IJEEP
INTERNATIONAL JOURNAL OF ENERGY ECONOMICS AND POLICY
EJ EconJournals ISSN: 2146-4553

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2023, 13(2), 364-372.

EJ EconJournals

The Relationship between Trade Liberalization, Sea Freight, and Carbon-Dioxide Emissions within the perspective of EKC: The Case of Mexico

Yunus Emre Kayabas*

Faculty of Business and Economics, American University of Cyprus, North Cyprus. *Email: dryunuskayabas@gmail.com

Received: 03 January 2022 **Accepted:** 07 March 2023 **DOI:** https://doi.org/10.32479/ijeep.14210

ABSTRACT

The main purpose of this research is to investigate the long-term nexus among trade liberalization, sea transportation, economic growth, energy consumption and carbon dioxide emissions by considering the EKC hypothesis for Mexico from 1980 to 2021. In this context, multiple regression, ADF, PP, FMOLS, Bayer-Hanck co-integration tests are employed in order to examine both the effect of independent variables on dependent variables and the long-run relationship. According to results of multiple regression, FMOLS analysis and Bayer-Hanck co-integration test, trade liberalization, sea transportation, economic growth, energy consumption have substantial impact on CO_2 emissions and there is a long-run relationship among variables from 1980 to 2021 for Mexico which verifies the EKC hypothesis. All empirical evidence demonstrates that the Mexican government should take radical steps to prevent environmental degradation. The presence of trade liberalization and the positive movement of the ecological footprint reveal the increasing effect of growth on carbon dioxide emissions, especially in a developing country such as Mexico, which aims for more economic growth. All these indicate the necessity of switching to practices aimed at reducing carbon dioxide emissions. In this sense, incentives for renewable energy sources, rate differentiation in motor vehicle tax, and regulations in the tax system for negative externalities are some of the applications that can be done. In addition, public expenditures for green infrastructure such as low-carbon energy production and energy efficiency in public buildings can be increased, investments can be made in R&D studies to support innovation, and activities can be preferred to increase environmental awareness. Besides, there are various sea transport green solutions in order to reduce emissions and pollution in maritime transport. Green energy suggest solutions such as reducing the cruise speed of the ship, reducing the use of fossil fuels, choosing new generation fuel types with cleaner content, increasing energy efficiency, and making a weather-dependent cruise plan.

Keywords: Sea Transport, Trade Liberalization, Energy Consumption, Economic Growth, CO_2 Emissions
JEL Classifications: L90, Q27, Q57, O4, Q54

1. INTRODUCTION

Since the beginning of human history, transportation and relocation have taken their place among the basic needs of people, both socially and economically. The irrepressible development of inventions and technology not only changes the face of human life, but also has negative effects on nature. After the industrial revolution, the transportation activities between countries and continents have increased even more. Today, logistics; In the developing, changing and globalizing world, it has become an increasingly important sector with many activities beyond its transportation activities. In recent years, some awareness has emerged with the development of technology and new systems. Decrease in underground resources, climate changes, deformities in demographic structures and competitive environment made it necessary to increase our environmental awareness. It has been use new techniques and technologies on how to correct or minimize the destructive effects of damage to the environment. Transportation methods are basically in the form of road, sea, rail and air transportation. In addition, pipelines and inland waterways can be counted as well (Millet et al., 2021).

Many humanitarian activities are carried out on the seas that serve economic, military, cultural and industrial purposes. Undoubtedly, the most important of these are maritime transport and port management activities. The biggest reason for this is that maritime transport by ships has a higher load carrying capacity at once with much lower costs compared to other types of transport. Although the transportation and delivery time of the cargo to the buyer in maritime transportation is longer compared to other transportation modes, companies prefer sea transportation primarily due to its low cost. This situation makes maritime transportation a voice in approximately 90% of the international trade in the world and makes it accepted as the most energy efficient transportation mode (Bayraktutan and Ozbilgin, 2015).

In recent years, with the growth in the world trade and economy and the developments in the shipbuilding sector, significant increases have been observed in the number and volume of ships in the world maritime merchant fleet. As of 2018, many ships (116,857 units, 1,361,920 gross tons) registered in the registry of flag states are engaged in international trade activities. With the development of industry and the increase in urbanization in the world due to population growth, air pollution has become an important problem in cities where the population is dense. Air pollution; It is the presence of pollutants in the atmosphere in the amount and time that will harm the health of living things, building materials and the environment. Sources of air pollution can be divided into two groups. The first group of resources is naturally occurring desert, storms, fires, volcanic eruptions, organic compounds thrown into the atmosphere from plants, liquid droplets emitted from the oceans and seas to the atmosphere. The second resources are artificial sources, whose share in air pollution is much higher than natural sources; Fuels used for heating purposes in residences, which are formed entirely as a result of human activities, can be listed as industrial sector and motor vehicles. Among motor vehicles, ships also consume more hydrocarbon fuel, causing more air pollution than other motor vehicles with the exhaust gases they emit from their chimneys to the atmosphere. This has made ships one of the major sources of air pollution worldwide (Friedrich et al., 2007).

Today, with the globalization of economic activities, complex two-way business processes that are interconnected like the rings of a chain or gear have emerged within and around each unit involved in economic activity and between other units. No business or country carries out a production activity that it does from beginning to end anymore. Every unit engaged in economic activity, as a link in a global supply-demand and distribution chain, has to continue this activity within the international division of labor. The 80s and 90s, which were especially symbolized by the fall of the Berlin wall, passed under the influence of liberalization and the economies of the countries that opened up to foreign countries grew rapidly in this period. So much so that when we look at this period, while world trade (products and services) was approximately 4 trillion USD in 1990, this figure became approximately 19 trillion USD in 2010 (Cevik and Gulcan, 2011).

With the developments in technology and especially in Communication technology, products coming from abroad to a country are now easily produced in those countries. On the other hand, situations such as free movement of capital and workforce, easier access to technology, and markets influencing each other for similar products have made it more difficult than in the past to create an advantage over each other in the competition of businesses. As a result, businesses that would like to make their products preferable have to bring their goods to the consumer faster and at a lower cost. For such reasons, when competition analysis is made in economies, it is seen that the weight of logistics activities in competition is increasing rapidly day by day. The logistics, which has become an important interface of production and distribution functions, has started to gain importance day by day. Countries have begun to specialize and compete with each other in the field of logistics. Thus, the logistics sector is developing rapidly and increasing its quality (Tutar et al., 2009).

The aim of this article is to draw attention to the increase in air pollution which is caused by carbon-dioxide emissions due to trade liberalization and ships in recent years and to reveal the effects of this pollution on the environment and human health. In the first part of the article, the importance of maritime transport in terms of world trade and its environmental dimensions are discussed. In addition, trade liberalization is briefly explained and its environmental effects are mentioned as well. In the second part of the manuscript, researches regarding trade liberalization and maritime transport based on the EKC hypothesis are criticized as positively. In the third part of the article, trade liberalization and sea transport are correlated based on the EKC hypothesis for Mexico and econometric analyzes are performed. In the conclusion part of the manuscript, comments are made in the context of the results obtained, and some recommendations are given to the Mexican government and policy makers regarding how to reduce environmental degradation.

2. LITERATURE REVIEW

There are lots of researches in the academic literature regarding the nexus among trade liberalization and the environmental degradation. In this context, so many findings attained from these works enhance the significance of investigating this subject. Besides, the relationship between energy consumption, economic growth, and environment pollution are taken into consideration as well in order to perform the EKC hypothesis. Some of these studies investigate the environmental degradation, economic growth, and energy consumption, through testing the Environmental Kuznets Curve (EKC) hypothesis in the academic literature (Acaravci and Ozturk, 2010; Bese and Kalayci, 2021; Bahadir, 2022a; Bahadir, 2022b; Dursun, 2022a; Dursun, 2022b; Kalayci, 2021; Kalayci and Yazici, 2016; Ozkan et al., 2019; Ozturk and Acaravci, 2010; Ozturk and Acaravci, 2013; Ozturk, et al., 2016; Ozturk, et al., 2021; Sarigul and Apak, 2022; Tarazkar, et al., 2021). If it is taken into account the both trade liberalization, sea transportation as independent variables and carbon-dioxide emissions as dependent variable in terms of testing the EKC hypothesis for Mexico, there is no study by employing three variables together in the academic literature. In addition, if those variables taken into account separately as dependent and independent variables, there are some works (Grofelnik, 2015; Kalayci and Ozden, 2021; Onifade et al., 2021; Yazici, 2022; Zafar, et al., 2013) in the academic literature.

Considering the relationship between trade liberalization and environmental degradation in terms of the EKC hypothesis; the content of all outputs produced in an economy may change through the liberalization of trade. Producing some outputs may create more pollution than other outputs, as well as lead to more natural resource exploitation. Therefore, countries with inadequate environmental protection standards may specialize in the production of more polluting goods with trade liberalization (Vasavada and Nimon, 2003).

Trade liberalization also has an impact on technology transfer. If trade liberalization allows the rapid diffusion of pollution-reducing technologies, then it can reduce the amount of pollution per output, resulting in a positive technical effect. In the opposite case, that is, the spread of technologies which increase pollution with trade liberalization, then a negative technical effect is caused as well (Andrew, 2000).

The relationship between trade and the environment in Costa Rica is examined by Dessus and Bussolo (1998) through a general balance analysis, taking into account the harmony between trade liberalization and emission reduction policies. In the research, it has been determined that environmental taxes in Costa Rica reduce development and cause a rapid decrease in emission amounts. However, outward-oriented policies increase the risk of specialization in polluting activities while encouraging economic development. In addition, free trade, appropriately combined with wastewater taxes, is reinforcing the factor allocation for competitive industries, boosting growth and significantly reducing emissions.

Townsend and Ratnayake (2000) tried to determine the effect of trade liberalization on welfare and emissions levels in the New Zealand economy by using general equilibrium analysis in New Zealand. As a result of the research, it was determined that the increase in welfare of trade liberalization depends on the existence of environmental policies combined with environmental externalities.

Anderson (2001) predict the effects of changes in Indonesia's economic activity in 2010 and 2020, including trade liberalization, on air and water pollution using general equilibrium analysis. In the article, the situation in question is discussed within the framework of two main scenarios in which trade reforms are implemented and not implemented in the world. Researchers predict that natural resource consumption, air and water pollution will decrease in Indonesia in the next two decades via trade reforms to be implemented as a result. However, it is thought that even in the worst case, the pollution that will occur in low amounts.

The economic benefits of multilateral foreign trade liberalization in Norway in recent years have been examined by Faehn and Holmoy (2003) in terms of air pollution and solid waste accumulation. Two scenarios developed with the general equilibrium model and trade reforms and without trade reforms are discussed. As a result, trade reforms applied to existing trade policies will lead to structural changes in the long run in favor of high polluting export industries. This situation, on the other hand, will cause the energy needs of exporting industries with high pollution and electricity consumption to be met from power plants with more polluting effects, instead of hydropower plants, which are clean energy sources.

Atici and Kurt (2007) examine the interaction of environmental pollution and trade liberalization in Turkey by using regression analysis for the 1968-2000 periods. Accordingly, while CO_2 emissions and per capita income act in harmony with the Environmental Kuznets Curve, it has been revealed that an increase in production and exports will increase CO_2 emissions as well.

Dean (1999) analyze variables such as world terms of trade, black market premium and industrial sector water pollution emissions by using the panel data fixed effect model for China between 1987 and 1995. While trade liberalization directly causes environmental pollution through its effect on the terms of trade, it also indirectly causes a decrease in environmental pollution through its effect on income growth.

In order to determine how useful the EKC is in the relationship between Development, Trade and Environment, the research conducted by Cole (2013) tried to find answers to the following questions: 1- How strong is the usefulness of the Environmental Kuznets Curve? 2-How much can the Environmental Kuznets Curve be explained by changing trade patterns against development-induced pollution reduction? In relation to the first question, the weakness of the EKC was tested and it was tried to determine the new EKC with the help of econometric models. Regarding the second question, the effect of trade liberalization varying from country to country, depending on whether countries have a comparative advantage in intensive polluting production or not, has been tried to be discussed. Then, depending on the environmental regulations and factor capitals of the countries, the effect of trade liberalization on environmental pollution was investigated. For this reason, the characteristics of the countries play an important role in the determination of the new EKC. As a result, there is a strong inverted U-shaped relationship between emissions and per capita income, and trade models are highly effective in revealing an inverted U-shaped relationship.

Considering the relationship between seaway and carbon emissions in the academic literature; Kalayci and Ozden (2021) reveal the effect of maritime transport, industrial development and trade liberalization on CO_2 emissions for China from 1960 to 2019 which is consistent with this paper's findings. In addition, results from FMOLS, DOLS and CCR models demonstrate that maritime transport, trade liberalization and industrial development are the long run determinants of carbon emissions, just as in the results of the ARDL model. It is also noteworthy that the findings obtained from FMOLS, DOLS and CCR models, which are described as new co-integration techniques and allowed the separation of short and long-term relationships, consistent with the long-term results obtained from the ARDL model. On the other hand, Yazici (2022) determine the long-run relationship between maritime freight, economic growth, energy consumption, and CO_2 emissions from 1960 to 2015 for Denmark and Sweden, which is verified by the EKC hypothesis. The findings cohered with this manuscript's results in terms of sea transport induced EKC hypothesis.

3. DATA, METHODOLOGY AND RESULTS

The main goal of this section is to examine the long-term relationship between sea transport, trade liberalization, economic growth, energy consumption and CO_2 emissions by using multiple regression and Fully Modified Least Squares method (FMOLS) for Mexico as well as to find out which independent variable affects and does not affect the dependent variable from 1980 to 2021. The dataset from 1980 to 2021 includes the World Bank (2023a), (2023b), UNCTAD (2023), and Our World in Data (2023a), (2023b) for economic growth, trade liberalization, sea freight, CO_2 emissions and energy consumptions which is retrieved from the official websites as respectively.

In Table 1, logarithms of the data of all variables are taken, respectively. The main reason for taking logarithms of the data is to provide easier linear distribution and to prevent variance explosion. In the next process, the @trend command is added to the model to detect whether there is a spurious regression between the variables, and the AR (1) command to find out whether the error terms and residual plot were randomly distributed.

GDP is used as an indicator of economic development in the analyses. CO_2 is determined as dependent variable and rest of them are selected as independent variables. According to result of multiple regression analysis, trade liberalization, sea transportation, economic growth, and energy consumption have substantial impact on CO_2 emissions in above Table 1.

Since AR(1) value is determined as values below 0.05, there is no autocorrelation problem in the model in Table 1. In addition, since the result of @trend was >0.05, it is determined that there is no spurious regression among the variables in the multiple regression model. On the other hand, according to Figure 1 (Mexico's autocorrelation plot), the random distribution of residues in the circle is another proof that there is no autocorrelation problem. Another indicator of whether there is an autocorrelation problem is the Durbin-Watson statistics. The score should be around 1.30 > 2.70. According to Table 1, the Durbin-Watson result is 1.893285, indicating that there is no autocorrelation problem due to its optimal position.

In Figure 2, the inverse root of the AR/MA polynomial test is confirmed, all the properties of the root mean remained within the graph, confirming the multiple regression, taking into account the effect of independent variables on the dependent variable in between 1980 and 2021. Thus, all indicators fully confirm the results of the analysis in Table 1.

Augmented Dickey Fuller (ADF) test is developed by Dickey and Fuller (1979) and is an improved version of the DF unit root test, which is used to measure whether time series contain a unit root. In this method, according to the H0 hypothesis, while the series contain a unit root (not stationary); according to the alternative hypothesis, the series do not contain a unit root (it is stationary).

Table 1: Multiple regression analysis of Mexico

Multiple regression analysis				
Coefficient covariance computed using outer product of gradients				
Method: ARMA maximum likelihood (OPG-BHHH)				
Convergence achieved after16 iterations/sample: 1980 2021				
Mean dep var	19.76935	Akaike inf crit	−4.120492	Dep Var: CO_2
SD. dep var	0.204243	Adj R-squ	0.981829	Inc obsr: 42
Log likelihood	96.53033	S.E. of reg	0.027532	
Schwarz	−3.706761	Sum squ res	0.024256	
Hannan-Quinn	−3.968843	Prob (F-stat)	0.000000	
Durbin-Watson	1.893285	F-stat	247.1543	
R-squ	0.985818			
Variable	**Prob.**	**t-Stat**	**Std. Error**	**Coef**
Econ_grwth	0.0243	−2.365026	0.036796	−0.087023
Energy_cons	0.0000	9.766945	0.110619	1.080414
Sea_fre	0.0001	−4.404985	0.036651	−0.161446
Trade_lib	0.0033	−3.174406	0.054599	−0.173319
C	0.0000	15.53789	1.027506	15.96528
@trend	0.2526	1.164983	0.002871	0.003345
AR (1)	0.0006	3.790351	0.159272	0.603698
Sigmasq	0.0202	2.445420	0.000236	0.000578

Figure 1: Multiple regression analysis' residual graph

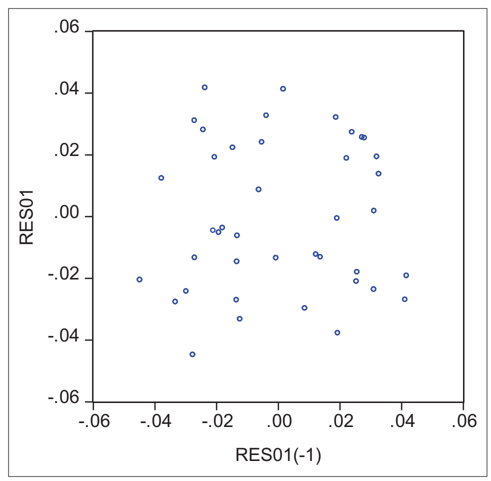
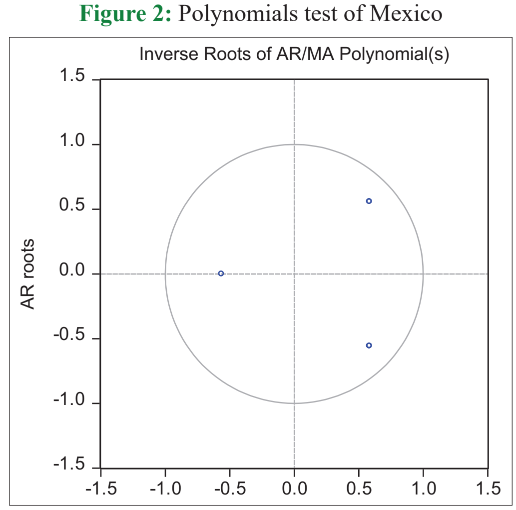


Figure 2: Polynomials test of Mexico



In this method, equation (1) shows models with constant and equation (2) with constant-trend.

$$\Delta Y_t = \beta_0 + \theta Y_{t-1} + \sum_{j=1}^{k} \lambda_i \Delta Y_{t-i} + \mu_t \quad (1)$$

$$\Delta Y_t = \beta_0 + \beta_1 t + \theta Y_{t-1} + \sum_{j=1}^{k} \lambda_i \Delta Y_{t-i} + \mu_t \quad (2)$$

In equation (1) and (2) above; ΔY_t is the first difference of the analyzed variable; β_0 constant term; t is the trend; Y_{t-1} is the lagged difference term; k is the optimal lag length; μ_t denotes the error term. In this method, it is tested whether the coefficient θ is equal to zero. By comparing the test statistic found with the MacKinnon table critical value, it is determined whether the series is stationary or not. The PP test is developed by Phillips and Perron (1988). It differs from the ADF test in terms of the error terms are not statistically independent, there is weak dependence between them, and those have heterogeneous distribution instead of homogeneous distribution. The equations involved in the PP method are shown below:

$$Y_t = \alpha_0 + \beta_1 Y_{t-1} + \varepsilon_t \quad (3)$$

$$Y_t = \alpha_0 + \beta_1 Y_{t-1} + \beta_2 (t - T/2) + \varepsilon_t \quad (4)$$

Equations (3) and (4) below show constant and constant-trend models, respectively. In this model; Y_t is the tested variable, α_0 constant term, t is the trend which indicated the number of observations and the error term. Besides, it is the coefficient of value to be tested in this method. By comparing the value found in the ADF method with the MacKinnon critical table value, it is determined whether the series is stationary or not.

According to the Augmented Dickey Fuller (ADF) and PP test findings in Tables 2' and 3., the series at the I(0) level are not stationary at the intersection point. The non-stationary series at the I(0) level are retested at the I(1) level in Tables 4' and 5, after the first order differences are taken, and it is observed that they are stationary according to the PP and ADF tests. After it is comprehended that all series are stationary, FMOLS analysis and Bayer-Hanck co-integration test are applied in Table 6 and 7.

According to the results of Table 2 above, all variables are not stationary at the I(0) level. Absolute values of all findings are considered after taking the first-order differences of the series for all variables such as maritime transport, trade liberalization, economic growth, energy consumption and carbon emissions, that is, after converting from I(0) to (I). The t-statistical values of the numbers whose absolute values are taken in the PP and ADF tests were found to be stationary at the I(1) in Table 4. And Table 5 level, higher than the numbers corresponding to 5%.

Considering Table 6 above, there is a long-run relationship between maritime transport, trade liberalization, economic growth, energy consumption, and carbon emissions, according to the results of a fully modified least squares model for Mexico from 1980 to 2021. The P-values of all variables are located below 0.05. These findings both demonstrated the long-run relationship between the variables and are consistent with the multiple regression test.

The FMOLS model is indicated via econometric symbols, where the series of long-run CO_2 emissions is investigated in equation (5). The FMOLS analysis is employed through stationary series whether there is a long-term nexus among, CO_2 emissions, economic growth, energy consumption, sea transport and trade liberalization at Table 6 above. The long-term relationship between those variables for Mexico from 1980 to 2021 is considered via FMOLS analysis and multiple regression test which are coincide with each other's. Beginning from equation (5), δ, Δ, and ε_{it} demonstrate constant term, difference operator and error term, respectively. In this analysis, the long-term

Table 2: Phillips perron (PP) unit root test results for Mexico from 1980 to 2021 at I (0)

Phillips perron (PP) unit root test		
Variable	**Prob.***	**Adj. t-stat**
CO_2	0.4499	−1.647317
Test critical values:	1% level	−3.600987
	5% level	−2.935001
Econ_grwth	0.9366	−0.150982
Test critical values:	1% level	−3.600987
	5% level	−2.935001
Energy_cons	0.3661	−1.819562
Test critical values:	1% level	−3.600987
	5% level	−2.935001
Sea_fre	0.3707	−1.809737
Test critical values:	1% level	−3.600987
	5% level	−2.935001
Trade_lib	0.9898	0.664079
Test critical values:	1% level	−3.600987
	5% level	−2.935001

The critical test values indicate the numbers corresponding to the percent confidence interval. When the absolute values of numbers are compared, if the top digit is biggest, the series are stationary

Table 3: Augmented dickey fuller (ADF) unit root test results for Mexico from 1980 to 2021 at I (0)

Augmented dickey fuller (ADF) unit root test		
Variable	**Prob.***	**t-Stat**
CO_2	0.4528	−1.641465
Test critical values:	1% level	−3.600987
	5% level	−2.935001
Econ_grwth	0.8874	−0.466644
Test critical values:	1% level	−3.600987
	5% level	−2.935001
Energy_cons	0.3558	−1.841494
Test critical values:	1% level	−3.600987
	5% level	−2.935001
Sea_fre	0.5767	−1.392357
Test critical values:	1% level	−3.600987
	5% level	−2.935001
Trade_lib	0.9276	−0.220376
Test critical values:	1% level	−3.600987
	5% level	−2.935001

The critical test values indicate the numbers corresponding to the percent confidence interval. When the absolute values of numbers are compared, if the top digit is biggest, the series are stationary relationship between factors is estimated and the equation is developed below.

Table 4: Phillips perron (PP) unit root test results for Mexico from 1980 to 2021 at I (1)

Phillips perron (pp) unit root test		
Variable	**Prob.***	**Adj. t-Stat**
CO_2	0.0000	−6.515083
Test critical values:	1% level	−3.605593
	5% level	−2.936942
Econ_grwth	0.0000	−6.819640
Test critical values:	1% level	−3.605593
	5% level	−2.936942
Energy_cons	0.0000	−5.635360
Test critical values:	1% level	−3.605593
	5% level	−2.936942
Sea_fre	0.0001	−5.130356
Test critical values:	1% level	−3.605593
	5% level	−2.936942
Trade_lib	0.0000	−7.285111
Test critical values:	1% level	−3.605593
	5% level	−2.936942

The critical test values indicate the numbers corresponding to the percent confidence interval. When the absolute values of numbers are compared, if the top digit is biggest, the series are stationary

Table 5: Augmented dickey fuller (ADF) unit root test results for Mexico from 1980 to 2021 at I (1)

Augmented dickey fuller (ADF) unit root test		
Variable	**Prob.***	**t-stat**
CO_2	0.0000	−6.507038
Test critical values:	1% level	−3.605593
	5% level	−2.936942
Econ_grwth	0.0000	−5.982839
Test critical values:	1% level	−3.610453
	5% level	−2.938987
Energy_cons	0.0000	−5.637559
Test critical values:	1% level	−3.605593
	5% level	−2.936942
Sea_fre	0.0001	−5.136800
Test critical values:	1% level	−3.605593
	5% level	−2.936942
Trade_lib	0.0000	−5.486867
Test critical values:	1% level	−3.610453
	5% level	−2.938987

The critical test values indicate the numbers corresponding to the percent confidence interval. When the absolute values of numbers are compared, if the top digit is biggest, the series are stationary

$$\Delta lnCO2_t = a_0 + \sum_{i=1}^{m_1} \sigma_{it}\, \Delta lnCO2_{t-i} + \sum_{i=0}^{m_2} \beta_{it}\, \Delta ln\text{econ\_grwth}_{i,t-i} + \sum_{i=0}^{m_3} \theta_{it}\, \Delta ln\text{energy\_cons}_{i,t-i}$$

$$+\sum_{i=0}^{m_4} \theta_{it}\, \Delta ln\text{sea\_fre}_{i,t-i} + \sum_{i=0}^{m_5} \theta_{it}\, \Delta ln\text{trade\_lib}_{i,t-i} + \delta_{1i}\, lnCO2_{t-1}$$

$$+\delta_{2i}\, ln\text{econ\_grwth}_{t-1} + \delta_{3i}\, ln\text{energy\_cons}_{t-1}$$

$$+\delta_{4i}\, ln\text{sea\_fre}_{t-1} + \delta_{5i}\, ln\text{trade\_lib}_{t-1} + \varepsilon_{it} \quad (5)$$

The effects of independent variables including sea transport, trade liberalization, economic growth and energy consumption on CO_2 emission is indicated empirically from 1980 to 2021 which is affirmed the EKC hypothesis for Mexico through multiple regression and FMOLS analyses in Tables 1 and 6 respectively. The P-value of all independent variables is <0.05.

Finally, Bayer and Hanck (2013), based on the contradictory results of various co-integration tests in the literature, Engle and Granger (1987), Johansen (1988), Boswijk (1994) and Banerjee et al. (1998) developed a new test that evaluates co-integration tests together. Bayer and Hanck (2013) combined the probability values calculated in their test through Fisher's formula in Equations 6 and 7.

$$EG - JOH = -2[\ln(P_{EG}) + \ln(P_{JOH})] \quad (6)$$

$$EG - JOH - BO - BDM = -2[\ln(P_{EG}) + \ln(P_{JOH}) + \ln(P_{BO}) + \ln(P_{BDM})] \quad (7)$$

P_{EG}, P_{JOH}, P_{BO}, P_{BDM} in equations 6 and 7 are respectively Engle and Granger (1987), Johansen (1988), Boswijk (1994) and Banerjee et al. (1998) refer the probability values of co-integration tests. If the calculated test statistic is greater than the critical values calculated by Bayer and Hanck (2013), the basic hypothesis stating that there is no co-integration relationship which is rejected.

Bayer and Hanck (2013) co-integration test results are given in Table 7. Since the test statistics calculated for the co-integration

Table 6: Fully modified least squares (FMOLS) test results of Mexico from 1980 to 2021

Method: Fully modified least squares (FMOLS)				
Dependent variable: $CO_2$1				
S.D. dep var	18636749	Long-run var	Sum squ resid	4.98E + 15
Mean dep var	3087441.	7.54E + 13	Adj R-squ	0.590429
S.E. of reg	11927094		R-squared	0.632436
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Econ_grwth1	−4.77E-06	2.06E-05	−0.231532	0.0183
Energy_cons1	212505.8	25501.60	8.333039	0.0000
Sea_fre1	−18514.79	9454.448	−1.958315	0.0482
Trade_lib1	−716303.7	394164.2	−1.817272	0.0077
C	−165006.4	1609046.	−0.102549	0.9189
Sample (adjusted): 1982 2021, Inc obsr: 40 after adj				

Long-run covariance est (Bartlett kernel, Newey-West fixed bandwidth

Table 7: Bayer-hanck cointegration test results

Fisher statistics		
	EG-JOH	EG-JOH-BO-BDM
	18.86	66.18
Significance level 10%	Critical values	
	8.35	16.23

relationship are greater than the critical values at the 10% level, the basic hypothesis is rejected and it is concluded that the variables are cointegrated including sea transport and trade liberalization, CO_2 emissions, economic growth, energy consumption for Mexico.

4. CONCLUSION

This manuscript examine the long-run relationship between sea transportation, trade liberalization, economic growth, energy consumption and carbon dioxide emissions by taking into account the EKC hypothesis for Mexico from 1980 to 2021. In this context, multiple regression, FMOLS analysis and Bayer-Hanck co-integration test are employed in order to examine both the effect of independent variables on dependent variables and the long-term linkage among variables. According to results of multiple regression model, FMOLS analysis and Bayer-Hanck co-integration test at Tables 1, 6, and 7 trade liberalization, sea transportation, economic growth, energy consumption have substantial impact on CO_2 emissions and there is a long-run relationship among variables from 1980 to 2021 for Mexico which verifies the EKC hypothesis. All empirical findings indicate that the Mexican government should take radical steps to prevent environmental degradation.

The demand for goods is growing, so the global trade volume is also expanding day by day due to the ever-increasing population in the world. Ship supplies are constantly growing in maritime transport, which is considered the most preferred mode of transport due to its economy of scale. In line with these developments, an increase is observed in air pollutant gases and particles released into the atmosphere as a result of fossil fuel consumption, depending on the increase in ship tonnage and speed. Most of the ports used by ships for loading, unloading, holding and supply activities are located in industrial and commercial centers where the population is concentrated. Considering that the effects of ship-borne pollution are mostly felt in ports and anchorage areas, it is important to examine this occurring. In addition, the increase in products and its import that cause carbon emissions with the liberalization of trade brings along other problems. The transport of ship-borne emissions due to fossil fuel consumption by wind and other weather events adversely affects the health of those living in coastal cities, especially in port cities. The most important health problems caused by these emissions are shortness of breath, respiratory failure, asthma, lung cancer, upper respiratory tract and cardiovascular diseases and premature births. The treatment of these diseases causes both economic losses and the deaths related to them cause both economic and labor loss.

Even though maritime transportation harms the environment at a lower rate than other transportation methods, these rates reach irreversible proportions, especially due to the frequency of use. Maritime transport also threatens the land due to water, air and ports when inland waterway transport is taken into account. It causes many environmental effects such as degradation of biological diversity, water pollution, air pollution, deterioration of human health, global warming, greenhouse effect. The main source of these effects is the preference of fossil fuels because they are cheap and accessible. There are various maritime transport green solutions to reduce emissions and pollution in maritime transport. Green energy suggest solutions such as reducing the cruise speed of the ship, reducing the use of fossil fuels, choosing new generation fuel types with cleaner content, increasing energy efficiency, and making a weather-dependent cruise plan. There are various computational methods to ensure the applicability and control of solutions with mathematical methods. If these methods are implemented effectively, it will give healthier results in terms of green logistics. On the other hand, Trade liberalization comes with the risk of increased imports of products that can cause ecological footprint and carbon-dioxide emissions. Therefore, restrictions should be imposed by the government depending on the emission values that may be caused by imported products.

The presence of trade liberalization and the positive movement of the ecological footprint reveal the increasing effect of growth on carbon dioxide emissions, especially in a developing country such as Mexico, which aims for more economic growth. In addition, it should not be overlooked that the intense population growth may affect the CO_2 emission factor. All these indicate the necessity of switching to practices aimed at reducing carbon dioxide emissions. In this context, incentives for renewable energy sources, rate differentiation in motor vehicle tax, and regulations in the tax system for negative externalities are some of the applications that can be done. In addition, public expenditures for green infrastructure such as low-carbon energy production and energy efficiency in public buildings can be increased, investments can be made in R&D studies to support innovation, the process can be facilitated by choosing applications that facilitate transition, and activities can be preferred to increase environmental awareness. In this sense, governments have more responsibilities than individuals. Therefore, many applications, especially the tax system, should be rearranged by the government. Although the additional costs of the practices for environmental awareness for households, companies and governments are seen as a burden in an intensely competitive environment and are not implemented adequately, countries have important duties in terms of human health and leaving a livable world to future generations.

REFERENCES

Acaravci, A., Ozturk, I. (2010), On the relationship between energy consumption, CO_2 emissions and economic growth in Europe. Energy, 35(12), 5412-5420.

Anderson, D. (2001), Technical progress and pollution abatement: An economic view of selected technologies and practices. Environment and Development Economics, 6(3), 283-311.

Andrew, D. (2000), Services trade liberalization: Assessing the environmental effects. In: First North American Symposium on Assessing the Linkages between Trade and Environment. North America: Commission for Environmental Cooperation of North America. pp. 11-12

Atici, C., Kurt, F. (2007), Türkiye'nin Dış Ticareti ve Çevre Kirliliği: Çevresel Kuznets Eğrisi Yaklaşımı. Tarım Ekonomisi Dergisi, 13(2), 61-69.

Bahadir, S. (2022a), The Interactions among air freight, GDP, energy usage and ecological footprint: An empirical investigation from Turkey. International Journal of Energy Economics and Policy, 12(6), 332-339.

Bahadir, S. (2022b), Analyzing the environmental Kuznets curve hypothesis in terms of airplane transport: Empirical examination for Baltic states. International Journal of Energy Economics and Policy, 12(5), 252-259.

Banerjee, A., Dolado, J., Mestre, R. (1998), Error-correction mechanism tests for cointegration in a single-equation framework. Journal of Time Series Analysis, 19(3), 267-283.

Bayer, C., Hanck, C. (2013), Combining non-cointegration tests. Journal of Time Series Analysis, 34(1), 83-95.

Bayraktutan, Y., Ozbilgin, M. (2015), Uluslararası ve yurtiçi ticarette taşıma türlerinin payı: Bir analitik hiyerarşi prosesi (AHP) uygulaması. Çankırı Karatekin Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 6(2), 405-436.

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.

Boswijk, H.P. (1994), Testing for an unstable root in conditional and structural error correction models. Journal of Econometrics, 63(1), 37-60.

Cevik, O., Gulcan, B. (2011), Lojistik faaliyetlerin çevresel sürdürülebilirliği ve Marco Polo programı. Karamanoğlu Mehmetbey Üniversitesi Sosyal ve Ekonomik Araştırmalar Dergisi, 2011(1), 35-44.

Cole, M.A. (2013), Development, trade, and the environment: How robust is the Environmental Kuznets Curve? Environment and Development Economics, 8(4), 557-580.

Dean, J.M. (1999), Testing the impact of trade liberalization on the environment: Theory and evidence. In: Trade, Global Policy, and the Environment. Washington, D.C., United States: World Bank. pp. 55-63.

Dessus, S., Bussolo, M. (1998), Is there a trade-off between trade liberalization and pollution abatement: A computable general equilibrium assessment applied to Costa Rica. Journal of Policy Modeling, 20(1), 11-31.

Dickey, D.A., Fuller, W.A. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366), 427-431.

Dursun, E. (2022a), Investigating the air transport-induced EKC hypothesis: Evidence from NAFTA countries. International Journal of Energy Economics and Policy, 2(4), 494-500.

Dursun, E. (2022b), The Nexus among civil aviation, energy performance efficiency and GDP in terms of ecological footprint: Evidence from France and Finland. International Journal of Energy Economics and Policy, 12(5), 243-251.

Engle, R.F., Granger, C.W. (1987), Co-integration and error correction: Representation, estimation, and testing. Econometrica: Journal of the Econometric Society, 55, 251-276.

Faehn, T., Holmoy, E. (2003), Trade liberalisation and effects on pollutive emissions to air and deposits of solid waste. A general equilibrium assessment for Norway. Economic Modelling, 20(4), 703-727.

Friedrich, A., Heinen, F., Kodjak, D. (2007), Air pollution and greenhouse gas emissions from ocean-going ships: Impacts, mitigation options and opportunities for managing growth. Maritime Studies, 2007(153), 3-10.

Grofelnik, H. (2015), A regular annual sea transport carbon footprint for the islands of Cres and Lošinj. Hrvatski Geografski Glasnik, 77(2), 73-83.

Johansen, S. (1988), Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 12(2-3), 231-254.

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. pp. 1277-1293.

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.

Kalayci, S., Yazici, S. (2016), The impact of export volume and GDP on USA's civil aviation in between 1980-2012. International Journal of Economics and Finance, 8(1), 229-235.

Millet, Y., Fidan, Y., Akoğlu, N. (2021), Ticari gemilerden kaynaklanan karbon emisyonlari üzerine bir araştirma. Ekonomi İşletme ve Yönetim Dergisi, 5(2), 223-242.

Onifade, S.T., Erdogan, S., Alagoz, M., Bekun, F.V. (2021), Renewables as a pathway to environmental sustainability targets in the era of trade liberalization: Empirical evidence from Turkey and the Caspian countries. Environmental Science and Pollution Research, 28, 41663-41674.

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

Our World in Data. (2023b), Energy Consumption. Available from: https://www.ourworldindata.org/energy-production-consumption

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

Ozturk, I., Acaravci, A. (2010), CO_2 emissions, energy consumption and economic growth in Turkey. Renewable and Sustainable Energy Reviews, 14(9), 3220-3225.

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.

Ozturk, I., Majeed, M.T., Khan, S. (2021), Decoupling and decomposition analysis of environmental impact from economic growth: A comparative analysis of Pakistan, India, and China. Environmental and Ecological Statistics, 28(4), 793-820.

Phillips, P.C., Perron, P. (1988), Testing for a unit root in time series regression. Biometrika, 75(2), 335-346.

Sarigul, H., Apak, S. (2022). Economic growth, energy consumption, and trade openness nexus: Evidence from net energy importing middle-income countries. Panoeconomicus, 1-30.

Tarazkar, M.H., Dehbidi, N.K., 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(5), 6734-6748.

The World Bank. (2023a), Economic Growth and GDP (current US$). United States: World Bank. Available from: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD

The World Bank. (2023b), Trade Liberalization. Trade is the Sum of Exports and Imports of Goods and Services Measured as a Share of

Gross Domestic Product. United States: World Bank. Available from: https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS

Townsend, B., Ratnayake, R. (2000), Trade Liberalisation and the Environment: A Computable General Equilibrium Analysis. University of Auckland, London: World Scientific Publishing.

Tutar, E., Tutar, F., Yetişen, H. (2009), Türkiye'de lojistik sektörünün gelişmişlik düzeyinin seçilmiş AB Ülkeleri (Romanya ve Macaristan) ile karşılaştırmalı bir analizi. Karamanoğlu Mehmetbey Üniversitesi Sosyal ve Ekonomik Araştırmalar Dergisi, 2009(2), 190-216.

UNCTAD. (2023), World Merchant Fleet/UNCTADstat (Merchant Fleet by Flag of Registration and by Type of Ship, Annual). Available from: https://unctadstat.unctad.org/EN/BulkDownload.html

Vasavada, U., Nimon, W. (2003), Environmental Effects of Further Trade Liberalization in Agriculture. Washington, DC: Economic Research Service, USDA. Available from: https://www.ers.usda.gov/briefing/wto/PDF/environmentandtradeliberalization.pdf

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

Zafar, F., Anwar, S., Hussain, Z., Ahmad, N. (2013), Impact of trade liberalization and corruption on environmental degradation in Pakistan. Journal of Finance and Economics, 1(4), 84-89.