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MACROECONOMIC DETERMINANTS OF AIR CARGO DEMAND: A PANEL DATA ANALYSIS

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Abstract:
The main purpose of the study is to determine macroeconomic factors affecting air cargo demand. The dependent variable of the study is FTK, and GDP, IMP, EXP and INF variables are independent variables. Thirteen countries with the highest air cargo capacity in the world between 1980 and 2018 were included in the study. In the application part of the study, analyses were performed using the panel data analysis method. As a result of the panel data analysis method, it has been determined that there are significant relationships between economic growth indicator (GDP) and inflation variables and air cargo demand. While the GDP variable affects the air cargo demand positively, the inflation variable affects the negatively. It is determined that import and export variables are not related to air cargo demand.

Key words:
air cargo, air cargo demand, panel data analysis

INTRODUCTION

Air cargo transportation is a special form of the airline business model. Airline companies can use the cargo compartments of passenger aircraft as well as transport with cargo aircraft [1].

Compared to passenger transportation, air cargo transportation is more complicated than passenger transportation business. It includes packaging, document preparation, insurance regulation, receiving goods from shippers, facilitating customs operations at both the departure point and the destination, and completing the final delivery [2].

According to ICAO data, when looking at the historical development of air cargo demand, it is understood that it has grown 5% on average by 2018 [3]. However, air cargo

demand experienced a notable slowdown in 2018, and grew by 3.4% compared to its exceptional growth of 9.7% in 2017 [4]. By year of 2018, worldwide FTK (Freight Tonne Km) data was realized as 220,000 million. Scenarios related to the development of air transport in the future have been developed. According to the basic scenario described, air freight traffic will grow to 264,000 million tonkilometres in 2023. The biggest positive impact on the development of air transport has reached 284,400 million tonkilometres in 2023, assuming a 6% increase in commercial trade volume from 2016. On the other hand, the smallest growth in air transport was achieved when predicting a recession in the share of manufacturers. This led to 240,100 million tonkilometres in 2023 [5].

There are various indicators that express the air transport demand. Air passenger demand is based on revenue passenger kilometre (RPK), number of passengers and load factor (LF) data. For air cargo demand, FTK data showing the load carrying capacity of airline cargo companies and RTK (Revenue Tonne Km) data showing the revenue of the cargo transported are used. The following table 1.1 provides data on air transport demand in the years 1990-2018:

Tab 1. *Demand Data On Air Transport Worldwide (1990-2018)*

Demand Factors	1990	2000	2010	2015	2018
Number of passengers (million)	1,165	1,672	2,698	3,533	4,322
RPK (million)	1,894,020	3,037,530	4,910,282	6,601,465	8,257,635
FTK (million)	58,830	118,080	186,230	197,549	230,967
Total RTK (million)	235,240	403,960	643,670	817,030	1,004,763
National RTK (million)	104,460	130,870	196,275	250,368	307,691
International RTK (million)	130,780	273,090	447,395	566,662	697,072
Load Factor (%)	68	71	78	80	82

Source: [6]

When Table 1.1 is examined, it is seen that the air passenger demand increases 3.3 times according to RPK data. Similarly, according to the FTK data, air cargo demand has increased approximately 3 times. When looking at the table in general, it can be observed that the demand for air transport increased rapidly between 1990 and 2018.

As a result of the increase in liberalization movements in aviation after 1978, the airline sector has become more sensitive to economic and political factors. Especially the air transportation sector has started to be affected by macroeconomic factors. In this context, it is very important to make analyses that will reveal the relationship between air transport and macroeconomic variables. In the studies, the factors that affect air transportation, air passenger and cargo demand, air transportation demand was investigated under 2 different headings. In some studies, passenger and cargo demand were analysed together. In this study, macroeconomic effects on air cargo demand, which has been studied less in the literature, constitute the subject of the research.

In the introduction part of the study, the indicators that measures the development of the air cargo and the air transport demand are mentioned. In the first part, the relationship between the variables to be used in the application and the air cargo demand is tried to be explained. In the second part, the related literature is mentioned. In the third part, the method used was mentioned and analyses were carried out. In the final part, the findings are interpreted.

1. THE FACTORS THAT AFFECTS AIR CARGO DEMAND AND ITS RELATIONSHIP

One of the most important factors affecting air cargo demand is GDP (Gross Domestic Product) data, which is accepted as an indicator of economic development of countries. The relationship between air cargo and GDP has been established for a long time in the air transport industry [7-10]. The growth in the world air cargo transportation and the growth in the economy are moving together. With the growth of the economy, trade increases and the increase of trade has positive effects on cargo traffic between countries [11].

For example, in the period of 1990-2018, the amount of GDP has increased approximately 3 times (279%). In the same period, the demand for the FTK (Freight Tonne Km), which is the indicator of air cargo demand, increased by about 3 times (293%) [12]. In this context, it is important to examine the relationship between air cargo demand and GDP. International trade is expected to increase with economic growth. The increase in international trade also causes air cargo shipments to increase [13]. One of the main indicators explaining the economic activity in air transport is the goods export data of countries [5]. The study also found that exports of goods have important effects on air cargo transport. Another study found that service trade, one of the main driving forces of International Air Transport, reduced total air transport [14]. The existence of international trade in air cargo transportation is an undeniable fact. It also parallels the increase in international trade and the increase in air cargo demand. For example, between 1990 and 2018, import and export data showed a 4.5 times increase. It was observed that FTK data, which is the indicator of air cargo demand, increased approximately 3 times in the same period [12]. In this context, it is important to examine the relationship between air cargo transportation and import and export data which are indicators of international trade.

Another important factor affecting economic growth and air transport demand is the inflation data, which is the main determinant of the prices of goods and services. As is known, the price of products increases when the inflation rate increases, while the price of products decreases when it falls. The high inflation rate has a decreasing effect on the incomes of individuals and firms. Air transport demand also decrease as a result of declining income levels of the countries. At the same time, it is assumed that operating demand will be adversely affected, as the total costs of air transportation enterprises will increase with the increase of inflation. Worldwide inflation statistics confirm this. The inflation rate between 1990 and 2018 decreased by around 70%. During the same period there was 3 times increase in FTK data, which is the indicator of air cargo demand [12]. In this context, it is important to examine the relationship between air cargo demand and inflation data , which is one of the macroeconomic factors.

2. LITERATURE REVIEW

There are many studies in the literature about macroeconomic factors affecting air transport demand. As mentioned in the first part of the study, 2 different demands are measured, namely passenger and cargo demand related to air transportation demand. Many studies on passenger demand in the literature [15-24]. However, there are also studies in which both passenger and air cargo demand are handled together [8, 14, 25, 26,]. Only studies that determine the air cargo demand [5, 27-32].

In literature, the most studied variable related to macroeconomic variables affecting air cargo demand is GDP data, which is an indicator of economic development. Most of the studies focused on the relationship between air cargo and economic growth. Chang and Ying

(2008) conducted a cointegration analysis in 1970-2012 to reveal the relationship between air cargo and GDP for African countries. As a result of the analysis, it has been determined that there are strong relationships between air cargo demand and GDP. Chang and Chang (2009) investigated the relationship between air cargo expansion and economic growth in Taiwan in the period of 1974-2006 with granger causality analysis, and long-term and bilateral relationship was found between air cargo and economic growth. Suryani et al. (2012) measured air cargo demand to decide whether to expand the air cargo-related terminal capacity at Taiwan international airport. As a result of the analysis, it was concluded that GDP size had strong effects on air cargo demand. Chi and Baek (2013) investigated the effects of economic growth and market shocks that affect air cargo and passenger demand in the USA by cointegration analysis. As a result of the analysis, significant effects of economic growth on both air cargo and passenger demand were observed. Yao (2005) measured the relationship between air cargo and economic fluctuations for the USA in the period of 1979-2004, as a result of the analysis, it was determined that there is a mutual causality between GDP and air cargo demand. Gao et al. (2016) analyzed the economic growth relationship of air cargo demand for China in the period 1978-2014. As a result of the analysis, it was determined that there is a positive correlation between air cargo traffic data and GDP of air cargo revenue. Hakim and Merkert (2016) analyzed the relationship between air transport and economic growth in the context of South Asian countries in the 42-year period (1973-2014) by cointegration and causality tests. As a result of the analysis, they found that GDP is the reason for the short-term passenger and cargo demand. Kiracı and Battal (2018), in Turkey for the period 1983-2015 for the study variables affecting the air transport demand applications with VAR (Vevtorel Auto Regression) analysis was performed. It is determined that GDP and industrial production index have a determining effect on air cargo demand. Apart from these studies, there are also studies examining the effects of air cargo development on economic growth [33,34,35]. In these studies, it was concluded that the development of air cargo positively affects GDP.

There are several studies in the literature examining the relationship between countries' export data and air cargo demand. Kupfer et al. (2011), in the study covering routes in Europe and Asia in the period 1983-2007, the relationship between air cargo and export was analysed by the pooled regression method. As a result of the analysis, it was determined that there were strong positive relations between air cargo and exports. Zhang and Graham (2018) was carried out using the panel data analysis method of air transport demand forecast for eight emerging markets in the period 1992-2014. As a result of the analysis, it was concluded that GDP and exports are the driving force of air cargo demand. Kupfer et al. (2017) have developed the air cargo model [32] they have made before and included the air cargo efficiency and oil price in the model. As a result of the analysis, they concluded that the export strongly influenced the air cargo demand, supporting their previous studies.

When we look at the literature in general, it is observed that GDP data, which is an indicator of economic growth, has a great effect on air cargo demand. There are several studies related to export and it has been determined that there is a positive relationship. However, there is no study examining the relationship between the inflation variable and air cargo demand. Similarly, there is no study on imports. Country and region-based sampling is mostly used in the studies in the literature. In the study, 13 countries with the highest demand for FTK were chosen. In this regard, it is thought that it will contribute to the literature by reaching more inclusive results. In this study, the relationship between GDP, Export, Import and Inflation data and air cargo demand was realized by panel data analysis method.

3. DATA SET, MODEL AND METHODOLOGY

Using a time series econometric model in demand forecasting models is a sound way of predicting future demand [36]. More solid findings can be obtained when both time series and horizontal section data are included in the model. Therefore, panel data analysis method is one of the econometric methods frequently used in recent years [14]. In the air transport forecast model, ICAO makes predictions based on the air passenger demand based on the RPK data, while the air cargo demand is based on the FTK data. As the determinant of air cargo demand, it makes estimates only by establishing relations with GDP data (ICAO, 2016). On the other hand, Airbus company uses models with about 15 variables such as GDP, export and import, population, number of employees, employment, oil price for the air transport demand forecast [37].

The data resulting from the combination of time series and horizontal section data is called longitudinal data or polled data. The time and horizontal cross-section dimensions of such data may differ. Longitudinal or pooled data, in which the horizontal section units remain unchanged, is called panel data [38]. In economic researches, panel data usage has many advantages over horizontal section or time series. Accordingly, more observations are obtained in panel data usage compared to horizontal section and time series. This increases the degree of freedom and reduces the collinearity between the independent variables. It increases the efficiency of econometric forecasts in researches using panel data. In addition, the use of longitudinal data allows the researcher to perform a series of analyses that cannot be obtained using a horizontal section or time series [39].

The panel data model is essentially the regression model estimated by panel data. For this reason, when the regression model is mentioned, the tests, assumptions and other features are also valid for panel data models. In panel data models, there is one dependent and one or more independent variables. In addition, since the model is a statistical or econometric model, the error term is also included in the model. Since the variables in the model will show the change according to both units and time, different indices will be used in the representation of both. In panel data analysis, *i*, sub-indices are used to indicate the units and *t*, sub-indices to indicate the time period [38]. The linear panel data model made with panel data, where the dependent variable *Y* is indicated by independent variable or variables *X*, can be shown as follows [40].

$$Y_{it} = \alpha_{it} + \beta_{it} + X_{it} + \varepsilon_{it}$$

The main purpose of the study is to determine macroeconomic factors affecting air cargo demand. Thirteen countries with the highest air cargo capacity in the world between 1980 and 2018 were included in the study. The data of the study were provided by the World Bank and ICAO. Panel data analysis was used as a method and GAUSS-10, STATA-15 and EViews-9 software packages were used.

***Tab. 2** Sample Included in the Study (Countries)*

USA	China
Qatar	South Korea
Japon	Canada
France	India
Singapore	Turkey
England	Netherlands

Germany	

Source: Author

Despite the fact that there are many countries related to air cargo transportation worldwide, the countries with the highest air cargo volume, in which the data of the variables determined in the 1980-2018 period, are reached and we think can be reliable, are included in the study.

Tab. 3 *Measurement Indicators and Abbreviations of Variables*

Variables	Symbol	Measurement Indicators
Amount Of Air Cargo Transported (demand)	FTK	Air Freight Tonne Km (Ton)
Gross Domestic Product	GDP	GDP ($)
Import	IMP	Import ($)
Export	EXP	Export ($)
Inflation	INF	Inflation Rate

Source: Author

FTK data, which is the demand indicator of air cargo transportation, was used as the dependent variable in the study. GDP, IMP, EXP and INF data are independent variables. In the model, the relationship between independent variables and dependent variable was investigated. The established model formulation is shown below:

$$FTK_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 IMP_{it} + \beta_3 EXP_{it} + \beta_4 INF_{it} + \varepsilon_{it}$$

As a result of the literature reviews, the relationship between the variables expressed in Table 3 above is wanted to be examined. Within the theoretical framework, hypotheses related to the relevant variables are listed below:

H_0: There is a relationship between macroeconomic factors and air cargo demand.

H_1: There is no relationship between macroeconomic factors and air cargo demand.

The relationship between explanatory variables and air cargo demand was estimated:

- There is a positive relationship between GDP and air cargo demand (FTK).
- There is a positive relationship between export and air cargo demand (FTK).
- There is a positive relationship between import and air cargo demand (FTK).
- There is a negative relationship between the inflation rate and the air cargo demand (FTK).

4. EMPIRICAL FINDINGS

Before the panel data time series of cross-sectional dependence between the variables, as in analysis and determination of stability is required. Then tests are made on which panel data model (fixed or random effects) to choose. After choosing the appropriate model, heteroskedasticity and autocorrelation tests are performed. Finally, depending on the heteroskedasticity and autocorrelation results, the model is estimated with a resistant estimate suitable for the model.

Tab. 4 *Correlation Matrix of Variables*

	FTK	GDP	EXP	IMP	INF
FTK	1	0.231148	0.199934	0.187646	-0.06565
GDP	0.231148	1	0.203055	0.231054	-0.17106
EXP	0.199934	0.203055	1	0.680297	-0.05651
IMP	0.187646	0.231054	0.680297	1	-0.05824
INF	-0.06565	-0.17106	-0.05651	-0.05824	1

Source: Author

The high correlation between the variables in the regression model causes multiple linearity problems. Looking at the correlation between all variables, it is observed that they are below the critical value (0.80 and above).

Tab. 5 *Cross-Sectional Dependence Test Results*

Variable	CDLM adj.		
	Statistics	p-value	Decision
FTK	-1.454	0.927	Ho Kabul
GDP	5.020	0.000	Ho Red
EXP	-0.385	0.650	Ho Kabul
IMP	1.105	0.135	Ho Kabul
INF	13.129	0.000	Ho Red

Source: Author

According to the horizontal section dependency test results, the cross-sectional dependence has been determined in the GDP and INF series and the 2nd generation unit root test can be applied. In other series (EXP, IMP and FTK), 1st generation stationarity tests can be used because of no cross-sectional dependence is detected.

Tab. 6 *CADF Panel Unit Root Test*

Variable	Model	Stat.	Critical Values		
			1%	5%	10%
GDP	Constant	-4.522	-2.44	-2.25	-2.14
	Constant and Trend	-4.514	-2.93	-2.76	-2.66
∆GDP	Constant	-6.924	-2.44	-2.25	-2.14
	Constant and Trend	-6.830	-2.93	-2.76	-2.66
INF	Constant	-3.386	-2.44	-2.25	-2.14
	Constant and Trend	-3.501	-2.93	-2.76	-2.66
∆INF	Constant	-6.163	-2.44	-2.25	-2.14

Constant and Trend	-6.121	-2.93	-2.76	-2.66

Source: Author
Note: The critical values of CADF test statistics were obtained from Pesaran (2007). In all hypothesis tests, 0.05 (5%) significance level was taken as basis.

According to the result of CADF panel unit root test, which is the 2nd generation unit root test, it is determined that they are stationary in the series since the GDP and INF values are lower than the critical values.

***Tab. 7** Panel Unit Root Test*

Variable	Model	Levin, Lin& Chu-t		Lm, Paseran and Shin-W		ADF-Fisher Chi2	
		Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
FTK	Constant	21.3431	1.0000	15.5857	1.0000	12.1310	0.9904
	Constant and Trend	16.1978	1.0000	10.9546	1.0000	12.1185	0.9905
∆FTK	Constant	-8.8404	0.0000	-11.9614	0.0000	229.6810	0.0000
	Constant and Trend	-11.4303	0.0000	-13.2193	0.0000	249.3720	0.0000
EXP	Constant	3.8506	0.9999	5.8412	1.0000	4.0735	1.0000
	Constant and Trend	0.5939	0.7237	-0.4872	0.3130	25.9736	0.4646
∆EXP	Constant	-13.4418	0.0000	-16.5237	0.0000	267.6090	0.0000
	Constant and Trend	-11.1730	0.0000	-15.1026	0.0000	225.3480	0.0000
IMP	Constant	2.8341	0.9977	5.5686	1.0000	2.8524	1.0000
	Constant and Trend	-0.9874	0.1617	-1.5277	0.0633	33.4042	0.1507
∆IMP	Constant	-15.7692	0.0000	-16.5791	0.0000	267.2190	0.0000
	Constant and Trend	-14.2558	0.0000	-15.6487	0.0000	227.6110	0.0000

Source: Author
Notes: The optimal delay length was determined according to the SIC (Schwarz Info Criteria) criterion and The maximum delay length was set at 1.

According to the 1st generation panel unit root test results, it was determined that all three series were not stationary at the level and it was observed that they were stationary when their first differences were taken. Accordingly, model prediction was made by taking the first differences of FTK, EXP and IMP variables.

After the cross-sectioanl dependence and stationarity tests, it should be determined which of the classical model, fixed effects model and random effects models is suitable for use. In this context, the F-test was used to test the validity of the classical model against the fixed effects model, the Breusch-Pagan LM test was used to test the suitability of the classical model against the random effects model, and the Hausman test was used to choose between fixed effects and random effects models.

***Tab. 8** Model Identification Test*

F Testi		LM Testi		Hausman	
Stat.	**Prob.**	**Stat.**	**Prob.**	**Stat.**	**Prob.**
10.6943	0.0000	13.0627	0.0003	1.4800	0.2242

Source: Author

According to the results of model determination tests, random effects model was found to be appropriate.

Tab. 9 *Heteroskedasticity And Autocorrelation Tests*

Modified Wald		**Durbin Watson**	**Baltagi-Wu**
Stat.	**Prob.**	**Stat.**	**Stat.**
11.0162	0.0000	2.0701	2.0951

Source: Author

According to the modified wald test result, it is understood that there is a Heteroskedasticity problem because the probability value is significant. It has been determined that Durbin Watson and Baltagi-Wu test statistics are larger than 2, so there is no autocorrelation problem.

The model is estimated with Huber (1967), Eicker (1967) and White (1980) resistive estimator only in cases where heteroskedasticity problem exists in the model. These estimators proposed for the variance-covariance matrix of the predicted parameters produce homoskedastic standard errors [41].

Tab. 10 *Huber, Eicker and White Resist Estimator Results by Random Effects*

Variable	**Coefficient Estimate**	**Huber and Eicker Standart Error**	**t**	**p-value**	**(95% Confidence Interval)**	
GDP	4.31E-11	1.60E-11	2.70	0.007	1.18e-11	7.43e-11
DIMP	1.61e-09	3.20e-09	0.50	0.615	-4.66e-09	7.88e-09
DEXP	6.43e-10	2.30e-09	0.28	0.780	-3.87e-09	5.16e-09
INF	-2.188901	0.8591544	-2.55	0.011	-3.872813	-0.5049898
C	131.6176	42.74818	3.08	0.002	47.83276	215.4025
Number of bservations: 494		F(4,12) = 10.69			R^2= 0.0804	
Number of Groups: 13		Prob > F= 0.0000			Maksimum Delay: 2	

Source: Author

According to the random effects model that examines the factors determining the air cargo demand, the GDP variable has been found to have a positive effect on the air cargo demand (FTK) at a 1% significance level. It has been determined that the inflation rate (INF) variable has a negative effect on FTK with a 5% significance level. It has been concluded that there are no significant relationships between export (DIMP) and import (DEXP) variables and air cargo demand. The relationship diagram formed as a result of the analysis is presented as follows.

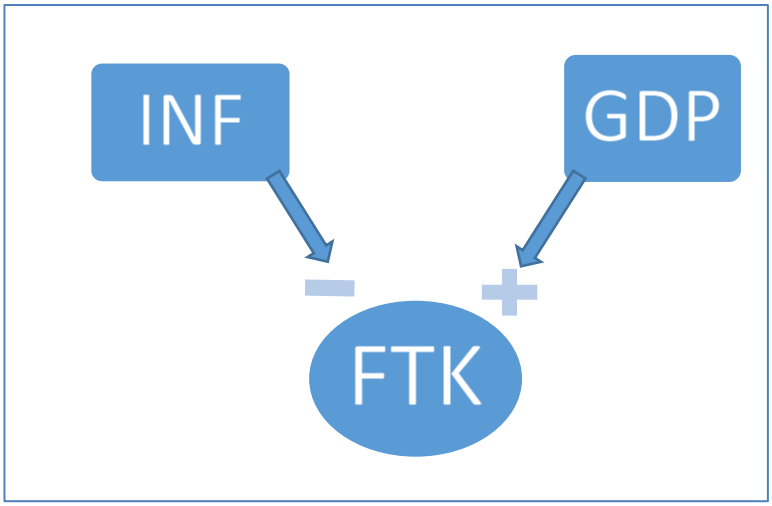

Fig. 1 *Relationship Diagram of Air Cargo Demand with Macroeconomic Factors*
Source: Author

In Table 11 below, the comparison of the theoretical expectations (hypothesis) with the findings is shown in a table.

Tab. 11 *Comparison of Findings with Theoretical Expectations*

Measurement Indicator	Hypothesis	Results
GDP	+	+
EXP	+	**No Relationship**
IMP	+	**No Relationship**
INF	-	-

Source: Author

As a result of comparing the hypotheses determined before the research with the findings of the analysis, GDP, which is an indicator of economic growth, and inflation variables, which are important factors in determining product prices, are consistent with the hypothesis as expected. However, while the export and import variables, which are two important indicators of foreign trade, are expected to have a positive relationship with the air cargo demand, as a result of the analysis, it has been determined that there is no relation with the air cargo demand. The fact that the GDP variable positively affects the air cargo demand is compatible with both the hypothesis and many studies in the literature [31,26,14]. Accordingly, it is thought that the existence of the GDP variable has become indisputable in the models established regarding the air cargo demand. As the inflation rate negatively affects the air cargo demand, it is thought that it will contribute to the literature since this variable is not used in the literature.

5. CONCLUSIONS

As a result of the increase in deregulation (liberilization) movements in aviation after 1978, the airline sector has become more sensitive to economic and political events.

Especially the air transportation sector has started to be affected by macroeconomic factors. In this context, it is very important to conduct analyzes that will reveal the relationship between air transport and macroeconomic variables. In the studies, the factors that affect air transportation, air passenger and cargo demand, air transportation demand was investigated under 2 different headings. In some studies, passenger and cargo demand were analyzed together. In this study, macroeconomic effects on air cargo demand, which has been studied less in the literature, constitute the subject of the research.

The main purpose of the study is to determine macroeconomic factors affecting air cargo demand. The dependent variable of the study is FTK, and GDP, IMP, EXP and INF variables are independent variables. Thirteen countries with the highest air cargo capacity in the world between 1980 and 2018 were included in the study. In the application part of the study, analyzes were performed using the panel data analysis method. In the first part of the analysis, unit root tests were applied to test the cross-sectional dependence and stationarity of the series. Then, model determination tests (classical, fixed and random) and pre-tests (heteroskedasticity and autocorrelation) were performed. Finally, the final findings have been reached by making model prediction.

As a result of the panel data analysis method, it was determined that there are significant relationships between economic growth indicators, GDP and inflation variables and air cargo demand. While the GDP variable affects the air cargo demand positively, the inflation variable affects the negatively. It is determined that import and export variables are not related to air cargo demand. The findings obtained as a result of the study are thought to contribute to the determination of the factors affecting air cargo demand, in this context, to air cargo managers and policy makers related to transportation, logistics and aviation. It also contributes to the literature for air cargo demand.

The study has some limitations that will affect the research results. The first is that the research sample is limited. Another constraint is the frequency and duration of the statistical data used in the research. Another constraint is the limited number of independent variables. In future studies, it is thought that more frequent and long-term studies with more samples (airline companies) and variables will have more accurate results.

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