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RESEARCH ARTICLE

Determinants of Air Transport in the BRICS-T Countries: Findings from Panel Data Analysis

Sevket PAZARCI[1], Emre KILIC[2], Asim KAR[3], Sila KALE[4]

ABSTRACT

This paper examines the factors that determine air transport in the BRICS countries, which account for approximately 42% of the world's population and occupy an important position among developing countries in terms of economic size. In more detail, in this study, air transport examines two different models, passenger and freight transport. The research is carried out for the period 1996-2020. Panel data methods were used as analysis methods. According to the results of the analysis, both air passenger transport and air freight transport act together with their macroeconomic and socioeconomic determinants in the long term. Income is positive and significant in the air passenger transportation model, while income is insignificant in the freight transportation model. In addition, inflation, exchange rate, industrialisation and urbanisation on a country basis are important determinants of both air passenger transport and air freight transport for BRICS-T.

Keywords: Airway transportation, Panel data analysis, BRICS-T
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[1]Research Assistant, Istanbul Nisantasi University, Department of Finance and Banking, Istanbul, Türkiye

[2]Research Assistant, Istanbul Nisantasi University, Department of Capital Markets and Portfolio Management, Istanbul, Türkiye

[3]Research Assistant, Pamukkale University, Department of International Trade and Finance, Denizli, Türkiye

[4]Research Assistant, Istanbul Nisantasi University, Department of Aviation Electric and Electronics, Istanbul, Türkiye

ORCID: Ş.P. 0000-0002-3675-909X;
E.K. 0000-0003-2900-5123;
A.K. 0000-0001-5763-1434;
S.K. 0000-0002-9034-5891

Corresponding author:
Emre KILIC,
Research Assistant, Istanbul Nisantasi University, Department of Capital Markets and Portfolio Management, Faculty of Economics, Administrative And Social Sciences, Istanbul, Türkiye
E-mail: emre.kilic@nisantasi.edu.tr

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1. Introduction

Recently, the developing air transport sector has positioned itself in an important position for the world economy. Determining the dynamics of air transport and conducting policy analyses are important for the economies of the countries. Considering the position of air transport, it is crucial to know the dynamics of this sector to move it forward. Determining the dynamics of the sector is also expected to shed light on the future of the sector. When we look at the economies of developed countries today, these countries have a say in the sector with the air transportation they have made. Developing countries, on the other hand, have become an important centre after investments in air transport in recent years.

The development of air transportation contributes to economic growth by creating employment and increasing trade (Law et al., 2022). The airline industry is intertwined with tourism, accommodation, and the back-and-forth related sectors (Tirtha, Bhowmik, and Eluru, 2023). Parallel to the economic growth, a rise is observed in the field of air transport. The reasons behind the increase in air transport are mainly population growth and economic activities (Goetz, 1992). Therefore, the recovery in this sector is expected to create a multiplier effect on the economy in general.

BRIC (Brazil, Russia, India, and China) countries, a concept introduced by the US investment bank Goldman Sachs in 2001, have an important place in the global economy. With the participation of South Africa in 2010 among these countries, which first came together in 2006, its name was changed to BRICS. Because of mentioning Türkiye, which has similar economic performance with the BRICS countries, with this group, it is expressed as the BRICS-T classification in the literature. It is thought that these countries will become one of the most important countries in the world because of their economic performance, location, area and population power.

With the beginning of the 21st century, BRICS-T countries have started to gain an important place in the world population and economy. In 2020, the BRICS-T countries accounted for 42.29% of the world's population and had a per capita income of $14,841, which is higher than the world average of $10,489. In terms of population and economic growth, these countries have an important position in air transport. The population power of BRISC-T countries, increasing economic growth and their share in world exports are also significant in air transport. The increase in the national income of these countries and their significant rural population among developing countries are another point that brings the countries examined to the fore.

There may be several reasons why it is desirable to relate air transport to macroeconomic and socio-economic variables. Increasing business volumes and international trade between countries increase air passenger and freight transport. As incomes rise, the propensity of individuals to travel increases (Hakim and Merkert, 2019). The effect of the inflation rate is negative. The mechanism here is that high inflation rates increase uncertainty in the economy and lead to an erosion of consumer confidence, causing them to avoid spending and postpone their travel needs (Adeniran and Adeniran, 2017). An increase in the exchange rate may increase passenger demand as it becomes cheaper for foreign tourists to travel to the country (Pacheco and Fernandes, 2017). The effect of industrialisation can increase production and trade, which can increase the demand for air freight. Finally, increasing urbanisation can increase the demand for airlines as people travel more. In short, air passenger and freight transport interact with many macro- and socio-economic variables such as income, inflation rate, exchange rate, industrialisation and urbanisation (Hakim and Merkert, 2019). Therefore, understanding these relationships helps shape economic policy by making better predictions about the future of the sector. Furthermore, modelling the impact of these variables on air transport can help to better understand the sector. This model allows us to make predictions about the future of the sector by analysing in more detail the impact of macroeconomic and socio-economic variables on air transport. It is an important guide for the sector and policy makers, in particular by predicting how air passenger and freight transport may change in parallel with economic changes in the BRICS-T countries.

As shown in Table 1, the population richness in BRICS-T countries has an advantage in terms of air transport. In China and India in particular, the population of more than 1 billion is eye-catching. The average economic growth rate of this group of countries in 2023 is 4.6%, which is higher than the world average of 2.71%, and a high economic growth rate compared to developed countries is also a remarkable indicator. In terms of annual inflation rates, it can also be said that these countries, which have single-digit inflation rates except Türkiye, have price stability.

Table 1: Indicators of BRICS-T Countries

Countries	Population (Person)	GDP Growth Rate (Annual, %)	Inflation (Annual, %)
Brazil	216 million	2,91	4,59
Russia	143 million	3,60	7,40
India	1,4 billion	7,58	5,64
China	1,4 billion	5,20	0,23
South Africa	60 million	0,60	6,07
Türkiye	85 million	4,52	53,85

Note: The values in the table are data for 2023. The data were taken from the world bank database.

The study examines the BRICS-T countries and uses data on macroeconomic and socio-economic indicators such as air passenger and freight traffic, GDP per capita, inflation rate, exchange rate, industrialisation and urbanisation for the period 1996-2020. The model provides a simple framework for understanding the factors affecting air transport. The study, which uses panel data econometrics, is expected to contribute to the literature in terms of the sample analysed, the model and the methodology used.

The empirical literature on air transportation appears to focus on high- and middle-income countries. However, as far as we know, there is no research focusing on BRICS-T countries. This study provides the literature by examining the determinants of air transport in BRICS-T countries.
The rest of the work is planned as follows: In the 2nd chapter, a literature review on air transport is made, in the 3rd chapter the methodology is summarised and in the 4th chapter the empirical findings are shared. Chapter 5 contains the conclusions and policy recommendations.

2. Literature

To plan and develop sound policies, it is important to identify the dynamics of air transport. The study of the factors that determine air traffic can also be used to improve the efficiency of those involved in the air travel sector. The WB (2021) states that air transportation contributes to economic recovery by promoting tourism, global trade, and job opportunities. According to an IATA (2023) study, air transportation creates an effect parallel to economic growth. In this context, this section provides a summary of the studies on air transport.

Goetz (1992) found a positive connection between economic growth and passenger demand. Chou (1993) argues that air transport is associated with both economic and population growth. Poore (1993) supports that in addition to income, population is also a factor that determines air transportation. Dargay and Hanly (2001) show that air ticket increases are negative for airline transportation and positive for economic growth. Zhang and Zhang (2002) found that global airline cargo growth is associated with business and economic growth. Castelli, Ukovich, and Pesenti (2003) shows that many variables such as population, per capita income, distance, and flight frequency are factors that determine air transport. Fu, Oum, and Zhang (2010) predicted that economic growth is the driving force for air transport. Dobruszkes, Lennert, and Van Hamme (2011) showed that besides national income, distance also significantly affects air transport. Yao and Yang (2012) indicate a positive relationship between economic growth, industrial structure, population density and air transport in China. The sensitivity of air passenger and freight traffic to economic growth is the subject of a paper by Chi and Baek (2013). Hu et al. (2015) provided support for a long-term link between economic growth and domestic air passenger traffic in their study, which was conducted in 29 provinces in China. Examining the air transport industry for China and India, Zhang and Zhang (2017) evaluated the efficiency performances of airlines by comparing them in their study. Because of the evaluation, they found that Indian companies are more efficient. Chsherbakov and Gerasimov (2019), who aim to analyse Russian air transport for the period 2007-2016, state that air transport is an important sector for Russia's gross domestic product. Balsalobre-Lorente et al. (2020) showed that air transport, urbanisation and social globalisation have a positive effect on economic growth. Empirically examining the relationship between air transport and economic growth for six sub-Saharan African countries between 1981 and 2018, Tolcha, Bråthen, and Holmgren (2020) established a unidirectional causality from economic growth to air transport for South Africa in the long run. Zhang and Graham (2020) discovered that air transportation is more likely to be relevant in underdeveloped economies. Gudmundsson, Cattaneo, and Redondi (2021) predicted the relationship between the magnitude of economic shocks and the temporal recovery in the global air transportation sector. Law et al. (2022) found a bidirectional causal relationship between air passenger traffic and economic growth. Ali, Bakhsh, and Yasin (2023) identified unidirectional long-term causality from air passengers and air transportation to economic growth in BRICS countries. Franciscone, Zou, and Fernandes (2024) emphasise the significant role of international air transportation in stimulating global trade, revitalising tourism, supporting people-to-people exchanges, and improving supply chain efficiency.

3. Model, Data, and Methodology

3.1. Model

Potential variables affecting air passenger transport and freight transport in BRICS-T countries are determined by following the study of Hakim and Merkert (2019). The basic models used in this study are as follows:

$$PAX = f(INC, INF, EXCR, IND, URB) \quad (1)$$

$$FREIGHT = f(INC, INF, EXCR, IND, URB) \quad (2)$$

PAX represents the total number of airline passengers, FREIGHT represents air freight, INC represents real GDP per capita, INF represents the percentage increase in the general level of prices, EXCR represents the price of each country's local currency in US dollars, IND represents the industrialisation level of each country, and URB represents urban population growth. The effects of income, industrialisation and urbanisation variables on air transport are examined by considering the studies of Hakim and Merkert (2019). In addition, in order not to ignore the macroeconomic effects on air transportation in different dimensions, the inflation variable is included following Adeniran and Adeniran (2017) and the exchange rate variable is implemented according to Pacheco and Fernandes (2017) in the model. In this respect, in the empirical analysis, airline passenger and freight transportation in BRICS-T countries are associated with macroeconomic and socio-economic variables in various dimensions. As the income level of economic decision units increases, the tendency to travel is expected to increase across the income coefficient, which is theoretically expected to be positive. Theoretically, the effect of the inflation rate on air transportation and its coefficient are expected to be negative. This theoretical expectation about inflation is based on the contraction in the expenditures of decision-makers for travel and freight transportation in an environment of price instability. If increases in the exchange rate make the destination country cheaper for foreign tourists, passenger demand is expected to increase, but if it makes it more expensive, travel is expected to decrease. On the other hand, there are two different situations because of the depreciation of the country's currency. First, the demand for foreign goods and imports decreases; therefore, there will be a decrease in air freight transportation. On the contrary, in the second case, the export of the home nation increases due to depreciation for currency. Therefore, when the export volume is greater than the import volume, the exchange rate coefficient is expected to be positive, and in the opposite case is negative. Hence, there is no definite theoretical expectation about the exchange rate coefficient in our models. Theoretically, the effect of industrialisation is expected to generate an upturn in both output and trade, pushing up the demand for air transport of passengers and freight. Thus, the coefficient of industrialisation indicator will be estimated as positive. It is expected that increasing urbanisation will rise the demand for airlines as a conclusion of the development of mobility of economic decision-making units and urbanisation designed to augment the need for goods subject to international trade. In this context, theoretically, the coefficient of urbanisation is expected to be positive in our models. In brief, development business volumes and international trade between countries increase air passenger and freight transport. In this respect, the economic and demographic dynamics of the two main indicators of air transportation in BRICS-T economies are not neglected in our models.

Due to the scale differences between the variables, we used by taking their natural logarithms, except for URB. Since the URB variable takes negative values, it is not possible to take logarithms. Finally, writing Equations 1 and 2 in linear form is as shown below:

$$lnPAX_{it} = \alpha_{1it} + \beta_1 lnINC_{it} + \beta_2 lnINF_{it} + \beta_3 lnEXCR_{it} + \beta_4 lnIND_{it} + \beta_5 URB_{it} + \varepsilon_{it} \quad (1.1)$$

$$lnFREIGHT_{it} = \alpha_{2it} + \beta_6 lnINC_{it} + \beta_7 lnINF_{it} + \beta_8 lnEXCR_{it} + \beta_9 lnIND_{it} + \beta_{10} URB_{it} + e_{it} \quad (2.1)$$

where $i = 1,2,3 \dots, N$ represents the cross-sectional dimension and $t = 1,2,3 \dots, T$ represents the time dimension. α_{1it} and α_{2it} represent constant terms. $\beta_1, \dots, \beta_{10}$ are regression parameters to be estimated. ε_{it} and e_{it} are error terms.

3.2. Data

Using panel data econometric techniques, this study examines the determinants of air passenger and freight transport for the BRICS-T countries. The analysis is carried out for the period 1996-2020. Data descriptions are shown in Table 2.

Table 2: Definition of the variables

Label	Long Defination	Measurement	Source
PAX	Passengers carried on domestic and international flights by air transport companies incorporated in the country.	Person	WDI (2023)
FREIGHT	Express and diplomatic baggage moved on each leg of the flight, calculated in metric tons multiplied by the number of kilometres travelled.	Million ton-km	
INC	Gross domestic product in relation to the mid-year population.	constant 2015 US$	
EXCR	The price of each country's local currency in US dollars.	LCU per US$, period average	
INF	Consumer price index (2010 = 100)	%	
IND	This covers value added in the extractive, manufacturing, building and electricity/water/gas sectors.	% of GDP	
URB	The urban population refers to people living in urban areas.	annual %	

The descriptive statistics are presented in Table 3 below.

Table 3: Descriptive statistics

Variables/ Countries	Brazil		Russia		India		China		S. Africa		Türkiye	
	M	SS	M	SS	M	SS	M	SS	M	SS	M	SS
lnPAX	17.79	0.54	17.46	0.61	17.61	0.83	19.03	0.87	16.33	0.42	17.20	0.95
lnFREIGHT	7.34	0.11	7.71	0.78	6.95	0.57	9.13	0.83	6.59	0.51	6.86	1.17
lnINC	8.96	0.12	8.92	0.28	7.01	0.36	8.39	0.61	8.62	0.12	9.03	0.25
lnINF	4.49	0.45	4.21	0.89	4.47	0.48	4.58	0.17	4.50	0.38	4.10	1.23
lnEXCR	0.82	0.40	3.39	0.67	3.92	0.21	1.99	0.12	2.14	0.36	0.30	1.05
lnIND	3.07	0.10	3.43	0.07	3.34	0.07	3.79	0.07	3.25	0.08	3.30	0.07
URB	1.52	0.47	-0.04	0.28	2.57	0.18	3.37	0.61	2.01	0.30	2.21	0.33

Notes: Descriptive statistics are calculated using logarithmic data except for the URB. M represents the mean; SD represents the standard deviation of the series.

According to Table 3, the country with the highest average for both passenger and freight transport over the period is China. The lowest average occurs in South Africa. The country with the highest average income is Türkiye, and the lowest is India. China had a high inflation rate compared to other countries on average in this period, while Türkiye, on the contrary, had a low inflation process. In terms of the exchange rate, the highest is India and the lowest is Türkiye. China is the country with the highest average in industrialisation and urbanisation. Brazil lags behind in industrialisation compared to other countries. On the other hand, Russia has a negative growth in urbanisation. Türkiye is the country with the highest standard deviation in air passenger transportation, inflation, and exchange rate. In freight transport, income and urbanisation China is the country with the highest standard deviation. South Africa (and Brazil) in passenger transportation and income, Brazil in freight transportation, China in inflation and exchange rate, and India in urbanisation are the countries with the lowest standard deviations. Lastly, all countries have similar standard deviations in the industrialisation variable.

3.3. Methodology

We are using a panel data testing framework for the empirical application. Panel data methods provide more accurate inferences about the model parameters. This is because, unlike both cross-sectional and time series data, it contains more degrees of freedom. Time series and cross-sectional studies do not control for heterogeneity (variability). Therefore, they carry the risk of slanted results. Panel data methods, on the other hand, increase the efficiency of the estimations by considering the heterogeneity. It contains more information than cross-section and time series data types to detect complex human behaviours. It keeps the effects of excluded or forgotten variables under control (Baltagi, 2008). In the unit root and co-integration methods to be applied in studies using panel data, preliminary information about the data plays a role in determining the test to be used. In this context, first, the homogeneity and the cross-sectional dependence of the panel data are examined. Homogeneity analysis is used to determine whether the cross-sections in the panel data have a similar structure, and cross-sectional dependence is used to determine whether a shock occurring in one cross-section affected the other cross-sections. In the case of a dependency between the cross-sections, ignoring this dependency may lead to inconsistent and biased results (Chudik and Pesaran, 2015). The results obtained from the cross-section dependency and homogeneity analysis affect the determination of the unit root test to be used in the stationarity analysis. In the absence of cross-sectional dependence, the panel unit root tests are used for the first and second generations. 1st and 2nd generation tests are divided into two groups for the homogeneous and heterogeneous panels. In this context, the stationarity test is performed by determining the unit root test suitable for the structure of the dataset. Then, in line with the findings obtained from the preliminary tests, the co-integration test that best explains the dataset is selected.

In this section, the methodology for the tests to be used in cross-sectional dependence, homogeneity, stationarity, co-integration, and long-term coefficient analysis will be explained.

3.3.1. Test of Homogeneity

The Swamy-S (1970) test is used to determine homogeneity. It is used when T>N. The formulation for the Swamy-S test is as follows:

$$\hat{S} = \sum_{i=1}^{N} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right)' \frac{X_i' M_\tau X_i}{\hat{\sigma}_i^2} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right) \sim \chi^2_{k(N-1)} \tag{3}$$

$$M_\tau = I_T - \tau_T (\tau_T' \tau_T)^{-1} \tau_T' \tag{3.1}$$

$$\hat{\sigma}_i^2 = \frac{(Y_i - X_i \hat{\beta}_i)' M_\tau (Y_i - X_i \hat{\beta}_i)}{(T - k - 1)} \tag{3.2}$$

$$\hat{\beta}_{WFE} = \left(\sum_{i=1}^{N} \frac{X_i' M_\tau X_i}{\hat{\sigma}_i^2} \right)^{-1} \sum_{i=1}^{N} \frac{X_i' M_\tau Y_i}{\hat{\sigma}_i^2} \tag{3.3}$$

where I_T is the unit matrix. $\hat{\beta}_{WFE}$ represents the slope coefficient. The hypotheses regarding the Swamy-S test are as shown below:

$H_o: \beta_i = \beta$ (Panel Data is Homogeneous)
$H_A: \beta_i \neq \beta$ (Panel Data Is Heterogeneous)

The null hypothesis is rejected if the test statistic obtained from equation 3 is greater than the critical value.

3.3.2. Test of Cross-Section Dependency

The CD_{LM} test proposed by Pesaran (2004) is used to test the cross-sectional dependence. The formulation for the test is as shown in Equation 4:

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=j}^{N-1} \sum_{j=i+1}^{N} (T \hat{\rho}_{ij}^2 - 1) \sim N(0,1) \tag{4}$$

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^{T} \varepsilon_{it} \varepsilon_{jt}}{\left(\sum_{t=1}^{T} \varepsilon_{it}^2\right)^{1/2} \left(\sum_{t=1}^{T} \varepsilon_{jt}^2\right)^{1/2}} \tag{4.1}$$

where $\hat{\rho}_{ij}$ is the number of correlations between the residuals. ε_{it} is the estimated residuals from each unit. The CD_{LM} test gives stronger results when T>N. The hypotheses for the test are as shown below:

$H_o: \rho_{ij} = \rho_{ji} = 0$ (for i$\neq j$) (No cross-section dependency) $(i = 1, \dots, N)$, $(j = 1, \dots, N)$
$H_A: \rho_{ij} = \rho_{ji} \neq 0$ (for i$\neq j$) (Cross-section dependency)

if the CD_{LM} statistic obtained from Equation 4 is greater than the critical value, the null hypothesis is rejected.

3.3.3. Test of the Unit Root

In order to test for stationarity, the CADF test recommended by Pesaran (2007) is used. The CADF test can give results at the same time for each country and for all panel. For the overall panel, Crooss-Sectionally Im, Pesaran and Shin (CIPS) statistics are used. The CIPS test can be used in the presence of cross-sectional dependence and regardless of whether the panel data is homogeneous or heterogeneous. It can give strong results in both N>T and T>N situations.
The formulation for the CIPS statistic is as shown in Equation 5:

$$CIPS = \frac{\sum_{i=1}^{N} CADF_i}{N} \quad (5)$$

where $CADF_i$ is a cross-sectional statistic that examines the existence of a unit root for each cross-section. By taking the average of the $CADF_i$ statistics, the CIPS statistics are obtained. The hypotheses regarding the CIPS statistic are as shown below:

$H_o: \beta_i = 0$ (For all cross-sections) (Unit root)
$H_A: \beta_i < 0$ $(i = 1, 2, 3, \dots, N_1;\ \beta_i = 0, i = N_1 + 1, N_1 + 2, \dots, N)$ (Stationary)

The H_o hypothesis is rejected if the CIPS statistic is greater than the critical values given in Pesaran (2007).

3.3.4. Test of Co-integration

To test the co-integration relationship, the LM bootstrap panel co-integration test on offer by Westerlund and Edgerton (2007) is used. In the presence of cross-sectional dependence, the LM test can be used. The LM test offers advantages such as heteroskedasticity, serial correlation, being robust to possible endogeneity problems and giving consistent results in small samples. The formulation for the LM Bootstrap panel co-integration test under the assumption of cross-sectional dependency is as shown in Equation 6:

$$LM_N^+ = \frac{1}{NT^2}\sum_{t=1}^{N}\sum_{t=1}^{T}\widehat{w}_i^{-2}S_{it}^2 \tag{6}$$

$$w_{it} = \sum_{j=0}^{\infty} a_{ij}e_{it-j} \tag{6.1}$$

where e_{it} are errors with i.i.d over time and has a zero mean. Since a_{ij} varies between all cross-sections, this model allows for a heterogeneous correlation structure. S_{it} is the partial sum of the error terms. The hypotheses regarding the LM test are as shown below:

$H_o: \sigma_i^2 = 0$ (For all cross-sections) (Co-integration)
$H_A: \sigma_i^2 > 0$ (For some cross-sections) (No co-integration)

The LM statistics and probability values obtained from Equation 6 are calculated using bootstrap. If the obtained bootstrap probability value is greater than 0.1, the H_o hypothesis cannot be rejected.

3.3.5. Estimating the Long-Run Coefficient in the Co-integration Analysis

If, as an outcome of co-integration analysis, there is a long-run relationship used in the model, co-integration estimators are used to provide information on the direction and magnitude of the relationship. At this point, the augmented mean group (AMG) derived by Eberhard and Bond (2009) and Eberhardt and Teal (2010) is used. The AMG estimator considers cross-sectional dependence. It is an estimator that is robust to the possible endogeneity problem. It can also be applied if the integration degrees of the series are different (Eberhardt, 2012: 64). The process of AMG coefficient estimation consists of 3 stages.

First, the coefficient estimates are obtained with the help of Equation 7 using the first-difference ordinary least square (FD-OLS) method.

$$\Delta Y_{it} = b'\Delta X_{it} + \sum_{t=2}^{T} c_t \Delta D_t + e_{it}\, , \hat{c}_t \equiv \hat{\mu}_t^* \tag{7}$$

Model estimation is then conducted by including in the regressions for each unit.

$$Y_{it} = a_i + b_i' X_{it} + c_i t + d_i \hat{\mu}_t^* + e_{it} \tag{8}$$

Finally, with the mean group (MG) approach proposed by Pesaran and Smith (1995), the AMG coefficient estimate is obtained by averaging the coefficients of each country in the panel.

$$\hat{b}_{AMG} = N^{-1} \sum_i \hat{b}_i \tag{9}$$

4. Empirical Results

By the current literature on panel data methods, specification tests must be applied for both series and models in the panel analysed in order to choose the right analysis methods. In this direction, the Swamy-S homogeneity test and cross-section dependence tests were used. Table 4 shows the results of these specifications below.

Table 4: Preliminary Tests

Panel A: Results for the Variables	Homogeneity: Swamy-S (1970)		Cross-Section Dependence: (2004)	
	Statistic	p-val.	Statistic	p-val.
lnPAX	1580.35	0.000***	4.163	0.000***
lnFREIGHT	1435.75	0.000***	4.115	0.000***
lnINC	773.51	0.000***	5.028	0.000***
lnINF	862.51	0.000***	4.120	0.000***
lnEXCR	460.93	0.000***	2.413	0.008***
lnIND	227.34	0.000***	1.683	0.046**
URB	153.15	0.000***	12.034	0.000***
Panel B: Results for the Models				
Model-1	369.51	0.000***	19.203	0.000***
Model-2	274.65	0.000***	5.103	0.000***

Notes: *** (1%), ** (5%), and * (10%).

According to the outcomes of the homogeneity and cross-sectional dependence tests outlined in Table 4, the variables and models are heterogeneous and have cross-sectional dependence. Therefore, unit root and co-integration tests and co-integration estimators that take heterogeneity and cross-section dependency into account should be used to continue the analysis.

For the empirical analysis, the CIPS panel unit root test procedure, which takes heterogeneity and cross-section dependence into account, was used to test whether the series had a unit root procedure. The results in Table 5 indicate that the variables exhibit a unit root at levels and are stationary in the first differences following the CIPS test. In this respect, it is possible to say that the series has an I (1) process.

Table 5: Results of the Panel Unit Root Test

Variables	Level: Constant Model	Level: Constant & Trend Model
lnPAX	-1.998	-2.630
lnFREIGHT	-2.329*	-2.411
lnINC	-1.538	-1.355
lnINF	-1.276	-2.067
lnEXCR	-1.850	-2.794*
lnIND	-1.355	-1.114
URB	-1.400	-2.011

	First Difference: Constant Model	First Difference: Constant & Trend Model
lnPAX	-4.307***	-4.440***
lnFREIGHT	-4.437***	-4.844***
lnINC	-2.357**	-2.590
lnINF	-2.955***	-2.909**
lnEXCR	-3.626***	-3.764***
lnIND	-3.364***	-3.806***
URB	-3.176***	-3.306***
Critical Values (N=10, T=30)	%1 ➔ -2.58 %5 ➔ -2.33 %10 ➔ -2.21	%1 ➔ -3.12 %5 ➔ -2.87 %10 ➔ -2.73

Notes: The maximum lag length is determined as 2 due to the annual data. The appropriate lag length is chosen according to the t-statistic information criterion. *** (1%), ** (5%), and * (10%).

Table 6 displays the outcomes of the panel co-integration test. The bootstrap values in the last column of Table 6 decide on the presence or absence of a co-integration relationship. As a result, the null hypothesis that the two models are co-integrated is not rejected. This implies that the series are co-integrated.

Table 6: Results of the Panel Co-integration Test

Model		Statistic	Asymptotic p-val.	Bootstrap p-val.
Model 1	Constant	7.339	0.000***	0.972
	Constant & Trend	13.347	0.000***	0.988
Model 2	Constant	7.663	0.000***	0.991
	Constant & Trend	14.216	0.000***	0.954

Notes: Bootstrap p-values are obtained with 5000 replication numbers. p-values <0.1, 0.5 and 0.01 indicate 1%(***), 5%(**) and 10%(*) significance levels, respectively. If the p-value > 0.1, the hypothesis cannot be rejected.

After determining the co-integration for both models, the long-term co-integration coefficient is estimated to determine the size and sign of this relationship between the variables. The results of estimating the AMG coefficients for Model 1 and Model 2 are indicated in Table 7 and Table 8 orderly. In accordance with the panel results of Model 1 in Table 7, the income variable has a significant effect on air passenger transport in the BRICS-T countries. Accordingly, a 1% increase in income leads to a 1.83% increase in air passenger transport. When the country-basis results are analysed, different results are observed for each country. However, as a result of the panel result, inflation, exchange rate and industrialisation lead to a change of 0.272%, 0.177%, and 0.145%, respectively, on airline passenger transport as a result of a 1% change, but there was no significant effect. Moreover, a 1-unit change in urbanisation creates an insignificant change of 4.9% in airline passenger transportation. Air passenger transport in Brazil is affected positively by income and exchange rate and negatively by the inflation rate. In Brazil, industrialisation and urbanisation have an adverse but not a significant effect on air transport. For Russia, only urbanisation has a positive and significant effect on the air transport of passengers, but the other variables have an insignificant effect. In India, income affects air passenger transportation positively and significantly, whereas inflation and urbanisation have negative and significant effect. Furthermore, in air passenger transportation, the exchange rate has negative, and industrialisation has positive effect but insignificant. When we are looking at China, all the independent variables have a positive and significant effect on air passenger transportation. Income and inflation affect, respectively, positive and negative air passenger transport in South Africa significantly. In contrast, industrialisation and urbanisation have negative and insignificant effects but exchange rate-positive on-air passenger transportation. For Türkiye, income and urbanisation display a direct linkage and significant influence on the air transport of passengers. Besides, industrialisation and exchange rate have negative and insignificant effects, but inflation has a positive impact on-air passenger transportation. In summary, when we look at the variables affecting air passenger transport in BRICS-T countries, income is at the forefront. Looking at the country-based results, income has a positive and significant effect in all countries except Russia. This means that income-increasing policies in these countries will increase the number of airline passengers carried.

Table 7: Results for Panel Co-integration Estimator (AMG)-Model 1

Countries/Variables	lnINC	lnINF	lnEXCR	lnIND	URB
Brazil	3.087*** (0.000)	-0.976*** (0.000)	0.241** (0.046)	-0.525 (0.214)	-0.300 (0.114)
Russia	1.048 (0.459)	-0.271 (0.721)	0.307 (0.480)	0.861 (0.283)	0.638** (0.045)
India	2.576*** (0.000)	-0.724** (0.018)	-0.416 (0.209)	0.603 (0.111)	-0.326* (0.065)
China	1.243*** (0.000)	0.848* (0.061)	1.015*** (0.000)	0.941*** (0.000)	0.156** (0.016)
South Africa	1.385*** (0.000)	-0.633** (0.015)	0.024 (0.850)	-0.956 (0.191)	-0.075 (0.166)
Türkiye	1.646*** (0.002)	0.123 (0.461)	-0.105 (0.362)	-0.050 (0.957)	0.203** (0.020)
Panel	1.831*** (0.000)	-0.272 (0.319)	0.177 (0.370)	0.145 (0.648)	0.049 (0.740)

Notes: Values in parentheses give p-values. *** (1%), ** (5%), and * (10%).

The results of Model 2 are reported in Table 8. As a conclusion of the panel result, income, inflation, exchange rate and industrialisation lead to a change of 2.209%, 1.407%, 0.299% and 1.420%, respectively, on freight transportation because of a 1% change, but there was no significant effect. Besides, a 1-unit change in urbanisation creates an insignificant change of 17.4% in freight transportation. However, the country-based results differ, except for Brazil. In Brazil, similar to the panel-based results, there is no variable with a statistically significant effect on freight transportation. The increase in income and inflation indicators, respectively, in Russia affect freight transport significantly positively and negatively. On the other hand, the exchange rate, industrialisation and urbanisation have a negative and insignificant impact on freight transportation. In India, only income has a positive and significant effect on freight transport. In contrast, inflation, industrialisation and urbanisation variables have positive and insignificant effects on freight transport, but the exchange rate has a negative impact. In China, all independent variables except income have a significant effect on freight transportation. Inflation, industrialisation, and urbanisation affect freight transportation positively but the exchange rate negatively in China. In South Africa, income and exchange rate affect freight transport significantly and positively, whereas inflation and industrialisation variables affect freight transport negatively. In addition, the impact of urbanisation on freight transport in South Africa is negative but insignificant. When the results for Türkiye are examined, the increases in income and exchange rates affect freight transportation significantly and positively, in contrast the increases in inflation rates affect negatively. However, the effects of industrialisation (negatively) and urbanisation (positively) on freight transport in Türkiye are insignificant. The increases in income in Türkiye are more dominant in freight transportation compared to the exchange rate. On the contrary, rising in inflation rate has a negative effect on freight transportation, so when price stability cannot be achieved, there is a decrease in air freight transportation.

Table 8: Results for Panel Co-integration Estimator (AMG)-Model 2

Countries/Variables	lnINC	lnINF	lnEXCR	lnIND	URB
Brazil	-0.803 (0.332)	0.033 (0.927)	-0.132 (0.434)	-0.627 (0.303)	-0.157 (0.564)
Russia	2.513*** (0.000)	-4.788*** (0.000)	-0.012 (0.978)	-0.066 (0.899)	-0.133 (0.297)
India	1.767*** (0.000)	0.133 (0.675)	-0.522 (0.132)	0.575 (0.144)	0.049 (0.790)
China	-2.335 (0.198)	1.785* (0.062)	-0.574 (0.305)	2.470*** (0.004)	1.215*** (0.000)
South Africa	5.838*** (0.000)	-4.190*** (0.000)	1.678*** (0.000)	-7.455*** (0.000)	-0.069 (0.641)
Türkiye	6.273*** (0.000)	-1.421*** (0.002)	1.359*** (0.000)	-3.418 (0.156)	0.141 (0.523)
Panel	2.209 (0.117)	-1.407 (0.185)	0.299 (0.452)	-1.420 (0.323)	0.174 (0.414)

Notes: Values in parentheses give p-values. *** (1%), ** (5%), and * (10%).

5. Conclusion

This study uses panel data econometrics to measure air passenger and freight transport in the BRICS-T countries. The data span the period 1996-2020. The model, which uses national income per capita, inflation, exchange rate, industrialisation and urbanisation as independent variables, examines how these variables affect air transport. In the model, income is expected to have a positive effect, and an increase in income leads people to travel more and companies to buy and sell more goods. An increase in inflation, on the other hand, is expected to reduce the demand for air travel as it increases economic uncertainty and reduces consumer confidence. In the case of an increase in the exchange rate, the effect is more complex. While the depreciation of the national currency will increase the demand for air travel by making it more attractive to foreign tourists, the opposite will be true for residents. In terms of trade in goods, the depreciation of the national currency is expected to increase exports and thus have a positive impact on freight transport. Industrialisation is expected to increase the demand for air travel as production and trade increase. Finally, urbanisation is expected to increase passenger demand as people travel more between cities and countries. As a result of the empirical analysis, both passenger and freight traffic move together with macroeconomic and socio-economic determinants in the long run. In the empirical model, income is important in both models, and this finding is similar to the existing literature (Goetz, 1992; Hakim and Merkert, 2019). In line with the literature, increases in income have a positive effect on passenger and freight traffic.

The empirical results differ between the cross sections in the BRICS-T countries analysed. For the BRICS-T countries, increases in national income per capita increase passenger transport, in line with theoretical expectations, except Russia. Brazil stands out with the highest coefficient. A 1% increase in the Brazilian national income leads to a 3.08% increase in air passenger transport. Inflation, which is one of the macroeconomic determinants of passenger transport, has a negative effect in Brazil, India, Russia and South Africa, in line with the theoretical expectation. The largest effect is observed in Brazil, where a 1% increase in the inflation rate leads to a 0.97% decrease in passenger transport. Rising inflation rates lead to higher living costs and have a significant impact on air passenger numbers. Looking at the socio-economic determinants of passenger traffic, industrialisation has a positive effect in line with the huge Chinese economy. A 1% increase in industrialisation is associated with a 0.94% increase in passenger traffic in China. Urbanisation, another socio-economic determinant, increases passenger transport in China, Russia and Türkiye but, contrary to expectations, reduces it in India.

Model 2, where air freight is the dependent variable, shows that increases in GDP per capita have a positive and statistically significant effect for all countries except Brazil and China. Another striking result is that the coefficients are higher than those for passenger transport. In other words, the national income per capita has a greater impact on freight transport than on passenger demand. An increase in the inflation rate has a negative and statistically significant effect on freight transport in all countries except Brazil and India. As a result of this finding, inflation has a negative impact on both freight and passenger transport. Exchange rate increases have a positive effect on freight transport in South Africa and Brazil. In this case, the depreciation of national currencies in these two countries could stimulate international trade by encouraging foreign trade. Increasing industrialisation leads to an increase in both freight and passenger transport in China. Contrary to the expected result, it reduces freight transport in South Africa. Increasing urbanisation has a positive effect on freight transport in China. A 1% increase in urbanisation in China increases freight transport by 1.21%. Looking at the results in general, passenger and freight transport is influenced by socio-economic and macro-economic variables, with income playing an important role. The change in national income per capita plays an important role in increasing the demand for air transport. Therefore, policy makers who want to develop the aviation industry should implement policies to increase income. Future studies can contribute to the literature by focusing on different determinants of air transport in different groups of countries.

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