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-RESEARCH ARTICLE-

THE DETERMINANTS OF AIR PASSENGER TRANSPORT DEMAND IN BRICS COUNTRIES: AN ECONOMETRIC ANALYSIS

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─Abstract─

The study examined the factors that influence the demand for air passenger travel in the BRICS countries. The study employed three (3) panel unit root tests: Levin, Lin, and Chu (LLC), Im, Pesaran, and Shin (IPS), and Fisher's panel unit root test (ADF & PP). Similarly, Pedroni and Kao panel co-integration tests were employed to examine the long-run correlations between the study's variables. Additionally, the impacts of long-run relationships between the variables under study were estimated using the Ordinary Least Squares (OLS) estimators Dynamic Ordinary Least Squares (DOLS) and Fully Modified Ordinary Least Squares (FMOLS). The tests confirmed that the variables in the model were cointegrated. There was discovered to be a long-run association between demand for air passengers and gross domestic product, population, and airfares. Additionally, economic growth and population expansion have a favourable effect on demand for air travel in the BRICS, whereas prices harm demand, ceteris paribus. The findings of this study are also consistent with economic theory, confirming that the model's implications are appropriate for use in BRICS policy decision-making.

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Keywords: economic analysis, determinants, passenger demand, panel unit root, panel co-integration, long-run relationship.

1. INTRODUCTION

Air travel continues to be a critical means of travel throughout the world, linking cities and countries. It is the quickest means of transport and is critical to the economic growth and development of numerous cities, countries, regions, and the world as a whole(Baikgaki, 2014). Air transportation is critical to worldwide commerce and tourism in various sectors of the economy (Higgoda et al., 2019). Analyzing air transport demand is critical for airport authorities to make decisions about capacity utilisation. Additionally, it is critical in the design and development of new airport facilities or enhancing current airport facilities. Forecasting demand for air passenger transport is critical for future infrastructure development and enhancements to passenger services at any airport facility. Analyzing air passenger demand in a city, country, or area will aid in classifying future airport facility requirements (Priyadarshana et al., 2015).

BRICS was created in 2011 when South Africa joined the BRIC trading bloc. Brazil, Russia, India, and China are the other countries. BRICS is often regarded as a formidable trading bloc composed of the world's fastest-growing economies (Marazzo et al., 2010). The BRICS countries account for 43% of the world's population and have a combined GDP of US$14.9 trillion, or 25% of global GDP (Thornley et al., 2015).

Numerous academics have examined the causal relationship between the consumer price index, the gross domestic product, the population, and the rise of air passenger traffic. However, most of this research concentrated on developing economies with developed aviation markets (Tolcha et al., 2020). The extent to which this empirical data holds for less developed or emerging countries, as well as trading blocs such as the BRICS and Sub-Saharan Africa, remains debatable (Tolcha et al., 2020). The current study intends to contribute to this field by establishing further empirical data on causal links in BRICS countries.

Thus, this study examined the short- and long-run correlations between air passenger demand and chosen explanatory factors in the BRICS alliance (Consumer Price Index, Gross Domestic Product, and Population). While air transport services include passenger and freight travel, this study focuses exclusively on passenger transit (Tolcha et al., 2020). The relationship between GDP, Pop, CPI, and air passenger demand will be explored, as well as the inverse relationship.

1.1 Research Problem

In 2030, global air passenger transport volumes will increase by 151%. (Baikgaki, 2014) This necessitates cities, countries, regions, and trading blocs preparing for the predicted increase in demand for air passenger transport. Consequently, it is critical to examine and comprehend the factors that influence demand for air travel in any city, country, or

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region, or even within a trading bloc such as the BRICS. Although the BRICS coalition was founded less than a decade ago, these countries have been proved to have the world's fastest-expanding economies. It is also critical to understand the contribution of air transport to the economy of these countries, as well as the factors that influence demand for air passenger travel in these countries (Njoya et al., 2020) Similarly, it is critical to ascertain the socioeconomic elements that influence air passenger travel demand in the BRICS countries (Lassen, 2010; Njoya et al., 2020).

The predicted expansion in air transport demand compels the world to plan for considerable improvements to airport facilities and develop a system that maximises airport terminal capacity utilisation (Baikgaki, 2014; Priyadarshana et al., 2015). Modeling approaches can determine the required capacity dimensions of airport infrastructure. Certain countries, such as Brazil, have been able to enhance the capacity of their airport terminals and maximise runway utilisation through the use of air transport modelling tools. Brazil improved the existing infrastructure for passenger arrivals and departures (Pai et al., 2017). The required facility capacity and dimensions can be evaluated by developing a demand model for air passengers in various regions (Mhlanga, 2017). However, the majority of studies on air transport demand have focused on established economies such as the United States, the United Kingdom, Australia, and large trading blocs such as the OECD and SADC. However, research on developing economies such as the BRICS countries has been sparse (Priyadarshana et al., 2015).

1.2 Research Aim

The purpose of this study was to add facts and value to the fundamental body of information regarding the economic analysis framework for determining the determinants of air passenger travel demand in developing markets, with a focus on the BRICS countries. This study was deemed significant since only a few studies had been conducted to ascertain the determinants of air transport demand within the BRICS at the time of writing. Thus, this study will focus on four objectives that address the following questions: What social and economic variables influence air passenger travel demand in BRICS countries? What type of relationship exists between air passenger travel demand and the exogenous variables chosen for this study?

Which model best describes the demand for air passenger travel in the BRICS countries?

How to create the optimal demand model for describing links between air passenger travel demand and the independent variables specified?

A more accurate forecasting of air passenger transport demand requires both quantitative and qualitative parameters to be considered.

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1.3 Objectives of the Research

The following objectives guided the current research: identifying the determinants of air passenger travel demand in BRICS countries; comprehending air passenger transport demand and the factors that influence it globally. It is critical to understand the aviation industry environment in terms of the factors of air passenger demand as they are employed by key stakeholders in the global aviation sector.

Analyze the exogenous variables identified and their effect on the demand for air passenger travel in the BRICS. Understanding the history and knowledge of the elements affecting air passenger travel demand is crucial for industry planning.

To create the most accurate demand model possible for forecasting air passenger's travel demand in the BRICS countries.

The remainder of this paper is organised as follows: section 2 covers the literature on air transport demand, section 3 explains the study's methodological framework, section 4 presents the study's empirical findings and analysis, and section 5 concludes and makes recommendations.

2. LITERATURE REVIEW

The demand for air passenger travel is essentially related to fundamental economic, demographic, behavioural, and market characteristics that enable people and enterprises to travel via air and therefore connect more quickly with the outside world (Baikgaki, 2014; Lei et al., 2021). Air passenger travel demand can be defined as the product of the supply of persons wanting and able to travel by air, with the time and financial resources to do so, and utilising airport facilities to meet the need to travel at the preferred time, location, and cost (Baikgaki, 2014; Lei et al., 2021). Access to and connectivity with transportation services is critical when deciding on a company location. Thus, it is critical to understand the factors that influence demand for air passenger transport (Lupi et al., 2010).

(Abed et al., 2001) discovered numerous factors affecting air transport demand and determined that each identified component possesses characteristics that either encourage or restrain the expansion of air travel (Abed et al., 2001). Elements such as a country's socioeconomic background and geographic position and other critical factors such as economic slump or liberalisation can either decrease or increase demand for air travel Baikgaki (2014); (C. Demirsoy, 2012) as mentioned in Baikgaki (2014), classified factors affecting air transportation demand into two major categories: external and internal. According to his concept, internal factors are under the control of the air transport industry itself, whereas external variables are those that are not under the sector's control. Internal considerations include, but are not limited to, airfares and the quality of air transportation services provided. External variables include long-term economic, social, demographic, and political developments (Baikgaki, 2014).

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Apart from the aforementioned, L. Demirsoy et al. (2012), as cited in Baikgaki (2014), claimed that additional short-term conditions such as inflation, interest rates, and currency exchange rates have a significant impact on the potential for development in demand for air transportation services (Baikgaki, 2014).

Hakim et al. (2016) link air transportation demand and gross domestic product in several nations. This demonstrates that economic growth affects air transport demand and, conversely, economic growth affects air transport demand. Demand for air passenger travel and economic growth (GDP) are inextricably linked variables that exert reciprocal influence on one another. Thus, air transportation facilitates access to markets for those who use it, while the presence of economic activity encourages demand for air transportation services (Baikgaki, 2014; C. Demirsoy, 2012).

Marazzo et al. (2010) discovered that the gross domestic product and air passenger movement are correlated. C. Demirsoy (2012) corroborated this by proving that a rise in regional economic activity promotes demand for air transport in that region. Similarly, (Baikgaki, 2014) confirmed that demand is more responsive to fluctuations in the gross domestic product in developing or emerging economies or regions such as the BRICS than in developed economies such as the United States (Baikgaki, 2014). On the other side, other research demonstrated that gross domestic product has a beneficial effect on air travel demand (Akinyemi, 2019).

Aderamo (2010), as cited in Baikgaki (2014), corroborated the association between air travel demand and GDP. Kulendran et al. (2000) examined the relationship between international commerce and international travel flows between Australia and its neighbours (United States of America, United Kingdom, New Zealand, and Japan). The study concluded that a positive correlation exists between the two factors examined (Chang et al., 2009; Kulendran et al., 2000; Pacheco et al., 2017).

Additional research conducted by Ng et al. (2014) examined the Granger Causality model in the relationship between commerce and passenger traffic on chosen Asian-Pacific trade routes. Thus, passenger traffic was found to be stimulated by commerce on the route connecting South Korea and the Philippines, while trade was also found to be stimulated by passenger traffic on the route connecting Australia and Malaysia (Balsalobre-Lorente et al., 2021; Ng et al., 2014). (Waseem et al., 2014) used the Granger Causality Model to examine the relationship between Pakistan's economic growth and air travel. As a result, it was established that demand for air transportation contributes positively to economic growth. In a similar study, Mehmood and Shahid (2014) demonstrated the existence of co-integration between demand for air travel and economic growth in the Czech Republic (Waseem et al., 2014).

3. METHODOLOGICAL FRAMEWORK

3.1 Theory of Air Travel Demand

A reviewed theoretical framework and empirical evidence on demand for air travel, economic growth, population, and inflation assume a demand function. Therefore, the following demand model was used in the study (Baikgaki, 2014; Küçükönal et al., 2017):

$$lnPax_t = f\ (lnGDP_t, lnPop_t, lnCPI_t) \quad 1$$

Where $lnPax_t$ is the natural logarithm of air travel demand over time, t, $lnGDP_t$ is the logarithm of economic growth over time (t) and $lnCPI_t$ is the logarithm of airfare over time (t).

3.2 Panel Data Method

The study used the three-stage Granger causality approach, which seeks to obviate the possibility of drawing incorrect conclusions due to erroneous data (Baker et al., 2015; Hakim et al., 2016). The first stage was conducting a panel root test, as economic theory argues that "although the future cannot alter the past or the present, the past can serve as a foundation for the future or present"(Hakim et al., 2016). As a result, if the data are not stationary, the results cannot be considered valid. As a result, it is critical to test for stationarity to avoid erroneous regression results (Hakim et al., 2016).

The second stage investigated all examined series (passenger volume, economic growth, population, and airfares) for co-integration in the same order to establish a long-run link between or among the variables. As a result of the findings, the type of causality testing employed in the upcoming phase was decided (Hakim et al., 2016).

If the series is discovered to be cointegrated for the same order, the vector error correction model (VECM) is employed to determine the causal relationship between variables in the third step. In the absence of co-integration, the usual Granger causality test known as vector autoregression (VAR) is used (Hakim et al., 2016; Phillips, 1993).

3.2.1 Panel Unit Root Test

The panel unit root test was used to examine the BRICS countries from 1989 to 2018 utilising the LLC, IPS, and Fisher's methods. The approaches mentioned above complement the conventional Augmented Dickey-Fuller (ADF) unit root test, making the limiting assumption that individual cross-sections are independent. The following equation is used to estimate the ADF unit root test's univariate model:

$$\Delta y_t = \ \rho y_{t-1} + \textstyle\sum_{\rho=1}^{\rho} \emptyset_p \Delta y_{t-\rho}\, \gamma_l' D_l + \varepsilon_1\ , t = 1, \dots T \quad 2$$

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Where $D_l, l = \{1,2,3\}$ symbolises a vector of deterministic terms specifying whether the technique has any of the following expressions:

- ✈ No constant terms and time trend (empty sets), or
- ✈ Only a constant term and no time trend, or
- ✈ Both the constant term and a time trend.

The Augmented Dicky Fuller tests the null hypothesis that the process y_t has the unit root test against the alternative hypothesis that assumes y_t is stationary (Kibret et al., 2020). Kibret et al. (2020) concluded that the Levin, Lin, and Chu test is applied to estimate the ADF regression on the pooled panel data through the ordinary least square, assuming an autoregressive process over the individual variables, which serves as an additional restriction (Bidirici et al., 2015). Furthermore, the Levin, Lin, and Chu approach, when assuming a common unit root, then tests the null; $H_0: \rho_i = 1 = 0\ \forall_i$, against the alternative hypothesis; $H_1: \rho_i = 1 < 0\ \forall_i$ (Kibret et al., 2020; Mitić et al., 2017). The Levin, Lin, and Chu focus on the asymptotic distributions of the t-statistics of the pooled panel estimates reported below (Mitić et al., 2017):

$$t_\rho = \frac{(\hat{\rho}-1)\sqrt{\sum_{i=1}^{N}\sum_{t=1}^{T}\dot{\gamma}_{i,t-1}^2}}{\frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\dot{u}_{it}^2} \tag{3}$$

And

$$s_e^2 = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\tilde{u}_{it}^2 \tag{4}$$

More importantly, according to (Bildirici et al., 2011), the Im, Persaran and Shin approach further developed the Levin, Lin and Chu framework by pursuing the heterogeneity of the coefficient for the lagged dependent variable (Air Passenger Transport Demand). Again, the Im, Persaran and Shin approach accepts a more pragmatic and flexible alternative hypothesis using the ADF method in a panel, as shown in the below equation (Bidirici et al., 2015):

$$\Delta y_t = u_1 + \beta_1 t + \rho_i y_{i,t-1} + \sum_{j=1}^{\rho} \emptyset_{ij}\, \Delta y_{i,t-1} + \varepsilon_{i.t} \tag{5}$$

Where y_{it} represents different variables used in the model. The null hypothesis and its alternative are therefore represented respectively as $H_0: \rho_i = 0$ and $H_i: \rho_i < 0$ for at least i. Instead of pooling and assuming that ρ_i is the same for all N's, the Im, Persaran and Shin method used a separate unit root test for the N (Bidirici et al., 2015).

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3.2.2 Panel Cointegration Test

Pedroni and Kao tests were used to determine panel co-integration between the variables under consideration. (Abed et al., 2001). Pedroni tests were further subdivided into seven (7) minor tests, the first four (4) of which are based on the panel's inner dimension (panel co-integration test statistics), while the remaining three (3), which account for potential panel member heterogeneity, are based on the panel's between-dimension. The first four (4) are as follows (Baker et al., 2015): (panel v-statistics; panel p-statistics; and panel p-statistics. t-statistics for panels (non-parametric); and T-statistics for panels (parametric).

The following are the remaining three (3) (Baker et al., 2015):

p-statistics for groups;

t-statistics for groups (non-parametric); and

T-statistics for groups (parametric).

As a first step, panel statistics are normalised using the error term, which qualifies all of the seven (7) tests above for calculating the regression residuals. (1999, Pedroni). As a result, the following equation was used to calculate the seven (7) statistical tests (Baker et al., 2015; Pedroni, 2001):

$$y_{it} = e_1 + x'_{it}\beta_i + \varepsilon_{it}, i = 1,2,..,N , t = 1,2, ...,T \qquad 6$$

The *second step* involved the use kernel estimator in calculating the long-run variance ($\hat{L}^2_{11i}$) from the residual ($\hat{\eta}_{it}$) of the differentiated regression as follow:

$$\Delta y_{it} = \sigma_{1i} x \Delta_{it} + \cdots . + \sigma_{mi} \Delta x_{mit} + \eta_{it} \qquad 7$$

The above equation represents a long-run variance needed to calculate the statistics derived from the panel data from BRICS countries.

The *third step* encompasses estimating the residual $\hat{\varepsilon}_{it}$ from equation 5 to calculate the corresponding auto-regressive model. As a result, for the non-parametric statistics, it is estimated that:

$$\hat{\varepsilon}_{it} = \hat{p}_i \hat{\varepsilon}_{i,t-1} + \widehat{\emptyset}_{it} \qquad 8$$

Equation 8 is then used to estimate the long-run variance($\hat{\sigma}_i^2$) as well as the simple variance ($\hat{s}_i^2$) from the residual $\left(\widehat{\emptyset}_{it}\right)$. Then the terms λ_i can be estimated as:

$$\lambda_i = \tfrac{1}{2}(\hat{\sigma}_i^2 - \hat{s}_i^2) \qquad 9$$

and $\tilde{\tilde{\sigma}}^2$ can be estimated as:

$$\tilde{\tilde{\sigma}}^2 \equiv \tfrac{1}{2}\textstyle\sum_{i=1}^{N} \hat{L}_{11i}^{-2}\, \hat{\sigma}_1^2 \qquad 10$$

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For the parametric statistic, it is estimated that:

$$\hat{\varepsilon}_i = \hat{\rho}_i\hat{\varepsilon}_{i,t-1} + \sum_{k=1}^{ki}\hat{\rho}_{ik}\Delta\hat{\varepsilon}_{i,t-k} + \widehat{\emptyset}_{it}^{*} \qquad 11$$

Equation 11 is therefore used to calculate the simple variance $(\hat{s}_i^{*2})$ from the residuals$(\emptyset_{it}^{*})$. In this equation, k signifies the termination interval, which may vary from country to country. The term $\tilde{\tilde{s}}^{*2}$ is calculated as:

$$\tilde{\tilde{s}}^{*2} \equiv \frac{1}{N}\sum_{i=1}^{N}\hat{s}_i^{*2} \qquad 12$$

The seven (7) panel data test statistics expressed in equations 6 to 12 above are therefore calculated using Pedroni's mean and variance adjustment terms as presented below in equation 13 – 19 that follows (Nasreen et al., 2014).

- ***Panel v-statistic (Nasreen et al., 2014):***

$$Z_\gamma \equiv T^2N^{3/2}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{\varepsilon}_{i,t-1}^{2}\right)^{-1} \qquad 13$$

- ***Panel p-statistic (Nasreen et al., 2014):***

$$Z_\rho \equiv \sqrt[T]{N}\left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{\varepsilon}_{i,t-1}^{2}\right)^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11t}^{-2}\left(\hat{\varepsilon}_{i,t-1}\Delta\hat{\varepsilon}_{it} - \lambda_i\right) \qquad 14$$

- ***Panel t-statistic (non-parametric) (Fan et al., 2010):***

$$\mathrm{Z_{pp}} \equiv \left(\tilde{\tilde{\sigma}}^2\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{\beta}_{i,t-1}^{2}\right)^{-1/2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{\varepsilon}_{i,t-1}^{*}\Delta\hat{\varepsilon}_{it}^{*} \qquad 15$$

- ***Panel t-statistic (parametric)*** (Thas et al., 2008):

$$Z_t^{*} \equiv \left(\tilde{\tilde{s}}^{*2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{\varepsilon}_{i,t-l}^{2}\right)^{-\frac{1}{2}}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{\varepsilon}_{i,t-1}^{*}\,\Delta\hat{\varepsilon}_{it} \qquad 16$$

- ***Group p-statistic (Azam et al., 2016):***

$$\tilde{\tilde{Z}}_\rho \equiv TN^{-\frac{1}{2}}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{\varepsilon}_{i,t-1}^{2}\right)^{-1}\sum_{t=1}^{T}\left(\hat{\varepsilon}_{i,t-1}\Delta\hat{\varepsilon}_{it} - \hat{\lambda}\right) \qquad 17$$

- ***Group t-statistic (non-parametric):***

$$\tilde{\tilde{Z}}_{\rho\rho} = N^{-1/2}\sum_{i=1}^{N}\left(\hat{\sigma}_i^2\sum_{t=1}^{T}\hat{\varepsilon}_{i,t-1}^{2}\right)^{-1/2}\sum_{t=1}^{T}\left(\hat{\varepsilon}_{i,t-1}\Delta\hat{\varepsilon}_{it}\right) - \hat{\lambda} \qquad 18$$

- ***Group t-statistic (parametric):***

$$\tilde{\tilde{Z}}_t^{*} \equiv N^{-1/2}\sum_{i=1}^{N}\left[\sum_{t=1}^{T}\hat{s}_i^{*2}\,\hat{\varepsilon}_{i,t-1}^{\alpha 2}\right]^{-1/2}\sum_{i=1}^{T}\hat{\varepsilon}_{i,t-1}^{*2}\Delta\hat{\varepsilon}_{it}^{*} \qquad 19$$

All the above seven equations were used to estimate the null hypothesis of "*no co-integration*" against the alternative hypothesis of "*co-integration*" (Chandra Parida et al., 2007). Dissimilarity is determined by the management of ρ_i in the creation of the

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alternative hypothesis. Thus, the panel co-integration statistic tests $\rho_i = 1$ for all i, versus the alternative hypothesis that $\rho_i = \rho < 1$ for all i. The panel co-integration statistic for the group mean tests the null hypothesis that $\rho_i = 1$ for all i, versus the alternative hypothesis that $\rho_i < 1$ for all i. The first hypothesis assumes a common value ρ_i (i.e. $\rho_i = \rho$) while the second hypothesis makes no similar assumption (García-Solanes et al., 2009).

3.2.3 Panel Co-Integration Model Estimate

After establishing long-run equilibrium relationships between and among the variables under consideration, the long-run effects of airfares, GDP, and population on demand for air transport were examined (Baikgaki, 2014; Liu et al., 2021; Mosikari et al., 2017). The study then used two ways to accomplish this: Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) (Mosikari et al., 2017).

3.2.4 Dynamic Ordinary Least Square (DOLS)

DOLS estimator is advantageous for small samples and generally performs well when dealing with co-integration panels (Colbert et al., 2016; Kao et al., 2001). It is therefore obtained by using the following regression equation (Liu et al., 2021)

;

$$_{it} = \alpha_i + \beta_1 X_{it} + \sum_{k=q}^{q} \zeta_{ij} \Delta x_{it-k} + \varepsilon_{it}; \quad t = 1, \ldots, T \ldots \ldots N \qquad 20$$

Where α_i denotes country-specific effect, q designates the number of lags normally selected using info-criteria (Mitić et al., 2017), ζ_{ij} signifies the coefficient of lags of the first differenced independent variables, Δx_{it+k} represents the differenced term x and ε_{it} characterise the error-term assumed I(0). The parameter estimates for DOLS are therefore measured using the following equation (Chaitip et al., 2010; Mosikari et al., 2017):

$$\hat{\beta}_{i,DOLS} = \left[N^{-1} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} Z_{it} Z^*{}_{it}\right)^{-1} \left(\sum_{t=1}^{T} Z_{it} \hat{Z}_{it}\right)\right] \qquad 21$$

Where i signifies the cross-section data and N denotes the number of cross-section data, t denoted the time series data, and T represents the number of time-series data, $\hat{\beta}_{i,DOLS}$ stands for the Dynamic OLS estimator, $Z_{it} = (x_{it} - \bar{x}_i, \Delta x_{it-k}, \ldots., \Delta x_{it+k})$ is the $2(k+1) * 1$, $\hat{Z}_{it}$ - $(x_{it} - x_i^*)$, and x_t^* - average of x_i.

The panel DOLS as compared to FMOLS, ignores the significance of diversity of cross-sectional in the substitute hypothesis. However, the FMOLS (between dimensions panel) uses a semi-parametric rectification to the OLS estimator, producing the t-statistics, which permits more flexibility in the alternative hypothesis (Sakyi, 2011).

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3.2.5 Fully Modified Ordinary Least Square (FMOLS)

The panel group mean FMOLS estimates the long-run co-integration parameters using the following equation (Lei et al., 2021):

$$y_{it} = \alpha_1 + \beta_1 x_{it} + \beta_2 x_{it}^2 + \beta_3 x_{it}^3 + \varepsilon_{it} \qquad 22$$

And
$$x_{it} = x_{it-1} + e_{it} \qquad 23$$

The innovation vector, $w_{it} = (x_{it,} e_{it})'$ is assumed to be I(0) with asymptotic long-run covariance matrix (Rehman et al., 2021):

$$\Omega_{\mathrm{i}} = \begin{pmatrix} \Omega_{11} & \Omega_{12} \\ \Omega_{21} & \Omega_{22} \end{pmatrix} \text{ and the auto-covariance} \qquad 24$$

Γ_i, and $Z_{it} = (y_{it}, x_{it})$ is $I(1)$ & y_{it} and x_{it} are said to be cointegrated. Then panel group mean (FMOLS estimator) for β is estimated as:

$$\widehat{\beta} = N^{-1} \sum_{i-1}^{N} (\sum_{t-1}^{T} (x_{it} - \bar{x}_{it})^2)^{-1} (\sum_{t-1}^{T} (x_{it} - \bar{x}_{it})) y^*{}_{it} - \hat{T}_{it} \qquad 25$$

Where $y_{it}^* = (y_{it} - \bar{y}_i) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta x_{it}$, $\bar{T}_i \equiv \hat{\Gamma}_{21i} + \widehat{\Omega}_{21i} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \left(\hat{\Gamma}_{22i} - \widehat{\Omega}_{22i}\right)$ and $\hat{L}_i$ is a sub-standard triangular breakdown of $\widehat{\Omega}_i$. The related t-statistics is therefore estimated as:

$$t_{\widehat{\beta *}} = N^{-1/2} \sum_{i=1}^{N} t_{\widehat{\beta *.\iota}} \qquad 26$$

Where $t_{\widehat{\beta *.\iota}} = \left(\left(\widehat{\beta} *_i - \beta_0 \right) \middle| \widehat{\Omega}_{11i}^{-1} \sum_{t=1}^{T} (x_* - x_1)^2 \right)^{1/2}$

3.3 Causality Test

Most econometrics studies and other social sciences have a common objective of analysing as to whether a change in one variable causes a change in another variable, thus, whether the change in one variable (A) helps to predict another variable (B) within the model (Brinkman et al., 2019; Hsu et al., 2012). Scholar refers to this as Granger Causality, i.e., variable (A) Granger causes another variable (B), if former variable (A) helps to make a more accurate prediction of latter variable (B). The current study used the pairwise Granger causality model to analyse the relationships amongst variables within a model. The approach is used to test for the absence of Granger causality in the model. The null hypothesis, H_0 = *No Granger causality*, is tested against the alternative hypothesis, H_1= *Granger causality*.

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4. PRAGMATIC RESULTS OF THE STUDY

The following section provides the pragmatic results comprising the unit root test, the panel co-integration test, the co-integration model estimation, and the causal co-integration analysis.

4.1 Unit Root Test

Table 1 in Appendix A of this research paper shows the results of three tests, which are the Levin, Lin and Chu (LLC); IM, Pesaran and Shin (IPS) and Fisher's panel unit root test (Shi et al., 2016). The result for LLC is presented in the upper part, while the IPS results are found in the middle part and at the lower part is the result of Fisher's tests (ADF and PP). The results for the unit root test were derived from an individual effect or the individual effect plus trend on the levels and again when differentiated once (Mosikari et al., 2017). These tests show that all variables examined are stationary at the first difference, I (1). However, the PP -Fisher test results show that only *ln*Pax, *ln*GDP and *ln*CPI are stationary when differentiated once, while lnPop is stationary at levels. Thus, we can conclude that all variables are stationary when differenced once (Al-mulali et al., 2012).

4.2 Empirical Result for Panel Co-Integration Test

The findings of the panel co-integration test are classified into two categories: "Within Dimension" and "Between Dimension." Within-dimension statistics for the panel PP and panel ADF were significant at 5% and 1% significance levels, respectively (Mosikari et al., 2017). This indicates that variables inside the model are cointegrated, as seen in Table 2. However, at all levels, the panel V statistics and the Rho statistics for the same dimension were shown to be inconsequential (Canpolat et al., 2016; Chandra Parida et al., 2007).

Pedroni panel co-integration is used in the second section (between dimension statistics) to demonstrate that the group PP and ADF statistics are statistically significant at the 1% level (Mosikari et al., 2017). On the other hand, the group Rho statistics indicate that the model has no significance level. In summary, the empirical findings demonstrate the co-integration of air passenger demand and population and airfares and economic growth (Pradhan et al., 2015). As a result, we may infer that over 57% (4/7) of the tests done confirm the existence of co-integration. As a result, the null hypothesis of "absence of co-integration" is rejected (Canpolat et al., 2016). This further establishes the model's long-run link between air passenger demand, economic growth, population, and airfares (Hakim et al., 2016).

In Table 3, the first column contains the statistical methods (ADF, residual variance, and HAC variance), the second column contains the t-statistics, and the third column has the probability values (Mosikari et al., 2017). The data indicate that the Kao ADF t-statistic is -0.0279, statistically significant at 1%. As a result, we cannot reject the null hypothesis

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that the variables in the study exhibit "no panel co-integration." This demonstrates that no long-run equilibrium exists between air passenger demand, economic growth, airfares, and population.

4.3 Panel Co-Integration Model Estimation Results

The study used two types of estimation methods (FMOLS and DOLS) to evaluate the long-run effects of airfares, GDP, and population on demand for air transportation services. This is summarised in Table 4 of Appendix A, which contains the long-run coefficients for the dependent variable passenger demand. Both DOLS and FMOLS findings revealed that airfares harmed air passenger demand. The findings indicate that ceteris paribus, an increase in airfares, declines air passenger demand. The results, however, are not statistically significant (Baikgaki, 2014). According to economic theory and the majority of empirical evidence, pricing (airfares) negatively correlates with demand for products and services, including demand for air passengers. Both FMOLS and DOLS thus validate that when ticket prices rise, demand for air travel in the BRICS countries decreases, ceteris paribus. The findings indicated a favourable association between the gross domestic product and the demand for air travel in the BRICS (Baikgaki, 2014). FMOLS and DOLS both confirm the existence of a model that is statistically significant at the 1% level.

Finally, both FMOLS and DOLS test findings indicate a positive link between population and air passenger demand. Similarly, the results verified the fitted R-squares of 0.9572 and 0.9875 for FMOLS and DOLS, respectively, indicating that the model accounts for 96 percent of air travel demand in FMOLS and 99 percent in DOLS.

This is the case when economic growth (*ln*GDP), population (*ln*Pop) and airfares (*ln*CPI) are used as explanatory variables in the model, *ceteris paribus*.

4.4 Causal Co-Integration Test

The purpose of this section of the empirical analysis was to evaluate the correlations between or among the variables used to research the BRICS countries (Mosikari et al., 2017). Table 5 of Appendix A contains the results of pairwise Granger causality. The findings indicate that causation exists between the demand for air passenger transportation and airfares and between airfares and demand for air passenger transportation (bidirectional). In a similar vein, the results established a causal link (causality) between population and air passenger transport demand and then between air passenger transport demand and population. As a result, the findings establish bidirectional causality between the two variables.

Additionally, the study confirms a causal relationship between airfares and air passenger transport demand, but not between passenger travel demand and airfares, i.e., uni-directional causality (Akinyemi, 2019; Hakim et al., 2016). There is a causal relationship between population and GDP, and between GDP and population (bidirectional).

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Additionally, the data indicate that causality exists between airfares and GDP, but not vice versa (uni-directional) (Akinyemi, 2019; Kais et al., 2017).

Finally, no causal relationship between airfares and population or between population and airfares has been established, ceteris paribus. Additionally, the study demonstrated that GDP has a beneficial effect on air passenger transport demand, suggesting that a gain in GDP increases air passenger transport demand (Baikgaki, 2014). Once again, an increase in demand for air passenger travel benefits GDP. Thus, growth in demand for air passenger transport services benefits the economy. Similarly, the population has a positive effect on air passenger travel demand, in that an increase in population results in an increase in demand for air passenger travel, ceteris paribus (Law et al., 2022; Shi et al., 2016).

5. RESEARCH CONCLUSIONS AND POLICY RECOMMENDATIONS

The current study's objective was to develop an exemplary sectoral econometric model that would assist BRICS countries in comprehending the dynamics of factors affecting demand for air transport services, strengthening the air transport sector's demand base, and progressing toward high levels of air readiness and economic diversification. The BRICS economic trade was founded in anticipation of its member countries' rapidly rising economies, leading the globe in terms of commodities and services output (Baikgaki, 2014). It is consequently self-evident that these countries appreciate the importance of air passenger transport demand in their particular economies and the BRICS collective economy as a whole. This illustrates the critical nature of examining the factors that influence demand for air passenger transport in the BRICS (Shi et al., 2016). This study aimed to gain a better understanding of the dynamics behind the demand for air passenger travel in the BRICS countries. The panel data analysis revealed a long-run link between air passenger transport demand (pax) and economic development (GDP), population growth (pop), and airfares (CPI) in the BRICS, ceteris paribus.

Additionally, the study indicated that demand for air passenger transport services has a beneficial effect on economic growth in the BRICS (GDP). The panel data econometric study revealed a long-term symmetrical positive link between the demand for air passenger travel and economic growth in all BRICS countries (Fan et al., 2010). Economic growth, likewise, was found to have a favourable effect on air passenger demand (Brida et al., 2018). This means that demand for air passenger travel and economic growth are inextricably linked in the BRICS countries (Shi et al., 2016). Additionally, this study's econometric analysis of panel data revealed the population's dependence on air passenger transport demand. Thus, population growth has a beneficial effect on demand for air passenger travel. This suggests that the BRICS's large population will result in a significant demand for aviation passenger travel (Abed et al., 2001; Baikgaki, 2014). Finally, this study's econometric analysis of panel data

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demonstrated a negative association between demand for air passenger transport services and airfares in the BRICS countries. Thus, prices have a detrimental effect on passenger demand for air travel in the BRICS countries (Akinyemi, 2019). This indicates that, ceteris paribus, an increase in airfares will result in a decrease in demand for airline tickets and vice versa. As a result of this investigation, the following recommendations are made:

Policymakers should establish a framework for boosting air passenger demand, eventually improving economic growth in the BRICS countries.

Policymakers in the BRICS countries should establish, implement, and support systems that promote population growth, ceteris paribus.

Policymakers should explore developing airports in densely populated areas to foster a flying culture. As a result, the population is significantly associated with the demand for air travel. The ability to travel by air adds value to a country, region, or continent's economic success, and the same is true for BRICS countries, ceteris paribus.

Air rates should be kept as low as feasible in the BRICS countries to stimulate demand for air passenger travel. Wherever possible, flight tickets should be subsidised to increase demand for air travel. This will also benefit the BRICS countries' economic progress. As a result, policymakers should explore promoting air travel through ticket subsidies.

Policymakers should develop economic growth policies. As a result, the BRICS countries should support and implement such policies. Economic growth in these countries is also associated with the demand for air travel. As a result, the BRICS economies must consider creating programmes to guarantee air transportation services in their home nations. Additionally, it is critical to refurbish existing airports and, where possible, construct new airports to accommodate the predicted global rise in demand for air passenger travel by 2030. As a result, demand for air passenger transport can be increased through ticket subsidies and increased investment in airport infrastructure.

Additionally, the BRICS countries may build procedures to attract investors to existing airports. Wherever possible, public-private partnerships will be the ideal model for these countries to emulate. Airports should encourage airlines to use their facilities by keeping landing and parking fees low, thereby lowering airlines' operating expenses and maintaining low ticket prices. Airport operational efficiency will also result in lower airline fares, which will enhance demand for air travel and stimulate economic growth and development in the BRICS countries (Law et al., 2022).

6. AUTHOR'S CONTRIBUTION

There is a dearth of academic literature on the factors of air transport demand. Thus, the author's objective is to ensure that a contribution is made to the body of knowledge on the subject by focusing on BRICS countries. The author derived new information from the time series and panel data econometric analyses. This work adds to the body of existing research in the topic. The research will make a significant contribution to pure experiential aviation economics and management science. Specifically, it adds fresh concepts and methodologies to forecasting and managing air passenger travel demand.

The study also established a methodology that the BRICS countries might use to manage the long-term sustainability of their airport networks. This study's econometric model will examine the determinants of air passenger travel demand in the BRICS countries. While most research focuses on individual countries or groups of countries or trade blocs, no such studies exist for the BRICS countries. As a result, our study sought to overcome this divide by concentrating on the BRICS countries.

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Appendix A

Table 1: Panel Unit Root Test Results for Variables lnPax, lnCPI, lnGDP, lnPop

Levin, Lin & Chu test	**Levels**		**First Difference**	
	Individual effect	Individual effect + Trend	Individual effect	Individual effect + Trend
lnPax	-0.1881 (0.4254)	-7.2874 (0.0000)***	-6.3683 (0.0000)***	-6.4753 (0.0000)***
lnGDP	-1.8827(0.0292)*	-1.1454 (0.1260)	-3.9713 (0.0000)***	-4.4356 (0.0000)***
lnPop	-2.5453 (0.0055)**	-3.5256 (0.0002)***	-2.4873 (0.0064)**	-1.1395 (0.1272)
lnCPI	-0.8035 (0.2108)	0.8619 (0.8056)	-4.4759 (0.0000)***	0.4037 (0.6568)
IM, Pesaran, Shin Test	**Individual effect**	**Individual effect + Trend**	**Individual effect**	**Individual effect + Trend**
lnPax	3.0757 (0.9989)	-5.3597 (0.0000)***	-7.0096 (0.0000)***	-6.7556 (0.0000)***
lnGDP	2.4231 (0.9923)	-1.6212 (0.0525)*	-4.4462 (0.0000)***	-4.0282 (0.0000)***
lnPop	-3.3845 (0.0004)***	-3.8495 (0.0001)***	-1.9724 (0.0243)**	-1.7570 (0.0395)**
lnCPI	-0.9553 (0.1697)	-6.7483 (0.0000)***	-7.9307 (0.0000)***	-4.6547 (0.0000)***
Fisher Chi Square- ADF	Individual effect	Individual effect + Trend	Individual effect	Individual effect + Trend
lnPax	-5.1089 (0.9989)	51.3165 (0.000)***	63.6229 (0.0000)***	55.7843 (0.0000)***
lnGDP	7.8571 (0.9923)	16.2893 (0.0914)	38.1423 (0.0000)***	33.6601 (0.0002)***
lnPop	29.1817 (0.0004)***	32.4864 (0.0001)***	18.9606 (0.0408)**	18.9327 (0.0411)**
lnCPI	14.6758 (0.1443)	58.9527 (0.0000)	75.6452 (0.0000)***	39.8193 (0.9645)
Fisher's Chi Square- PP	Individual effect	Individual effect + Trend	Individual effect	Individual effect + Trend
lnPax	4.8981 (0.8979)	88.2681 (0.0000)***	63.6229 (0.0000)***	81.1806 (0.0000)***
lnGDP	2.2037 (0.9945)	9.3519 (0.4991)	38.6155 (0.0000)***	35.4989 (0.0001)***
lnPop	61.1719 (0.0000)***	27.9267 (0.0019)**	17.6975) (0.0603)	3.5734 (0.9645)
lnCPI	70.2161 (0.0000)***	56.4492 (0.0000)***	60.2339 (0.0000)***	65.3839 (0.0000)**

Source: Data compilation and computation by the research scholar using Eviews 10
//*10% statistical significance **5%statistical significant ***1% statistical significance

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Table 2: Pedroni Panel Cointegration Results

Within – Dimension Statistics	**Panel t-statistics**	**Panel Probability**
Panel V-Statistics	0.4563	0.3241
Panel Rho-Statistics	-0.3151	0.3764
Panel PP- Statistics	-2.5469	0.0054**
Panel ADF-Statistics	-1.8696	0.0008***
Between Dimension Statistics	**Panel t-statistics**	**Panel Probability**
Group Rho-Statistics	0.4436	0.6713
Group PP- Statistics	-4.4434	0.0000***
Group ADF-Statistics	-1.3924	0.0000***

Source: Data compilation and computation by the research scholar using Eviews 10
//*10% statistical significance **5% statistical significant ***1% statistical significance

Table 3: Kao Panel Cointegration Results

Statistical Method	**t-statistic**	**Probability**
ADF	-0.0279	0.488
Residual Variance	0.0107	
HAC Variance	0.0119	

Source: Data compilation and computation by the research scholar using Eviews 10
//*10% statistical significance **5% statistical significant ***1% statistical significance

Table 4: FMOLS and DOLS Results

Independent variables	**Parameter Coefficients (FMOLS)**	**Parameter Coefficients (DOLS)**
lnGDP	1.2935 (0.0000)***	1.7126(0.000)***
lnPop	1.8192 (0.0001) **	0.6163 (0.3198) ***
lnCPI	-2.0254 (0.1947)	-0.0202 (0.5376)
Adjusted R-Squared	**0.9593**	**0.9874**

Source: Data compilation and computation by the research scholar using Eviews 10
//*10% statistical significance **5% statistical significance ***1% statistical significance

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Table 5: Causal Cointegration Test Results

Pairwise Null Hypothesis	Obs	F-Statistics	P-value	Decision	Type for Causality
LnCPI *does not Granger Cause* LnPax	144	13.7390	0.0003***	Reject H_0	Bi-directional
LnPax *does not Granger Cause* LnCPI	144	10.5282	0.0015**	Reject H_0	Bi-directional
LnGDP *does not Granger Cause* LnPax	144	11.4550	0.0009***	Reject H_0	Bi-directional
LnPax *does not Granger Cause* LnGDP	144	83.2511	7.E-16	Reject H_0	Bi-directional
LnPop *does not Granger Cause* LnPax	144	26.9485	7.E-07	Reject H_0	Uni-directional
LnPax *does not Granger Cause* LnPop	144	0.3732	0.5423	Do not reject H_0	No causality
LnGDP *does not Granger Cause* LnCPI	144	55.3637	9.E-12	Reject H_0	Bi-directional
LnCPI *does not Granger Cause* LnGDP	144	88.7317	1.E-16	Reject H_0	Bi-directional
LnPop *does not Granger Cause* LnCPI	144	23.9544	3.E-06	Reject H_0	Uni-directional
LnCPI *does not Granger Cause* LnPop	144	1.5193	0.2198	Do not reject H_0	No causality
LnPop *does not Granger Cause* LnGDP	144	0.4824	0.4882	Do not reject H_0	No causality
LnGDP *does not Granger Cause* LnPop	144	0.0025	0.9603	Do not reject H_0	No causality

Source: Data compilation and computation by the research scholar using Eviews 10
*10% statistical significance **5% statistical significant ***1% statistical significance