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Causal Relationship Between Air Transport and Economic Growth: Evidence from Panel Data for High, Upper-Middle, Lower-Middle and Low-Income Countries

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Abstract

This study aims to find out the causal relationship between air transport and economic growth based on income level. To this end, selected countries with high-income, upper-middle-income, lower-middle-income, and low-income levels were included in the analyses for this study. Focusing on the 1990-2016 period, a total of 70 countries were classified according to their income levels and were analyzed empirically. In the study, panel causality analyzes by Kónya (2006) and Emirmahmutoğlu & Köse (2011) were used. Our findings show that GDP has a certain degree of effect on air transport. They also indicate that the unidirectional or bidirectional causal relationships running from GDP to air transport and air transport to GDP vary by the income level of countries.

Keywords: air transport, economic growth, panel causality, income level

JEL classification: L93, O11, C23, D63

Introduction

The close relationship between the demand for air transport and the country/ individual income is often underscored. Presumably, with the increase in income, individuals allocate more budget to traveling, and countries increase their infrastructure investments for air transport as well. Thus, a positive relationship is expected between the level of income of the country/individual and the demand for air transport. Therefore, in recent years there have been several studies on the relationship between air transport and economic growth (Hakim & Merkert, 2016; Hu *et al.*, 2015; Beyzatlar, Karacal & Yetkiner, 2014; Mehmood & Shahid, 2014; Profillidis & Botzoris, 2015). In these studies, the relationship was examined empirically on the basis of a particular country or group of countries, whereas the relationship between air transport and economic growth was not addressed on the basis of countries' income levels. As such, the current study focuses on whether there is a causal relationship between air transport and economic growth, based on the income level of the ten countries, and whether the income level is has an effect on this relationship.

Many studies in the research literature examine the factors that determine the nature of air transport. In these studies, an air transport model was created to model GDP change, and it was analyzed to see if the GDP/per capita income had any effect on the air transport. The studies on factors affecting demand in air transport clearly show that GDP has a significant influence on air transport demand (Hutchinson, 1993; Alperovich & Machnes, 1994; Aderamo, 2010). Additionally, some studies found a high correlation between the variables of air transport and economic determinants (Ba-Fail, Abed & Jasimuddin, 2000; Baikgaki & Daw, 2013).

The results of the above-mentioned studies show that GDP is an important determinant of air transport, but so far, very few studies have investigated the exact nature of the causality between GDP and air transport. Table 1 shows the studies on the causal relationship between air transport and economic growth. As seen in Table 1, there is an uncertainty about the direction of the relationship between GDP and air transport. The determination of this relationship is crucial in making infrastructure investments for air transport or prioritizing these investments. In addition, the determination of the relationship between GDP and air transport based on countries' income levels may be a guide for developing air transport policies in lower-middle-income and low-income countries.

This study is aimed to expand and strengthen the previous studies on the relationship between air transport and economic growth. Unlike previous studies, this study examined the causal relationship between air transport and economic growth based on the income level of countries. Another contribution of this study to the literature is its method of classifying countries into four different subcategories according to income level in order to solve the problem of “lumping-together” in the panel data analysis. Therefore, this study extends the empirical literature on the causal relationship between low-income, low-middle-income, high-middle-income, and high--income countries, air transport, and economic growth.

The purpose of this study is to examine the causal relationship between air transport and economic growth in 70 countries for the period of 1990-2016, by using the panel causality analysis of Kónya (2006) panel Granger causality analysis and Emirmahmutoğlu & Köse (2011) panel causality analysis. The rest of this article is organized as follows: in the following section, the method and data used in the study will be described. In the third section, the empirical findings obtained from the analysis will be presented. In the fourth section, the findings will be discussed followed by a conclusion.

Table 1. Summary of empirical studies on air transport – economic growth nexus.

Authors	Period	Country	Methodology	S-L Run/ Causality
Baker, Merkert & Kamruzzaman (2015)	1985-2011	Australia (88 regional airports)	Cointegration and Granger causality	GDP → AT
Profillidis & Botzoris (2015)	1980-2013	World (8 geographical area)	Econometric models	AT → GDP
Mehmood & Shahid (2014)	1970-2012	Czech Republic	Cointegration, FMOLS, DOLS and CCR	GDP → AT
Beyzatlar, Karacal & Yetkiner (2014)	1970-2008	15-EU countries	Granger causality	GDP → AT
Hu *et al.* (2015)	2006-2012 (Q)	China	Heterogeneous panels-Granger causality	AT → GDP
Chi & Beak (2013)	1996–2011(m)	United States	Cointegration ARDL and ECM	Short-run causality
Hakim & Merkert (2016)	1973–2014	8 South Asian countries	Cointegration and Granger causality	GDP → AT
Brida *et al.* (2014)	1995-2013	Mexico	Cointegration and Granger causality	GDP ↔ AT Long-run causality
Nisansala & Mudunkotuwa (2015)	1976-2012	Sri Lanka	Cointegration, Granger causality	GDP ↔ AT Long-run causality
Bal, Manga & Gümüş Akar (2017)	1967-2015	Turkey	Granger causality	AT → GDP
Anfofum, Saheed & Iluno (2015)	1980-2012	Nigeria	Cointegration, Granger causality	GDP → AT Long-run causality
Mukkala & Tervo (2013)	1991-2010	13 countries (in Europa)	Cointegration, Granger causality	AT → GDP
Marazzo, Scherre & Fernandes (2010)	1996-2006	Brazil	Cointegration, Granger causality	GDP → AT Long-run causality
Mehmood & Shahid (2014)	1970-2012	Romania	Granger causality	AT → GDP
Fernandes & Pacheco (2010)	1966-2006	Brazil	Granger causality	Long-run causality

Note: GDP → AT means that the causality runs from economic growth to air transport. AT → GDP means that the causality runs from air transport to economic growth. GDP ↔ AT means that bidirectional causality exists between air transport and economic growth. AT (air transport**),** GDP= gross domestic product, VAR=vector autoregressive model, FMOLS= fully modified ordinary least square, DOLS= dynamic ordinary least square, CCR= conical cointegration regression ECM= error correction model and ARDL=autoregressive distributed lag, S-L Run = short or long-run causality.

Data and Method

Two key variables (air transport (AT) and GDP per capita in $US) were used in this study to examine the causal relationship between air transport and economic growth. In the study of 1990-2016 period, a total of 70 countries were analyzed, including 20 high income, 20 upper middle income, 20 lower middle income and 10 low income. These countries are shown in Appendix-1. All data were obtained from the World bank database (The World Bank, 2018). Descriptive statistics of the AT and GDP variables for the four groups of countries classified by income level are shown in Table 2.

Two different analyses were used to examine the causal relationship between air transport and economic growth on the basis of income level of countries. The first of these is the bootstrap panel Granger causality analysis based on the heterogeneity hypothesis developed by Kónya (2006). The second is the panel causality test developed by Emirmahmutoğlu & Köse (2011) and used for heterogeneous mixed models.

Table 2. Descriptive statistics of included variables

	Variables	**Mean**	**Maximum**	**Minimum**	**Std. Dev.**
High income	GDP	44298.67	111968.30	20469.26	15503.04
	AT	61455129	823000000	405700	139000000
Upper middle income	GDP	6563.96	14071.17	730.77	2354.05
	AT	19768458	488000000	62798	47996885
Lower middle income	GDP	1584.66	3786.53	193.24	853.31
	AT	4476181	120000000	8000	11454513
low income	GDP	540.08	1342.54	161.83	263.63
	AT	534411	8242115	5856	962936

Note: AT is air passengers carried include both domestic and international aircraft passengers of air carriers registered in the country and GDP per capita is gross domestic product divided by midyear population. Data are in constant 2010 U.S. $.

Empirical Findings

Cross-sectional dependence

The cross-sectional dependence test was performed before the causality analysis was conducted. Cross-sectional dependence is related to whether the shock panel formed in one of the series affects all the units in the panel data. In this study, Breusch & Pagan (1980), Pesaran (2004), and Pesaran et al. (2008) cross-sectional dependence tests were used. Table 3 shows the cross-sectional dependence test results. The results of the analysis show that the H_0 hypothesis is rejected for all four income levels. Thus, cross-sectional dependence is achieved in the series.

Table 3. Cross-sectional dependence test results

Country Group	Test	GDP	ATP
High income	CDlm (Breusch & Pagan, 1980)	417.780*	444.771*
	CDlm (Pesaran, 2004)	11.685*	13.069*
	LMadj (Pesaran, Ullah & Yamagata, 2008)	30.009*	33.068*
Upper middle income	CDlm (Breusch & Pagan, 1980)	274.317*	336.037*
	CDlm (Pesaran, 2004)	4.325*	7.492*
	LMadj (Pesaran, Ullah & Yamagata, 2008)	27.941*	22.802*
Lower middle income	CDlm (Breusch & Pagan, 1980)	274.760*	622.986*
	CDlm (Pesaran, 2004)	4.348*	22.212*
	LMadj (Pesaran, Ullah & Yamagata, 2008)	34.326*	31.845*
low income	CDlm (Breusch & Pagan, 1980)	73.061*	117.372*
	CDlm (Pesaran, 2004)	2.958*	7.629*
	LMadj (Pesaran, Ullah & Yamagata, 2008)	49.324*	21.951*

Note: * indicates that the null hypothesis (H_0) was rejected at the 1% level of significance.

Kónya (2006) Panel Causality Test

In the panel causality method developed by Kónya (2006), the seemingly unrelated regressions (SUR) estimator is used instead of the least squares (OLS). In addition, in the Wald test performed, bootstrap test statistics are used instead of asymptotic critical test statistics. In this way, cross-sectional dependency and heterogeneity are taken into account, and preliminary tests on the series such as stability and cointegration are not required. In this method, a common hypothesis is not required for all members of the panel because the direction of causality is analyzed based on country-specific bootstrap critical values in the Wald test (Kılıç, Buğan & Öz-bezek, 2016; Kar, Nazlıoğlu & Ağır, 2011). The Kónya (2006) panel causality approach describes a system that contains two sets of equations. The bootstrap based panel causality method can be expressed by the following equation system:

$$y_{1t} = \alpha_{1,1} + \sum_{i=1}^{ly_1} \beta_{1,1,i} y_{1,t-i} + \sum_{i=1}^{lx_1} \delta_{1,1,i} x_{k,1,t-i} + \varepsilon_{1,1,t}$$

$$y_{2t} = \alpha_{1,2} + \sum_{i=1}^{ly_1} \beta_{1,2,i} y_{2,t-i} + \sum_{i=1}^{lx_1} \delta_{1,2,i} x_{k,2,t-i} + \varepsilon_{1,2,t} \quad (1)$$

$$y_{N,t} = \alpha_{1,N} + \sum_{i=1}^{ly_1} \beta_{1,N,i} y_{N,t-i} + \sum_{i=1}^{lx_1} \delta_{1,N,i} x_{k,N,t-i} + \varepsilon_{1,N,t}$$

and

$$x_{k,1,t} = \alpha_{2,1} + \sum_{i=1}^{ly_2} \beta_{2,2,i} y_{2,t-i} + \sum_{i=1}^{lx_2} \delta_{2,2,i} x_{k,2,t-i} + \varepsilon_{2,1,t}$$

$$x_{k,2,t} = \alpha_{2,2} + \sum_{i=1}^{ly_2} \beta_{2,2,i} y_{2,t-i} + \sum_{i=1}^{lx_2} \delta_{2,2,i} x_{k,2,t-i} + \varepsilon_{2,2,t} \quad (2)$$

$$x_{k,N,t} = \alpha_{2,N} + \sum_{i=1}^{ly_2} \beta_{2,N,i} y_{N,t-i} + \sum_{i=1}^{lx_2} \delta_{2,N,i} x_{k,N,t-i} + \varepsilon_{2,N,t}$$

In this equation, *y* is the air transport (AT), and *x* is the GDP per capita (GDP). Further, *N* is the number of units (countries) in the panel, (*j=1,…,N*), *t* is the time period, and (*t=1,…,T*), *l* is the delay number. ly_1 and lx_1 are the maximum delay lengths of the variables in the first equation set, ly_2 and lx_2 are the maximum delay lengths of the variables in the second equation system. As a result of the application, for a unit (country) if all the (*i*), $\delta_{1,i}$ coefficients are not equal to zero and $\beta_{2,i}$ coefficients are all equal to zero, then there is a unidirectional causal relationship from variable *x* to variable *y*; there is a unidirectional causal relationship from variable *y* to variable *x* if $\beta_{2,i}$ coefficients are all not equal to zero and $\delta_{1,i}$ coefficients are all equal to zero. In addition, if all the $\delta_{1,i}$ and $\beta_{2,i}$ coefficients are not equal to zero, then there is bidirectional causality between the variables. If $\delta_{1,i}$ and $\beta_{2,i}$ coefficients are all equal to zero, it is concluded that there is no causal relationship between the variables. The bootstrap panel causality test

results obtained from the analysis are shown in the following tables.

Table 4. Kónya (2006) causality test results for high-income countries

Country	GDP → AT				AT → GDP			
	w_i	Bootstrap Critical Values			w_i	Bootstrap Critical Values		
		1%	5%	10%		1%	5%	10%
Australia	16.589	99.193	56.866	45.078	0.291	66.349	39.636	27.074
Austria	15.151	173.064	127.554	102.539	1.028	184.002	108.717	83.170
Belgium	0.002	12.753	8.582	6.487	0.409	43.987	25.370	17.831
Canada	19.197	138.947	88.207	72.982	3.530	184.371	113.995	76.683
Finland	1.010	45.306	28.291	22.209	1.210	144.007	83.571	66.840
France	30.474	243.730	171.175	139.447	0.131	586.777	291.069	224.068
Germany	0.048	162.859	93.155	72.316	53.763	340.450	224.616	175.333
Iceland	10.923*	10.041	5.426	3.709	19.234	125.606	58.739	48.858
Ireland	51.848	101.492	65.726	55.813	4.221	38.638	27.800	22.395
Israel	65.843	573.504	315.597	232.315	3.014	683.525	359.168	259.927
Italy	47.470	320.088	236.739	180.225	22.148	640.617	306.166	216.966
Japan	2.041	105.896	52.187	37.427	0.310	369.387	238.932	186.025
Luxembourg	0.814	34.879	22.986	18.809	8.438	204.584	102.366	71.492
Netherlands	0.005	83.563	55.457	44.938	57.891	356.576	226.937	180.980
New Zealand	6.173	373.519	213.185	158.173	25.094	281.306	173.008	135.749
Singapore	33.027	505.349	309.788	257.755	21.770	343.225	216.447	166.308
Switzerland	8.163	152.474	87.422	65.601	2.338	78.240	54.053	40.649
United Arab Emirates	192.9***	304.955	188.070	137.244	5.047	48.639	29.215	21.041
United Kingdom	0.325	61.636	41.502	35.355	0.752	110.341	67.715	51.411
United States	28.813	438.689	293.553	236.682	6.999	367.445	225.502	181.234

Note: GDP → AT means that the causality runs from GDP to air transport. AT → GDP means that the causality runs from air transport to GDP. GDP ↔ AT means that bidirectional causality exists between air transport and GDP *, ** and *** indicate that the test statistic is significant at the 1%, 5% and 10% significance levels, respectively. The optimal lag length was decided according to the Akaike information criterion. The bootstrap number is 1000. The maximum delay length is 3.

In Table 4, the results of causality analysis for high-income countries are displayed. Accordingly, Iceland and United Arab Emirates have a causal relationship running from GDP to air transport. In contrast, none of the high-income countries has a causal relationship with direction from air transport to GDP.

Table 5. Kónya (2006) causality test results for upper-middle-income countries

Country	GDP → ATP				ATP → GDP			
	w_i	Bootstrap Critical Values			w_i	Bootstrap Critical Values		
		1%	5%	10%		1%	5%	10%
Argentina	8.544	210.395	130.848	100.199	1.342	140.536	80.022	59.955
Botswana	2.018	58.901	29.311	22.838	31.967	143.693	77.213	51.462
Brazil	304.4**	312.304	173.772	145.288	20.630	550.996	310.436	239.563
Bulgaria	7.93***	15.699	8.262	5.678	151.98*	110.492	63.005	43.054
China	4.418	314.794	165.152	132.641	44.204	137.261	71.625	49.286
Colombia	38.037	253.407	166.549	139.682	0.094	248.425	168.679	126.652
Costa Rica	7.150	79.568	49.237	40.113	6.060	110.480	63.727	44.663
Ecuador	40.900	393.226	246.720	182.109	0.492	478.206	284.175	210.920
Lebanon	44.445	203.516	123.309	102.244	4.591	15.392	9.806	6.288
Malaysia	13.951	175.908	115.985	87.530	24.003	101.889	60.438	51.771
Mauritius	23.595	227.740	139.738	110.551	0.967	78.428	37.442	23.528
Mexico	0.037	330.964	195.587	143.288	3.200	101.946	64.225	52.881
Panama	99.749	253.088	181.440	140.748	4.131	76.048	43.106	29.378
Peru	12.991	218.238	142.811	118.924	9.695	181.221	103.897	79.249
Romania	25.541	202.509	120.920	101.912	5.525	624.361	317.424	251.516
Russian Federation	11.274	53.861	34.802	27.524	103.65*	87.250	33.834	22.924
South Africa	0.618	269.442	162.431	121.909	16.278	335.695	214.692	177.170
Suriname	0.566	34.239	17.038	13.114	24.756	102.346	58.915	43.741
Thailand	1.869	155.568	82.470	64.331	3.821	58.238	35.417	29.346
Turkey	29.504	222.929	136.595	105.744	11.161	173.789	117.922	92.039

Note: GDP → AT means that the causality runs from GDP to air transport. AT → GDP means that the causality runs from air transport to GDP. GDP ↔ AT means that bidirectional causality exists between air transport and GDP *, ** and *** indicate that the test statistic is significant at the 1%, 5% and 10% significance levels, respectively. The optimal lag length was decided according to the Akaike information criterion. The bootstrap number is 1000. The maximum delay length is 3.

In Table 5, the causality analysis results for the upper-middle-income countries are shown. The findings of the analysis show that there is a causal relationship that runs from GDP to air transport in Brazil. In Bulgaria, there is a bidirectional causal relationship running from GDP to air transport as well as from air transport to GDP. In the Russian Federation, the relationship indicates a unidirectional causality towards air transport GDP.

Table 6. Kónya (2006) causality test results for lower-middle-income countries

Country	GDP → ATP				ATP → GDP			
	w_i	Bootstrap Critical Values			w_i	Bootstrap Critical Values		
		1%	5%	10%		1%	5%	10%
Angola	27.391	63.369	45.510	37.543	0.079	27.424	12.220	8.175
Bangladesh	22.735	96.386	56.362	45.120	176.6***	417.163	230.096	171.002
Bhutan	33.826	120.219	79.331	63.662	12.748	52.137	22.289	15.305
Bolivia	38.7***	76.993	45.389	33.956	0.067	100.159	45.782	30.203
Cabo Verde	5.389	87.976	49.176	31.813	24.925	100.880	59.211	48.258
Cameroon	0.295	21.024	12.224	7.507	70.5***	139.534	71.925	48.787
Egypt	408.6**	424.555	317.052	272.227	7.287	184.610	76.234	52.076
India	8.026	126.817	82.679	69.078	10.982	42.161	23.725	14.464
Jordan	15.044	314.340	218.830	182.142	4.842	98.599	53.806	37.883
Kenya	1.013	442.326	232.794	183.948	152.791	314.559	195.406	153.262
Lao PDR	29.364	115.257	82.398	69.432	38.877	205.496	109.327	85.109
Mauritania	16.722	93.931	41.523	27.910	9.392***	35.750	12.993	8.290
Morocco	80.353	352.358	247.448	197.436	83.95**	181.549	78.999	55.986
Myanmar	30.715	146.041	88.442	73.134	35.358	133.254	57.250	38.429
Nigeria	42.813	321.322	208.024	179.415	0.082	61.670	36.696	26.426
Pakistan	2.843	157.225	76.452	61.190	1.007	88.291	51.153	37.671
Philippines	121.96**	151.937	106.132	89.406	0.098	17.162	9.668	6.757
Sudan	4.982	87.253	40.949	29.624	104.6**	193.717	76.618	48.593
Vanuatu	32.550	174.563	99.814	81.098	10.266	26.838	15.694	11.652
Vietnam	1.888	33.559	17.479	12.898	0.254	88.173	57.884	45.053

Note: GDP → AT means that the causality runs from GDP to air transport. AT → GDP means that the causality runs from air transport to GDP. GDP ↔ AT means that bidirectional causality exists between air transport and GDP *, ** and *** indicate that the test statistic is significant at the 1%, 5% and 10% significance levels, respectively. The optimal lag length was decided according to the Akaike information criterion. The bootstrap number is 1000. The maximum delay length is 3.

In Table 6, the causality analysis results for the lower-middle-income countries are shown. Accordingly, there is a unidirectional causal relationship that runs from GDP to air transport in three countries. These countries are Bolivia, Egypt and Philippines. In addition, the results of the analysis show that in five countries there is a unidirectional causal relationship running from air transport to GDP. These countries are Bangladesh, Cameroon, Mauritania, Morocco and Sudan.

Table 7. Kónya (2006) causality test results for low-income countries

Country	**GDP → ATP**				**ATP → GDP**			
	w_i	**Bootstrap Critical Values**			w_i	**Bootstrap Critical Values**		
		1%	**5%**	**10%**		**1%**	**5%**	**10%**
Burkina Faso	0.307	7.225	4.573	3.431	1.645	4.604	2.584	1.883
Ethiopia	10.862	52.194	40.125	34.509	12.347	93.014	68.523	58.732
Madagascar	35.804*	12.271	6.356	4.054	0.219	27.576	15.948	12.036
Malawi	16.01***	22.980	16.682	14.658	0.657	13.342	9.010	7.323
Mozambique	14.843	38.882	30.057	26.457	3.76**	4.421	2.341	1.596
Nepal	0.014	6.043	4.059	2.878	0.035	5.964	3.330	2.389
Senegal	1.958	17.865	10.851	8.464	0.541	8.452	4.932	3.358
Tanzania	8.615	27.883	19.114	17.043	2.62***	5.908	3.280	2.099
Uganda	3.528	10.398	6.303	3.968	2.323	9.634	5.084	3.052
Zimbabwe	0.214	43.795	30.013	24.204	36.5***	64.281	37.725	30.847

Note: GDP → AT means that the causality runs from GDP to air transport. AT → GDP means that the causality runs from air transport to GDP. GDP ↔ AT means that bidirectional causality exists between air transport and GDP *, ** and *** indicate that the test statistic is significant at the 1%, 5% and 10% significance levels, respectively. The optimal lag length was decided according to the Akaike information criterion. The bootstrap number is 1000. The maximum delay length is 3.

Table 7 shows the causality analysis results for low-income countries. The results demonstrate that there is a causal relationship from GDP to air transport for Madagascar and Malawi. In addition, there are three countries where there is a causal relationship running from air transport to GDP. These countries are Mozambique, Tanzania and Zimbabwe.

Emirmahmutoğlu & Köse (2011) Panel Causality Test

The panel causality test, a panel data version of the causality test developed by Toda & Yamamota (1995), was used in the study. Developed by Emirmahmutoğlu & Köse (2011), this test is based on meta analysis in mixed heterogeneous panes. In the meta analysis developed by Fisher (1932), N units are tested and the significance levels (probability values) of this test are used (Zeren & Ergün, 2013:p.233). In a later stage, a single panel statistic is created using these probability values of the units. The advantage of this test is that it reduces long-term information loss by modelling with the level values of series, that it allows delay length to vary for each series, and that it takes the cross-sectional dependency into account (Gözbaşı, 2015:p.277; Gümüş & Koç, 2015:p.155; Büberkökü, 2016:p.189).

In this method, first, a standard Panel VAR estimate is made and the appropriate delay length (p) is determined. Then, for the appropriate delay length, the degree of integration of the variable with the highest degree of integration (d_{max}) is added. In the last stage, a Panel VAR model is estimated using the level values of the variables for the delay level ($p + d_{max}$) (Göçer, 2013:p.132; Kılıç, Buğan & Özbezek, 2016:p.1139; Emirmahmutoğlu & Köse, 2011:pp.871–872; Topallı, 2016:p.89). In the Emirmahmutoğlu & Köse (2011) method, the following Panel VAR model is estimated for each cross-section.

$$x_{it} = \mu_i^x + \sum_{j=1}^{k_i+d\,max_i} A_{11,ij} x_{i,t-j} + \sum_{j=1}^{k_i+d\,max_i} A_{12,ij} y_{i,t-j} - u_{i,t}^x \quad (3)$$

$$y_{it} = \mu_i^x + \sum_{j=1}^{k_i+d\,max_i} A_{21,ij} x_{i,t-j} + \sum_{j=1}^{k_i+d\,max_i} A_{22,ij} y_{i,t-j} - u_{i,t}^x \quad (4)$$

In the analysis, the modified Wald test is performed for the predicted k_i delay length. H_0 hypothesis is formed as "there is no causal relationship from y to x". Panel Fisher test statistics used in the study are presented in the following tables according to the income level of the countries.

Table 8. Emirmahmutoğlu & Köse (2011) causality test results for high-income countries

Country		**GDP → ATP**		**ATP → GDP**	
	k_i	w_i	**prob.**	w_i	**prob.**
Australia	3	19.407*	0.0000	2.700	0.4400
Austria	3	20.289*	0.0000	0.400	0.9400
Belgium	1	0.180	0.6710	0.011	0.9160
Canada	3	1.353	0.7170	0.026	0.9990
Finland	2	3.245	0.1970	1.271	0.5300
France	1	0.190	0.6630	0.868	0.3520

Germany	3	4.405	0.2210	0.455	0.9290
Iceland	2	8.408**	0.0150	1.159	0.5600
Ireland	3	0.822	0.8440	9.564**	0.0230
Israel	1	0.030	0.8620	0.535	0.4640
Italy	2	5.603***	0.0610	5.963***	0.0510
Japan	2	4.243	0.1200	1.002	0.6060
Luxembourg	1	0.107	0.7430	0.278	0.5980
Netherlands	2	7.197**	0.0270	1.814	0.4040
New Zealand	2	4.633***	0.0990	0.044	0.9780
Singapore	1	0.891	0.3450	1.689	0.1940
Switzerland	2	3.177	0.2040	0.832	0.6600
United Arab Emirates	1	6.458**	0.0110	1.229	0.2680
United Kingdom	3	6.616***	0.0850	0.054	0.9970
United States	2	1.318	0.5170	1.657	0.4370
Panel Fisher		94.857*	0.0000	33.988	0.737

Note: GDP → AT means that the causality runs from GDP to air transport. AT → GDP means that the causality runs from air transport to GDP. GDP ↔ AT means that bidirectional causality exists between air transport and GDP *, ** and *** indicate that the test statistic is significant at the 1%, 5% and 10% significance levels, respectively. The optimal lag length was decided according to the Akaike information criterion. The bootstrap number is 1000. The maximum delay length is 3.

In Table 8, causality analysis results for high-income countries are shown. Accordingly, there is a direct causal relationship between GDP and air transport in Australia, Austria, Iceland, Netherlands, New Zealand, United Arab Emirates and United Kingdom. In addition, in Ireland, there is a causal relationship from air transport to GDP. In Italy, there is bidirectional causality running from GDP to air transport as well as from GDP to air transport. The Fisher test statistic results show that high-income countries have a unidirectional causal relationship running from GDP to air transport.

Table 9. Emirmahmutoğlu & Köse (2011) causality test results for upper-middle-income countries

Country		**GDP → ATP**		**ATP → GDP**	
	$\boldsymbol{k_i}$	$\boldsymbol{w_i}$	**prob.**	$\boldsymbol{w_i}$	**prob.**
Argentina	2	5.312***	0.0700	3.471	0.1760
Botswana	3	5.129	0.1630	5.864	0.1180
Brazil	3	45.022*	0.0000	8.52**	0.0360

Bulgaria	2	0.101	0.9510	3.001	0.2230
China	2	0.863	0.6500	2.669	0.2630
Colombia	1	0.199	0.6560	1.148	0.2840
Costa Rica	3	11.574*	0.0090	5.969	0.1130
Ecuador	2	6.554**	0.0380	2.417	0.2990
Lebanon	3	11.035**	0.0120	4.628	0.2010
Malaysia	1	1.691	0.1930	0.255	0.6140
Mauritius	1	2.033	0.1540	0.006	0.9400
Mexico	1	3.588***	0.0580	0.684	0.4080
Panama	3	10.993**	0.0120	5.147	0.1610
Peru	1	1.243	0.2650	0.098	0.7550
Romania	3	10.844**	0.0130	13.054*	0.0050
Russian Federation	3	0.837	0.8410	3.329	0.3440
South Africa	2	0.222	0.8950	0.631	0.7290
Suriname	2	2.685	0.2610	1.806	0.4050
Thailand	1	0.109	0.7410	0.920	0.3380
Turkey	2	4.329	0.1150	4.770***	0.0920
Panel Fisher		118.467*	0.0000	61.95**	0.0150

Note: GDP → AT means that the causality runs from GDP to air transport. AT → GDP means that the causality runs from air transport to GDP. GDP ↔ AT means that bidirectional causality exists between air transport and GDP *, ** and *** indicate that the test statistic is significant at the 1%, 5% and 10% significance levels, respectively. The optimal lag length was decided according to the Akaike information criterion. The bootstrap number is 1000. The maximum delay length is 3.

Table 9 shows the causality analysis results for the upper-middle-income countries. The results indicate a unidirectional causal relationship running from GDP to air transport in Argentina, Costa Rica, Ecuador and Lebanon. Furthermore, in Brazil and Romania, there is a bidirectional causal relationship running from GDP to air transport as well as from GDP to air transport. In Turkey, there is a causality from air transport to GDP. For the upper-middle-income countries, the Fisher test statistics point to the presence of a causal relationship running from GDP to air transport at the 1% level of significance, and from air transport to GDP at the 5% significance level.

Table 10. Emirmahmutoğlu & Köse (2011) causality test results for lower-middle-income countries

Country		**GDP → ATP**		**ATP → GDP**	
	k_i	w_i	**prob.**	w_i	**prob.**
Angola	1	1.344	0.2460	0.227	0.6340
Bangladesh	1	0.021	0.8860	4.599**	0.0320
Bhutan	3	2.418	0.4900	0.747	0.8620
Bolivia	1	2.778***	0.0960	0.107	0.7430
Cabo Verde	2	1.548	0.4610	0.610	0.7370
Cameroon	2	5.110***	0.0780	18.210*	0.0000
Egypt	3	2.603	0.4570	1.593	0.6610
India	3	3.652	0.3020	4.329	0.2280
Jordan	3	30.329*	0.0000	1.471	0.6890
Kenya	3	6.559***	0.0870	23.260*	0.0000
Lao PDR	1	0.011	0.9150	1.171	0.2790
Mauritania	1	0.179	0.6720	0.820	0.3650
Morocco	2	3.392	0.1830	6.905**	0.0320
Myanmar	1	0.424	0.5150	0.005	0.9450
Nigeria	2	3.572	0.1680	3.638	0.1620
Pakistan	1	0.607	0.4360	0.117	0.7320
Philippines	2	0.588	0.7450	3.320	0.1900
Sudan	3	5.903	0.1160	0.646	0.8860
Vanuatu	2	5.422***	0.0660	2.503	0.2860
Vietnam	2	0.128	0.9380	0.489	0.7830
Panel Fisher		73.328*	0.0010	74.922*	0.0010

Note: GDP → AT means that the causality runs from GDP to air transport. AT → GDP means that the causality runs from air transport to GDP. GDP ↔ AT means that bidirectional causality exists between air transport and GDP *, ** and *** indicate that the test statistic is significant at the 1%, 5% and 10% significance levels, respectively. The optimal lag length was decided according to the Akaike information criterion. The bootstrap number is 1000. The maximum delay length is 3.

Table 10 shows the causality analysis results obtained for the lower-middle-income countries. Accordingly, there is a unidirectional causal relationship between GDP and air transport (running from GDP to AT) in Bolivia, Jordan and Vanuatu. In Bangladesh and Morocco, there is a causal relationship from air transport to GDP. Cameroon and Kenya are the countries that have bidirectional causal relationship from GDP to air transport as well as from GDP to air transport. The Fisher test statistics results show that the lower-middle-income countries have a causal relationship directed from GDP to air transport and from air transport to GDP at the 1% significance level.

Table 11. Emirmahmutoğlu & Köse (2011) causality test results for low-income countries

Country		**GDP → ATP**		**ATP → GDP**	
	k_i	w_i	**prob.**	w_i	**prob.**
Burkina Faso	1	1.938	0.1640	0.364	0.5460
Ethiopia	3	8.927**	0.0300	1.224	0.7470
Madagascar	1	2.558	0.1100	0.122	0.7270
Malawi	3	8.488**	0.0370	5.445	0.1420
Mozambique	1	0.348	0.5550	0.552	0.4580
Nepal	1	0.048	0.8270	0.227	0.6340
Senegal	1	0.612	0.4340	0.006	0.9400
Tanzania	3	21.357*	0.0000	5.630	0.1310
Uganda	2	2.437	0.2960	5.589***	0.0610
Zimbabwe	2	2.132	0.3440	9.372*	0.0090
Panel Fisher		48.082*	0.0000	27.958	0.1100

Note: GDP → AT means that the causality runs from GDP to air transport. AT → GDP means that the causality runs from air transport to GDP. GDP ↔ AT means that bidirectional causality exists between air transport and GDP *, ** and *** indicate that the test statistic is significant at the 1%, 5% and 10% significance levels, respectively. The optimal lag length was decided according to the Akaike information criterion. The bootstrap number is 1000. The maximum delay length is 3.

Table 11 shows the causality analysis results for the low-income countries. The results of the analysis show that there is a causal relationship between GDP and air transport (from GDP to AT) in Ethiopia, Malawi, and Tanzania. In addition, Uganda and Zimbabwe have a causal relationship from air transport to GDP. The Fisher test statistics results show that in the low-income countries, there is a unidirectional causal relationship between GDP and air transport (from GDP to AT) at the 1% significance level.

Conclusion

In this study, the causal relationship between air transport and GDP was examined using two different methods based on the income level of the countries. The first of these methods is the bootstrap-based panel causality analysis developed by Kónya (2006), which factors in the cross-sectional dependence and heterogeneity. The second is the panel causality method developed by Emirmahmutoğlu & Köse (2011), which uses meta-analysis of composite heterogeneous panels. Representing four different levels of income, a total of 70 countries selected on the basis of data accessibility were included in the analysis covering the period of 1990-2016.

Kónya (2006) panel causality findings indicate that, for two countries in the high-income country group, there is a causal relationship directed from GDP to air transport. In this country group, no causality from air transport to GDP could be established. In the upper-middle-income country group, one country has causality running from GDP to air transport, one from air transport to GDP, and one has a bidirectional causal relationship. In the lower-middle-income country group, three countries have causality with direction from GDP to air transport, and two countries have causality running from air transport to GDP. Finally, in the low-income country group, two countries exhibit a causal relationship running from GDP to air transport, and three countries have this causality running from air transport to GDP. Proportionally speaking, 10% of the countries in the high-income and upper-middle-income groups, 15% of the countries in the lower-middle-income group, and 20% of the low-income group have causality running from GDP to air transport. These ratios indicate that as the income level declines, the number of countries with a GDP-to-air transport type causal relationship proportionally increases. Similarly, there are only two countries with air transport-to-GDP type causal relationship in the high-income and upper-middle-income groups. However, this number rises to eight in the lower-middle-income and low-income country groups (although the number of countries included in the sampling is lower). Therefore, as the income level of the countries decreases, the number of causal relationships running from air transport to GDP is observed to increase.

When the Emirmahmutoğlu & Köse (2011) panel causality analysis results are examined, it is clear that in the high-income country group, there is a causal relationship from GDP to air transport in seven countries and from GDP to air transport in one country. In one of the countries, there is bidirectional causality from GDP to air transport as well as from GDP to air transport. Analyzing the Fisher test statistics values for all the countries in the panel, it is noticed that there is a unidirectional causal relationship from GDP to air transport at the 1% significance level in the high-income country group. In the upper-middle-income country group, six countries have a causal relationship from GDP to air transport and one country has it from air transport to GDP. In two countries, a bidirectional causal relationship has been identified. At this level of income, the Fisher test statistics values for the country group indicate the presence of a bidirectional causal relationship from GDP to air transport as well as from air transport to GDP, with significance of 1% and 5%, respectively. In the lower-middle-income country group, in three countries there is a causal relationship from GDP to air transport, and in two countries from air transport to GDP. Two of the countries in this group have a bidirectional causal relationship both from GDP to air transport and from GDP to air transport. For all countries in the panel, the Fisher test statistics values through which the causal relationship was analyzed demonstrate that a bidirectional causal relationship at a level of 1% significance exists in the lower-middle-income country group. Finally, in the low-income country group, the causality runs from GDP to air transport in three countries, while it runs from air transport to GDP in two of them. Fisher test statistics values for the country group at this income level point to the presence of a unidirectional causal relationship from GDP to air transport at the 1% significance level.

Some countries stand out in both empirical analyzes by demonstrating both a causal relationship running from GDP to air transport and from air transport to GDP. Thus, the existence of a GDP-to-air transport causal relationship in Iceland, United Arab Emirates, Brazil, Bolivia and Malawi has been proven by both causality analyses. Furthermore, both causality analyses have also confirmed that Bangladesh, Cameroon, Morocco and Zimbabwe have a causal relationship running from air transport to GDP. Most notably, the countries for which air transport-to-GDP causality has been verified in both empirical analyses belong to the lower-middle- income and low-income country groups, which supports the hypothesis that especially in the countries with below-average income level, air transport has an effect on economic growth.

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