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Analyzing the Environmental Kuznets Curve Hypothesis in terms of Airplane Transport: Empirical Examination for Baltic States

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ABSTRACT

The main goal of this paper is to investigate the long-term nexus among energy consumption, economic growth, civil aviation, and CO_2 emissions by performing the ARDL, DOLS and Panel data analysis for Baltic countries including Estonia, Finland, Latvia, and Lithuania from 1992 to 2021 within the context of EKC hypothesis. The long-term ARDL and DOLS models result indicate that there is a statistically significant relationship between the air transport, CO_2, GDP, and energy consumption for Estonia from 1992 to 2021. On the other hand, the impact of independent variables containing air transport, GDP, and energy consumption on CO_2 emission is demonstrated empirically from 1992 to 2021 which is affirmed the EKC hypothesis for Baltic countries through panel data analysis. According to empirical findings, legal arrangements should be made for the production and use of alternative fuels by policy makers in order to provide economic and social benefits in terms of reduction environmental pollution. Low-emission fuels and hybrid or electric vehicles must be used to reduce carbon dioxide emissions as a solution for environmental degredation in Baltic countries.

Keywords: Economic Growth, Energy Consumption, Civil Aviation, CO_2 Emissions, Econometric Models, Environmental Economics
JEL Classifications: O47, P28, L93, O44, C4, Q5

1. INTRODUCTION

The fight against adverse weather conditions caused by global warming has deepened more, especially since the 1970 s. The increase in the concentration of greenhouse gases in the atmosphere, which is raised with the start of the industrial Revolution, is shown as the most important reason for the changes in the global climate system and the deterioration of the natural balance of the climate system over time. According to academic research, it is estimated that 3% of the CO_2 emitted into the atmosphere originates from aviation sector and this rate will reach to 5% in 2050. This demonstrates that the carbon emissions of airplanes create very serious problem in terms of environmental pollution. The Transportation Research Board (TRB) operates in the USA in order to develop solutions for the major environmental impacts of civil aviation, global climate change, air pollution, emissions, ecology and natural habitat, noise, land, material use, energy consumption, water consumption, water pollution and waste. On the other hand, the rapid growth of the aviation industry continues in the world and this growth is expected to continue through greenhouse gas emissions resulting from the combustion of jet fuel in aircraft engines will inevitably increase.

Global warming and climate change are one of the most important environmental problems of the world. In particular, the increasing level of CO_2 emissions due to its intense contribute to greenhouse gas emissions (GHG) fuels environmental problems. For this reason, scientists and policy makers have started to take initiatives to evaluate the negative effects of global warming in the world economy since the beginning of the 1990s. According to Haggar (2012), efforts to reduce GHG to mitigate global warming are among the agendas of national and international climate policies. In this context, industrialized countries have started to organize important environmental agreements and meetings to control and reduce the atmospheric concentration of GHG. For instance, the Kyoto Protocol, signed in the United Nations Framework

Convention on Climate Change and adopted in Kyoto, Japan on December 11, 1997, entered into force on February 16, 2005. The purpose of the protocol was to set restrictive targets for GHG levels in 37 industrialized countries and the European Union. The signatory parties have committed to reduce GHG levels by at least 5% from the 1990 level between 2008 and 2012. In the light of these developments, experts have started to discuss the environment-economy relationship within the scope of environmental economics.

For example, the relationship between environmental pollution and income is an important research topic under the name of the environmental Kuznets curve.

The EKC is derived from the original Kuznets curve introduced by Kuznets (1955), which deals with the relationship between economic growth and income inequality. The EKC hypothesis assumes an inverse U-relationship between environmental pollution and economic growth.

Apergis and Payne (2010) state that the EKC hypothesis considers GHG as a function of income, when the income level increases, the emission level firstly increases, but after the income level reaches a certain threshold and exceeds this value, both the emission and the level of environmental pollution begins to decrease.

A mega city has a large permanent resident population and high demand for transport, food and consumer goods. This requires a large number of motor vehicles, high volume passenger and freight transportation. Motor vehicles, trains and airplanes produce greenhouse gas emissions such as nitrogen oxides (NOX), hydrocarbons (HC), carbon monoxide (CO) and particulate matter (PM) during fuel combustion, which have a strong impact on the atmospheric environment and human health (Xue et al., 2020).

According to environmental reports and assessments, particulate matter, nitrogen oxides (NOx), hydrocarbon (HC), sulfur oxides (SOx) and carbon monoxide (CO) from aircraft engine emissions can affect air quality, health and welfare. Aviation-related emissions at ground level and around the airport are not limited to aircraft emissions; ground support equipment also cause an increase in emissions (Sameh and Scavuzzi, 2016).

While maritime transport has been the most efficient mode of transport in terms of CO_2 emissions, with only 14 grams per ton/km, it is followed by rail, road and air transport, respectively. The CO_2 emissions emitted by different types of transportation differ numerically. On the other hand, the frequency of the transportation mode used is the most important factor affecting the total CO_2 emissions emitted. When examined from this aspect, according to EU reports, 73% of Europe's total greenhouse gas emissions originate from road transport. This is followed by sea transportation with 14% and air transportation with 12%. The percentage of the railway remains at the level of 1% (Sampson and Chambers, 2002).

The aviation industry is sensitive to growth forecasts, as it is a sector that will accelerates trade relations as well as passenger and freight transport. In summary, the recent developments in the world put the sector in a rapid growth process, and this phenomenon is directly and bilaterally.

Reflected as increase in the world trade volume and growth rates. The Figure 1 shows the world airline passenger transport volume which is obtained from World Bank's (2022a) official website. The number of air passenger transport was around 400 million in 1973; this amount increased to 4.5 billion in 2019.

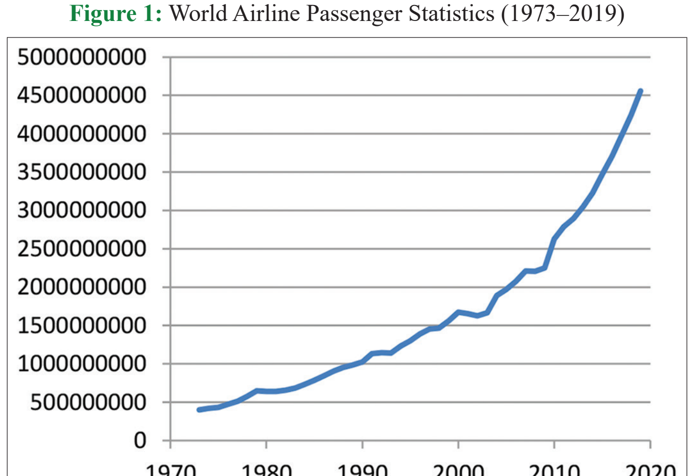
When the contributions and novelties of this paper to the literature are taken into account through panel data analysis, The impact of independent variables containing air transport, GDP, and energy consumption on CO_2 emission (dependent variable) is demonstrated empirically from 1992 to 2021 which is affirmed the EKC hypothesis for Baltic countries including Estonia, Finland, Latvia, and Lithuania. In addition, the long-run relationship of variables containing air transport, GDP, energy consumption, and CO_2 emission is demonstrated via ARDL, DOLS models which is confirmed the EKC hypothesis for Estonia as well. Finally, all time series models of the manuscript verify that air transport, GDP, and energy consumption among 1992 and 2021 cause environmental degradation. There is no other research in the academic literature for the Baltic countries that correlates relevant variables through air transport-induced EKC hypothesis by econometric models.

The remainder of the manuscript is structured as follows. Part 2 presents a brief literature review. Part 3 describes the data and the methodology of this research. Part 4 discusses the empirical findings and conclusion by providing some recommendations to the policy makers of Baltic countries in terms of how to reduce the environmental pollution.

2. LITERATURE REVIEW

There are kinds of research in the academic literature examining the nexus between CO_2 emissions, air transportation and GDP. Some of these manuscript investigate the carbon emissions and economic growth theory known as Environmental Kuznets Curve (EKC) in the academic literature (Beşe and Kalayci, 2021; Dursun, 2022; Egilmez, 2020; Güdül, 2021; Kalayci and Özden, 2021;

Figure 1: World Airline Passenger Statistics (1973–2019)



Kalayci and Yazici, 2016; Özkan et al., 2019; Öztürk et al., 2016; Öztürk et al., 2021; Sarkodie and Öztürk, 2020; Sumaira and Siddique, 2022; Tarazkar et al., 2021; Yazici, 2022). The major goal of this manuscript is to examine the stable long-run nexus among energy consumption, economic growth, civil aviation, and CO_2 emissions by performing the ARDL, DOLS and panel data analysis for Baltic countries from 1992 to 2021. There are limited researches in the academic literature in terms of the air transport-induced EKC hypothesis. In this context, the airway-induced EKC hypothesis is investigated for the Baltic States.

The civil air transport industry is an important part of the social economy and plays a very crucial role in the functioning of the development economy. The relationship between the development of civil air transport and economic growth has become the focus of industry study and research topics. The civil aviation industry has grown rapidly and increased gradually due to the applying reforms and open economy policy in so many countries. Air transport is the modern form of transport and is a concept that reflects the level of development of a country. Air transport is also a significant sector for the circulation of the economy, and the growth in this field depends on the economic level and the degree of impact of the activities (Kalayci and Yanginlar, 2016).

Akinyemi (2019) investigates the determinants of domestic airway demand in Nigeria which is examined by using the ARDL and vector error correction technique through data for the period of 1982–2005. GDP, number of domestic passengers, agricultural production index, manufacturing industry index and CPI variables are considered in the analysis. As a result of the ARDL analysis, while the GDP has a positive effect and the manufacturing industry has a negative effect on the airline demand, the effect of the CPI and agricultural production index are found to be statistically insignificant. In the short term, positive effect of GDP and negative effect of manufacturing industry are observed. The effect of CPI and agricultural production index are also found to be less in this period. Bal et al. (2017) aim to measure the effect of air passenger demand and cargo transportation on economic growth, which are indicators of air transportation in the Turkish economy from 1967 to 2015. According to the results of the Vector Error Correction Model (VECM) and Granger causality test, it was concluded that there is a one-way positive impact between the aviation industry and economic growth in the long run.

McKinnon (2019) analyzes carbon dioxide emissions from freight transport in the UK. Particularly, the difficulties in calculating air and sea cargo emissions are emphasized. As a result of the study, it was determined that 33.7 million tons of carbon dioxide emissions are generated from freight transport in 2004, and freight transport carbon dioxide emissions constituted 6% of the total emissions of the United Kingdom.

Erdogan (2020) examines the relationship between airline investments, trade openness, economic growth and ecological footprint in 21 OECD countries within the scope of the EKC hypothesis by using Pedroni co-integration method and FMOLS long-term estimators from 2000 to 2015. The author states that airline investments increase environmental pollution, while railway investment decreases it, and also concluded that the EKC hypothesis is confirmed.

Georgatzi et al. (2020) elaborate the relationship between airway, highway infrastructure investments, and environmental pollution in their study conducted in 12 European countries from 1994to 2014 by means of panel co-integration test, FMOLS and dynamic least squares long-term estimators and Granger causality method. As a result, they state that airline and highway infrastructure investments do not affect environmental pollution.

Erdogan et al. (2020) ascertain the validity of the EKC hypothesis by using the data for the period of 1995-2014 in the 10 countries by considering the air transportation. The findings show that the EKC hypothesis is affirmed. Azlina et al. (2014) find that energy consumption in airlines increases CO_2 emissions in their analysis for Malaysia through VECM test between 1975 and 2011. Khan et al. (2017) investigate the relationship between logistics, economic growth, environmental pollution and fossil energy consumption in the period of 2007–2015 by using the panel generalized moments method in 15 selected countries and it is determined that the logistics sector increased economic growth.

Mukkala and Terro (2013) investigate the direction of causality between air traffic and economic growth through the Granger causality test. The results show that causality processes from regional growth to air traffic are homogeneous. In addition, it was concluded that there is causality from air traffic to regional growth in the peripheral regions and the causality is less in the core regions. Nasution et al. (2020) analyze the causal relationship between air transport and economic growth for Indonesia by using the Granger causality test. According to the empirical findings, there is a relationship between air transport tax and economic growth in Indonesia.

In the study of Altuntaş and Kılıç (2021), the relationship between total airline passenger and freight traffic and gross domestic product for Turkey are examined by ARDL and Toda-Yamamoto methods. According to the findings of the study, there is a co-integrated relationship between passenger traffic and gross domestic product. In the study,

While no statistically significant effect of passenger and freight traffic on economic growth is found in the long term, it was concluded that passenger traffic had an increasing effect on economic growth in the short term. The study also demonstrates that there is a bidirectional causality relationship between passenger traffic and gross domestic product.

3. DATA AND METHODOLOGY

Panel data analysis is performed for Baltic countries containing Estonia, Finland, Latvia, and Lithuania from 1992 to 2021 by using annual data. Variables are selected as CO_2, energy usage, air transportation, and economic growth (GDP). The data is obtained from World Banks' official website (World Bank, 2022a), (World Bank, 2022b), and (World Bank, 2022c) for air transportation, CO_2 emissions, and GDP respectively. Energy consumption data is collected from Our World in Data's (2022) official website. CO_2 emission is selected as dependent variable, energy usage, air transportation, and economic growth (GDP) are determined as independent variables in order to test the EKC hypothesis of Baltic countries in terms of air transport induced environmental pollution.

PP and ADF tests are so crucial in order to test the stationarity of the series. According to both Table 1 and 2, all variables are not stationary at I(0). However, after taking the first differences of all variables including air transport, CO_2, GDP, and energy consumption for Baltic countries, they all become stationary at I(1). All series must be stationary in order to proceed to ARDL and DOLS tests. Phillips and Perron (1988) suggest an alternative (non-parametric) control method for serial correlation while testing for unit root. The PP method estimates the Dickey-Fuller (DF) test equation and changes the t-value of the α coefficient. Thus, the serial correlation does not affect the asymptotic distribution of the test statistic.

The Augmented Dickey Fuller (ADF) unit root test (which is calculated according to the AIC Akaike Information Criterion) is performed to the series including CO_2 emissions, energy use, economic growth, and air transportation in order to test for stability. The maximum lag length is selected to be 2 as per Serena and Perron's (2001) suggestion. The ADF test generates a parametric correction for higher-order correlation, assuming that the series follow an AR (k) process and add the lagged difference terms of the dependent variable to the right side of the series.

$$\Delta y_t = c + \alpha y_{t-1} + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \quad (1)$$

$$\Delta y_t = c + \alpha y_{t-1} + \beta t \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \quad (2)$$

Equation (1) examines the null hypothesis against a mean stationary alternative unit root in of the studied time series y. Equation (2) examines the unit root of the null hypothesis against the trend-stationary alternative. The term Δ_{yt-j} denotes the first difference in the error term that provides the serial correlation. A constant and linear time trend can be included in the ADF test regression, as illustrated in the above equations. The most appropriate model is chosen as the model via the smallest value (4, 0, 3, 4) within the framework of the AIC criterion in Figure 2. The result of the boundary test is applied to determine the long-term relationship between the variables and the diagnostic test

Table 1: PP unit root test results of Baltic countries

Results	Countries	Variables	PP URT at I (0)	PP URT at I (1)
I (1)	Estonia	Air_trns	−1.2694−2.9677	−5.7015* −2.9718
I (1)		Energy_cons	−1.1315−2.9677	−7.4493* −2.9718
I (1)		GDP	0.8461−2.9677	−4.5177* −2.9718
I (1)		CO_2	−1.8992−2.9677	−3.7263* −2.9718
I (1)	Finland	Air_trns	−2.5429−2.9677	−9.7167* −2.9718
I (1)		Energy_cons	−1.7057−2.9677	−7.9726* −2.9718
I (1)		GDP	−0.7107−2.9677	−5.0918* −2.9718
I (1)		CO_2	−1.1698−2.9677	−6.5943* −2.9718
I (1)	Latvia	Air_trns	−1.6267−2.9677	−7.0235* −2.9718
I (1)		Energy_cons	−1.6025−2.9677	−7.4097* −2.9718
I (1)		GDP	−0.3486−2.9677	−4.8091* −2.9718
I (1)		CO_2	−1.7558−2.9677	−5.7211* −2.9718
I (1)	Lithuania	Air_trns	−1.9454−2.9677	−4.6983* −2.9718
I (1)		Energy_cons	−1.7804−2.9677	−6.8827* −2.9718
I (1)		GDP	−0.5808−2.9677	−4.4806* −2.9718
I (1)		CO_2	−1.5054−2.9677	−4.8508* −2.9718

"*" symbols demonstrate the unit root test of the variables which is performed in the estimation process, 1 and 5% significance levels, respectively. Bold values represent PP test statistics

Table 2: Augmented Dickey Fuller unit root test results of Baltic Countries

Results	Countries	Series	ADF test at I (0)	ADF test at I(1)
I (1)	Estonia	Air_trns	−1.2694−2.9677	−5.7015* −2.9718
I (1)		Energy_cons	−2.1021−2.9677	−6.8040* −2.9718
I (1)		GDP	0.4490−2.9677	−4.9756* −2.9762
I (1)		CO_2	−1.4355−2.9677	−4.1402* −2.9762
I (1)	Finland	Air_trns	−1.7876−2.9677	−4.2595* −2.9762
I (1)		Energy_cons	−1.8697−2.9677	−5.7641* −2.9762
I (1)		GDP	−0.7107−2.9677	−5.0918* −2.9718
I (1)		CO_2	−1.4182−2.9677	−5.8197* −2.9762
I (1)	Latvia	Air_trns	−1.7654−2.9677	−6.2450* −2.9718
I (1)		Energy_cons	−4.5716−2.9677	−7.1232* −2.9718
I (1)		GDP	−0.6313−2.9677	−5.0883* −2.9762
I (1)		CO_2	−1.8733−2.9677	−3.7211* −2.9718
I (1)	Lithuania	Air_trns	−1.9454−2.9677	−4.7042* −2.9718
I (1)		Energy_cons	−1.7790−2.9677	−5.7944* −2.9762
I (1)		GDP	0.3739−2.9677	−4.7563* −2.9762
I (1)		CO_2	−1.1574−2.9677	−4.7709* −2.9718

"*" symbols demonstrate the unit root test of the variables which is performed in the estimation process, 1 and 5% significance levels, respectively. Bold values represent ADF test statistics. ADF: Augmented Dickey Fuller results of the model are given in Table 3 within the context of this model which is recommended by Pesaran et al. (2001), and Narayan (2005).

The F statistical value, which demonstrates the existence of a co-integration relationship between the variables, is calculated as 5.45. When this result is met with the lower and upper table critical values, it is determined that there is a long-term relationship between the variables at the 0.05 significance level. In addition, there is no autocorrelation or multiple linear correlation problems within the framework of the diagnostic statistics in the model. The coefficient value of the long-term relationships is obtained in the model which is given at Table 4.

The long-run linkage of variables including air transport, GDP, energy consumption, and CO_2 emission is demonstrated via ARDL, DOLS models which is confirmed the EKC hypothesis for Estonia as well at Table 4 and 5. Thus, time series models of the research confirm that air transport, GDP, and energy consumption among 1992 and 2021 cause environmental pollution.

The long-term ARDL and DOLS models result indicate that there is a statistically significant relationship between the air transport, CO_2, GDP, and energy consumption for Estonia from 1992 to 2021. When the signs of the coefficients are evaluated, it is obtained that there is a positive relationship between air transport, CO_2, GDP, and energy consumption. The result of long-term ARDL model at Table 4 is consistent with DOLS test at Table 5. The ARDL equation is demonstrated through econometric symbols, where the series of long-term CO_2 emissions is examined in equation (3).

Figure 2: Optimal Lag Length Selection for the ARDL Model for Estonia

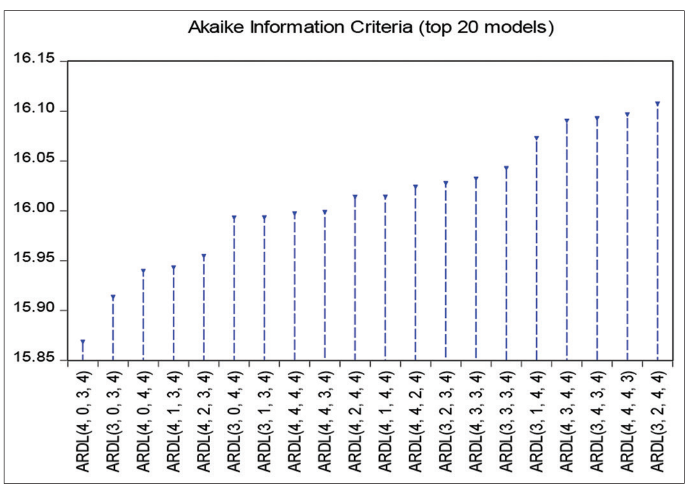


Table 3: ARDL model bounds test results for Estonia

Bounds test		Results	
ARDL model		(4, 0, 3, 4)	
F statistics value		5.45	
Narayan (2005) critical value	10%	5%	1%
Lower level	3.43	4.26	6.18
Upper level	4.47	5.47	7.87
Pesaran et al. (2001) critical value	10%	5%	1%
Lower level	4.04	4.94	6.84
Upper level	4.78	5.73	7.84

Decision: There is co-integration between variables

The ARDL test is performed with DOLS analysis whether there is a long-run linkage between, economic growth, civil aviation, CO_2 emissions, and energy usage at Table 4. The long-run nexus among GDP, civil aviation, energy usage, and CO_2 for Baltic countries from 1992 to 2021 are taken into account via f bounds test which is considered as zero hypothesis. Starting from equation (3) δ Δ, and ε_{it} demonstrate constant term, difference operator and error term, respectively. In this analysis, the long-term relationship between factors is estimated and the hypothesis is developed below.

$$\Delta lnCO2_{t} = a_0 + \sum_{i=1}^{m_1} \sigma_{it} \Delta lnCO2_{t-i} + \sum_{i=0}^{m_2} \beta_{it} \Delta ln\text{air\_trns}_{i,t-i} + \sum_{i=0}^{m_3} \theta_{it} \Delta ln\text{GDP}_{i,t-i} + \sum_{i=0}^{m_4} \theta_{it} \Delta ln\text{energy}_{\text{usage}_{i,t-i}} + \delta_{1i} lnCO2_{t-1} + \delta_{2i} ln\text{air}_{\text{trns}_{t-1}} + \delta_{3i} ln\text{GDP}_{t-1} + \delta_{4i} ln\text{energy}_{\text{usage}_{t-1}} + \varepsilon_{it} \quad (3)$$

If F statistic is less than specified minimum value, which is recommended by Pesaran et al. (2001), and Narayan (2005) then the null hypothesis is not verified, thus determining that there is no long-term linkage between the variables. In addition, if the calculated F statistic is greater than the upper limit value, then it is determined that there is no long-term linkage between the variables.

On the other hand, Hausman test is used at Table 6 by performing fixed or random effect test. In order to verify whether fixed or random effect would be appropriate for the series, Hausman test is employed. According to findings of Table 6, the $P < 0.05$. Thus, H0 null hypothesis is declined and alternative hypothesis is approved to implement fixed effect model. The test findings indicate that as long as energy consumption, air transportation, and economic growth is increasing, the CO_2 emissions of four Baltic countries rises as well. According to Table 7, the pooled panel data regression demonstrates that economic growth, energy consumption, and air transportation influence the CO_2 emissions.

$$\ln\left(CO2\right)_t = \alpha_0 + \alpha_1 \ln\left(Econ\_Growth\right)_t + \alpha_2 \ln\left(Energy\_Cons\right)_t + e_t \quad (4)$$

t is the time index, α_0, α_1, α_2, are the estimated parameters, and e is the error term.

Table 4: Long-term ARDL results of Estonia

Variables	Coefficient	*T*-statistics	Probability
AIR_TRANS1	−0.436995	2.634403	0.0192
ENERGY1	0.518915	2.516209	0.0274
GDP1	−0.80E-07	−1.729760	0.0323
C	−31.55485	−0.029816	0.9768

Table 5: DOLS test results of Estonia

Variables	DOLS		
	T-statistic	*P*	Coefficient
AIR_TRANS1	2.532115	0.0392	0.006775
ENERGY1	1.951123	0.0213	4.52E-11
GDP1	−1.898321	0.0025	−1.11E-23
C	1.523784	0.1802	0.052389

Table 6: Hausman test results for 4 Baltic Countries

Test results	Chi-square statistic	Chi-square df	Probability	
Cross-section random	38.105884	3	0.0000	
Cross-section fixed effects test comparisons				
Variable	**Fixed**	**Random**	**Variable (difference)**	**Probability**
GDP	−0.000782	−0.000687	0.000000	0.4774
ENRGY	−0.000000	−0.000000	0.000000	0.0329
CO_2	197.172075	172.932183	791.053886	0.3888

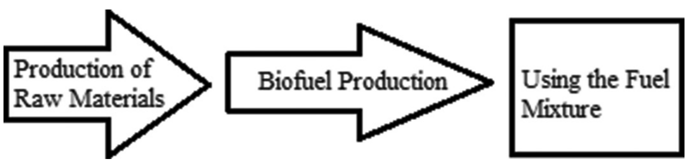
GDP: Gross Domestic Product, ENRGY: Energy Consumption, CO_2: Carbon Dioxide Emissions

Table 7: The results of the panel data regression of 4 Baltic countries

Dependent variable: Air_trns, total pool observations: 120				
Variable	**Coefficient**	**SE**	***t*-statistic**	**Probability**
Constant	−702.5111	4270.414	−0.164507	0.8696
Air_trns	−0.000782	0.000315	−2.478082	0.0147
GDP	−1.59E-09	1.54E-08	−0.102703	0.0184
Energy	197.1721	29.01906	6.794572	0.0000
Effects specifications Cross-section fixed (dummy variables)				
R^2	**0.950266**	**Mean dependent variable**	**24110.92**	
Adjusted R^2	0.947625	SD dependent variable	19306.08	
SE of regression	4418.295	Akaike info criterion	19.68146	
Sum squared residency	2.21E+09	Schwarz criterion	19.84406	
Log likelihood	−1173.887	H/Q criterion	19.74749	
F-statistic	359.8484	Durbin-Watson stat	0.859337	
Probability (*F*-statistic)	0.000000			

SD: Standard deviation, SE: Standard error

Figure 3: Alternative Fuel Development in the Long-term



$$\ln\left(CO2\right)_t = \alpha_0 + \alpha_1 \ln\left(Econ\_Growth\right)_t + \alpha_2 \ln\left(Energy\_Cons\right)_t + \alpha_3 \ln\left(air\_trns\right)_t + e_t \quad (5)$$

t is the time index, α_0, α_1, α_2, α_3 are the estimated parameters, and e is the error term.

The impact of independent variables containing air transport, GDP, and energy consumption on CO_2 emission (dependent variable) is demonstrated empirically from 1992 to 2021 which is affirmed the EKC hypothesis for Baltic countries including Estonia, Finland, Latvia, and Lithuania through panel data analysis at Table 7. The P-value of all independent variables is <0.05. Besides, the long-term linkage of variables containing air transport, GDP, energy consumption, and CO_2 emission is demonstrated via ARDL, DOLS models which is confirmed the EKC hypothesis for Estonia as well at Table 4 and 5. Thus, time series models of the research verify that air transport, GDP, and energy consumption from 1992 to 2021 cause pollution which confirms the EKC hypothesis.

4. DISCUSSION AND CONCLUSION

There is a long-run nexus among energy consumption, economic growth, civil aviation, and CO_2 emissions by performing the ARDL, DOLS and Panel data analysis for Baltic countries including Estonia, Finland, Latvia, and Lithuania from 1992 to 2021 within the context of EKC hypothesis. The long-term ARDL and DOLS models result indicate that there is a statistically significant relationship between the air transport, CO_2, GDP, and energy consumption for Estonia from 1992 to 2021 at Table 4 and 5. When the signs of the coefficients are evaluated, it is obtained that there is a positive relationship between air transport, CO_2, GDP, and energy consumption. The impact of independent variables containing air transport, GDP, and energy consumption on CO_2 emission (dependent variable) is demonstrated empirically from 1992 to 2021 which is affirmed the EKC hypothesis for Baltic countries including Estonia, Finland, Latvia, and Lithuania through panel data analysis at Table 7.

These empirical findings show that in fact, the damage through growth rate to the environment increases and as a result, it becomes necessary to take measures within the body of international organizations and states. Within the framework of the measures taken, it is aimed to keep the level of damage to nature at a certain rate by keeping global warming at acceptable levels. For this, obligations are brought to the aviation sector in connection with the rate of increase and solutions are tried to be produced by technology developing companies, governments and airlines for the related obligations. In this context, heavy deterrent taxes should be imposed on airline companies that cause environmental pollution by policy makers.

Establishing new industries for alternative fuel production takes lots of time and great effort. The raw materials of alternative fuels used in road vehicles are suitable for alternative fuels to be developed for airline vehicles. It is important to establish a new industry so that the fuel properties are suitable for the aircraft engine operating condition and fuel storage conditions, environment and flight safety. The main purpose of the biofuel industry should be the production of raw materials and the ability to convert the source obtained from this production into biofuel and uses it as a mixture in a short time.

Studies carried out until this process has shown that alternative fuels can be used safely in aircraft. In this context, despite the economic stagnation in terms of production costs compared to oil prices, these studies and the use of produced fuels should not slow down. Large organizations such as IATA and ICAO should ensure that necessary measures are taken for the use of alternative fuels to reduce CO_2 emissions in flights through partnerships to be established by bringing together airline companies and aircraft engine companies. With this motivation, some suggestions for long-term alternative fuel development studies in the aviation sector (see Figure 3) are listed as a result of the study;

- Legal arrangements should be made for the production and use of alternative fuels by policy makers in order to provide economic and social benefits.
- In the development of production technologies, it should be aimed that the fuel to be produced will have widespread use.
- It should contribute to the reduction of greenhouse gas formation in the environmental cycle, therefore, chemicals should not be used in raw material production to protect soil and water resources.
- Low-emission fuels and hybrid or electric vehicles must be used in order to reduce carbon dioxide emissions.

Air traffic management systems should be used for the direction, separation, coordination and control of aircraft movements. Some limitations in these systems (aircraft hold, misroute, etc.) cause excessive fuel combustion and therefore excessive emissions. For existing aircraft fleets and operations, addressing the above limitations in air traffic management systems can reduce fuel burned. The improvement required for these fuel burn reductions is expected to be fully implemented in the next 20 years, provided the necessary institutional and regulatory steps are taken in a timely manner. Other operational measures to reduce the amount of fuel burned per passenger-km include increasing occupancy rates, eliminating unnecessary weight, optimizing airspeed, limiting the use of auxiliary.

Power (for example, for heating, ventilation), and reducing taxi usage. Potential improvements in these operational measures can reduce fuel burned and emissions.

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