Artekin, Ayşe Özge

Article

The long-run linkage among the macroeconomic factors and CO2 emissions in terms of sea transport induced EKC hypothesis in USA

International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Artekin, Ayşe Özge (2024). The long-run linkage among the macroeconomic factors and CO2 emissions in terms of sea transport induced EKC hypothesis in USA. In: International Journal of Energy Economics and Policy 14 (3), S. 1 - 8.
https://www.econjournals.com/index.php/ijeep/article/download/15734/7844/36806.
doi:10.32479/ijeep.15734.

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2024, 14(3), 1-8.

The Long-Run Linkage among the Macroeconomic Factors and CO_2 Emissions in terms of Sea Transport Induced EKC Hypothesis in USA

Ayse Ozge Artekin*

Department of Finance Banking and Insurance, Yunak Vocational School, Selçuk University, Konya, Türkiye.
Email: aoartekin@selcuk.edu.tr

Received: 03 January 2024 **Accepted:** 04 April 2024 **DOI:** https://doi.org/10.32479/ijeep.15734

ABSTRACT

The main aim of this article is to comprehend the long-run relationship among sea transportation, energy use, GDP, and CO_2 for USA from 1980 to 2023. In this sense, FMOLS, DOLS, CCR, and ARDL analyses are employed in order to investigate the entity of long-run linkage between the relevant variables. According to results of this manuscript, except energy use there is no both long-run relationship among variables and effects of independent variables (GDP, sea transportation) on dependent variable (CO_2 emissions) from 1980 to 2023 in USA. Therefore, the sea transport-induced EKC hypothesis has not been confirmed empirically. Although the hypothesis has not been confirmed, there are some issues to consider in terms of energy consumption. Transportation energy consumption and greenhouse gas emissions are seen as an alarming threat to leaving a livable and sustainable green environment and economy to future generations. Fossil fuels used in transportation have an important place in carbon dioxide emissions. This is seen as a crucial environmental factor that all stakeholders should consider when planning energy and environmental policy decisions. In order to prevent environmental quality from being negatively affected by greenhouse gas and exhaust emissions, policy makers need to encourage more energy efficient and healthier transportation ways. Thus, the harmful effects of transportation energy consumption can be reduced as well.

Keywords: Macroeconomic Factors, Sea Transportation, CO_2 Emissions, FMOLS, ARDL
JEL Classifications: E00, L91, Q5, B23, C01, C10, C22

1. INTRODUCTION

Energy is one of the most important factors that enable countries to develop in economic and social fields and raise the living standards of citizens living in these countries. Today, phenomena such as population growth, globalization, industrialization and urbanization and increasing the level of welfare increase countries' demands for energy. This increasing energy demand causes an increase in energy dependency, which requires countries to focus more on new energy sources and implement projects related to the energy sector. On the other hand, the environmental factor can be ignored while serving the purpose of meeting energy demand. Consumption of primary energy resources brings with it high levels of toxic gas emissions. Undoubtedly, the share of the transportation sector in the emission of these gases is quite high. Climate changes, especially global warming, are one of the most important problems faced by the international community.

The main greenhouse gases causing climate change are including Carbon Dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbon (HFC), Perfluorocarbon (PFC) and Sulfur hexafluoride (SF_6). The most important of these is carbon dioxide gas, and its share in the total amount of greenhouse gases reaches 80%. The USA and China release for almost half of carbon dioxide emissions in the world. In the sectoral distribution of CO_2 emissions worldwide, industry ranks first with 22%, and transportation sector ranks second with 20% (Isik and Kilinc, 2014).

Energy has gained rapidly increasing importance all over the world after the industrial revolution. Today, energy has become a strategic input in terms of production. However, it is also a mandatory need in terms of energy consumption. The fact that traditional energy sources, oil, natural gas and coal, are not distributed equally among countries which caused the issue to be discussed at the international level. Especially the fuel types known as marine diesel oil (MDO) and marine gas oil (MGO) used on ships also cause environmental degradation (Yenisu, 2018).

As a result of the unplanned and uncontrolled use of resources in the world, the rapid and irregular consumption of resources brings to the agenda the problem of leaving a livable environment to future generations. At this point, fundamental issues such as environmental problems, climate change, global warming and sustainable development are at the center of global discussions. Countries are rapidly consuming natural resources and trying to achieve their growth targets through industrialization, urbanization, population growth, technology-oriented production and specialization. Economic growth has always been an important goal for countries and has been tried to be solved in different ways, and has become a special area of endeavor for economic decision makers and managers. With the increasing industrialization, population and globalization in countries, a sustainable clean (green) environment emerges as one of the most important national and global agendas of recent times. Countries that have to face the paradox between economic growth and environmental protection are in a position where they cannot give up on both situations (Ucar and Coban, 2023).

Countries are increasing their use of energy to carry out production activities through the development of technological opportunities after the industrialization process. Due to the unbalanced distribution of energy reserves in the world, while energy resources are abundant in some countries which are less abundant in some countries. Economies with abundant energy resources are in a more advantageous position than those with less energy resources. Countries can reduce the costs required for production costs with the contribution of the technological opportunities they have developed through their know how. As developed countries complete their industrialization process, their demand for energy has gradually increased. For these countries, energy consumption is as important as the use of labor and capital, which are production factors. In addition, the high-speed growth seen in the economies of these countries occurs as a result of the production activities they carry out with the use of energy. Electrical energy, which is the easiest to access and use among energy types, is one of the most preferred energy source (Hepaktan and Sertkaya, 2016).

Carbon is a substance found in all organic substances. Carbon dioxide (CO_2) is emitted into the Earth's atmosphere mostly as a result of the burning of carbon-containing fuels and the decay of wood and other plant matter. Carbon dioxide, found naturally on Earth, is an invisible and odorless type of gas. Although other gases also cause the world's climate to warm, carbon dioxide has a greater effect than others. Between 1970 and 2004, carbon dioxide emissions increased by 70%, while the transportation sector accounted for 13.1% of carbon dioxide emissions; Greenhouse gas (GHG) emissions from the transportation sector are also the fastest growing greenhouse gas emissions (Oncu and Ozdemir, 2020).

Determining the factors affecting greenhouse gas emissions that cause global warming and climate change has become important for policy makers and researchers, especially since the 20th century. By determining these factors, various policies have been produced and necessary measures have begun to be taken in order to continue growth and development in an environmentally friendly manner and to reduce environmental pollution. Carbon (CO_2) emissions are the gas that has the highest share in greenhouse gas emissions. The relationships between economic growth, one of the most important macroeconomic indicators affecting CO_2 emissions, and these emissions are generally tested empirically with the environmental Kuznets curve (EKC) hypothesis. According to the EKC hypothesis, environmental destruction will increase with the increase in income level in the early stages of economic growth; It is assumed that environmental pollution will decrease only after reaching a certain income level. When the concept of EKC is valid; The milestone achieved indicates the income level at which economic growth increases both environmental quality and living standards. Additionally, this turning point indicates that energy consumption or carbon emissions will eventually decrease no matter how much greater than the current income level (Pata and Yurtkuran, 2018).

Since the transportation sector's energy demand is largely met by fossil fuels, it is one of the sectors that increases CO_2 and negatively affects environmental quality. In efforts to reduce the negative effects of climate change, identifying practices to reduce the amount of CO_2 is among the top issues addressed in improving environmental quality. Because increases in the amount of CO_2 cause global warming, natural disasters that threaten living things in the long term, loss of agricultural products, difficulty in accessing clean air and water resources, decrease in biodiversity, etc. It is discussed as the cause of the events. For this reason, steps towards determining the factors affecting the amount of CO_2 and creating solution suggestions in studies aimed at improving environmental quality are among the issues that are given importance by policy makers as well as researchers. The importance of this issue is further demonstrated by the fact that at the COP28 meeting, in which the USA also participated, preliminary information was included regarding the implementation of international restrictive or cost-increasing sanctions, especially against countries that cannot develop an action plan to reduce the amount of CO_2 (Cil, 2023).

The major goal of this study is to contribute to the developing literature on determining the macroeconomic factors affecting the amount of CO_2, which has been frequently examined by researchers in the USA in recent years, and to determine the relationship by using advanced econometric methods specific to the sector. When the contributions and novelties of this research to the literature are considered, the results of the research are important in that they will contribute to the determination of the road map of the USA in action plans in which decisions on environmental issues will be taken. In the first part of the article, general conceptual approaches to the subject are included and relevant variables are explained. In the second part of the article, the literature in terms of the subject is given in detail. In the third part, econometric analyzes are performed and the existence of the EKC hypothesis is tested. In the last part, empirical findings are discussed and some recommendations are given to US policy makers as well.

2. LITERATURE REVIEW

Nowadays, the causes of environmental pollution are being researched as a popular topic because environmental pollution has reached significant levels and affects human life. Factors that cause carbon dioxide emissions have an important place in this content because they cause global warming. The literature is examined chronologically to investigate the impact of economic growth and the transportation-induced EKC hypothesis in terms of carbon dioxide emissions. An inverted U-shaped relationship between environmental pollution indicators and economic growth was first detected by Grossman and Krueger (1991). This relationship was called the EKC hypothesis by Panayotou (1993), and many studies on the subject were carried out in the following years, following these two pioneering studies. In order to prevent loss of information due to missing variables, many explanatory variables such as fossil fuel consumption, renewable energy consumption, trade openness, financial development, population density, tourism, globalization, democratization, education, urbanization and industrialization have been included in the studies, in addition to the income variable over time. One of the most frequently added variables to the traditional model, which tests the relationship between economic growth and environmental pollution in two variables, is transportation induced EKC hypothesis. In the existing literature, it can be realized that there are many studies testing the EKC hypothesis in various countries in terms of different income groups.

Fodha and Zaghdoud (2010), Nasir and Rehman (2011), Ozturk and Acaravci (2013), Saboori and Sulaiman (2013), Farhani et al. (2014), Lau et al. (2014), Apergis and Ozturk (2015), Rabbi et al. (2015), Jebli et al. (2016), Ozturk et al. (2016), Kalayci (2017), Ozkan et al. (2019), Ozmen et al. (2019), Kalayci (2021), and Tarazkar et al. (2021) analyze the validity of the EKC hypothesis in countries and/or country groups. It seems that studies addressing the EKC hypothesis on a sectoral basis are in the minority. Bese and Kalayci (2021) investigate the EKC hypothesis for 3 developed countries, which are Denmark, the United Kingdom, and Spain, for the period between 1960 and 2014 by considering the variables including GDP, CO_2 and energy consumption. For this reason, ARDL bounds, the Toda and Yamamoto Granger non-causality, the VAR Granger Causality/Block Exogeneity Wald, and the Johansen cointegration tests are employed. According to results, the EKC hypothesis is not confirmed for Denmark, the United Kingdom, and Spain. Unidirectional causality running from energy consumption to CO_2 is found for Denmark, and unidirectional causality running from CO_2 to energy consumption is found for the United Kingdom. If the EKC hypothesis is considered in terms of sea transport, for the Denmark, Yazici (2022), for China, Kalayci and Ozden (2021) for Mexico Kayabas (2023) found that the hypothesis is confirmed. In the aforementioned studies, researchers reached a consensus that total, fossil fuel-based, non-renewable energy sources such as coal and oil increase CO_2 emissions.

In the study of Zadek and Schulz (2010), general methods, calculation models and some existing methods for calculating carbon dioxide (CO_2) emissions in logistics activities are summarized. General calculation formulas are presented mainly for truck and train transport from logistics vehicles. CO_2 emission factors for different fuel types and partially average figures for various transport companies are listed in this study. According to the authors, it is reported that the level of CO_2 emission calculation in the logistics sector affects the sustainability of the logistics sector. Khan et al. (2018) investigate the relationship of logistics activities with the environment was investigated using the panel generalized method of moments (GMM) economic and environmental data of 43 countries between 2004 and 2016. The results revealed that logistics operations consume energy and fossil fuels, and the amount of fossil fuels and non-green energy sources creates a significant detrimental impact on environmental sustainability and also negatively affects economic growth. In addition, CO_2 and other greenhouse gas emissions are increasing as a result of the logistics service provided with inadequate transportation infrastructure. However, carbon emissions reduce economic growth. According to the authors, renewable energy sources and green practices can reduce the harmful effects of logistics operations on environmental sustainability and will stimulate economic activities with the large export opportunities.

There are many studies that analyze the relationship between economic growth and environmental pollution within the framework of the EKC hypothesis, and these papers differ in terms of the indicators and methods it is used, as well as the countries and country groups they analyze. For example, Rasool et al. (2019) used the ARDL, Granger causality test and VECM model to examine the effects of oil prices, road transport, energy intensity, economic growth and population density on CO_2 to examine CO_2 emissions from transportation in Pakistan during the period 1974-2014. In long-term results, they found that increases in economic growth contributed to reduce CO_2 emissions from the transportation sector. Danish et al. (2018) analyze the relationship between energy consumption, economic growth and CO_2 resulting from the transportation sector in Pakistan between 1990 and 2015 by using ARDL and VECM models. As a result, it is revealed that the impact of economic growth and urbanization on CO_2 emissions from the transportation sector to be statistically insignificant. In the study of Polat (2017), the relationship between carbon emissions and economic growth in transportation, manufacturing industry, commercial and public residences in selected countries is tested through FMOLS method for the period 1980-2013. The results obtained demonstrated that the inverted-u-shaped EKC hypothesis is valid for CO_2 emissions arising from the transportation sector in most of the developed countries. Talbi (2017) investigate the validity of the EKC hypothesis in the transportation sector of Tunisia between 1980 and 2014 with the Vector Autoregressive (VAR) model. As a result of the empirical analysis, it was concluded that there is an inverted U-shaped relationship between carbon emissions resulting from activities in the transportation sector and economic development, in other words, the EKC hypothesis is valid in this sector. Timilsina and Shrestha (2009) analyze the potential factors affecting the growth of transportation sector CO_2 emissions in Asian countries by separating the annual emission increase into components representing changes in fuel mix, modal change, and GDP per capita. Changes in GDP per capita, population growth and transport energy intensity have been identified as the main factors driving transport sector CO_2 emissions growth in the countries considered.

Ong et al. (2012) recommend an energy model and policy for the transportation sector in Malaysia. According to 2012 data, the transportation sector alone accounts for 36% of total energy consumption and this rate is gradually increasing. It is revealed that approximately 24 million tons of CO_2 were emitted in 1995 and increased to 50 million tons in 2008. Therefore, the need to adopt appropriate energy policy to balance energy demand and reduce emissions in this sector has been stated. At this point, many policies such as fuel economy standard, fuel economy label and fuel switching applied in road transportation have been mentioned to reduce fuel consumption. The mandatory implementation of fuel economy has been shown to be an effective tool in controlling energy demand and greenhouse gas emissions from the transportation sector in many countries. Beyond this, biodiesel is increasingly gaining acceptance in the market as an environmentally friendly alternative diesel fuel, with the view that switching fuel to alternative renewable fuel could solve the fossil fuel consumption shortage. Malaysia has great potential for the production of palm oil-based biodiesel, and biodiesel will play an important role in reducing the negative impact of fossil fuel on the environment. However, the use of inedible vegetable oils as alternative fuel to diesel engines is accelerating with the need for edible oil as food and the decrease in the cost of biodiesel production. Therefore, jatropha and calophyllum inophyllum have great potential as feedstocks for biodiesel in Malaysia. Apart from this, various issues need to be examined and overcome in order for biodiesel to be established and continue to mature in the market.

Alshehry and Belloumi (2017) examine the relationship between carbon emissions resulting from transportation and economic growth in Saudi Arabia between 1971 and 2011 by using the ARDL bounds test and Granger causality approach, and concluded that the EKC hypothesis is not valid. Chen and Lei (2017) aimed to measure the causality between the transportation sector, energy consumption and CO_2 in their study specifically for China (Beijing). As a result, the direct positive effect of GDP per capita on CO_2 has been determined, and the indirect effect of the transportation sector on CO_2 emissions has been revealed. However, the change in the economic growth model somehow hinders the growth rate of CO_2 emissions by directly reducing the energy intensity of the transportation sector and indirectly reducing the transportation intensity. A significant positive impact of energy intensity on carbon emissions has been identified. For this reason, it has been determined that the decrease in energy intensity in the transportation sector prevents the increase in carbon emissions to some extent. Wang et al. (2017) investigate the trend of factors affecting transportation sectors using the LMDI method in China. According to the results, the CO_2 emissions of passenger and freight transportation have shown growth from 1990 to 2015, the GDP per capita and the population encourage the increase of CO_2 emissions for both passenger and freight transportation, and the transportation structure encourages the increase of CO_2 emissions for freight. Among these, it has been revealed that the economic factor makes the biggest contribution as well. It is revealed that activity intensity limits the increase in CO_2 emissions and transportation structure limits the increase in CO_2 emissions for passengers.

3. DATA AND METHODOLOGY

The data sets covering the years 1980-2023 for the USA and with a sample size of 44 were used to empirically examine whether there is a long-term relationship between the variables in terms of the EKC hypothesis by using ADF, PP, LS, FMOLS, DOLS, CCR, and ARDL methods in the analysis part of this study. In this context, data sets for the variables including the Energy Consumption, CO_2 emissions, maritime transport and GDP are obtained from the relevant official websites of Our World in Data (2023a), (2023b), Unctadstat (2023) and World Bank (2023) respectively. First of all, stationarity tests are carried out at the I(0) level of the series in order to apply the Fully Modified Least Squares (FMOLS), Dynamic Ordinary Least Square (DOLS) and Canonical Co-integration Regression (CCR) methods. In this context, in order to comprehend whether there is a unit root problem in the series, Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Lee-Strazicich (LS) unit root tests are implemented among the relevant variables.

The Augmented Dickey Fuller unit root test (which is calculated according to the AIC Akaike Information Criterion) is employed to the series containing energy use, GDP, maritime cost, and CO_2 emissions to analyze for stability. The maximum lag length is determined to be 2 as per Serena and Perron's (2001) recommendations.

The Augmented Dickey Fuller (ADF) test originates a parametric correction for higher-order correlation, supposing that the series follow an AR (k) process and attach the lagged difference terms of the dependent variable to the right section of the series.

$$\Delta y_t = c + \alpha y_{t-1} + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \Delta_t \tag{1}$$

$$\Delta y_t = c + \alpha y_{t-1} + \beta t \sum_{j=1}^{k} d_j \Delta y_{t-j} + \Delta_t \tag{2}$$

Equation (1) demonstrates the null hypothesis towards a mean stationary alternative unit root in yt of the studied time series y. Equation (2) indicates the unit root of the null hypothesis against the trend-stationary alternative. The term Δ_{yt-j} examines the first difference in the error term that ensures the serial correlation. A constant and linear time trend can be contained in the ADF test regression, as illustrated in the above equations.

The results of the unit root tests performed in Tables 1-3 are not found to be stationary at the I(0) level. Respectively, the t-statistic values of the ADF, PP, and LS tests of the first-order differenced series are below the figures corresponding to 1%, 5%, and 10%. For this reason, first order differences of all series are taken.

All series at I(I) level became stationary within the 99% and 95% confidence interval. In other words, in all 3 tests for all variables, t-statistic values are at the desired level and became stationary. Thus, FMOLS, DOLS, CCR and ARDL tests can be applied through the stationary series.

After empirically proving that all series are stationary at the I(I) level, CCR, DOLS, ARDL and FMOLS analyzes are performed. As it is known, FMOLS, DOLS, and CCR analyzes both enable us to comprehend whether there are long-term relationships between variables and reveal which independent variable affects the dependent variable or not.

Table 1: ADF unit root test results of USA

Results	Country	Series	ADF Test at I (0)	ADF Test at I (1)
I (1)		Sea_Transport	**−0.4660**	**−4.0600***
			−2.9369	−3.5966
I (1)	USA	Energy_Use	**−1.0890**	**−6.6844***
			−2.9314	−3.6009
I (1)		GDP	**2.4088**	**−13.4474***
			−2.9369	−3.6055
I (1)		CO_2 Emissions	**−1.2395**	**−2.9645****
			−2.9314	−2.9369

Bold values indicate ADF test results. "*" and "**" symbols indicate the unit root test of the variables which is employed in the estimation process, 1 and 5% significance levels, respectively

Table 2: PP unit root test results of USA

Results	Country	Series	PP Test at I (0)	PP Test at I (1)
I (1)		Sea_Transport	**−0.4292**	**−3.9498***
			−2.9314	−3.5966
I (1)	USA	Energy_Use	**−1.0400**	**−6.3655***
			−2.9314	−3.5966
I (1)		GDP	**0.9918**	**−5.6269***
			−2.9314	−3.5966
I (1)		CO_2 Emissions	**−1.2170**	**−6.4119***
			−2.9314	−3.5966

Bold values show PP test results. "*" and "**" symbols indicate the unit root test of the variables which is employed in the estimation process, 1 and 5% significance levels, respectively

Table 3: LS unit root test results of USA

Results	Country	Series	LS Test at I (0)	LS Test at I (1)
I (1)		Sea_Transport	**−5.1851**	**−6.6021****
			−6.1850	−6.2880
I (1)	USA	Energy_U	**−4.9667**	**−8.3653***
			−6.1850	−6.8210
I (1)		GDP	**−3.8852**	**−27.1019***
			−5.9170	−6.7500
I (1)		CO_2 Emissions	**−5.8684**	**−8.9635***
			−6.1750	−7.1960

Bold values demonstrate LS test results. "*" and "**" symbols indicate the unit root test of the variables which is employed in the estimation process, 1 and 5% significance levels, respectively

In this context, when Tables 4-6 are examined in depth, it is observed that only the p-value of energy use was below 0.05. In other words, energy use affected carbon emissions in all 3 tests. Additionally, energy use has affected carbon emissions.

As a result, considering the research model, maritime transport, GDP, and energy consumption are determined as independent variables and CO_2 emissions is determined as dependent variables. When we look at the FMOLS, DOLS and CCR analyzes in Tables 4-6 in detail, only energy consumption affected CO_2 emissions. The p-value of energy consumption is determined as "0.000" in Table 4, "0.001" in Table 5 and "0.0000" in Table 6 respectively. All these results are empirically significant findings.

After all the derivatives of the least squares methods are made, both questioned the existence of a long-term relationship between the variables and tested which independent variable affected or not the dependent variable in Table 7. In this respect, in order to implement the ARDL test, bound test should be made which is so vital to determine the appropriate model.

When the ARDL F-bound test is taking into account, long-term ARDL forecasts are employed by the ascertaining long-run co-integration through econometrical models which is performed between the relevant variables. Long-run ARDL estimates are demonstrated in Table 8 above. Long-run ARDL estimates ascertain that the effecting major factors of CO_2 changed with energy use which is consistent with previous findings including

Table 4: FMOLS test results of USA

Country	Dependent variable	FMOLS		
	CO_2 Emissions			
	Independent variables	**T-stats**	**P-vl**	**Coeff**
	Sea_Transport	1.109399	0.2742	1.344194
	Energy_Use	11.03116	0.0000	73.72432
USA	GDP	0.487545	0.6287	0.010130
	C	0.492065	0.6255	10284.60

Table 5: DOLS test results of USA

Country	Dependent variable	DOLS		
	CO_2 Emissions			
	Independent variables	**T-stats**	**P-vl**	**Coeff**
	Sea_Transport	0.753807	0.4575	1.595973
	Energy_Use	4.520155	0.0001	85.36624
USA	GDP	−0.574646	0.5703	−0.051986
	C	0.718693	0.4785	40583.63

Table 6: CCR Test Results of USA

Country	Dependent variable	CCR		
	CO_2 Emissions			
	Independent variables	**T-stats**	**P-vl**	**Coeff**
	Sea_Transport	0.958404	0.3439	1.344456
	Energy_Use	8.677349	0.0000	75.82860
USA	GDP	−0.336167	0.7386	−0.014793
	C	0.774319	0.4435	24774.12

Table 7: Long-Term ARDL Results of USA

Dependent Var	CO_2 Ems	T-Statistics	Prob
Variables	Coefficient		
SEA_TRANS1	0.902656	1.283831	0.2076
ENERGY1	74.90757	18.75538	0.0000
GDP1	0.002323	0.188056	0.8519
C	43933.92	2.429992	0.0204

Table 8: ARDL Model Bounds Test Results for USA

Bounds Test		Results	
ARDL Model		(1, 1, 1, 0)	
F Statistics Value		6.73	
Pesaran et al. (2001) crt val	10 %	5 %	1 %
Lower Values	5.59	6.56	8.74
Upper Values	6.26	7.30	9.63

FMOLS, DOLS, and CCR. The most convenient model is selected with the smallest value (1, 1, 1, 0) by means of the AIC criterion. The finding of the boundary test is used to comprehend the long-run linkage among the series and the diagnostic test results are given in Table 7 within the sense of this model.

There is no entity of the long-term relationship of series including sea transport, CO_2 emissions and GDP which are indicated through ARDL, FMOLS, DOLS and CCR models which is not verified the EKC hypothesis for USA. Thus, only ARDL model of the research reveal that there is long-run relationship between CO_2 emissions and energy use from 1980 to 2023 which points out the environmental pollution.

The long-run FMOLS, CCR, ARDL and DOLS models findings demonstrate that there is no a statistically significant linkage among the sea transport, CO_2 emissions, and GDP for USA from 1980 to 2023 except energy use. When the signs of the coefficients obtained are evaluated, it is revealed that there is no a positive linkage among sea transport, CO_2 emissions, and GDP. The findings of long-term ARDL model at Table 8 is consistent with all previous the derivatives of the least square methods test. The ARDL equation is indicated through econometric symbols, where the series of long-term CO_2 emissions is examined in equation (3). The ARDL test is employed through all OLS analyses. The long-run nexus among GDP, sea transport, energy usage, and CO_2 for USA countries from 1980 to 2023 are considered through f bounds test which is assumed as zero hypothesis. Starting from equation (3), δ, Δ, and ε_{it} indicate 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.

$$\Delta \ln CO_{t} = a_0 + \sum_{i=1}^{m_1} \sigma_{it} \Delta CO_{t-i}$$
$$+ \sum_{i=0}^{m_2} \beta_{it} \Delta \ln sea\_trns_{i,t-i} + \sum_{i=0}^{m_3} \theta_{it} \Delta \ln GDP_{i,t-i}$$
$$+ \sum_{i=0}^{m_4} \theta_{it} \Delta \ln energy_{usage_{i,t-i}} + \delta_{1i} CO_{t-1} + \delta_{2i} sea_{trns_{t-1}} \quad (3)$$
$$+ \delta_{3i} \ln GDP_{t-1} + \delta_{4i} \ln energy_{usage_{t-1}} + \Delta_{it}$$

If F statistic is less than specified minimum value, which is recommended by Pesaran et al. (2001), 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. Consequently, the F statistics of Table 7 ARDL bound test is in required level which is 6.73. For this reason, the hypothesis is rejected.

4. CONCLUSION AND DISCUSSION

Consequently, when it is employed FMOLS, DOLS, CCR, and ARDL analyses except energy consumption there is no both long-run relationship among variables and effects of independent variables (GDP, sea transportation) on dependent variable (CO_2 emissions) from 1980 to 2023 in USA. Therefore, the sea transport-induced EKC hypothesis has not been confirmed empirically. Although the hypothesis has not been confirmed, there are some issues to consider in terms of energy consumption.

When the empirical findings of the article are interpreted, vehicle sales and emissions are increasing rapidly in the United States. It is important for the protection of the environment and health that new vehicles to be launched in the coming years have the best possible technology and the lowest emission levels. Some solution suggestions can be developed to reduce the amount of carbon footprint released by the transportation sector, especially by shipping. By choosing public transportation instead of personal vehicles, transportation-related carbon footprint can be reduced by up to 90%. Not choosing a cruise, especially for distances that can be covered by bus, is also a way to reduce CO_2 emissions. The reason for this is that the amount of emissions per unit distance in cruises is quite high compared to other transportation methods. Transportation energy consumption and greenhouse gas emissions are seen as an alarming threat to leaving a livable and sustainable green environment and economy to future generations. Fossil fuels used in transportation have an important place in carbon dioxide emissions. This is seen as a crucial environmental factor that all stakeholders should consider when planning energy and environmental policy decisions. In order to prevent environmental quality from being negatively affected by greenhouse gas and exhaust emissions, policy makers need to encourage more energy efficient and healthier transportation ways. Thus, the harmful effects of transportation energy consumption can be reduced. Policies that encourage and support energy consumption in transportation with alternative energy sources such as CNG4, LPG5, electricity and recycled biofuels should be one of the most important policies for a sustainable and livable environment that will be transferred to future generations. In addition to clean energy, building more comfortable roads instead of uncomfortable roads and old technology engines, which are thought to increase fuel consumption, and encouraging the use of fuel-efficient new generation motor vehicles will also contribute to reducing CO_2 consumption and preserving environmental quality. The increase in the number of individual vehicle uses is also considered as an inefficient use of resources. This situation again causes an increase in CO_2 emissions and a deterioration in environmental quality. Encouraging people to go to work campuses and public living areas by public transportation will be a vital policy as well. In the USA, it is necessary to prevent the increase in CO_2 emissions by making necessary regulations regarding energy consumption and population density, in addition to income level. In the short term, the transition from fossil fuel consumption to alternative energy sources may be costly, and this may pose an obstacle to economic growth. Therefore, long-term structural reforms need to be carried out in order to increase the production and consumption of alternative energy resources efficiently and to ensure the continuation of a sustainable economy. In addition, necessary steps should be taken to support further energy-related research activities, to encourage the production of alternative energy sources that contribute to the reduction of CO_2 emissions, and to increase the consumption share of these resources in total energy.

There is a constant increase in the number of people both in the world and in the USA. Population growth brings with it many negative factors. One of these negative factors is environmental pollution. Population density increases CO_2 emissions in both the short and long term. With rapid population growth, natural resources are being consumed rapidly; this situation negatively affects the environmental quality. The reasons for the population growth rate in the USA must be identified, necessary steps must be taken to solve this problem and this increase rate must be taken under control. Moreover; It is of great importance to prevent the crowded and unplanned urbanization phenomenon caused by the increasing population constantly migrating to cities, with the measures taken by policy makers. In order to reduce population density in cities in the USA, in addition to supporting agricultural activities in rural areas, it should also contribute to the development of sociocultural activities. In this way, the living standards of people living in rural areas will increase and the rate of migration from villages to cities will decrease. In conclusion; well-planned and balanced villages and cities with reduced population density will contribute to the reduction of CO_2 emissions.

On the other hand, USA government need to develop electric cargo ship and passenger ships and make more R&D investments in this field in order to control the environmental degradation. Determining the long-term relationship between variables reveals the importance and necessity of environmentally friendly plans based on the R&D for the transportation sector in efforts to increase environmental quality for the USA. In this context, the aim of contributing to the drawing of a road map for policy makers to follow in the steps that need to be taken is another contribution of the study to the literature. In this sense, policy makers can make incentive regulations for financial institutions that provide investment financing for low carbon projects. It can be also developed regulations that will encourage special fund formations that will implement diversification policies for transportation vehicles that use energy efficiency and environmentally friendly fuel. Tax advantages for financial institutions that support environmentally friendly projects can also contribute to the formation of more effective policies.

REFERENCES

Alshehry, A.S., Belloumi, M. (2017), Study of the environmental Kuznets curve for transport carbon dioxide emissions in Saudi Arabia. Renewable and Sustainable Energy Reviews, 75, 1339-1347.

Apergis, N., Ozturk, I. (2015), Testing environmental Kuznets curve hypothesis in Asian countries. Ecological Indicators, 52, 16-22.

Bese, E., Kalayci, S. (2021), Environmental Kuznets curve (EKC): Empirical relationship between economic growth, energy consumption, and CO_2 emissions: Evidence from 3 developed countries. Panoeconomicus, 68(4), 483-506.

Chen, W., Lei, Y. (2017), Path analysis of factors in energy-related CO_2 emissions from Beijing's transportation sector. Transportation Research Part D: Transport and Environment, 50, 473-487.

Cil, D. (2023), Ekonomi ve çevre etkileşimi: Türkiye'de finansal gelişim ve ulaşim kaynakli CO_2 ilişkisi üzerine fourier ADL analizi. Sosyal Mucit Academic Review, 4(4), 456-476.

Danish, D., Baloch, M.A., Suad, S. (2018), Modeling the impact of transport energy consumption on CO_2 emission in Pakistan: Evidence from ARDL approach. Environmental Science and Pollution Research, 25, 9461-9473.

Farhani, S., Mrizak, S., Chaibi, A., Rault, C. (2014), The environmental Kuznets curve and sustainability: A panel data analysis. Energy Policy, 71, 189-198.

Fodha, M., Zaghdoud, O. (2010), Economic growth and pollutant emissions in Tunisia: An empirical analysis of the environmental Kuznets curve. Energy Policy, 38(2), 1150-1156.

Grossman, G.M., Krueger, A.B. (1991), Environmental Impacts of a North American Free Trade Agreement (No. w3914). Cambridge: National Bureau of Economic Research.

Hepaktan, E., Sertkaya, Y. (2016), Türkiye'de elektrik tüketimi, kişi başına GSYİH, CO_2 emisyonu ve petrol tüketimi ilişkisi. Yalova Sosyal Bilimler Dergisi, 6(12), 163-182.

Isik, N., Kilinç, E.C. (2014), Ulaştırma sektöründe CO_2 emisyonu ve enerji AR&GE harcamaları ilişkisi. Sosyoekonomi, 22(22), 321-346.

Jebli, M.B., Youssef, S.B., Ozturk, I. (2016), Testing environmental Kuznets curve hypothesis: The role of renewable and non-renewable energy consumption and trade in OECD countries. Ecological Indicators, 60, 824-831.

Kalayci, S. (2017), Dışsal faktörlerin ulaşım sektörüne etkisi: Lojistik firmalarından kanıtlar. Finans Politik ve Ekonomik Yorumlar, 54(633), 41-59.

Kalayci, S. (2021), Analysing transportation-induced economic growth, energy use, and CO_2 emissions: An empirical investigation from EU countries. In: Research Anthology on Clean Energy Management and Solutions. United States: IGI Global. p1277-1293.

Kalayci, S., Ozden, C. (2021), The linkage among sea transport, trade liberalization and industrial development in the context of CO_2: An empirical investigation from China. Frontiers in Environmental Science, 9, 633875.

Kayabas, Y.E. (2023), The relationship between trade liberalization, sea freight, and carbon-dioxide emissions within the perspective of EKC: The case of Mexico. International Journal of Energy Economics and Policy, 13(2), 364-372.

Khan, S.A.R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., Qianli, D. (2018), Green supply chain management, economic growth and environment: A GMM based evidence. Journal of Cleaner Production, 185, 588-599.

Lau, L.S., Choong, C.K., Eng, Y.K. (2014), Investigation of the environmental Kuznets curve for carbon emissions in Malaysia: Do foreign direct investment and trade matter? Energy Policy, 68, 490-497.

Nasir, M., Rehman, F.U. (2011), Environmental Kuznets curve for carbon emissions in Pakistan: An empirical investigation. Energy Policy, 39(3), 1857-1864.

Oncu, E., Ozdemir, O. (2020), Ekonomik büyüme ve ulaştirma altyapi kalitesinin CO_2 emisyonuna etkisinin incelenmesi. Nişantaşı

Üniversitesi Sosyal Bilimler Dergisi, 8(1), 45-54.

Ong, H.C., Mahlia, T.M.I., Masjuki, H.H. (2012), A review on energy pattern and policy for transportation sector in Malaysia. Renewable and Sustainable Energy Reviews, 16(1), 532-542.

Our World in Data. (2023a), Energy Use, Dataset. Available from: https://ourworldindata.org/explorers/energy?tab=chart&facet=none&country=~usa&total+or+breakdown=total&energy+or+electricity=primary+energy&metric=per+capita+consumption

Our World in Data. (2023b), CO_2 Emissions, Dataset. Available from: https://ourworldindata.org/co2-emissions

Ozkan, T., Yanginlar, G., Kalayci, S. (2019), Testing the transportation-induced environmental Kuznets curve hypothesis: Evidence from eight developed and developing countries. International Journal of Energy Economics and Policy, 9(1), 174-183.

Ozmen, I., Gerçeker, M., Mucuk, M. (2019), BRIC-T ülkelerinde ekonomik büyüme, dişa açiklik, elektrik tüketimi ve çevre ilişkisine yönelik ampirik bir çalişma. Hacettepe Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 37(4), 675-701.

Ozturk, I., Acaravci, A. (2013), The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Economics, 36, 262-267.

Ozturk, I., Al-Mulali, U., Saboori, B. (2016), Investigating the environmental Kuznets curve hypothesis: The role of tourism and ecological footprint. Environmental Science and Pollution Research, 23(2), 1916-1928.

Panayotou, T. (1993), Empirical Tests and Policy Analysis of Environmental Degradation at Different Stages of Economic Development. Geneva, Switzerland: International Labour Office, Working Paper; WP238.

Pata, U.K., Yurtkuran, S. (2018), Yenilenebilir enerji tüketimi, nüfus yoğunluğu ve finansal gelişmenin CO2 salimina etkisi: Türkiye Örneği. Uluslararası İktisadi ve İdari İncelemeler Dergisi, 11(21), 303-318.

Pesaran, M.H., Shin, Y., Smith, R.J. (2001), Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289-326.

Polat, M.A. (2017), Çevresel kuznets eğrisinin sektörel analizi: Gelişmiş ülkeler örneği. Journal of Social and Humanıtıes Sciences Research, 4(10), 360-36.

Rabbi, F., Akbar, D., Kabir, S.Z. (2015), Environment Kuznets curve for carbon emissions: A cointegration analysis for Bangladesh. International Journal of Energy Economics and Policy, 5(1), 45-53.

Rasool, Y., Zaidi, S.A.H., Zafar, M.W. (2019), Determinants of carbon emissions in Pakistan's transport sector. Environmental Science and Pollution Research, 26, 22907-22921.

Saboori, B., Sulaiman, J. (2013), Environmental degradation, economic growth and energy consumption: Evidence of the environmental Kuznets curve in Malaysia. Energy Policy, 60, 892-905.

Serena, N., Perron, P. (2001), Lag length selection and the construction of unit root tests with good size and power. Econometrica, 69(6), 1519-1554.

Talbi, B. (2017), CO_2 emissions reduction in road transport sector in Tunisia. Renewable and Sustainable Energy Reviews, 69, 232-238.

Tarazkar, M.H., Kargar Dehbidi, N., Ansari, R.A., Pourghasemi, H.R. (2021), Factors affecting methane emissions in OPEC member countries: Does the agricultural production matter? Environment, Development and Sustainability, 23, 6734-6748.

Timilsina, G.R., Shrestha, A. (2009), Transport sector CO_2 emissions growth in Asia: Underlying factors and policy options. Energy Policy, 37(11), 4523-4539.

Ucar, M., Coban, S. (2023), Ulaştırma sektöründeki enerji tüketimi, ekonomik büyüme ve çevresel kalite ilişkisi. Nevşehir Hacı Bektaş Veli Üniversitesi SBE Dergisi, 13(1), 485-506.

Unctadstat. (2023), Merchant Fleet by Flag of Registration and by Type of Ship, Dataset. Available from: https://unctadstat.unctad.org/datacentre/dataviewer/us.merchantfleet

Wang, B., Sun, Y., Chen, Q., Wang, Z. (2018), Determinants analysis of carbon dioxide emissions in passenger and freight transportation sectors in China. Structural Change and Economic Dynamics, 47, 127-132.

World Bank.v (2023), GDP (Current US$), Dataset. Available from: https://data.worldbank.org/indicator/Ny.Gdp.Mktp.Cd

Yazici, S. (2022), Investigating the maritime freight-induced EKC hypothesis: The case of Scandinavian countries. Frontiers in Environmental Science, 289, 1-18.

Yenisu, E. (2018), Enerji tüketimi, CO_2 emisyonu ve ekonomik büyüme ilişkisi: Türkiye örneği. Van Yüzüncü Yıl Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 3(5), 9-29.

Zadek, H., Schulz, R. (2010), Methods for the Calculation of CO_2 Emissions in Logistics Activities. In: Advanced Manufacturing and Sustainable Logistics. In: 8th International Heinz Nixdorf Symposium, IHNS 2010, Paderborn, Germany, Proceedings. Springer Berlin Heidelberg. p263-268.