Dursun, Erdal

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Investigating the Air Transport-Induced EKC Hypothesis: Evidence from NAFTA Countries

Erdal Dursun*

School of Civil Aviation, Nisantasi University, Istanbul, Turkey. *Email: erdal.dursun@nisantasi.edu.tr

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ABSTRACT

The aim of this research is to evaluate the long run relationship of economic growth, energy consumption, CO_2 emissions and air transportation within the context of EKC hypothesis for the period from 1970 to 2020. In this sense, ADF and PP unit root tests, FMOLS, DOLS, CCR and ARDL tests are performed in order to determine the coefficient of effects of independent variables on dependent variable CO_2 emissions. According to FMOLS, DOLS, CCR tests there is a long-term stable linkage between CO_2 emissions and energy consumption from 1970 to 2020 for all NAFTA countries including USA, Canada, and Mexico which is demonstrated empirically. It can be interpreted that increased consumption of the non-renewable energy or fossil will increase the amount of carbon dioxide emissions. For this reason, all three countries need to benefit from more environmentally friendly renewable energy sources.

Keywords: Air Transportation, Energy Consumption, Economic Growth, NAFTA Countries
JEL Classifications: L93, P18, O47, F13

1. INTRODUCTION

There is a very close and reciprocal relationship between the economy and environmental problems, which are becoming increasingly important. While the rapid increase in economic activities causes environmental problems, it also negatively affect economic development and economic structure. Economic development increases environmental pollution, and environmental pollution increases the economic and social costs of economic development. The main reason is the economy and the environment are closely related and it is impossible to exclude environmental problems. In this context, effective use of environmental resources has great importance in terms of sustainable economic development. Furthermore, the environmental degradation occurring throughout the world and the declining environmental quality and reaching levels that threaten future generations have recently increased the interest in the environment. The environment interacts with the economy as well as with many other fields. Economic growth harms nature due to air pollution and environmental degradation. For this reason, environmental degradation increases the cost of economic development.

Simon Kuznets (1955) reveals that there is a relationship between income distribution and economic growth in his study. In the aforementioned study, he reports that the amount of per capita income increased due to economic development, but income inequality also increased in the first stage of development. Moreover, Kuznets argued that increasing income inequality begins to decrease after a certain turning point, depending on the continuation of economic development. This relationship is defined as the "Inverted U shape" hypothesis, and the curve showing the relationship between income distribution and income level which is expressed as the Kuznets Curve Approach.

There are lots of researches in the academic literature examining the relationship between economic growth and carbon emissions. Some of these studies (Anwar et al., 2022; Cui et al., Dinda, 2004; 2022; Ozturk and Acaravci, 2013; Ozturk and Acaravci, 2010;

Zubedi et al., 2022) discuss whether economic growth and carbon emissions parallel with Environmental Kuznets Curve (EKC).

According to the EKC hypothesis (Figure 1), environmental pollution increases with economic development initially, but after income reaches a certain level, environmental pollution begins to decrease. This hypothesis determines the relationship between economic growth and the intensity of greenhouse gases, which are a component of environmental pollution (Figure 2). Different methods can be used to measure environmental pollution. Sulfur dioxide, nitrogen oxide, lead, chlorofluorocarbon, waste water and other chemicals released directly into the air or water cause several environmental pollutions. For instance, the epidemiological index is used to measure the effects of pollution on health in China (Brajer et al., 2011).Most of the energy used in production in the world is obtained from primary energy sources (oil, natural gas, coal, etc.). However, when these gases are burned, they release carbon dioxide (CO_2) into the atmosphere, among other gases. This situation affects the air quality negatively and more importantly, it rises in the atmosphere and causes the greenhouse gas effect. Thus, as a result of global warming, it has negative effects on water resources in terms of human health and living species, and it causes large-scale climate changes. While all this is happening, the world population is increasing rapidly and human needs are increasing in this direction. Meeting human needs also depends on the increase of capital. A further increase of capital also requires more resources; Residues of used resources cause environmental pollution. This contradiction between economic growth and the environment makes it difficult to solve the current environmental problems in the world. In the economics literature, this issue has been discussed intensively, especially in recent years. When the novelties and contributions of this research paper to the academic literature are considered, time series models including ARDL, FMOLS, CCR, and DOLS model reveal the long-term linkage among energy usage, and CO_2 emissions from 1970 to 2020 for NAFTA economies.

Figure 1: EKC Hypothesis

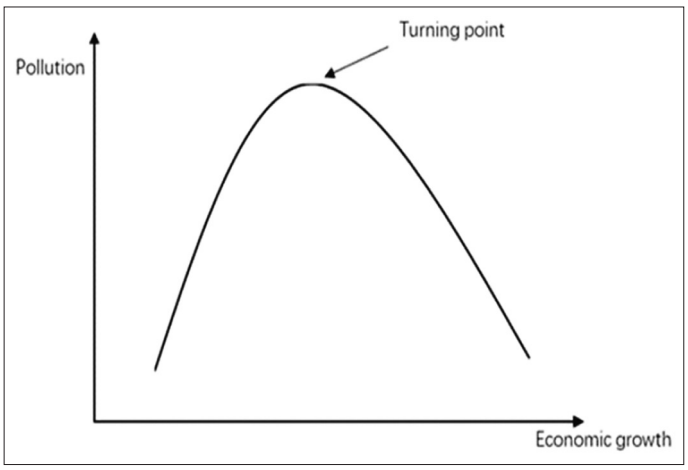
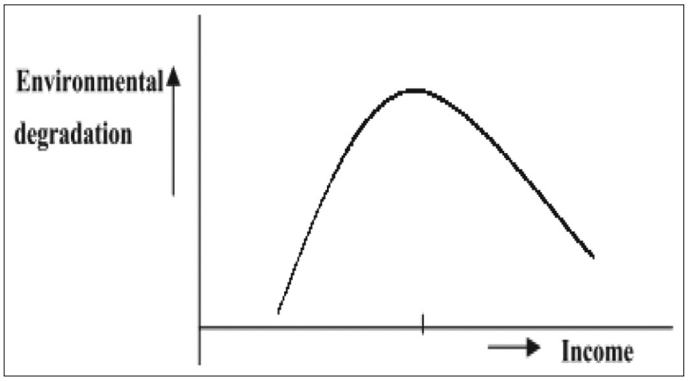


Figure 2: It was developed by the authors based on the study of Dinda (2004)



2. LITERATURE REVIEW

There are so many researches in the academic literature elaborating the connection among economic growth, energy consumption, and CO_2 emissions. However; in this part of the article, primarily the series that consider the relationship among economic growth, energy consumption, air transportation and CO_2 emissions are discussed as well. Some of these research paper investigate the CO_2 emissions, energy consumption, and economic growth by taking into account the Environmental Kuznets Curve (EKC) in the academic literature (Beşe and Kalayci, 2021; Farooq et al., 2022, Kalayci and Özden, 2021; Ozkan et al., 2019; Ozturk et al., 2016; Ozturk et al., 2021; Sheikhzeinoddin et al., 2022; Yazici, 2022). Considering the air transportation as independent variable in terms of EKC hypothesis, there are limited amount researches (Erdoğan et al., 2020; Gyamfi et al., 2022; Kalayci and Yanginlar, 2016; Kalayci and Yazici, 2016) in the academic literature. While generating this part, besides investigating the most recent manuscript, researches on different countries are taken into account as well. In this sense, Raza et al. (2019) examine the effect of energy consumption on gas emissions in the USA. According to researcher results, gross regional products and energy usage and are primary resources of gas emissions and damages to environmental sustainability. Therefore, environmental quality in USA is endangered by immoderate consumption of non-renewable energy resources. The results of their findings for USA from 1973 to 2015 (monthly data) demonstrates that the energy usage crucially affects greenhouse gas emissions which is coincide with this manuscript's findings.

Some groups of research are mostly related with relationship between air transportation and economic growth in the academic literature. Brida et al. (2016) examine the long-term linkage among economic growth and air transport for Mexico from 1995 to 2013. According to their findings, long-term connection among GDP and air transportation is existed which is proved empirically. In addition, the causality test finds out the existence of a mutual linkage among economic growth and air transport. Law et al. (2022) reveal that there is bi-directional causality among GPD and air transportation in the long term in their research performing ADRL in order to investigate the empirical connection among economic growth and air transport in Myanmar, Laos, Cambodia, and Vietnam.

Erdoğan et al. (2020) analyze the validity of the EKC hypothesis by using the data from the period of 1995 to 2014 for 10 countries through using the air transportation data. The findings indicate that

the EKC hypothesis is confirmed for all countries. Furthermore, by making more expedite the tourism as one of the fundamental drivers of GDP, air logistics indirectly employs an important factor in poverty alleviation and reacquiring profits (Balsalobre-Lorente et al., 2021). Habib et al. (2022) examine the heterogeneous effect of air freight and passenger transport on CO_2 emissions for G20 countries from 1990 to 2016. They implement the fixed-effect panel quantile regression model by estimating the distributional heterogeneity and unobserved discrete. According to their findings the effect of the air freight and passenger transport on CO_2 emissions is considerably heterogeneous across various quantiles. Besides, the influence of air passenger and freight transport and on CO_2 emissions is positive and becomes more assertive through the rising trend at upper quantiles and is quite heterogeneous across all quantiles. Economic growth, urbanization, and tourism are conducive elements in boosting the CO_2 emissions of air transport, while crude oil price crucially decreases CO_2 emissions.

Benjamin (2022) performed cointegration test, correlated effect mean group (CCEMG) the Pesaran CD, average mean group (AMG), analysis by considering the relationship between air transport and the environment. Results from the research demonstrate that the proliferation of the emerging economies including China, Brazil, India, Mexico, Indonesia, Turkey and Russia has largely promoted to the growth of environmental sustainability. Iqbal et al. (2022) investigate the air transport freight, economic growth, and endogenous growth theory for R&D investment s in 7 emerging economies. There is no significant result in terms of dynamic connection between air transport freight, economic growth, and technological innovation for BRICS-MT countries in the academic literature. Therefore, their research examine the dynamic relationship among air transport, economic growth, and technological innovation in 7 selected emerging BRICS-MT economies, containing China, South Africa, Brazil, Russia, India, Turkey, and Mexico by using the dynamic ordinary least square (DOLS), fully modified ordinary least square (FMOLS), and panel cointegration test through annual data from 2000 to 2019. The Kao residual cointegration and Pedroni panel tests verify the long-term nexus between the relevant variables. The findings of DOLS test demonstrate that technological innovation and air transport crucially affect the economic growth.

Tarasawatpipat et al. (2020) peruse the relationship between air transportation and CO_2 emissions for 27 years by performing unit root tests, co-integration test and VAR model in Thailand. According to their findings, there is a crucial impact of air transportation on CO_2 emission which is coherent with this manuscript's result. Ali et al. (2021) elaborate the role of energy consumption, air transportation, economic growth and international trade on CO_2 emissions in Pakistan from 1980 to 2017 by performing ARDL model. The result indicates that there is a substantial positive long-term nexus among energy consumption, air transportation, and economic growth. The findings ascertain that tourism activities including air passenger transportation in Pakistan are not environment friendly and it can add to preserve the scenic areas and major visitors' spots in the country to attract more visitors to increase the revenue of the country. Ju and Chen (2020) emphasize the total productivity of the air transport under CO_2 emission restrictions has attracted much attention. Based on the data of Chinese air transport listed companies from 2012 to 2018, the super-efficiency DEA and Malmquist-luenberger index are performed in order to evaluate its total productivity and after further decomposition, it is found that: both the low-carbon total factor productivity and the traditional factor productivity of aviation transport enterprises demonstrated a changing trend of increasing at first and then falling. In addition, the low-carbon total factor productivity was generally higher than the traditional total factor productivity; after further decomposition of the low CO_2 emission, it is indicated that technological development is the major driving component behind the low CO_2 emission rate, and scale efficiency limits the improvement of technical efficiency.

3. DATA AND METHODOLOGY

This manuscript elaborates the linkage between energy consumption, CO_2 emissions, economic growth, and air transportation by using the ARDL, FMOLS, DOLS, and CCR models from 1970 to 2020 for NAFTA countries containing USA, Canada, and Mexico. The annual data are collected for air transport, economic growth from World Bank (2022a), (2022b), energy consumption, and CO_2 from (2022a), (2022b), Ourworldindata's official website database respectively.

ADF and Phillips-Perron unit root tests are employed to determine whether series are stationary or not within this context. On the other hand, FMOLS (Fully Modified Ordinary Least Squares), DOLS (Dynamic Ordinary Least Square), and CCR (Canonical Correlation Regression) tests are performed to conceive the long-term co-integration linkage among CO_2 emissions, energy consumption, economic growth, and air transportation. The CO_2 is selected as dependent factor and the rest of them are determined as independent variable including energy usage, economic growth, and air transportation. Finally, ARDL test is implemented to comprehend the long-term co-integrated linkage between energy consumption, CO_2 emissions, economic growth, and air transportation for NAFTA countries from 1970 to 2020 as yearly data in conclusion part. In this manuscript, log-linear specifications of the factors are assumed to estimate the equation as below:

$$InCO_{2t} = \beta_0 + \beta_1\, Inenergy\_cns_t + \beta_2\, InGDP_t + \beta_3\, Inair\_trns_t + \varepsilon_t \quad (1)$$

Where CO_{2t}, $energy\_cns_t$, GDP_t, air_trns_t indicate CO_2 emissions, energy consumption, economic growth, and air transportation respectively. β_1, β_2 and β_3 demonstrate the elasticity of the explanatory series. Phillips-Perron PP (1989) test is used to reveal the structure of factors from the point of its stationarity. In this respect, pursuant to PP test results all variables involving energy consumption, CO_2 emissions, economic growth, and air transportation are not stationary at I(0) level which is demonstrated at Table 1. Thus, first differences of all series are performed to comprehend the structure of series to proceed the FMOLS, DOLS, CCR, and ARDL models. According to findings of ADF and PP test results, the structure of variables selected as stationary after implementing first degree the of series. Furthermore, ARDL,

Table 1: Augmented Dickey Fuller and Phillips-Perron Unit Root Test of NAFTA Countries

Countries	Variables	ADF Unit Root Test I (0)	ADF Unit Root Test I (1)	
USA	Air Transport	−1.8024 (−3.5683)	−4.3956* (−3.5713)	
	Energy Consumption	−1.5590 (−3.5683)	−4.9742* (−3.5713)	
	Economic Growth	2.2501 (−3.5744)	−3.8767* (−3.6104)	
	CO_2 emissions	−1.5590 (−3.5683)	−4.9567* (−3.5713)	
Canada	Air Transport	−1.6848 (−3.5683)	−3.2953* (−3.5713)	
	Energy Consumption	−2.6402 (−3.5683)	−5.4128* (−3.5744)	
	Economic Growth	−0.2067 (−3.5683)	−5.1077* (−3.5713)	
	CO_2 emissions	−2.0634 (−3.5683)	−5.5813* (−3.5744)	
Mexico	Air Transport	0.7787 (−3.6055)	−5.7149* (−3.6055)	
	Energy Consumption	−1.9126 (−3.5713)	−3.5542** (−2.9224)	
	Economic Growth	−0.6525 (−3.5683)	−6.2140* (−3.5744)	
	CO_2 emissions	−2.5773 (−3.5683)	−3.2752** (−2.9224)	
Countries	**Variables**	**PP I (0)**	**PP I (1)**	**Decision**
USA	Air Transport	−1.7828 (−3.5683)	−7.1147* (−3.5713)	I (1)
	Energy Consumption	−1.8872 (−3.5683)	−5.0210* (−3.5713)	I (1)
	Economic Growth	2.3079 (−3.5683)	−3.9321* (−3.5713)	I (1)
	CO_2 emissions	−1.5832 (−3.5683)	−5.0125* (−3.5713)	I (1)
Canada	Air Transport	−1.6848 (−3.5683)	−3.0966** (−2.9224)	I (1)
	Energy Consumption	−3.2882 (−3.5683)	−4.8067* (−3.5713)	I (1)
	Economic Growth	−0.2067 (−3.5683)	−5.0126* (−3.5713)	I (1)
	CO_2 emissions	−2.0985 (−3.5683)	−5.1144* (−3.5713)	I (1)
Mexico	Air Transport	−1.5283 (−3.5683)	−4.1164* (−3.5713)	I (1)
	Energy Consumption	−2.1819 (−3.5683)	−3.5542** (−2.9224)	I (1)
	Economic Growth	−0.5739 (−3.5683)	−5.8386* (−3.5713)	I (1)
	CO_2 emissions	−2.3559 (−3.5683)	−3.4538** (−2.9224)	I (1)

*and **symbols demonstrate the series of results from the point of unit root test which is employed in the calculation process, 1% and 5% importance levels, respectively

FMOLS, DOLS, and CCR analysis are employed after determining the stationarity of the series at I(1) level.

CCR, FMOLS, and DOLS analysis are performed to ascertain the long-term impact coefficient among energy consumption, economic growth, air transportation, and CO_2 emissions in terms of NAFTA economies from 1970 to 2020. CCR analysis is developed by Park (1992), DOLS analysis is developed by Stock and Watson (1993) and FMOLS analysis is developed by Hansen and Phillips (1990). The FMOLS is a semi-parametric analysis in order to remove the correlation error which is asymptotically neutral, efficient and logically same as CCR test. Besides, it contains normal mixture distribution and eliminates coefficient error for non-scalar, ensures for chi-square analysis as asymptotic. Dynamic Ordinary Least Square regenerates the explanatory series by considering the leads and lags. In addition, DOLS test extrapolates the vertical scale parameters by taking into account the co-integrating equation errors. In order to eliminate the error of autocorrelation and endogeneity including the trouble parameters, both FMOLS and DOLS are so essential models (Pedroni, 2001). CCR, FMOLS, and DOLS analysis principally contain the series involving the traditional co-integration test which should be confirmed the series' stationarity.

According to FMOLS, DOLS, CCR tests there is a long-term stable linkage between CO_2 emissions and energy consumption from 1970 to 2020 for all NAFTA countries including USA, Canada, and Mexico which is demonstrated empirically (Table 2). The p statistics of energy usage is <0.01 for all countries which are significant findings. It can be interpreted that increased consumption of the non-renewable energy or fossil will increase the amount of carbon dioxide emissions. For this reason, all three countries need to benefit from more environmentally friendly renewable energy sources. Additionally, there is no long-run nexus among air transportation, GDP and CO_2 emissions for three countries. The second significant functions of three models are evaluating the coefficient effect of independent variables on dependent variable. In this context, there is no impact of air transportation and economic growth on CO_2 emissions except energy consumption. There is no effect of economic growth on carbon dioxide emissions, which is the most important condition of the EKC hypothesis is not confirmed for the USA, Canada and Mexico. The combinations of lineer and non-lineer linkage generates the inverted U shape and not verified the EKC hypothesis for NAFTA economies. The other widely known analysis of assessing the long-term linkage between variables is ARDL test which verifies the results of former model's findings.

The ARDL equation is indicated via econometric symbols, where the series of long-run CO_2 emissions is investigated in equation (2). The ARDL analysis is employed for CCR, FMOLS, and DOLS analysis whether there is a long-term nexus among, air transportation GDP, CO_2 emissions, and energy usage. Table 3 indicates the results for the ARDL test below. To sum up, the findings of ARDL test consistent with the results of CCR, FMOLS, and DOLS analysis. Thus, the results acquired via the bound test, it is determined to search the long and short-run dynamics.

$$\Delta lnCO2_t = a_0 + \sum_{i=1}^{m_1} \sigma_{it} \Delta lnCO2_{t-i} + \sum_{i=0}^{m_2} \beta_{it} \Delta ln\text{air\_trns}_{i,t-i}$$
$$+ \sum_{i=0}^{m_3} \theta_{it} \Delta ln\text{GDP}_{i,t-i} + \sum_{i=0}^{m_4} \theta_{it} \Delta ln\text{Energy}_{\text{cons}i,t-i} + \delta_{1i}\, lnCO2_{t-1} +$$
$$\delta_{2i}\, ln\text{air\_trns}_{t-1} + \delta_{3i}\, ln\text{GDP}_{t-1} + \delta_{4i}\, ln\text{Energy\_cons}_{t-1} + \varepsilon_{it} \quad (2)$$

Table 2: Co-integration Models of NAFTA Countries

Dependent Variable	FMOLS			DOLS			CCR		
CO_2 emissions									
Independent Variables	T-stats	P-value	Coeff	T-stats	P-value	Coeff	T-stats	P-value	Coeff
USA									
Air Transport	0.257712	0.7978	0.029230	0.055423	0.9561	0.042539	0.450636	0.6544	0.183216
Energy Cons	19.35495	0.0000	268271.6	7.831001	0.0000	256737.0	14.00755	0.0000	266392.6
Economic Growth	−1.21778	0.2297	−3.80E-0	−1.186637	0.2436	−5.71E-05	−1.26597	0.2120	−4.35E-0
C	−0.63037	0.5316	−8916159	0.009718	0.9923	193876.6	−0.60745	0.5466	−8885916
Canada									
Air Transport	2.344358	0.2235	0.319000	0.328876	0.7443	0.231799	1.084758	0.2838	0.352786
Energy Cons	6.799047	0.0000	120131.2	3.468833	0.0014	149584.9	5.290568	0.0000	123281.9
Economic Growth	0.355840	0.7236	6.10E-06	−0.177990	0.8598	−5.77E-06	0.071041	0.9437	1.46E-06
C	−0.99133	0.3268	−1443873	−0.871276	0.3897	−2424330.0	−0.88094	0.3830	−1490813
Mexico									
Air Transport	−1.06489	0.2926	−0.29667	−1.257993	0.2170	−0.968010	−0.56384	0.5757	−0.27569
Energy Cons	9.200322	0.0000	269588.2	3.565480	0.0011	274236.1	6.955715	0.0000	291353.3
Economic Growth	−0.48228	0.6319	−9.46E-0	−0.093649	0.9259	−4.97E-06	−0.74062	0.4628	−2.01E-0
C	−1.49679	0.1414	−2140944	−0.492626	0.6254	−1498725.0	−1.45934	0.1514	−2701936

Table 3: Long-Term ARDL Estimation Results of USA

Dependent Variable: $lnCO_2$ emissions				P-value
Variables	Coef	Stndr error	t-Stat	
Long-run Results				
ln Air_trns	0.3367	0.0324	5.3247	0.3420*
ln GDP	−0.0813	0.3252	−0.6172	0.2127
ln energy_cns	0.4113	0.0476	4.3356	0.0032*
Constant	4.2153	0.7148	3.0187	0.0017*
Trend	0.0022	0.0019	2.8836	0.0031*

*Statement indicates the unit root test results of variables implemented in the estimation process at 1% level of significance

The long-term relationship between air transportation, economic growth, energy consumption, CO_2 emissions for NAFTA economies from 1970 to 2020 are considered through f bounds test which is taken into account as zero hypothesis. Starting from equation (2), δ, Δ, and ε_{it} denote constant term, difference operator and error term, respectively. In this analysis, the long-run linkage among factor is examined and the hypotheses are established as follows.

$$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0 \text{ (There is no long-term relationship)}$$
$$H_1: \delta_1 \neq \delta_2 \neq \delta_4 \neq 0 \text{ (There is a long-term relationship)} \quad (3)$$

If F statistic is less than specified minimum value, which is suggested by Pesaran et al. (2001), then the null hypothesis is not confirmed, thus deciding that there is no long-run connection among the series. Besides, if the calculated F statistic is greater than the upper limit value, then it is decided that there is no long-run nexus among the series except energy consumption.

Besides these, if the determined F statistic is among the upper and lower values, then unclear findings can be acquired. In addition, verifying the entity of a long-run linkage among series via the boundary test, the process of forecasting the long-run coefficients of the factors can be performed.

The long-run analysis is employed through considering co-integration between series by performing ARDL Bound Test at Table 4. Afterwards, ARDL Log-term estimation statistics are shared in Table 5. Long-term ARDL estimation findings demonstrate that the main components of CO_2 emissions changes in energy consumption for USA.

Considering the long-run ARDL results summarized in Table 3; if energy consumption rises by 1 %, carbon emissions rises by 0.4113% for USA. In general, when other variables are considered, no analysis shows any effect between variables. As a result, there is only a long-term relationship between energy consumption and carbon emissions. Therefore, considering all analyses including CCR, FMOLS, DOLS and ARDL models, the EKC hypothesis is not confirmed for any country. From another point of view, all NAFTA countries have fulfilled the requirements of the Kyoto Protocol and have grown economically clean without deteriorating the environment. For this reason, all three countries need to benefit from more environmentally friendly renewable energy sources.

4. CONCLUSION

The vast majority of the researches have concentrated on the nexus among economic growth and the environmental deterioration, by considering the relationship between energy consumption, air transportation, CO_2 emissions, and economic growth which is a new research topic and there is a lack of academic work regarding this subject for some economies notably in terms of transportation sector. This research paper addresses the long-run relationship and impact of air transportation economic growth, environmental development, and energy consumption on CO_2 emissions. In this context, ADF and PP unit root tests, FMOLS, DOLS, CCR and ARDL tests are performed in order to determine the coefficient of effects of independent variables on dependent variable CO_2 emissions by interpreting the Kyoto Protocol's political results and its effects considering the periods from 1970 to 2020 as annual data. According to empirical findings of this research there is a long-term stable relationship between CO_2 emissions and energy consumption from 1970 to 2020 for all NAFTA countries including USA, Canada, and Mexico which is demonstrated empirically. The P-value of energy consumption is <0.00 for all countries which are significant findings. It can be interpreted that increased consumption of the non-renewable energy or fossil will increase the amount of carbon dioxide emissions.

For this reason, all three countries need to benefit from more environmentally friendly renewable energy sources. ARDL

Table 4: ARDL Bound Test Results of USA

Model	Optimal lag length	
flnCO$_2$; lniar_trns; energy_cns; lnGDP	(4, 1, 4, 1)	
F	**Bound Test Critical Value**	
Statistics	I (0)	I (1)
5.3715*	4.01	5.16

*Critical values for F-statistics are 4.01 for the lower limit at 5% significance level and 5.16 for the upper limit. For this reason, there is a long-run co-integration linkage among the elements at the 5% level of significance in the forecasted model

Table 5: Short-Run ARDL and Error Correction Model of USA

Dependent Variable: lnCO$_2$ emissions				P-value
Variables	**Coef**	**St. er**	**t-Stat**	
Short-run Results				
D (lnCO$_2$ ems (-1))	0.139776	0.166074	0.841648	0.4066
D (lnCO$_2$ ems (-2))	0.169100	0.154506	1.094458	0.2825
D (lnCO$_2$ ems (-3))	0.148303	0.147090	1.008245	0.3214
D (lnGDP)	0.000124	3.70E-05	3.341649	0.0022
D (lnEnergy_cons)	234208.6	11983.43	19.54437	0.0001*
D (lnEnergy_cons (−1))	−12836.00	40078.68	−0.320270	0.0410**
D (lnEnergy_cons (−2))	−61855.59	37877.41	−1.633047	0.0129**
D (lnEnergy_cons (−3))	−17912.94	37651.71	−0.475754	0.0377**
D (lnAir_trns)	−0.300028	0.095869	−3.129575	0.2139
Constant	9990988.0	12647234	0.789974	0.0057
Trend	0.0034	0.0018	5.9876	0.0061*
CointEq (−1)	−0.7921	0.3116	−4.5823	0.0035*

*,** and ***expressions demonstrate 1%, 5% and 10% level of importance, respectively

analysis consistent with FMOLS, DOLS, and CCR analysis of NAFTA economies. Given the latest trends, the ability to decrease carbon emissions from energy consumption does not seem emboldened. By NAFTA economies' energy usage, these countries will reduce their CO_2 emissions and ensure a better retainable economic development and environmental awareness. USA, Canada, and Mexico should supply intelligent urbanisation green energy usage such as clean and intelligent energy production systems. Besides, economic growth acts as a crucial driver leading to energy production, which should be assumed when environmental application is projected. In this sense, relevant countries should encourage the R&D in energy production systems by ensuring eco-friendly new technologies. The recommendation of this research is that production resources ought to be established in the optimal regions of target countries, so that energy production, transportation, and CO_2 emissions, costs would be reduced unambiguously.

The manuscript is applicable not only to the NAFTA economies studied here, but can be performed to analyze the linkage among carbon emission and economic growth for all over the world. Owing to limited data existence, the findings in this study can be expanded further in the future.

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