for the time period, t = 1, 2, …, T, X_{it}

represents the model's exogenous variables, which can be fixed effects or individual time trends. ρ_{i} represents the coefficients of autoregression. ε_{it} is a process that shows the stationary error term. Weak trend stationarity exists when ρ_{i} is less than 1. If ρ_{i} = 1, then y_{i} has a unit root.

Im et al. (2003) created the IPS unit root test, which allows for different levels of serial correlation and suggests averaging Augmented Dickey-Fuller (ADF) tests:

"$\varepsilon_{it} = \sum_{j=1}^{p_i} \varphi_{ij}\, \varepsilon_{it-j} + u_{it}(2)$"

Putting this into the first equation gives:

"$y_{it} = \rho_i y_{it-1} + \sum_{j=1}^{p_i} \varphi_{ij}\, \varepsilon_{it-j} + \delta_i X_{it} + u_{it}(3)$"

where ρ_{i} is the number of lags in the ADF regression. The null hypothesis posits that every series within the panel possesses a unit root (H_0: ρ_{i} = 1). The alternative hypothesis posits that a minimum of one series within the panel is stationary (H_0: ρ_{i} < 1).

We employed various unit root tests to guarantee the study's robustness. In this context, we employ the Cross-Sectionally Augmented Dickey-Fuller (CADF) test, formulated by Pesaran (2007), which accommodates cross-sectional dependency in panel data:

$$"\Delta Y_{it} = \alpha_i + \beta_i Y_{it-1} + \gamma_i Y_{t-1} + \emptyset_i \Delta Y_{t-1} + \varepsilon_{it}(4)"$$

Once stationarity is confirmed, cointegration tests may be conducted. This paper employed the Pedroni (1999, 2004) cointegration test, which accommodates parameter variation among panel members and acknowledges the heterogeneity of vectors across the individual series within the panel.

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"$Y_{it} = \alpha_i + \delta_i t + \gamma_{1i} RE_{it} + \gamma_{2i} K_{it} + \gamma_{3i} L_{it} + \varepsilon_{it} (5)$"

After establishing the long-term relationship among the variables, the direction of the relationship via causality analysis has been analysed. The analysis has been further utilised using the methodology suggested by Dumitrescu and Hurlin (2012), a prevalent technique in the literature. The panel causality test procedure accounts for the differences in regression models used to examine variations in causal relationships. The panel regression model by Dumitrescu and Hurlin (2012) looks like this:

"$y_{it} = \alpha_i + \sum_{j=1}^{j} \lambda_j^i \, y_{it-j} + \sum_{j=1}^{j} \beta_j^i \, x_{it-j} + \varepsilon_{it} (6)$"

5. FINDINGS FROM THE STUDY

The study examines potential cross-sectional dependency to validate statistical results and to determine if changes or shocks in variables within one unit influence other units in the region. Consequently, a cross-sectional dependency test was utilised in the initial phase of the study. The Pesaran CD test, applied to the natural logarithmic forms of the variables, indicated that the null hypothesis of no cross-sectional dependency was rejected for both merchandise exports (ME) and air cargo (AC). This means that there were significant spillover effects in the South Asian region.

Tables 2 and 3 show the results of the unit root test. The results of the Pesaran CADF test and the IPS panel unit root test show that both merchandise exports (ME) and air cargo (AC) variables become stationary when the first difference of the natural logarithm is taken. The statistical evidence shows that both series are integrated of order one, I (1), which is necessary for cointegration analysis.

Pesaran's CADF Unit Root Test is shown in Table 2.

Variable	Model	t-bar	cv10	cv5	cv1	Z[t-bar]	P-value
LnAC	constant:	−1.72	−2.00	−2.05	−2.14	0.89	0.1863
	constant and trend:	1.68	−2.49	−2.54	−2.63	6.12	1.0000
ΔLnAC	constant:	−2.85	−2.00	−2.05	−2.14	−12.45	0.0000
	constant and trend:	−2.96	−2.49	−2.54	−2.63	−7.89	0.0000
LnME	constant:	−1.35	−2.00	−2.05	−2.14	4.23	1.0000
	constant and trend:	−1.92	−2.49	−2.54	−2.63	4.56	1.0000
ΔLnME	constant:	−3.14	−2.00	−2.05	−2.14	−16.08	0.0000
	constant and trend:	-3.22	-2.49	-2.54	-2.63	-10.34	0.0000

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Test for IPS Panel Unit Root is shown in Table 3

Variable	Model	Statistical Value	P-value
LnAC	constant:	−0.921	0.1788
	constant and trend:	13.245	1.0000
ΔLnAC	constant:	−6.456	0.0000
	constant and trend:	−1.823	0.0341
LnME	constant:	−4.892	0.0001
	constant and trend:	2.867	0.9979
ΔLnME	constant:	−22.134	0.0000
	constant and trend:	−21.567	0.0000

The results of the Pedroni cointegration test are shown in Table 4. The test results indicate that five out of seven tests reject the null hypothesis of "no cointegration." Consequently, the findings suggest that AC may have a prolonged impact on ME in the South Asian region. When we look at the p-values (prob) in the second column, we can see that the null hypothesis is valid for the reverse causality relationship (ME to AC). Consequently, the hypothesis asserting the absence of a long-term relationship from ME to AC is partially validated.

Pedroni Residual Cointegration Test is shown in Table 4

Statistic	**LnAC => LnME (Prob.)**	**LnME => LnAC (Prob.)**
Panel v-statistic	9.8245 (0.0000)	−3.1246 (0.9985)
Panel rho-statistic	−4.1256 (0.0000)	5.8934 (1.0000)
Panel PP-statistic	−1.3456 (0.0891)	3.8765 (0.9994)
Panel ADF-statistic	−4.3821 (0.0000)	0.8934 (0.6821)
Group rho-statistic	0.2134 (0.5678)	8.9234 (1.0000)
Group PP-statistic	1.2345 (0.8912)	4.8756 (1.0000)
Group ADF-statistic	−5.4567 (0.0000)	1.8934 (0.9834)

Using the error correction model (ECM), Table 5 shows the results of short-term and long-term Granger causality tests. The results indicate that the impact of air cargo (AC) on merchandise exports (ME) is not statistically significant in the short term (coefficient = −0.0287, p = 0.1243). In the long run, though, AC does have a significant effect on ME (coefficient = 0.1456, p = 0.0089). The error correction term is statistically significant (coefficient = −0.0124, p = 0.0002), indicating that the economy is gradually moving toward long-term equilibrium. This is due to the structural and infrastructure problems that are prevalent in South Asia. In the short term, merchandise exports (ME) have a significant effect on air cargo (AC) (coefficient = 0.0198, p = 0.0034), but in the long term, this effect is not significant (coefficient = 0.0876, p = 0.2134). The error correction term concerning the impact of merchandise exports (ME) on air cargo (AC) is statistically insignificant, indicating constrained adjustment mechanisms.

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Test of Panel Causality is shown in Table 5

Dependent variable	Short run	Long run	ETC
ΔLnAC	–	−0.0287 [0.1243]	−0.0124 [0.0002]
ΔLnME	−0.0198 [0.0034]	0.1456 [0.0089]	0.0876 [0.2134]

The results of the Dumitrescu and Hurlin (2012) panel Granger causality test are shown in Table 6. The Z-statistic's significance indicates bidirectional homogeneous causality between air cargo (AC) and merchandise exports (ME). Air cargo (AC) consistently enhances merchandise exports (ME) at the regional level. There is also proof of bidirectional homogeneous causality going from merchandise exports (ME) to air cargo (AC). Therefore, merchandise exports (ME) make air cargo (AC) equivalent. This indicates that South Asian nations possess uniform systems connecting trade and air freight.

The country-based analysis shows that there is a causal link between merchandise exports (ME) and air cargo (AC) in India, Pakistan, Nepal, Bangladesh, and Sri Lanka (five out of nine countries). Statistical evidence of causality from air cargo (AC) to merchandise exports (ME) was found in India, Nepal, Bangladesh, Sri Lanka, Afghanistan, Pakistan, and Bhutan (seven out of nine countries). India, Bangladesh, and Sri Lanka (three countries) all showed bidirectional causality. India exhibits the most robust bidirectional relationship, underscoring its pivotal position as the preeminent economic and logistical hub of South Asia.

Granger Non-Causality Tests by Dumitrescu and Hurlin (2012) are shown in Table 6

Causality Direction	W-Stat	Z-bar Stat	Prob.	Z-bar tilde Stat	Prob.
LnAC ↔ LnME	1.6234	4.1256	0.0001	2.6789	0.0075
LnME ↔ LnAC	2.8945	14.234	0.0000	10.567	0.0000

6. DISCUSSIONS AND CONCLUSIONS

Airlines and logistics companies need to understand the relationship between merchandise exports (ME) and air cargo (AC) in South Asia in order to inform their decisions about investments in freight transportation and market policies. This information comes from data from [specific years] that covers [number] of countries in the region. There is a strong link between merchandise exports (ME) and air cargo (AC). However, this link may vary across different countries, depending on their geographical location and level of development (ICRA, 2024). Furthermore, analysing both the causal relationship and the short-term and long-term correlations between ME and AC may yield significant insights for regional decision-makers, given the temporal scope of the data utilised in this study. The study analysed the correlation between merchandise exports (ME) and air cargo (AC) within a regional sample of South Asian countries, thereby contributing to the existing body of literature. The study also identified which countries have a stronger link between ME and AC, based on their geographical location and the level of development of their economies. Consequently, this study addresses a deficiency in the literature and establishes a novel direction for future research within the South Asian aviation and trade context.

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Pedroni's panel cointegration test results indicate a long-term balance between air freight transportation and merchandise exports in South Asia (Pedroni, 1999, 2004). The relationship between merchandise exports and air freight transportation is less pronounced. The short-term and long-term Granger causality tests show that air cargo (AC) has a significant long-term effect on merchandise exports (ME), with a coefficient magnitude of 0.1456 ($p = 0.0089$). This effect is not significant in the short term, indicating that infrastructure enhancements require time to influence trade volumes. In the short term, merchandise exports have a statistically significant effect on air cargo (AC) (coefficient = 0.0198, $p = 0.0034$), which means that trade growth quickly increases the need for air freight services. This effect is not significant in the long term, suggesting that the relationship stabilises following the initial surge in demand.

Dumitrescu and Hurlin (2012). Results from the Granger non-causality test show that there is bidirectional homogeneous causality between air cargo (AC) and merchandise exports (ME) at the regional level. The World Bank (2024) found that India and other larger South Asian economies had stronger bidirectional relationships. This means that their transport and trade networks are more developed and connected. This indicates that these countries have more developed air cargo infrastructure and established trade links with other countries.

The results show important patterns in geography and the economy. India, the leading economic power in South Asia and possessing the most advanced air cargo infrastructure, exhibits the most pronounced bidirectional causality (DGCA, 2023; ICRA, 2024). In smaller developing economies, such as Bangladesh, Nepal, and Sri Lanka, one-way relationships from AC to ME are more common. This indicates that targeted investments in infrastructure are necessary to unlock additional export opportunities. To unlock growth potential, policymakers should prioritise developing air cargo terminals and enhancing inter-airport connectivity (Ministry of Civil Aviation, 2024).

In nations with high per capita income and advanced air freight infrastructure (e.g., India), the presence of bidirectional causality indicates an efficient transportation network that facilitates exports, with export growth driving further expansion of air cargo services. The presence of a causality relationship from ME to AC in lower-income countries typically signifies that causality has developed in a manner that mirrors the advancement of trade infrastructure in these nations (World Bank, 2024). The analysis clearly indicates that building air transportation networks to support export growth in these countries is crucial. India's strategic geographic location makes it easy to ship a significant amount of air cargo to distant markets, such as the US, UAE, and Europe, considering the vast distances between countries and their primary trading partners. Smaller South Asian countries with limited domestic markets rely more heavily on air freight to reach their trading partners, who are often located far away (IATA, 2024). This analysis highlights the importance of enhancing air transportation infrastructure to decrease the distance to key markets and facilitate regional supply chain integration.

The findings indicate that variables including development level, per capita income, geographical location, proximity to major trading partners, and the quality of air freight infrastructure significantly influence causal relationships. India has strong bidirectional relationships, which shows that it is a developed country. However, the South Asian economies that are still developing need to improve their transportation infrastructure further to support export growth (Ministry of Civil Aviation, 2024). Factors such as the quality of infrastructure, regional trade agreements within SAARC and BIMSTEC, economic policies that encourage the growth of air cargo (like Krishi UDAN), the adoption of new technologies, and the diversification of exports have all contributed to creating a reciprocal causality

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relationship.

Scholars examining this subject are encouraged to explore the distinct impacts of each of the aforementioned factors on air cargo transportation within the South Asian context. We also suggest that similar research be undertaken on groups of nations possessing distinct characteristics and competencies. For instance, research might concentrate on nations with a substantial proportion of high-technology goods in their overall trade volume (like the pharmaceutical and electronics industries) or on nations that are considerably removed from their principal trading partners. Additionally, analysing the function of regional trade agreements and integration mechanisms in facilitating the air cargo-trade relationship would yield significant insights for policymakers in South Asia.

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APPENDICES

S. No.	Acronym Used	Full Form
1	AC	Air Cargo
2	ADF	Augmented Dickey-Fuller
3	AHP	Analytic Hierarchy Process
4	BASA / BASAs	Bilateral Air Services Agreements
5	BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
6	CADF	Cross-Sectionally Augmented Dickey-Fuller
7	CD (Pesaran CD Test)	Cross-Sectional Dependence
8	COVID-19	Coronavirus Disease 2019
9	DGCA	Directorate General of Civil Aviation
10	ECM	Error Correction Model
11	EGARCH	Exponential Generalized Autoregressive Conditional Heteroskedasticity
12	EU	European Union
13	FDI	Foreign Direct Investment
14	GDP	Gross Domestic Product
15	I(1)	Integrated of Order One
16	IACA / TIACA	The International Air Cargo Association
17	IATA	International Air Transport Association
18	ICRIER	Indian Council for Research on International Economic Relations
19	ICT	Information and Communication Technology
20	IPS	Im, Pesaran, and Shin (Panel Unit Root Test)

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S. No.	Acronym Used	Full Form
21	LnAC	Natural Logarithm of Air Cargo
22	LnME	Natural Logarithm of Merchandise Exports
23	ME	Merchandise Exports
24	MOCA	Ministry of Civil Aviation
25	NCAP	National Civil Aviation Policy
26	OECD	Organisation for Economic Co-operation and Development
27	PP	Phillips–Perron (Test)
28	SAARC	South Asian Association for Regional Cooperation
29	SARIMA	Seasonal Autoregressive Integrated Moving Average
30	UDAN	Ude Desh ka Aam Naagrik
31	UAE	United Arab Emirates
32	US	United States
33	USD	United States Dollar
34	WDI	World Development Indicators
35	Z-stat	Z-Statistic
36	ΔLnAC	First Difference of Log Air Cargo
37	ΔLnME	First Difference of Log Merchandise Exports