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THE ANALYSIS OF THE FACTORS DETERMINING THE AIR CARGO DEMAND OF TÜRKİYE WITHIN THE FRAMEWORK OF LIBERAL AVIATION POLICIES[1]

Asst. Prof. Doğan KILIÇ (Ph.D.)*

Prof. Ferhan KUYUCAK ŞENGÜR (Ph.D.)**

ABSTRACT

In order for the airlines and the associated stakeholders operating in the field of air cargo transport to realise their operational planning, make strategic investment decisions, and gain competitive advantage on a global scale, it is necessary to determine the factors affecting air cargo demand in Türkiye. This study utilizes bilateral balanced panel comprising 15 countries that ranked among the top 10 in Türkiye's total air cargo volume at least once in any given year between 2013 and 2022. It analyzes the impact of the level of liberalization of bilateral air service agreements between Turkey and these 15 countries, along with other variables identified in the literature, on the volume of outbound and inbound air cargo. Adopting a gravity-model framework, we estimate separate equations for outbound (Türkiye to partner) and inbound (partner to Türkiye) air cargo volumes, and we evaluate, country by country, the level of liberalisation of bilateral air service agreements signed by Türkiye using the WTO/QUASAR Air Liberalisation Index. The results of the empirical analysis show that the level of liberalisation of bilateral agreements and Türkiye's import volume and the distance between countries positively affect both inbound and outbound air cargo volumes, while increases in jet fuel prices have a negative impact on demand.

Keywords: *Air Cargo Demand, Liberalisation, Bilateral Air Service Agreements, Air Liberalisation Index, Transport Policy.*

JEL Codes: *L93, O18, R42.*

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*Zonguldak Bülent Ecevit University, Department of Civil Air Transport Management, Zonguldak/Türkiye, E-mail: dogankilic@beun.edu.tr

** Eskisehir Technical University, Department of Aviation Management, Eskişehir/Türkiye, E-mail: fkuyucak@eskisehir.edu.tr

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1. INTRODUCTION

The Chicago Convention is the convention that forms the basis of the global civil air transport system and determines the basic rules of civil aviation activities to be carried out among countries. The restriction or liberalisation of the international air transport services had been talked about during the negotiations of the Chicago Convention and it was accepted that the market entry conditions should be determined by the bilateral agreements rather than the multiple agreements. Bilateral Air Service Agreements (BASAs) are agreements between countries that set out the basic rules on how air services are to be performed and the conditions for market access. These air service agreements delineated which airlines were authorized to operate between the two countries, the routes and destination airports they were allowed to serve, whether they could provide additional services such as fifth-freedom rights, the constraints on flight frequency and capacity, and often included regulatory controls on airline pricing. The rules set within the body of the agreement determine whether the air transport services between the two countries are restricted or liberal. BASA is categorised under three headings: traditional, open market and open skies agreements. Although all three types of agreements are still being signed, the majority of agreements in force worldwide are traditional agreements (Belobaba, Odoni and Barnhart, 2016; Kuyucak and Vasigh, 2012; Doganis, 2006; Hanlon, 2006).

Although bilateral air service agreements remain the cornerstone of international civil aviation, the past three decades have witnessed a pronounced global shift toward more liberal regulatory frameworks, particularly in the European Union and North America. The liberalisation process gained momentum when the United States began signing bilateral open skies agreements with several European countries, starting with the Netherlands in 1992. This agreement marked a critical turning point in transatlantic aviation by progressively dismantling restrictions on routes, capacity, and pricing, and establishing open skies as the dominant model for transatlantic air transport (Belobaba et al., 2016; Doganis, 2006). Within Europe, the implementation of the three liberalisation packages between 1992 and 1997 led to the creation of the EU Single Aviation Market, which effectively eliminated bilateral restrictions among member states for both passenger and cargo operations and fostered an integrated competitive environment across the bloc (Hanlon, 2006). This process culminated in the 2007 EU–US Air Transport Agreement and its 2010 Second-Stage Protocol, which currently constitutes the most liberal major bilateral arrangement worldwide and provides reciprocal market access between the two largest aviation markets. Comparable developments have taken place in North America, where the Canada–US Open Skies Agreement of 1995 — substantially expanded in 2007 — and Canada's "Blue Sky" policy introduced in 2006 have established a regional environment characterised by minimal regulatory restrictions on bilateral air services. Within this evolving international landscape, Türkiye occupies a comparatively conservative position: as a country that has predominantly signed traditional

or open-market bilateral agreements rather than open skies arrangements, Türkiye remains relatively less liberal than the EU and North American benchmark. This regulatory asymmetry is not merely descriptive; it directly motivates the central research question of the present study, namely how variations in the level of liberalisation embedded in bilateral air service agreements affect the volume of bilateral air cargo flows between Türkiye and its main trading partners.

The air cargo serves as an indispensable logistics tool for international trade in the manufacturing world. Thanks to the fast and reliable transport services, the production sector can avoid the risk of holding stocks and entering the end markets quickly (Yamaguchi, 2008). The Air cargo provides a fast and reliable connection to distant markets and the global supply chain, regardless of the location of the countries. The countries with a strong air cargo connectivity possess greater competitive advantages in the trade and the production compared with those lacking such connectivity (Kasarda and Green, 2005). The Air cargo has a crucial effect in the national improvement and foreign trade of landlocked countries, as well as those whose primary exports consist of perishable goods and high-value (Abeyratne, 2018). The Countries with a 1 % improvement in air cargo connection increase their trade by 6 %. The Air cargo has a significant potential to increase the competitiveness in global trade if the governments implement policies that encourage the efficient practices (IATA, 2024).

The different ways of the transportation, such as rail, road, sea, and air, can generally transport the same products. While domestic and regional markets are dominated by road and rail transport, for intercontinental transport, carriers usually have two options, namely the maritime and the air transport. The primary benefit of the maritime transport is that it is low cost, while the primary benefit of the air transport is that it is fast and more reliable. While the maritime transport carries time-insensitive and low-value products such as oil, minerals, cement, the air cargo carries products that account for lower than 1% of global trade in weight and 35% in value (Boeing, 2022).

The Air cargo carries very different products in terms of physical properties and value. In the state of emergency caused by pandemics, natural disasters, famine and wars, humanitarian aid, the perishable food and health products are transported. In addition, the high-value electronic products, the valuable cargo items such as money, gold and jewellery, the perishable products, jet engines, the defence industry products, satellites and engineering equipment, heavy and large-sized single-piece products and live animals are transported (ICAO and WCO, 2023; Sales and Scholte, 2023; Schäfer, 2023; Morrell, 2011). In addition, the urgently needed products such as the spare parts that can help minimize the opportunity costs despite their low monetary value are also transported by air cargo (Schäfer, 2023).

Analysing the air transport demand is essential for the aviation industry stakeholders to effectively undertake activities such as corporate planning, infrastructure development, supply chain management, and the formulation of policies by the governments and the regulatory authorities. The Demand analysis is used for the stakeholders such as airlines, airports, and ground handling companies, navigation system

providers and agencies to manage their investments correctly and to rise the productivity of the air transportation. Besides, it is also used to ensure that regulations are made correctly and the state support is provided (Hakim and Merkert, 2019). The Air cargo carriers need demand forecasts to manage their budgets and cash flows efficiently in the short term and to optimise their decisions to invest in aircraft and other facilities in the medium and long term (Morrell, 2011).

In order for the airline companies and the other stakeholders are engaged in air cargo transport to plan their activities, to make investment decisions, and to compete globally, it is necessary to determine the factors influencing the air cargo demand in Türkiye. In this situation, a review of the literature has been conducted, by revealing that studies analyzing the factors influencing air cargo demand in Türkiye remain limited (Aydın and Ülengin, 2022a, 2022b; Tuncer and Aydoğan, 2019; Kiracı and Battal, 2018). In addition none of the study analyses the amount of air cargo departing and arriving mutually between Türkiye and the partner countries and determines the effect of BASAs liberalisation on air cargo demand. Therefore, it is aimed to determine the liberalisation levels of bilateral air agreements signed by Türkiye with the relevant countries and to determine how liberalisation levels and other variables affect Türkiye's international air cargo demand. Within the scope of this objective, research questions below have been identified.

Research Question-1: What is the impact of the level of liberalisation of bilateral air service agreements on Türkiye's international outbound and inbound air cargo volume?

Research Question-2: What are the factors affecting Türkiye's international outbound and inbound air cargo volumes?

The Liberalisation of air transport is a cricual effect that positively shapes the amount of the air cargo carried between countries. In addition to the liberalisation, the variables such as the economic size of states, the distance between these states and the population also affect the amount of the air cargo. In this article, in the first place, the liberalisation levels of the agreements signed between Türkiye and the BASA countries have been determined. The World Trade Organisation (WTO) conducted a study titled Quantitative Review of BASAs (QUASAR) in 2006 to evaluate the level of the liberalisation of air service agreements. In conculusion this study, the Air Liberalisation Index (ALI) was created. The ALI scoring system consists of the granting of traffic rights, assignment, ownership, tariffs, capacity, and mutual exchange of statistics and the authorisation of cooperation. The sub-headings of these issues are determined and scored between 0 and 8 according to the restriction or liberalisation status. The lowest score that can be obtained from the ALI is 0, and the highest score is 50 (WTO, 2006).

ALI scores were calculated by coding the texts of bilateral air transport agreements signed by Turkey with the 15 countries included in the sample (obtained from the Official Gazette and Foreign Affairs Commission Reports) item by item according to the WTO/QUASAR method. ALI values can also change over time; they are updated from the relevant year when agreements are revised or new

protocols are signed. Therefore, ALI is a variable that shows variation in both unit and time dimensions; however, since the agreement text does not change between years for most countries, its variation over time is limited. The ALI variable has been created as a categorical measure converted into a numerical form.

Secondly, in this study the impacts of Türkiye's and partner countries' Gross Domestic Product (GDP), bilateral export and import volumes, the number of flights operated between Türkiye and its partners, the real effective exchange rate, jet fuel prices, population, and distance on both outbound and inbound air cargo volumes have been identified.

The target of this study is to make a contribution to the literature by examining the liberalisation levels of bilateral agreements signed by Türkiye with the relevant countries and the effects of other variables on Türkiye's international outbound and inbound air cargo traffic. Firstly, unlike the rare studies on the factors affecting the air cargo demand in Türkiye, this study analyses the factors affecting the amount of outbound and inbound air cargo on a country basis separately. Secondly, this study evaluates the impact of liberalisation on the air cargo. Finally, this study analyses the economic, social and aviation-related independent variables' effect on the air cargo volume. In this context, it is aimed to make contribution to the academic literature as well as the sectoral applications. It is aimed to show the effect of the liberalisation level of the agreements on the air cargo demand to the persons and the institutions that sign the bilateral air agreements on behalf of Türkiye. In addition, it is aimed to ensure that the airline companies, in case they want to fly to a new route or increase the number of flights on an existing flight line, make decisions by taking into account the factors affecting the air cargo demand and focus on flight lines that may be more profitable.

The remainder of the paper is organised as follows. Section 2 reviews the empirical literature on the determinants of air cargo demand, paying particular attention to studies that examine the role of bilateral liberalisation, macroeconomic variables, and operational factors. Section 3 introduces the data set and outlines the gravity-based panel data methodology. Section 4 presents the empirical results, including the random effects estimation with cluster-robust standard errors and the fixed effects robustness check. Section 5 discusses the findings in light of the existing literature, and Section 6 concludes with policy implications and recommendations for future research.

2. LITERATURE REVIEW

For the stakeholders operating in airline transport, the demand forecasting is important in terms of personnel and the resource planning, fleet planning, the development of infrastructure elements and the policy determination of governments. Therefore, it is necessary to find out the factors affecting passenger and cargo demand in airline transport. In the literature, the number of studies analysing the passenger demand is higher than the number of studies analysing the cargo demand. Since this study

seeks to identify the factors affecting the air cargo demand in Türkiye, it reviews the literature focusing specifically on air cargo demand.

The relation between the aviation activities and the economic values is multifaceted (Hakim and Merkert, 2019). GDP is one of the most commonly used variables in academic studies analysing air cargo demand. In the studies, there are different outcomes on the effect of GDP on air cargo demand. Some studies have found that GDP positively affects air cargo demand (Nguyen, Tran and Ngo, 2025; Fageda, Fioravanti, Ricover, Café and Ansaldo, 2023; Adenigbo, Mageto and Luke, 2022; Aydın and Ülengin, 2022b; Gong, Wang, Fan, Fu and Xiao, 2018; Chi, 2016; Chang and Chang, 2009; Kasarda and Green, 2005), while some studies have found no effect (Ali, Bakhsh and Yasin, 2023; Choi, 2023; Altuntaş and Kılıç, 2021; Hakim and Merkert, 2016). In addition, Hwang and Shiao (2011) and Alnıpak and Kale (2022) state that GDP has a negative effect on air cargo demand, which, although statistically significant, does not seem economically plausible.

One of the variables frequently applied in the literature on the air cargo demand is the capacity of trade, which refers to the amount of exports and imports between states or the sum of these. While some studies conclude that trade volume positively affects air cargo demand (Nguyen et al., 2025; Alnıpak and Kale, 2022; Kupfer, Meersman, Onghena and Van de Voorde, 2017; Kasarda and Green, 2005), Alıcı and Akar (2020) found that the export and the import numbers are not connected to the air cargo demand. Taşdemir and Yıldız (2022), in their study conducted in 11 countries in Europe, have found that there is a causality relationship between the export and the import variables and air cargo demand in some countries, while there is no causality relationship in some countries. Üçler (2026), investigated the causal relationships between air freight, air passenger transport, and economic growth in the G7 countries and Türkiye. The empirical findings reveal substantial heterogeneity: a causal effect from air-cargo volume on economic growth is identified only for Canada, while a causal effect running from economic growth to air cargo is detected in Italy. In contrast, the causal links involving air passenger transport are far more pervasive.

The Studies examining the impact of exchange rate values on the air cargo demand have produced mixed results. Chi (2016), have found that in air and sea transport between China and The US, the exchange ratio has no importance on The U.S. exports to China, whereas it exerts a positive and statistically significant influence on The U.S. imports from China. Tuncer and Aydoğan (2019), concluded that while the domestic air cargo volumes in Türkiye are negatively affected by the U.S. dollar exchange rate, the international cargo volumes remain unaffected. Güzel and Tunalı (2025) concluded that increases in exchange rates have a positive effect on air cargo demand in Türkiye. Akinyemi (2023), reported that, for four African countries over the time span 1980–2019, the influence of the exchange ratio on air cargo demand change among countries in both the short and long term.

One of the most important cost items of the air transport is fuel. Since the changes in the fuel prices affect costs and prices, the jet fuel price or Brent oil price variable is used in studies analysing the air cargo demand. Kupfer et al.(2017), Hakim and Merkert (2019), have found out that there is a negative relation between the air cargo demand and the oil prices, Tuncer and Aydoğan (2019), have concluded that the change in the fuel prices in Türkiye has a negative effect on the quantity of domestic air cargo, while it does not affect the amount of international air cargo.

Beyond economic and trade-related variables, regulatory frameworks — and the level of liberalisation in particular — have emerged as another central determinant of air cargo demand in the literature. Liberalisation means the removal of some or all of the strict rules set by states in the international air transport. Liberalisation in air transport ensures that the basic factors such as market entry, flight frequency, capacity and price are determined according to the market conditions. Micco and Serebrisky (2006), have concluded that air transport expanses have decreased in improved and upper-middle-income developing countries after the signing of open skies agreements and that in the first four years of the agreement, the transport costs decreased by 1% per year up to four years and by 5%-6% after four years. Kasarda and Green (2005), Gong et al.(2018), Grosso and Shepherd (2011), Oesingmann (2022), in their studies conducted in different countries, have concluded that the liberalisation of air transport positively affected the amount of cargo transported. Hwang and Shiao (2011) argue that opening up flight destinations among countries to competition and giving airline companies a wider area to carry out their activities increases the quantity of air cargo transported, increasing the efficiency of airlines and airports.

In airline industry, the flight frequency is an important factor in delays caused by the difference between the flight time requested by the passenger and cargo sender/receiver and the nearest available flight time. The higher the number of flights, the lower the expected frequency delay (Hwang and Shiao, 2011). Chen, Kuo, Chang and Wang (2012), in their article to determine the factors affecting cargo and the passenger demand on flights from Japan to Taiwan, found that the number of flights only affected carried passenger number, but not the amount of cargo. Hakim and Merkert (2019) have concluded that flight frequency positively affects air cargo demand.

Another significant variable affecting airline demand is the population structure of countries. Hwang and Shiao (2011), Aydın and Ülengin (2022b), Fageda et al. (2023) state that the rise in population the amount of air cargo carried. Chen et al. (2012), in their article to determine the factors play role on cargo and passenger demand on flights from Japan to Taiwan, concluded that the population of Japan only affects the carried passenger number, while the population employed in Japan, the population of Taiwan and the population employed in Taiwan positively affect the amount of cargo. In the studies carried out to determine the factors affecting the airline demand, there are different results regarding the frequently used distance variable. Gong et al. (2018), Aydın and Ülengin (2022b) have

identified a negative correlation between the distance and the air freight demand, but Aydın and Ülengin (2022a) and Oesingmann (2022) saw a positive correlation.

Studies seeking to identify the variables of air cargo demand commonly employ economic variables, aviation-related indicators, demographic factors, and distance measures. The findings in the literature indicate that the effects of these values on air cargo demand vary across contexts and methodologies. The primary factor contributing to this variety that the results in the literature might have stemmed from that in addition to economic indicators, variables such as the use of other modes of transport, geographical location of countries, and investment strategies also affect the capacity of air cargo carried. Since outcomes obtained from a certain sample group will not be valid for all countries, the factors affecting the amount of air cargo transported should be analysed country-specifically. It is seen that studies on the air cargo demand have increased worldwide after the 2010s, while more studies have been conducted in Türkiye in 2018 and later. Although studies on the air cargo demand have lagged behind the studies on airline passenger demand, it is noteworthy that there has been an increase recently. Despite this growing body of work, the Turkish literature still lacks a comprehensive country-pair-level analysis that simultaneously incorporates the level of liberalisation embedded in bilateral air service agreements, gravity-model variables, and operational indicators within a unified panel data framework. The present study contributes to filling this gap by combining the WTO/QUASAR Air Liberalisation Index with macroeconomic, demographic, and operational variables in a balanced panel of 15 partner countries over the 2013–2022 period.

3. DATA AND METHODOLOGY

This part outlines the data set and the methodology employed in the study. Firstly, the criteria for selecting the countries included in the study and the rationale behind these criteria are explained, followed by a description of the variables and time period used. Then, the analyses used in the study are explained.

3.1. Data

In this study, the top 10 countries with the highest air cargo number departures and arrivals from Türkiye in each year between 2013 and 2022 have been selected. Since the 10 countries with the highest number of air cargo transported each year vary, all countries that were in the top 10 at least once between 2013 and 2022 were included in the study. This study utilizes bilateral balanced panel comprising 15 countries. These countries are Germany, the U.S, Azerbaijan, the UAE, the United Kingdom, China, France, India, the Netherlands, Spain, Israel, Qatar, Kazakhstan, Kyrgyzstan, and Saudi Arabia. In the study, these 15 countries selected as a sample are used as the relevant countries. The reason for choosing 2013 as the starting year is that the General Directorate of State Airports Authority (DHMI) shared the data on the amount of air cargo carried between Türkiye and other countries as of 2013. Table 1 shows the explanation and data of the variables used in the article.

Table 1. Description of Variables Used in the Study and Data Sources

Variables and Abbreviations	Explanation	Period	Source
Outbound Air Cargo (DAC)	Air Cargo from Türkiye to Other Countries	2013-2022	DHMI Statistical Yearbook
Inbound Air Cargo (AAC)	Air Cargo Arrivals to Türkiye from Other Countries	2013-2022	DHMI Statistical Yearbook
BASA Liberalisation Level (ALI)	Liberalisation Level of Bilateral Air Agreements Signed between Türkiye and Related Countries	2013-2022	Official Gazette of the Presidency of the Republic of Türkiye, Foreign Affairs Commission Reports
Türkiye GDP (TRGDP)	Türkiye'nin Gross Domestic Product	2013-2022	World Bank
Other GDP (OGDP)	Gross Domestic Product of the Comparison Country	2013-2022	World Bank
Export (EXP)	Total Export Amount from Türkiye to the Partner Country	2013-2022	Turkish Statistical Institute (TÜİK)
Import (IMP)	Total Imports from the Partner Country to Türkiye	2013-2022	Turkish Statistical Institute (TÜİK)
Number of Flights (FRQ)	Number of Landings and Take-offs between Türkiye and the Partner Country	2013-2022	DHMI Statistical Yearbook
Real Effective Exchange Rate (EXR)	Real Effective Dollar Exchange Rate in Türkiye	2013-2022	Central Bank of the Republic of Türkiye
Jet Fuel Price (JOP)	Jet Fuel Price (Galon) $	2013-2022	U.S. Energy Information Administration
Türkiye Population (TRPOP)	Population of Türkiye	2013-2022	World Bank
Other Population (OPOP)	Population of the Partner Country	2013-2022	World Bank
Distance (DIST)	Distance between Istanbul and Capitals of Partner Countries	2013-2022	https://www.airmilescalculator.com

Table 2 shows the descriptive statistics of the variables used in the article. The analysis have been made by taking the natural logarithms of the data.

Table 2. Descriptive Statistics of Variables

Variables	Number of Observations	Mean	Standard Deviation	Minimum	Maximum
LOGDAC	150	16.7657	.7456953	12.97234	18.26755
LOGAAC	150	16.54927	.789286	12.83621	17.96066
LOGALI	150	2.829588	.2336571	2.397895	3.332205
LOGTRGDP	150	27.46152	.0884547	27.30292	27.5879
LOGOGDP	150	27.41543	2.000056	22.62211	30.86824
LOGEXP	150	14.96527	1.100252	12.44738	16.86676
LOGIMP	150	14.95548	1.503511	11.06712	17.53769
LOGFRQ	150	9.065193	.9919399	6.918695	11.62602
LOGEXR	150	4.352209	.2617058	3.863043	4.66051
LOGJOP	150	.6417707	.3480302	.0944007	1.216099
LOGTRPOP	150	18.21919	.0343577	18.1538	18.26217
LOGOPOP	150	17.52313	1.819675	14.52625	21.07193
LOGDIST	150	7.969698	.5048265	7.058758	9.037058

3.2. Methodology

The model employed in this study is based on the gravity model, which was adapted to the international trade by Tinbergen (1962) from Newton's Law of Universal Gravitation. According to the application of this law in the context of international trade, the trade volume between two countries is influenced by their Gross National Product (GNP) and the geographical distance separating them. Specifically, export and import volumes are directly proportional to GNP and inversely proportional to the distance between the countries. The greater distances negatively impact trade volumes by increasing transportation costs. The equation for the basic gravity model is as follows (Tinbergen, 1962):

$$T_{ij} = a_0 \frac{Y_i^{a1} \, x \, Y_i^{a2}}{D_{ij}^{a3}} \quad (1)$$

T_{ij}: trade flows between countries i and j, Y_i: gross national product of country i, Y_i: gross national product of country j, D_{ij}: distance between countries i and j, U_{ij}: error term, a_0: constant term, a_1, a_2, a_3: parameters of the model. The model is linearised by taking the logarithm of the two sides in the simple gravity model.

$$logT_{ij} = a_0 + loga_1 Y_i + loga_2 Y_j + loga_3 D_{ij} + U_{ij} \quad (2)$$

Tinbergen has stated that political or semi-economic variables are likely to have a role in appoiting the volume of trade between countries in addition to basic variables and added dummy variables to the model. The dummy variables have added to the model are whether the countries are members of a community or not and whether they are border neighbours or not. Dummy variables are given a value of 1 if present and 0 if absent (Tinbergen, 1962). After Tinbergen, Pöyhönen (1963), Linneman (1966), Anderson (1979), contributed to the progress of the gravity model. For the first time, Linneman (1966) has used the population variable in the gravity model. In addition, Linneman states that the most important variables in explaining trade volumes between countries are the GNP of two countries and the distance between them, while other variables are of secondary importance.

Based on the gravity model, the equations of the air cargo model from Türkiye to the partner countries and the air cargo model from the partner countries to Türkiye are as follows. The Air cargo model from Türkiye to the relevant countries:

$$logDAC_{ij} = a_0 + loga_1 ALI_{ij} + loga_2 TRGDP_i + loga_3 OGDP_j + loga_4 EXP_{ij} + loga_5 IMP_{ij} + loga_6 FRQ_{ij} + loga_7 EXR_i + loga_8 JOP_{ij} + loga_9 TRPOP_i + loga_{10} OPOP_i + loga_{11} DIST_{ij} + u_{ij} \quad (3)$$

The Air cargo model arriving in Türkiye from the relevant countries:

$$logAAC_{ij} = a_0 + loga_1 ALI_{ij} + loga_2 TRGDP_i + loga_3 OGDP_j + loga_4 EXP_{ij} + loga_5 IMP_{ij} + loga_6 FRQ_{ij} + loga_7 EXR_i + loga_8 JOP_{ij} + loga_9 TRPOP_i + loga_{10} OPOP_i + loga_{11} DIST_{ij} + u_{ij} \quad (4)$$

DAC_{ij}: Amount of air cargo carried from Türkiye to partner countries, AAC_{ij}: Amount of air cargo transported from partner countries to Türkiye, ALI_{ij}: the degree of liberalisation of bilateral air agreements signed between countries i and j, $TRGDP_i$: GDP of Türkiye, $OGDP_j$: GDP of the partner countries, EXP_{ij}: The amount of exports from Türkiye to the partner countries, IMP_{ij}: Amount of imports from partner countries to Türkiye, FRQ_{ij}: Number of flights between Türkiye and the partner countries, EXR_i: Real effective dollar exchange rate in Türkiye, JOP_{ij}: Jet fuel price in the world, $TRPOP_i$: Population of Türkiye, $OPOP_{ij}$: Population of partner countries, $DIST_{ij}$: Distance between country i and j, u_{ij}: error term, a_0: constant term, $a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}$: parameters of the model.

In panel data analysis, various models are employed depending on the characteristics of the data. When using panel data, the unit-specific effects whicg are unobservable may exist for every unit. If these effects are treated as a random variable, similar to the error term, the model of random effects is applied. The Generalized Least Squares (GLS) method is the most commonly used approach for estimating the random effects model. If effects of unit are considered as an estimated parameter, fixed

effects model is used (Tatoğlu, 2021). The Hausman test can be used to determine which of the random effects and the fixed effects models is appropriate(Baltagi and Hausman, 2012; Gujarati and Porter, 2012).

The major distinction between the random effects and the fixed effects models lies in whether there is a correlation between the independent variables and the unit-specific effects. To test for the existence of this correlation, Hausman (1978), has formulated the following hypotheses. The Hausman test statistic is computed based on the difference between the variance-covariance matrix of the GLS estimator for the random effects model and that of the within-group estimator for the fixed effects model. The test statistic is calculated by the following equation (Tatoğlu, 2021; Sarıkovanlık, Koy, Akkaya, Yıldırım and Kantar, 2020). Equation of Hausman Test statistic:

$$H = \left(\hat{\beta}_{SE} - \hat{\beta}_{TE}\right)' [Avar\left(\hat{\beta}_{SE}\right) - Avar(\hat{\beta}_{TE})]^{-1} (\hat{\beta}_{SE} - \hat{\beta}_{TE} \quad (5)$$

In the equation, SE stands for the estimators of the fixed effects model and TE stands for the estimators of the random effects model. $Avar\left(\hat{\beta}_{SE}\right)$ and $Avar(\hat{\beta}_{TE})$ denote the asymptotic variance corvariance matrices obtained in the estimation of fixed and random effects models. The Hausman test tests whether the difference between the variance correlation matrices is equal to zero. The hypotheses for this test are as follows:

H_0: 'There is no correlation between the independent variables and the error term.'

H_1: 'There is a correlation between the independent variables and the error term.'

If the hypothesis H_0 cannot be rejected, it is suitable to use the random effects model. If the hypothesis H_1 is accepted, it is suitable to use the fixed effect model.

In panel data analysis, the unobserved unit-specific effects might exist for every unit. If these effects are dealed as a random variable, similar to the error term, a random effects model is suitable. When the cross-sectional units are randomly sampled from the population, the differences between units can be considered random, justifying the application of a random effects model. Consequently, the random effects arise as a result of the sampling process. A major distinction between the random effects and the fixed effects models lies in the correlation between the unit-specific effects and the independent variables. If such a correlation exists, the fixed effects model is more suitable; if no correlation is present, the random effects model is preferred (Tatoğlu, 2021; Sarıkovanlık et al., 2020). Equation of GLS:

$$[W_{\bar{X}\bar{X}} + \psi B_{\bar{X}\bar{X}}] \begin{bmatrix} \hat{\beta}_0 \\ \hat{\beta} \end{bmatrix}_{GLS} = [W_{\bar{X}\bar{Y}} + \psi B_{\bar{X}\bar{Y}}] \quad (6)$$

When the equation is solved, the following equation is obtained;

$$\begin{bmatrix} \hat{\beta}_0 \\ \hat{\beta} \end{bmatrix}_{GLS} = \begin{bmatrix} \psi NT & \psi T \sum_{i=1}^{N} \bar{X}_i' \\ \psi T \sum_{i=1}^{N} \bar{X}_i & \sum_{i=1}^{N} X_i' Q X_i + \psi T \sum_{i=1}^{N} \bar{X}_i \bar{X}_i' \end{bmatrix}^{-1} \begin{bmatrix} \psi NT \bar{Y}_i \\ \sum_{i=1}^{N} X' Q Y_i + \psi T \sum_{i=1}^{N} \bar{X}_i \bar{Y}_i \end{bmatrix} \quad (7)$$

Using the partial inverse formula, the calculation of the GLS estimators of the β vector and β_0 is as follows;

$$\hat{\beta}_{GLS} = \left[\frac{1}{T}\sum_{i=1}^{N} X_i' Q X_i + \psi \sum_{i=1}^{N} (\bar{X}_i - \bar{X})(\bar{X}_i - \bar{X})'\right]^{-1} \left[\frac{1}{T}\sum_{i=1}^{N} X_i' Q Y_i + \psi \sum_{i=1}^{N} (\bar{X}_i - \bar{X})(\bar{Y}_i - \bar{Y})\right] = \Delta\hat{\beta}_{GAT} + (I_K - \Delta)\hat{\beta}_{G\dot{I}T} \quad (8)$$

To assess the stability of the empirical findings and to address potential heteroskedasticity and within-cluster autocorrelation in the panel, the random effects model is estimated with cluster-robust standard errors clustered by country. This estimator follows the Arellano (1987) sandwich estimator and is robust to arbitrary forms of heteroskedasticity and serial correlation within each country pair. In addition, as a robustness check, the model is also estimated using the within fixed effects estimator, even though the Hausman test favours random effects. The fixed effects estimator excludes time-invariant regressors (such as distance) and rarely changeable regressors (such as the BASA Liberalisation Index, which changes only when a new agreement is signed) from the estimable parameter set, but it provides a useful benchmark for the variables that exhibit sufficient within-country variation.

4. EMPIRICAL RESULTS

This section shows the findings of the analyses obtained to examine the effect of the variables identified in the literature review on outbound and inbound air cargo volumes between Türkiye and its partner countries from 2013 to 2022. In the study, the outbound and the inbound air cargo volumes serve as the dependent variables. The Hausman test determines whether the fixed effects or the random effects model is suitable, the Breusch-Pagan Lagrange Multiplier test assesses the presence of heteroskedasticity, and the Wooldridge test evaluates the existence of autocorrelation. The results of the panel regression analysis using the random effects model are presented below.

The Hausman test has been conducted to determine if the fixed effects or the random effects model is more appropriate. If the null hypothesis H_0 is not rejected, the random effects model is considered suitable; if the alternative hypothesis H_1 is accepted, the fixed effects model is preferred. The Hausman test results for the outbound and the inbound cargo are presented in Table 3.

Table 3. Outbound and Inbound Cargo Hausman Test Results

Test	Statistic Value	Probability Value
Outbound Cargo Hausman Test	9.14	0.1034
Inbound Cargo Hausman Test	0.00	1.0000

The Hausman test consequences indicate a p-value of 0.1034 for outbound cargo and 1.0000 for the inbound cargo. Since both p-values have exceeded 0.05, the null hypothesis H_0 cannot be rejected, suggesting that the random effects model is suitable. Panel data models rely on the fundamental supposition that the error term is free from the heteroskedasticity and the autocorrelation. Therefore, in

order to use the random effects model, there should not be the heteroskedasticity or the autocorrelation problems. In the case of these problems, the forecasts lose their effectiveness. In order not to lose the efficiency of the forecasts, the basic assumptions should be checked and in case of deviations, the forecasts should be made by using appropriate methods (Tatoğlu, 2021).

In this study, the Breusch-Pagan Lagrange Multiplier test has been applied to check if there is a problem to test for heteroskedasticity. The basic hypothesis of this test is that the model has constant variance (Tatoğlu, 2021). The results of the outbound and the inbound cargo Breusch-Pagan test are shown in Table 4.

Table 4. Outbound and Inbound Cargo Breusch-Pagan Test Results

Test	Statistic Value	Probability Value
Outbound Cargo Breusch-Pagan Test	18.76	0.0000
Inbound Cargo Breusch-Pagan Test	5.12	0.0236

It is understood that the possibility value is 0.0000 in outbound cargo Breusch-Pagan test results, and the possibility value is 0.0236 in inbound cargo Breusch-Pagan test results. The fact that the probability value is less than 0.05 for both models shows that the hypothesis H_0 is rejected and the hypothesis H_1 is accepted. In other words, heteroskedasticity is detected in both models.

The Wooldridge test was used to examine the existence of autocorrelation. The null hypothesis of this test assumes that there is no autocorrelation in the model (Çakır and Küçükkaplan, 2012). The results of the outbound and inbound cargo Wooldridge test are shown in Table 5.

Table 5. Outbound and Inbound Cargo Wooldridge Test Results

Test	Statistic Value	Probability Value
Outbound Cargo Wooldridge Test	9.063	0.0094
Inbound Cargo Wooldridge Test	0.079	0.7829

For outbound cargo, the Wooldridge test results show a p-value of 0.0094. As this value is less than 0.05, the null hypothesis H_0 is rejected in favor of the alternative hypothesisH_1, pointing the presence of autocorrelation in the outbound cargo model. In contrast, the inbound cargo Wooldridge test results yield a p-value of 0.7829. As this value exceeds 0.05, the null hypothesis cannot be rejected, suggesting that there is not an autocorrelation problem in the inbound cargo model.

When the test results are analysed, both heteroskedasticity and autocorrelation are detected. In the inbound cargo model, there is only a problem of heteroskedasticity. If at least one of the problems of heteroskedasticity and autocorrelation is found, estimators that are robust to these problems should be used (Tatoğlu, 2021; Çakır and Küçükkaplan, 2012). The robust estimators are used to reduce the effect of deviant values and to obtain reliable results when the values in the data set are

not homogeneously distributed (Erdinç and Aydınbaş, 2021; Sturm and de Haan, 2005). A robust estimator, which makes the random effects regression estimator robust to the problem of heteroskedasticity and autocorrelation, is used to estimate both models.

4.1. Outbound and Inbound Cargo Random Effects Model Results

Table 6 presents the results of the random effects model estimated with cluster-robust standard errors clustered at the country level, examining the impact of the independent variables identified in the literature review on the outbound and the inbound air cargo volumes between Türkiye and the relevant countries from 2013 to 2022.

Table 6. Outbound and Inbound Cargo Random Effects Model Results

Dependent Variable: Outbound Air Cargo (DAC)				**Dependent Variable: Inbound Air Cargo (AAC)**		
Independent Variables	**Coefficient**	**Standard Error**	**p value**	**Coefficient**	**Standard Error**	**p value**
BASA Liberalisation Level (ALI)	.62725	.3500597	0.073*	.9578009	.5606705	0.088*
Türkiye GDP (TRGDP)	1.283324	1.735832	0.460	.8447827	.7916237	0.286
Other GDP (OGDP)	-.1044788	.1156996	0.367	-.1707845	.1945286	0.380
Export (EXP)	.0217367	.1360118	0.873	.0545252	.2062081	0.791
Import (IMP)	.3586185	.11202	0.001***	.3561882	.1806977	0.049**
Number of Flights (FRQ)	.3313233	.1039259	0.001***	.1598191	.1439441	0.267
Real Effective Exchange Rate (EXR)	-.3964694	.4187242	0.344	-.2616223	.5390219	0.627
Jet Fuel Price (JOP)	-.4457821	.22292	0.046**	-.3542875	.1756257	0.044**
Türkiye Population (TRPOP)	6.886604	2.602948	0.008***	3.279497	3.347656	0.327
Other Population (OPOP)	-.1955132	.1067792	0.067*	-.0678492	.1453813	0.641
Distance (DIST)	.700233	.3420659	0.041**	.8059749	.3300187	0.015**

Standard errors are clustered at the country level (cluster-robust standard errors).

*** is statistically significant at 1%, ** at 5%, * at 10% level.

According to the random effects model estimation results, it is concluded that 7 of the 11 independent variables in the outbound air cargo model significantly influence the outbound air cargo

volumes, while 4 variables do not. Similarly, 4 of the 11 independent variables in the inbound air cargo model are found to have a significant effect on inbound air cargo volumes. The level of liberalisation of bilateral agreements signed between Türkiye and the relevant countries, the amount of imports, jet fuel price, and the distance variables affect both the amount of the outbound air cargo and the amount of the inbound air cargo.

The ALI variable exhibits a positive correlation with both the outbound and the inbound air cargo volumes at the 10% significance level. An increase of 1 unit in ALI variable causes an increase of 0.62 units in outbound air cargo quantity and 0.95 units in inbound air cargo quantity. The number of flights is positively correlated with o the utbound air cargo volumes at the 1% significance level. An increase of 1 unit in the number of flights variable causes an increase of 0.33 units in the amount of outbound air cargo. The jet fuel price is negatively correlated with both outbound and inbound air cargo volumes at the 5% significance level. Specifically, a one-unit increase in the jet fuel price results in a decrease of 0.44 units in the outbound air cargo and 0.35 units in the inbound air cargo.

At the 1% significance level, imports exhibit a positive relations with outbound air cargo, with a one-unit increase in the import variable causing to a 0.35-unit increase in total air cargo transported. Imports are also positively correlated with the inbound air cargo at the 5% significance level, where a one-unit increase in imports results in a 0.35-unit increase in the inbound air cargo. Furthermore, distance is positively associated with both outbound and inbound air cargo volumes at the 5% significance level. Specifically, a one-unit increase in the distance variable corresponds to a 0.70-unit increase in outbound air cargo and a 0.80-unit increase in inbound air cargo.

A positive correlation exists between the population of Türkiye and the volume of outgoing air cargo at a 1% significance level. An increase of 1 unit in the population of Türkiye variable causes an increase of 6.88 units in the amount of the outbound air cargo. There is a negative relationship between the population of the partner countries and the amount of outbound cargo at the 10% level of significance. An increase of 1 unit in the population of the relevant countries causes a decrease of 0.19 units in the amount of air cargo carried. This is due to the fact that the amount of air cargo carried between the countries with large populations, such as the USA, China, and India, and other countries with relatively small populations are close to each other.

4.2. Robustness Check: Fixed Effects Estimation

To assess the stability of the random effects estimates, the model is re-estimated using the within fixed effects estimator. Although the Hausman test in Table 3 supports the random effects specification ($p = 0.1034$ for outbound cargo and $p = 1.0000$ for inbound cargo), reporting the fixed effects estimates as a robustness check allows readers to evaluate whether the substantive conclusions depend on the specification. Two structural features of the panel must be acknowledged. First, the distance variable (DIST) is strictly time-invariant within each country pair and is therefore absorbed by the unit fixed

effects. Second, the BASA Liberalisation Index (ALI) is almost time-invariant, since it changes only in those few country-years in which a new bilateral agreement or protocol is signed. As a result, both DIST and ALI cannot be identified under the fixed effects specification (Tatoğlu, 2021; Wooldridge, 2010). The fixed effects estimates for the remaining variables are presented in Table 7.

Table 7. Outbound and Inbound Cargo Fixed Effects Model Results

Dependent Variable: Outbound Air Cargo (DAC)				**Dependent Variable: Inbound Air Cargo (AAC)**		
Independent Variables	**Coefficient**	**Standard Error**	**p value**	**Coefficient**	**Standard Error**	**p value**
BASA Liberalisation Level (ALI)	—	—	—	—	—	—
Türkiye GDP (TRGDP)	1.761217	2.211519	0.439	1.602852	1.052628	0.150
Other GDP (OGDP)	-.6068118	.6897056	0.394	-.7908416	.5321902	0.159
Export (EXP)	.4953116	.4353874	0.274	.502349	.3552786	0.179
Import (IMP)	.2528382	.1865412	0.197	.0420482	.224276	0.854
Number of Flights (FRQ)	.6709973	.2196884	0.009***	.480343	.1345414	0.003***
Real Effective Exchange Rate (EXR)	-1.551639	1.293825	0.250	-1.562297	.7542734	0.057*
Jet Fuel Price (JOP)	-.5801513	.2576485	0.041**	-.4017012	.1776261	0.040**
Türkiye Population (TRPOP)	5.247489	2.0586	0.023**	4.528678	2.67069	0.112
Other Population (OPOP)	-4.965677	4.600696	0.299	-7.619789	3.311519	0.037**
Distance (DIST)	—	—	—	—	—	—

Standard errors are clustered at the country level (cluster-robust standard errors).

*** is statistically significant at 1%, ** at 5%, * at 10% level.

The fixed effects estimator excludes explanatory variables that do not change over time, such as distance, and explanatory variables that change infrequently (such as the BASA Liberalization Index, which changes when a new agreement is signed) from the estimable parameter set, but provides a useful benchmark for variables that show sufficient intra-country variation. Fixed effects estimates generally support the qualitative results of the random effects model. Flight frequency is found to positively and statistically significantly affect outgoing cargo volume at the 1% level in both models. This reinforces the main finding that flight frequency is a strong determinant of bilateral air cargo flows. Jet fuel price

maintains a negative and statistically significant effect at the 5% level in both equations, demonstrating the strong influence of fuel prices on air cargo demand. The Turkish population positively and significantly affects outgoing cargo volume at the 5% level in the fixed effects model, consistent with the random effects model. The variables TRGDP, OGDP, and EXP, which were insignificant in the random effects model, remain insignificant in the fixed effects model. The import variable, which was significant in the random effects model, is insignificant in the fixed effects model. When these results are considered together with the Hausman test results, the main findings regarding flight frequency, jet fuel prices, and the Turkish population from the fixed effects model support the selection of the random effects model as the main model.

5. DISCUSSION

Although the aviation sector is an international sector by nature, it is a sector where the control remains at the national level due to intensive economic, technical, and legal regulations. The air transport activities between countries are carried out within the rules specified in bilateral agreements. The restrictive nature of these rules causes states to control the air transport market. Increasing the liberalisation level of bilateral agreements enables air transport to be carried out in a fair, competitive environment, more airlines to compete, competitive price structure to be formed, capacity constraints to be reduced, traffic volume, service quality, benefits provided to passengers and competition in the air cargo transportation to increase. Increases in flight frequency, passenger numbers, and cargo volumes resulting from the liberalization also provide a significant opportunity for the airport operators to enhance their revenues.

The level of liberalisation of bilateral agreements signed between countries is used as an independent variable in many studies analysing air cargo demand. The analysis further reveals a statistically significant positive correlation between the volumes of the outbound and the inbound air cargo between Türkiye and the countries included in the study, and the degree of liberalization of bilateral agreements. This finding is consistent with the results reported by Hwang and Shiao (2011), Grosso and Shepherd (2011), Gong et al. (2018), and Oesingmann (2022). This indicates that the liberalization of bilateral agreements exerts a positive influence on the air cargo demand. Therefore, it is expected that the new agreements to be signed by the Directorate General of Civil Aviation, which signs the BASA on behalf of the Republic of Türkiye, should be liberal, and the revision and the liberalisation of the existing agreements will positively affect the air cargo demand and increase the international trade volume.

Gross Domestic Product (GDP) is the predominant independent variable in research examining air cargo demand. This variable is also included in the study, and the analysis indicates that there is no statistically significant correlation between GDP and the volumes of the outbound and the inbound air cargo between Türkiye and its partner countries. Considering most of the studies such as Kasarda and

Green (2005), Chi (2016), Gong et al. (2018), Alıcı and Akar (2020), Adenigbo et al. (2022), Aydın and Ülengin (2022b), Fageda et al. (2023) has been concluded that GDP positively affects air cargo demand, this study also has anticipated a positive correlation between GDP and air cargo demand; however, the findings from the Türkiye sample the a negative relationship instead.

Therefore, these results are consistent with those of former studies conducted by Hwang and Shiao (2011), Alnıpak and Kale (2022), Chen et al. (2012), Altuntaş and Kılıç (2021), Ali et al. (2023), Choi (2023), Akinyemi (2023), Taşdemir and Yıldız (2022). The variations in the outcomes of the studies found in the literature and the characteristics of air cargo indicate that results derived from a specific country, region, or sample group cannot be generalized to all countries. The primary factors influencing these disparities include variations in the national economies, the investment strategies, the geographical location, and the neighboring countries, the utilization of diverse transportation modes, and the characteristics of products transported via air cargo, all of which impact the volume of the air cargo transported.

The findings also strengthen the notion that the air cargo demand is shaped by a multifaceted interaction of elements that extend beyond macroeconomic indicators. Therefore, using GDP alone to determine the amount of the air cargo that will come in and out of a country could lead to wrong conclusions, especially in places where air freight isn't the main way that goods are shipped or stored and the factors influencing the demand for the air cargo must be examined on a country-by-country basis or sample group are not valid for all countries, and the factors affecting the demand for the air cargo should be analyzed.

Another significant finding of our study is the relationship between air cargo volume export and import. The analysis has shown that there is no statistically significant relation between the exports from Türkiye to the countries examined and both the outgoing and the incoming air cargo volumes. This finding is similar to the results of research conducted by Alıcı and Akar (2020), Taşdemir and Yıldız (2022), Kiracı (2025). Conversely, a statistically significant positive relationship has been identified between imports from the relevant countries to Türkiye and the volume of the outbound and the inbound air cargo. This finding is consistent with the results of research by Chen et al. (2012) and Taşdemir and Yıldız (2022).

These findings indicate the absence of a statistically significant relation between Türkiye's exports and the volumes of the inbound and the outbound air cargo, implying that Turkish exports to the selected countries operate largely independently of air freight logistics. The characteristics of the the exported goods may not necessitate the speed, security, or additional costs linked to air transport, leading to the preference for more economical alternatives like maritime or road freight. Furthermore, the logistics infrastructure of Türkiye and the policies that are oriented towards exports may be designed to favor alternative transportation modes over air cargo for specific destinations, and intermodal and

multimodal transport policies may be supported more. In contrast, the observed statistically significant positive relationship between imports to Türkiye and the volume of the inbound and the outbound air cargo indicates that air freight is crucial in facilitating inbound trade flows. This may indicate the urgency, high value, or time-sensitivity of specific imported goods, particularly intermediate goods, electronics, or medical supplies, which are commonly transported by air. Türkiye's growing integration into global production networks necessitates the swift and the dependable importation of inputs, thereby elevating the strategic significance of air cargo in facilitating national production and just-in-time manufacturing systems.

Since the improvement in the number of flights increases the access of cargo shippers to air transport, the number of flights or frequency is used as an independent variable in many studies analysing air cargo demand. This study also examines this relationship and finds a statistically significant positive association between the number of flights and the volume of air cargo transported from Türkiye to the partner countries. This finding corresponds with the evidence presented in the study by conducted Hakim and Merkert (2019) in South Asian countries, which found that flight frequency has a positive effect on air cargo demand. The positive relationship between the flight frequency and the outbound air cargo from Türkiye highlights the importance of service availability and the accessibility in promoting the air cargo exports. Increased flight frequencies can lead to shorter transit times, greater scheduling flexibility, and improved reliability, which are essential for timely transporting time-sensitive goods and high-value commonly freighted by air.

However, no statistically significant relationship has been observed between the volume of air cargo arriving in Türkiye from the relevant countries and the number of flights. The lack of a significant association between the inbound air cargo and the flight frequency suggests that factors beyond flight availability—such as trade policies, the structure of import demand, or supply-side constraints in partner countries—may play a more prominent role in determining import cargo volumes. This asymmetry underscores that the influence of flight frequency on the air cargo demand can vary depending on the trade direction and the fundamental trade dynamics between nations. Aligning with earlier research like that of Chen et al. (2012), which noted similar dynamics in the Japan–Taiwan corridor and found that the number of flights does not affect the amount of cargo; these findings strengthen the argument that the effect of air connection on cargo flows varies by context and direction.

The exchange rate is frequently employed as an independent variable in studies examining the air cargo demand. In this study, the real effective exchange rate is used, and no statistically significant relationship is found between the real effective exchange rate and the volumes of the outbound and the inbound air cargo. This result is similar to the results in the research by Tuncer and Aydoğan (2019), Chen et al. (2012), Choi (2023). Chi (2016), have concluded that the exchange rate does not affect the amount of the air cargo from the USA to China, and that there is a statistically significant positive relationship between the amount of the air cargo from China to the USA and the exchange rate.

Adenigbo et al. (2022) has concluded in their research that there is a positive relation between the air cargo demand and the exchange rate in Ghana. Although some studies conclude that the exchange rate positively affects the weight of the air cargo transported, the number of studies that find that the exchange rate does not affect the weight of air cargo is higher. The limited or inconsistent impact of exchange rate fluctuations on air cargo volumes, as noted in this study and the wider literature, can be linked to the characteristics of the goods generally transported by air. The air cargo is primarily utilized for specific goods, including perishable items, high-value commodities, pharmaceuticals, and time-sensitive industrial components. As a result, its demand is generally more inelastic and less affected by the exchange rate fluctuations compared to other freight transport methods. Additionally, differences in the inflation rates and the currency fluctuations among trading partners can result in uneven pricing effects, where the consequences of exchange rate changes are either absorbed by suppliers or alleviated through contractual agreements. In these situations, even the considerable changes in exchange rates might not lead to a corresponding impact on the amount of air cargo transported, particularly if air freight continues to be the most practical or sole option for transporting specific types of goods.

A statistically significant negative relationship is observed between the jet fuel prices and the volumes of the outbound and the inbound air cargo in Türkiye. The results in the researches by Kupfer et al. (2017), Hakim and Merkert (2019), are similar to the results obtained in this study. However differ from those obtained in this study, Akinyemi (2023) has concluded that the effect of jet fuel prices on air cargo varies in selected countries in the short and long run, and Choi (2023) has concluded that the oil price does not affect the amount of the air cargo carried. In countries such as Türkiye, which function as regional hubs yet are significantly affected by global fuel price fluctuations, cargo operators may modify their capacity or frequency to alleviate increasing operational costs, consequently decreasing the overall cargo transported. The variation in results across studies and regions, as demonstrated by Akinyemi (2023) and Choi (2023), may be attributed to the less pronounced nature of this situation in countries with more subsidized or hedged fuel procurement mechanisms. On the contrary to the conclusions of Tuncer and Aydoğan (2019), who have concluded that the price of Brent oil have not have significantly impact the amount of foreign cargo that Turkey transported, our analysis reveals an adverse relationship between the two variables. This disparity may be the result of differences in countries that were included in the sample as well as differences in the timeframes that were investigated in the two studies.

In this study, the populations of both Türkiye and the partner countries are included as separate variables. The analysis reveals a statistically significant positive relationship between Türkiye's population and the volume of the outbound air cargo. Conversely, no statistically significant relationship is observed with respect to the volume of the inbound air cargo. Similar results with this study have been found in studies conducted by Hwang and Shiao (2011), Aydın and Ülengin (2022b), and Fageda et al. (2023). The significant positive correlation between Türkiye's population and the outbound air cargo

volume indicates that increased production capacity may enhance international air freight, particularly for export-oriented sectors such as computers, electronics, etc. Larger populations, particularly younger demographics, and higher industrial output contribute to increased air freight demand, especially for the time-sensitive goods or the high-value driven by e-commerce. However, no statistically significant relationship is observed between the populations of the relevant countries and the volume of inbound air cargo. Interestingly, a statistically significant negative relationship is identified between the populations of these countries and the volume of the outbound air cargo from Türkiye. Conversely, the lack of a substantial correlation between the inbound air cargo and Türkiye's population may suggest that the import dynamics are more affected by economic specialization, trade agreements, or industrial demand than consumption patterns driven by population. The significant negative correlation between the populations of partner countries and Türkiye's outbound aviation cargo volume is noteworthy. Given that both populous nations (e.g., USA, China, India) and smaller countries get comparable amounts of cargo from Türkiye, the population alone may not adequately predict cargo demand, particularly when the traded items and bilateral trade patterns exhibit heterogeneity.

Distance is another important determinant of trade between countries and is therefore commonly included as a variable in studies examining the factors influencing demand for the air transport and the other modes of freight. Our analysis indicates a statistically significant positive relationship between distance and the volumes of both the outbound and the inbound air cargo in Türkiye. This positive correlation between distance and the outbound and the inbound air cargo in Türkiye indicates that the air transport becomes increasingly advantageous as the geographical distance between trading partners expands. Further distances generally diminish the competitiveness of land or sea transport regarding speed, thus enhancing the relative appeal of the air cargo, particularly for time-sensitive or high-value items. This finding is consistent with Oesingmann (2022), who has concluded that the distance positively affects the weight of the air cargo and increases the weight of the air cargo carried on the medium and the long-haul routes.

The robustness checks reported in Section 4.2 reinforce the reliability of these findings. The clustered robust standard errors used in Table 6 account for both heteroskedasticity detected by the Breusch-Pagan test and intra-country autocorrelation detected by the Wooldridge test. The fixed-effects estimates reported in Table 7 confirm that the baseline findings on flight frequency, jet fuel prices, and the Turkish population are stable across all specifications; however, the time-independent nature of the distance variable and the infrequent change in the liberalization index (both of which are theoretically central to the gravity model framework) explain why these two variables could not be identified under the fixed-effects estimator. This pattern is fully consistent with the panel data literature and highlights the suitability of the random-effects estimator as the baseline specification for the present study.

The discrepancies in findings between this study and the research conducted by Gong et al. (2018) in China may be ascribed to variations in the logistics infrastructures, trade composition, and the regional

trade patterns specific to each country. China's extensive domestic air cargo network and robust maritime logistics capabilities may diminish the sensitivity of air cargo demand to distance, especially in the context of regional trade. Türkiye's geographic position as a bridge between continents may influence the role of distance in determining transport mode, particularly for intercontinental trade routes. These differing outcomes underscore the necessity of contextualizing distance as a variable, encompassing its physical dimensions and the geopolitical, infrastructural, and economic factors influencing the transportation choices.

6. CONCLUSION AND RECOMMENDATIONS

The liberalization policies and bilateral air transport agreements play a pivotal role in the growth of the air transport sector. This study seeks to assess the liberalization levels of bilateral air agreements concluded by Türkiye with the relevant countries and to examine how these levels, along with other variables, influence Türkiye's international outbound and inbound air cargo volumes. This study emphasizes that the connection between essential macroeconomic and operational factors and air cargo demand in Türkiye reveals the intricate and context-dependent patterns. The analysis indicates a positive relationship between the amount of the air cargo from Türkiye to the partner countries and the level of the liberalization of the bilateral agreements, imports from the partner countries to Türkiye, the number of flights between Türkiye and the partner countries, Türkiye's population, and distance. Conversely, the jet fuel prices and the populations of the partner countries exhibit a negative relation with outbound air cargo. Regarding inbound air cargo, a positive relation is observed with the level of liberalization of bilateral agreements, imports from the partner countries to Türkiye, and distance, whereas jet fuel prices show a negative association. The inverse connection between the jet fuel prices and the cargo volume indicates that increasing operational expenses can greatly influence air cargo operations, particularly in emerging markets where cost is critical and profits are on edge. Moreover, the inconsistent impact of exchange rates or the populations of partner countries highlights the significance of national economic frameworks, trade characteristics, and products transported by air. The findings indicate that air cargo dynamics are not universally applicable across countries and require a contextual analysis that takes into the account local economic conditions, the trade characteristics, and the infrastructure strategies.

Similar to the results obtained in this research, it is concluded that the liberalisation of the bilateral agreements increases the amount of the air cargo carried between Türkiye and the countries concerned, therefore, new BASAs to be signed by the Republic of Türkiye should be liberalised and existing BASAs should be liberalised. Analysing the liberalisation process of the developing countries like Türkiye civil aviation and developing strategies for the future are among the main objectives of this study. In this context, since there is a positive correlation between the liberalization process of countries and the weight of air cargo carried, it is considered that it may be useful for countries to analyze the liberalization process in detail and to make more liberal decisions while taking future steps. As a policy

recommendation, our study suggests that Türkiye negotiates the special cargo transportation rights in bilateral agreements, particularly the 5th and 7th freedom rights, prioritizes negotiating more liberal and open skies agreements concerning cargo capacity, and invests in infrastructure to create the regional cargo hubs. The New Istanbul Airport Cargo Center, with its advantageous geographic position linking Europe and Asia and accommodating about 5.5 million tons of cargo per year at full operational status, offers a comprehensive infrastructure for cargo aircraft, cargo terminals, customs operations, and bonded logistics facilities and substantially aids Türkiye's objective of establishing itself as a regional aviation cargo center. Besides, the airports such as Istanbul Sabiha Gokcen, Izmir, Bursa, Gaziantep, Kayseri, and Eskisehir possess the basic requisite infrastructural amenities, and strengthening these airports as regional air cargo hubs and integration into global air freight networks may be accomplished via more liberal bilateral agreements supported by government incentives, multimodal especially railway connections, multinational alliances, and, innovative commercial models. Those airports may serve as physical and operational foundations underpinning the liberalized air cargo policy, bilateral air service agreements, and the broader objective of establishing Türkiye as a logistics and commercial hub in the area. Furthermore, it is recommended that the industry representatives be included in negotiation processes with a cargo diplomacy strategy and that a data-driven, adaptive agreement management platform be established. These regulations allow Türkiye to position itself as a regional hub in the air cargo industry, facilitating the transport of high-value-added and the time-sensitive goods.

Airline companies and other stakeholders engaged in air cargo transport should make demand forecasts based on the factors affecting air cargo demand to plan their activities, make investment decisions, and compete globally. If the airline companies want to fly to a new line or increase the number of flights on the present flight line, they should make decisions by considering the factors affecting the cargo demand and focusing on flight lines that may be more profitable. They also must consider country-specific and contextual factors.

This study, conducted within the framework of two research questions, is limited to the mutual outbound and inbound air cargo demand among Türkiye and 15 countries. Since the analysis has been conducted using data from the origin and destination of flights rather than the actual origin and destination of cargo, the findings may not fully reflect the actual demand between these countries. Furthermore, since the statistics provided by DHMI are only available from 2013 onwards, the analysis period is restricted by the lack of the historical data prior to that year.

It is observed that studies on the air cargo demand in Türkiye have increased since 2018. Although research on the air cargo demand has historically lagged behind studies on airline passenger demand, the recent growth is noteworthy. Future studies could examine the short- and long-term effects of the variables considered in this study on air cargo demand, as well as air cargo flows between Türkiye and countries not included in the current sample. This study has found that the number of flights has a statistically significant positive effect on the volume of air cargo departing from Türkiye to the partner

countries, but no statistically significant effect on the amount of the air cargo arriving in Türkiye. Accordingly, it is recommended that the factors influencing the preferences of the air cargo shippers in Türkiye be further investigated.

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KATKI ORANI / *CONTRIBUTION RATE*	**AÇIKLAMA / *EXPLANATION***	**KATKIDA BULUNANLAR / *CONTRIBUTORS***
Fikir veya Kavram / *Idea or Notion*	Araştırma hipotezini veya fikrini oluşturmak / *Form the research hypothesis or idea*	Asst. Prof. Doğan KILIÇ (Ph.D.) Prof. Ferhan KUYUCAK ŞENGÜR (Ph.D.)
Tasarım / *Design*	Yöntemi, ölçeği ve deseni tasarlamak / *Designing method, scale and pattern*	Asst. Prof. Doğan KILIÇ (Ph.D.) Prof. Ferhan KUYUCAK ŞENGÜR (Ph.D.)
Veri Toplama ve İşleme / *Data Collecting and Processing*	Verileri toplamak, düzenlenmek ve raporlamak / *Collecting, organizing and reporting data*	Asst. Prof. Doğan KILIÇ (Ph.D.) Prof. Ferhan KUYUCAK ŞENGÜR (Ph.D.)
Tartışma ve Yorum / *Discussion and Interpretation*	Bulguların değerlendirilmesinde ve sonuçlandırılmasında sorumluluk almak / *Taking responsibility in evaluating and finalizing the findings*	Asst. Prof. Doğan KILIÇ (Ph.D.) Prof. Ferhan KUYUCAK ŞENGÜR (Ph.D.)
Literatür Taraması / *Literature Review*	Çalışma için gerekli literatürü taramak / *Review the literature required for the study*	Asst. Prof. Doğan KILIÇ (Ph.D.) Prof. Ferhan KUYUCAK ŞENGÜR (Ph.D.)

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