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Article

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International Journal of Energy Economics and Policy

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

Reference: Kayabas, Yunus Emre (2022). Testing the EKC hypothesis in terms of trade openness, industrial and construction development : evidences from Northern European and Latin American Countries. In: International Journal of Energy Economics and Policy 12 (5), S. 319 - 331.
https://econjournals.com/index.php/ijeep/article/download/13442/6933/31192.
doi:10.32479/ijeep.13442.

This Version is available at:
http://hdl.handle.net/11159/12631

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2022, 12(5), 319-331.

Testing the EKC Hypothesis in terms of Trade Openness, Industrial and Construction Development: Evidences from Northern European and Latin American Countries

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Received: 22 June 2022 **Accepted:** September 03, 2022 **DOI:** https://doi.org/10.32479/ijeep.13442

ABSTRACT

The objective is to examine the long-run relationship between trade openness, industrial and construction development, economic growth, energy consumption, and ecological footprint by performing the Westerlund co-integration, FMOLS, DOLS, and CCR tests for Northern European (Denmark, Finland, Netherlands, Norway, and Sweden) and Latin American Countries (Argentina, Brazil, Chile, Colombia, and Uruguay) from 1980 to 2018. Considering the FMOLS, DOLS, and CCR test results of Northern European countries the EKC hypothesis is not confirmed for Finland, Norway and Sweden except Denmark and Netherlands. There is a long-run relationship among industrial and construction development, economic growth, and ecological footprint for both Denmark and Netherlands which verifies the EKC hypothesis from 1980 to 2018. When the remaining countries are examined, the results are opposite. There is no long-run relationship among relevant variables for Finland, Denmark, and Sweden from 1980 to 2018. Besides, there is no effect of industrial and construction development, economic growth, energy consumption, and trade openness on ecological footprint for Finland, Denmark, and Sweden from 1980 to 2018. The EKC hypothesis is not confirmed for Latin American countries as well. Similar results are obtained by using the same variables and other models including FMOLS, DOLS, and CCR for all Latin American countries. The pollution problem in question is of particular concern to developed countries. Because, these countries are forced to use heavy industry, which is far from the nano-technological industry structure and has high environmental degradation. In this context, Denmark should build an artificial island as a precaution against the climate crisis. Another main recommendation is Dutch government should build hydrogen heated homes in order to wage a fight against air pollution.

Keywords: Trade Openness, Industrial and Construction Development, Economic Growth, Energy Consumption, Ecological Footprint, Environmental Economics

JEL Classifications: O24, L74, O4, P18, Q57, Q5

1. INTRODUCTION

Discussions on whether natural resources are sufficient for sustainable economic growth began in the early 1970s (Meadows et al., 1972). With globalization, the problem of "environment-sustainable growth" has gained an international dimension. Pessimistic economists argue that international competition fueled by global growth in access to limited natural resources increases environmental damage and weakens economic growth dynamics. On the other hand, some optimistic economists state that growth has a positive effect on reducing environmental damage and it is not impossible to achieve sustainable growth (Beckerman, 1992; World Bank, 1992; Grossman and Krueger, 1995). The Environmental Kuznets Curve plays an important role in analyzing the growth-environment relationship. The fact that Simon Kuznets revealed in a study in 1955 that there is an inverted-U-shaped relationship between income inequality and per capita income (Kuznets, 1955) pave the way for the emergence of the Environmental Kuznets Curve. In the early 1990 s, many researchers determine that there is a similar relationship between the level of environmental degradation and per capita income, and they considered it appropriate to call this relationship the Environmental Kuznets Curve analysis (Grossman and Krueger, 1995; Shafik, 1994; Panayotou, 1997). The Environmental Kuznets Curve was introduced for the first time with the joint work of Grossman and Krueger in 1991 and later gained a well-deserved reputation on the world scale with the World Bank's 1992 Report. The importance of the relationship between economic growth and air pollution emissions has increased even more since the implementation of the Kyoto Protocol in 2005.

Kuznets (1955) investigates the relationship between income per capita and income inequality in his study. In his study, while income inequality has a tendency to increase at low levels of income, this inequality tends to decrease at high levels of income, and it refers the inverted-U-shaped relationship between the two parameters. This bell-shaped relationship between per capita income and income inequality is known as the "Kuznets Curve" which is demonstrated at Figure 1. Therefore, the inverted-U-shape relationships obtained from the studies give Kuznets's relationship between economic growth and income inequality adapted to the relationship between economic growth and environmental pollution.

According to the Environmental Kuznets Curve hypothesis, environmental pollution is generally low at the mostly agricultural production levels, where economic activity is low. However, if the development continues, environmental pollution will increase with factors such as increased resource use per capita, amount of waste and deforestation rate. In advanced stages of development, it is revealed that environmental degradation will gradually decrease with the investment in knowledge-intensive resources due to better implementation of environmental regulations, increased environmental awareness and technological developments (Panayotou, 1993). The Environmental Kuznets Curve can be illustrated as in Figure 2 (Yandle et al., 2002).

In the period from the industrial revolution to the present, the emissions released to the atmosphere play an important role in the changes in the natural cycle of the world climate. The rapidly increasing production after the industrial revolution largely uses fossil fuels as an energy input. The increase in the dependence of countries on fossil fuels and their derivatives has led to environmental problems on a global scale. Since the main problem of nations is the problem of economic growth and development, environmental problems were initially ignored. In the last half century, environmental awareness has increased all over the world, with international trade, one of the most important components of economic globalization, growing much faster than world economies, especially in the post-World War II period. As statement of Copeland and Taylor (2004), the discussions on the trade liberalization-environment relationship came to the fore especially in the Uruguay round of the North American Free Trade Agreement and the General Agreement on Tariffs and Trade (GATT). In the mentioned interviews, it has been claimed that since many developing middle-income countries do not take the necessary precautions in industrial production, it triggers global warming by causing dangerous wastes polluting the air, water and soil, and high greenhouse gas emissions.

Figure 1: Kuznets' curve

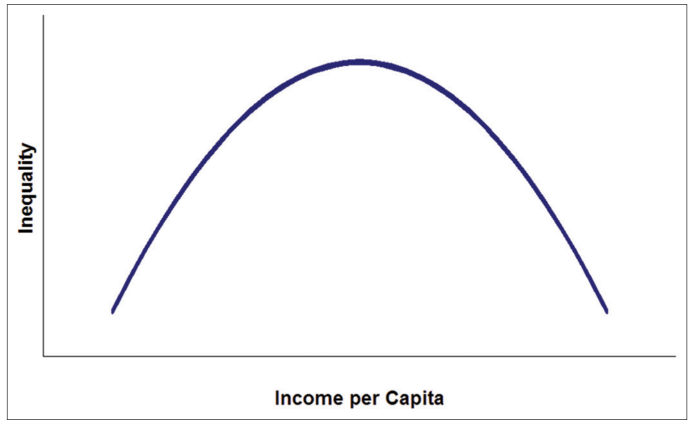
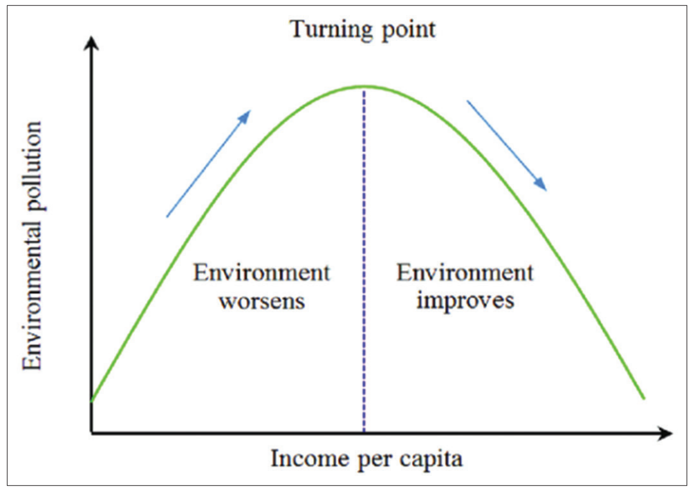


Figure 2: Environmentally adapted kuznets' curve



When the novelties and contributions of this research paper to the existing academic literature is taken into account, what makes this manuscript different is that there is no other study in the academic literature that comparatively tests the construction sector and industrial development induced environmental Kuznets curve for northern European and Latin American countries. In this sense, FMOLS, DOLS, and CCR analysis reveal the long-term linkage among trade openness, industrial and construction development, economic growth, energy consumption, and ecological footprint from 1980 to 2018 which is verified the EKC hypothesis for Denmark and Netherlands. Furthermore, the impact of independent variables including trade openness, industrial and construction development, economic growth, energy consumption on ecological footprint is indicated via Westerlund co-integration test, FMOLS, DOLS, and CCR models which are also confirmed the EKC hypothesis for Netherlands. Thus, all econometric models of this manuscript reveal that industrial and construction development and economic growth from 1980 to 2018 cause environmental degradation for Denmark and Netherlands. The EKC hypothesis is not confirmed for remaining northern countries including Finland, Norway, and Sweden at Table 1. The EKC hypothesis is not confirmed for Latin American countries at Table 2 as well. This research paper is designed as follows; Part 1 presents general overview and the theoretical background of the research through the environmental Kuznets curve hypothesis,

Table 1: FMOLS, DOLS, and CCR test results of Northern European countries from 1980 to 2018

Dependent variable *ecol_foot*	Independent variables	FMOLS			DOLS			CCR			EKC hypothesis Verified/ unverified
		T-stats	*P*	Coefficient	*T*-stats	*P*	Coefficient	*T*-stats	*P*	Coefficient	
Argentina	*trd_opn*	1.582267	**0.1231**	0.009571	-0.125281	**0.9017**	-0.001768	1.537009	**0.1341**	0.008533	
	indus_const_dev	−0.049676	**0.9607**	−2.97E-13	1.015650	**0.3233**	1.36E-11	−0.281962	**0.7798**	−1.58E-12	
	gdp	0.801237	**0.4287**	1.15E-12	−0.730253	**0.4746**	−2.48E-12	0.980324	**0.3343**	1.38E-12	X
	energy_cons	1.793561	**0.0821**	0.011402	0.483461	**0.6346**	0.006533	2.085854	**0.1050**	0.011549	
	C	−0.319063	0.7517	−0.006670	0.297810	0.7693	0.007305	−0.279846	0.7814	−0.003887	
Brazil	*trd_opn*	−1.043375	**0.3046**	−0.003242	0.005208	**0.9959**	5.32E-05	−1.009922	**0.3201**	−0.004764	
	indus_const_dev	−0.456648	**0.6510**	−2.22E-13	0.734881	**0.4719**	1.17E-12	−0.382261	**0.7048**	−2.59E-13	
	gdp	1.673222	**0.1040**	1.99E-13	−0.403462	**0.6914**	−1.64E-13	1.158533	**0.2552**	1.98E-13	X
	energy_cons	1.442126	**0.1590**	0.003316	0.197431	**0.8457**	0.002174	1.042362	**0.3051**	0.004831	
	C	0.463594	0.6461	0.003585	0.924339	0.3675	0.012001	0.491907	0.6261	0.004079	
Chile	*trd_opn*	0.712616	**0.4812**	0.003035	−0.896358	**0.3819**	−0.009624	0.195946	**0.8459**	0.001247	
	indus_const_dev	−0.176591	**0.8609**	−1.04E-12	0.654737	**0.5209**	1.19E-11	0.007482	**0.9941**	6.88E-14	
	gdp	1.821234	**0.1779**	4.42E-12	−0.397651	**0.6956**	−2.70E-12	1.011288	**0.3195**	3.70E-12	X
	energy_cons	2.322302	**0.1267**	0.006819	1.099748	**0.2859**	0.014185	1.575345	**0.1250**	0.009115	
	C	0.702912	0.4872	0.012005	1.746831	0.0977	0.044120	0.815076	0.4211	0.015284	
Colombia	*trd_opn*	0.210892	**0.8343**	0.000537	0.556233	**0.5849**	0.003929	0.242847	**0.8097**	0.000844	
	indus_const_dev	−0.416443	**0.6799**	−1.13E12	0.472020	**0.6426**	2.52E12	−0.331594	**0.7424**	−1.11E12	
	gdp	0.522011	**0.6053**	5.24E13	−0.175773	**0.8624**	−3.70E-13	0.402317	**0.6901**	5.21E-13	X
	energy_cons	1.762777	**0.0875**	0.001457	1.707499	**0.1049**	0.006783	1.166180	**0.2522**	0.002336	
	C	0.622262	0.5382	0.003392	0.142505	0.8883	0.001131	0.582803	0.5641	0.003391	
Uruguay	*trd_opn*	−0.464640	**0.6453**	0.003255	−0.599464	**0.5563**	−0.012637	−0.304516	**0.7627**	0.003382	
	indus_const_dev	2.586505	**0.1144**	1.27E10	1.576779	**0.1323**	2.54E-10	1.967352	**0.0579**	1.27E-10	
	gdp	−1.175155	**0.2486**	−1.48E11	−1.706650	**0.1051**	−6.95E-11	−1.000093	**0.3248**	−1.77E-11	X
	energy_cons	−1.542209	**0.1312**	0.007197	−0.252051	**0.8039**	−0.003276	−1.380674	**0.1769**	0.006496	
	C	−1.302448	0.2021	−0.047430	−0.209978	0.8360	−0.009359	−1.092614	0.2827	−0.043013	

*The lag length is taken as a maximum of 6 according to the Schwarz information criterion. Barlett Kernel method is used for long-term coefficient estimations and bandwidth is determined by Newey-West method. EKC: Environmental Kuznets Curve

part 2 elaborates the results of the academic literature for EKC hypothesis in terms of trade openness and industrial development, part 3 discusses methodological framework and empirical findings of the manuscript, finally part 4 contains interpretation of results and findings of the research paper by giving some suggestions to Northern European and Latin American countries' governments.

2. LITERATURE REVIEW

When the relationship between environmental pollution and trade openness is evaluated, the important starting point of the discussion between them is whether free world trade is compatible with the idea of environmentally sustainable growth and development. From another point of view, it is whether the restrictions concerning the environment are compatible with the idea of trade openness. After the trade liberalization period, with the trade openness, there has been an increase and movement in world foreign trade relations of countries. CO_2 emissions have also increased through the rise of trade volume. There are many studies in the literature dealing with the relationship between trade openness and the environment. The different results obtained from these studies increase the importance of examining this subject. However; in this part of the article, the linkage between economic growth, energy usage, and environment pollution are also taken into consideration. Some of these manuscripts examine the ecological footprint, economic growth, and energy consumption, through testing the Environmental Kuznets Curve (EKC) hypothesis in the academic literature (Beşe, and Kalayci, 2021; Dursun, 2022; Kalayci and Özden, 2021; Kalayci and Yazici, 2016; Ozkan et al., 2019; Ozturk, et al., 2016; Ozturk, et al., 2021; Tarazkar, et al., 2021; Yazici, 2022). Considering the both trade openness, industrial development and construction as independent variables in terms of testing the EKC hypothesis, there is no works by using two variables together. However, if those variables considered separately as independent variables, there are some researches (Adedoyin et al., 2022; Ali, et al., 2021; Li and Haneklaus, 2022; Zhou, et al., 2021) in the academic literature. While generating this part, besides examining the most recent work, researches on different economies are considered as well. In the literature, there are many studies conducted for different country economies regarding the determinants of carbon emissions, which is one of the main issues that have been emphasized globally in recent years. In these studies, it is seen that variables such as economic growth, energy consumption, and trade openness are used as determinants of carbon emissions. In this direction, in recent studies, especially the variable of trade openness has been used in research testing the EKC hypothesis. However, the effect of trade openness on pollution

Table 2: FMOLS, DOLS, and CCR test results of Latin American countries from 1980 to 2018

Dependent variable *ecol_foot*	Independent variables	FMOLS			DOLS			CCR			EKC hypothesis Verified/ unverified
		T-stats	*P*	Coefficient	*T*-stats	*P*	Coefficient	*T*-stats	*P*	Coefficient	
Denmark	*trd_opn*	0.370867	**0.7132**	0.002640	−2.465900	**0.7239**	−0.033928	0.243771	**0.8090**	0.002095	
	indus_const_dev	1.951588	**0.0398**	3.60E-11	2.914105	**0.0093**	1.05E-10	1.927632	**0.0428**	4.59E-11	
	gdp	−2.019925	**0.0418**	−8.98E-12	−2.550902	**0.0201**	−1.98E-11	−2.041626	**0.0495**	−1.14E-11	✓
	energy_cons	1.047185	**0.3029**	0.002391	−0.385992	**0.7040**	−0.004801	1.110371	**0.2751**	0.004991	
	C	0.887615	0.3814	0.023690	1.251512	0.2268	0.038507	0.967477	0.3406	0.027028	
Finland	*trd_opn*	1.269776	**0.2133**	0.008913	−1.092081	**0.2892**	−0.018416	0.836210	**0.4092**	0.007682	
	indus_const_dev	2.927374	**0.0062**	4.20E-11	2.286626	**0.0310**	4.19E-11	2.264620	**0.0304**	4.04E-11	
	gdp	−1.549490	**0.1311**	−7.21E-12	−0.705488	**0.4895**	−6.62E-12	−1.191571	**0.2422**	−6.88E-12	X
	energy_cons	−0.877410	**0.3868**	−0.003698	−0.800701	**0.3785**	−0.079260	−0.762372	**0.4514**	−0.009481	
	C	0.365141	0.7174	0.010388	0.168045	0.8684	0.006914	0.375019	0.7101	0.011107	
Netherlands	*trd_opn*	3.247290	**0.0027**	0.012439	2.615250	**0.0461**	0.006775	1.847245	**0.0440**	0.011071	
	indus_const_dev	2.721238	**0.0104**	2.30E-11	1.879967	**0.0464**	4.52E-11	2.185104	**0.0363**	2.77E-11	
	gdp	−1.745063	**0.0381**	−2.71E-12	−1.705535	**0.0053**	−1.03E-11	−1.306532	**0.0207**	−4.03E-12	✓
	energy_cons	2.119295	**0.0419**	0.013625	2.181205	**0.0234**	−0.017247	1.005536	**0.0222**	0.011255	
	C	−0.190134	0.8504	−0.005684	1.394209	0.1802	0.079977	0.220785	0.8267	0.008244	
Norway	*trd_opn*	0.905815	**0.3718**	0.017994	−0.742480	**0.4674**	−0.034045	0.773242	**0.4451**	0.020302	
	indus_const_dev	−0.506633	**0.6159**	−5.23E-12	0.316072	**0.7556**	8.28E-12	−0.068625	**0.9457**	−1.17E-12	
	gdp	0.869265	**0.3912**	4.49E-12	−0.294694	**0.7716**	−3.62E-12	0.324617	**0.7476**	2.70E-12	X
	energy_cons	−0.615885	**0.5423**	−0.002661	1.786458	**0.0909**	0.056921	−0.964017	**0.3423**	−0.009436	
	C	−0.827248	0.4142	−0.039055	0.032687	0.9743	0.002014	−0.616965	0.5416	−0.031939	
Sweden	*trd_opn*	0.089206	**0.9295**	0.000946	0.421205	**0.6786**	0.012954	0.182395	**0.8564**	0.002690	
	indus_const_dev	2.462660	**0.1194**	3.95E-11	0.160672	**0.8741**	8.49E-12	1.722859	**0.0946**	3.91E-11	
	gdp	−1.894807	**0.0972**	−8.22E-12	−0.138901	**0.8911**	−1.89E-12	−1.239658	**0.2241**	−7.74E-12	X
	energy_cons	1.596718	**0.1202**	0.008316	−0.221129	**0.8275**	−0.008028	1.616143	**0.1159**	0.015181	
	C	0.583476	0.5637	0.023229	0.196773	0.8462	0.015501	0.350053	0.7286	0.016186	

*: The lag length is taken as a maximum of 6 according to the Schwarz information criterion. Barlett Kernel method is used for long-term coefficient estimations and bandwidth is determined by Newey-West method. EKC: Environmental Kuznets Curve

is controversial. Trade openness can have a pollution-increasing effect due to goods produced in energy-intensive sectors. In support of this situation, Kasman and Duman (2015) in new EU member countries, Ozatac et al. (2017) conclude that trade openness in Turkey and Bento and Moutinho (2016) conclude that international trade positively affects carbon dioxide emissions in Italy. However, with the technologies developed in the production sector, trade relations that will pollute the environment less can be established. GDP and energy consumption draw attention among the main variables affecting environmental degregation in terms of the validity of the EKC hypothesis in recent studies. For instance, Pao and Tsai (2010) in BRICS countries, Arouri et al. (2012) and Cheikh et al. (2021) in MENA countries, Yazici (2022) in Scandinavian countries, and Balado-Naves et al. (2018) conclude that energy consumption and GDP increase carbon dioxide emissions in 173 countries. In addition, the validity of the EKC hypothesis has been proven in these studies. Acaravci and Ozturk (2010) determine the positive effects of energy consumption and GDP on carbon dioxide emissions, and obtained results that differed from country to country in terms of the validity of the EKC hypothesis. While energy consumption and real income are among the main factors affecting environmental pollution, there are also variables that affect the income-energy-environment relationship apart from these variables. Therefore, in order to reach a correct result, the neglected variables should be added to the model (Le and Ozturk, 2020).

Variables such as environmental pollution, energy, economic growth, trade openness, urbanization, population, and financial development indicators have recently been included by some of researchers in the models to test the EKC hypothesis. In addition, some studies use data such as deforestation and ecological footprint as environmental pollution data instead of CO_2 emissions. For example; Ahmed et al. (2015) test the validity of the EKC hypothesis in Pakistan for the period covering the years 1980–2013 in terms of deforestation, economic growth, energy consumption, trade openness and population data using ARDL bounds test and it is concluded that the hypothesis is valid. Al-mulali et al. (2015) test the validity of the EKC hypothesis between 1980 and 2008 by using ecological footprint, growth, energy consumption, urbanization and trade openness data for 93 countries. According to the results of the test, the validity of the hypothesis is confirmed in upper middle and high income countries.

Bozkurt and Okumuş (2015) examine the long-term relationship between variables including carbon emissions, economic growth, energy consumption, trade openness and population density for the 1966–2011 period in Turkey. It is observed that economic growth increases environmental degradation. In addition, it is determined that energy consumption, population growth and trade openness also cause environmental degradation by increasing carbon emissions, and thus the Environmental Kuznets Curve is valid in Turkey. Hussain and Ali (2016) examine the relationship between trade, economic growth, energy consumption and the environment in the case of Pakistan.

In the study, the period of 1980–2015 is discussed and the Johansen cointegration test is used. According to the findings of the research, it is concluded that energy consumption and trade openness have a positive effect on carbon emissions. Shahbaz et al. (2017) determine the relationship between trade openness and CO_2 emissions by using panel data analysis method for the period 1980–2014 in 105 countries consisting of high, middle and low income groups. Although the results of the analysis differ in country groups, it shows that trade openness causes deterioration in environmental quality. Çetin and Yüksel (2018) use GMM and DOLS estimation methods for Turkey by performing energy consumption, CO_2 emissions, economic growth, trade openness and financial development variables from 1960 to 2014. They conclude that there is a positive relationship and co-integration between trade openness, energy consumption and CO_2 emissions in the long run. Alper (2018) discusses the CO_2 emissions, trade openness, GDP, population density variables of 25 high-income, 25 middle-income and 11 low-income countries between 1995 and 2016. Although high-income countries are sensitive to environmental enhancement, it has been observed that insensitivity is high in middle and low-income countries. In addition, it is found that the increase in trade openness and per capita income negatively affected CO_2 emissions.

When the subject is considered in terms of the relationship between industrial development and the EKC hypothesis, Ali et al. (2021) perform ARDL model through structural breaks co-integration test to examine the existence of a dynamic relationship between industrial development and CO_2 by capturing the impact of fossil fuel usage and economic growth on Carbon emission. All variables have been discovered to be co-integrated and the short-run and long-run dynamics have demonstrated the existence of inverted U-shaped of the EKC hypothesis where there has been inverted U-shaped association between carbon emission and industrial development which had been established by Lind and Mehlum test as well. The Granger causality demonstrates unidirectional causality running from fossil fuel to carbon emission, and bidirectional causalities relationship among industrial growth and fossil oil and financial development and fossil fuel.

When the subject is examined in terms of the relationship between the construction sector and carbon emissions, Zhang et al. (2019) investigate the linkage among construction industries and CO_2 emissions by taking in to account the EKC hypothesis for 121 countries from 1960 to 2014. The construction industries have significantly contributed to the increase of CO_2 emissions and analysis indicates that the EKC hypothesis is confirmed for 95 out of 121 countries. The result of examining the presence of EKC at the four income levels indicate that higher income nations have a higher rates of countries, confirming the EKC hypothesis. Yıldırım and Yıldırım (2021) examine the link between carbon dioxide (CO_2) emissions, real GDP, energy use, trade, and construction sector activities in Turkey within the framework of autoregressive distributed lag (ARDL), and Environmental Kuznets Curve (EKC). The findings of the study pertain that the increase in construction sector activities plays a positive role in CO_2 emissions. The results also argue that CO_2 emissions increase statistically significantly with increases in real GDP and energy use. Moreover, while trade openness contributes positively to carbon emissions, financial development does not explain environmental pollution in the long run. The study suggests that the government should take action against environmental degradation with efficient policies that save energy and reduce emissions, such as financial support and tax breaks to the companies involved in the activities of the construction and housing sectors.

3. DATA AND METHODOLOGY

This manuscript investigates the nexus between trade openness, industrial and construction development, economic growth, energy consumption, and ecological footprint by performing the Westerlund co-integration, FMOLS, DOLS, and CCR tests for Northern European (Denmark, Finland, Netherlands, Norway, and Sweden) and Latin American Countries (Argentina, Brazil, Chile, Colombia, and Uruguay) from 1980 to 2018. Annual data are collected for trade openness, economic growth, industrial and construction development from World bank (2022a), (2022b), (2022c) database respectively, and ecological footprint variable are derived from Global Footprint Network's (2022) official database. The Energy Consumption dataset is collected from the official website of Our world in data (2022), due to insufficient data in the World Bank which until 2015. ADF, PP and Zivot-Andrew tests are performed in order to comprehend the existence of unit root or not which is indispensable condition of FMOLS, DOLS, and CCR test.

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). 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) above 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 Table 3, which shows the ADF test results in the fixed-trend model, the test statistic becomes stationary when the first-order difference of all variables is taken. Trade openness, industrial and construction development, economic growth, energy consumption, and ecological footprint are not stationary at I(0) according to ADF unit root test for Northern European countries from 1980 to 2018. After taking first difference of all variables, they all become stationary at I(1). The results of ADF unit root test for Northern European countries at Table 3 are consistent with PP unit root test findings at Table 4 below.

Since the calculated probability values of the test statistics given in Table 4 are above the value of 0.05, the H0 hypothesis is rejected and the H1 hypothesis is accepted. In this context, it has been revealed that all variables are stationary and there is no unit root at I(1). The existence of a long-term relationship between the time series that is found to be stationary is investigated by FMOLS, DOLS, and CCR co-integration tests. According to Table 5, the series are not stationary at I(0) level for trade openness, industrial and construction development, economic growth, energy consumption, and ecological footprint. After taking first difference of all series for Latin American countries from 1980 to 2018, all variables became stationary at I(1) in terms of ADF unit root test results.

In addition, the series are not stationary at I(0) level for trade openness, industrial and construction development, economic growth, energy consumption, and ecological footprint at Table 6 as well. Similarly, after taking first difference of all series for Latin American countries from 1980 to 2018, all variables became stationary at I(1) in terms of PP unit root test results. The results of ADF unit root test at Table 5 are consistent with the findings of PP unit root test at Table 6.

In the Zivot and Andrews test, the regression equation is estimated for each possible breakpoint in the sample with the sequential ADF test, and the t-statistics is calculated for the predicted parameters. The unit root fundamental hypothesis is tested, as opposed to the trend stationary hypothesis with a single time break (T_B) in the autonomous and trend function slope at an unknown time point. Zivot and Andrews developed three different models for testing

Table 3: Augmented Dickey Fuller unit root test results for Northern European countries from 1980 to 2018

Countries	Series	Series at I (0) (nonstationarity) *t*-stat/crit-val %5/*P*	After converting from I (0) to I (1) (stationarity) *t*-stat/crit-val %5/*P*
Denmark	*trd_opn*	−0.38/−2.94/0.9022	−5.97/−2.94/0.0000*
	indus_const_dev	−0.55/−2.94/0.8686	−5.96/−2.94/0.0000*
	gdp	−0.30/−2.94/0.9149	−5.35/−2.94/0.0001*
	energy_cons	−1.88/−2.94/0.6721	−8.55/−2.94/0.0000*
	ecol_foot	−2.21/−2.94/0.2042	−8.48/−2.94/0.0000*
Finland	*trd_opn*	−0.94/−2.94/0.7641	−5.76/−2.94/0.0000*
	indus_const_dev	−1.09/−2.94/0.7072	−5.23/−2.94/0.0001*
	gdp	−0.57/−2.94/0.8641	−5.06/−2.94/0.0002*
	energy_cons	−1.74/−2.94/0.4428	−8.43/−2.94/0.0000*
	ecol_foot	−1.86/−2.64/0.3443	−6.89/−2.94/0.0000*
Netherlands	*trd_opn*	−0.25/−2.94/0.9229	−6.38/−2.94/0.0000*
	indus_const_dev	−0.79/−2.94/0.8089	−4.90/−2.94/0.0000*
	gdp	−0.23/−2.94/0.9246	−5.11/−2.94/0.0002*
	energy_cons	−0.90/−2.94/0.3654	−5.79/−2.95/0.0000*
	ecol_foot	−1.41/−2.94/0.5654	−7.13/−2.94/0.0000*
Norway	*trd_opn*	−1.01/−2.94/0.6658	−6.33/−2.94/0.0000*
	indus_const_dev	−0.89/−2.94/0.7784	−5.26/−2.94/0.0001*
	gdp	−0.44/−2.94/0.8907	−4.64/−2.94/0.0006*
	energy_cons	−1.31/−2.95/0.5876	−6.23/−2.95/0.0000*
	ecol_foot	−1.48/−2.94/0.6187	−7.17/−2.94/0.0000*
Sweden	*trd_opn*	−0.92/−2.94/0.7694	−5.34/−2.94/0.0001*
	indus_const_dev	−0.86/−2.94/0.7870	−6.16/−2.94/0.0000*
	gdp	−0.44/−2.94/0.8910	−5.66/−2.94/0.0000*
	energy_cons	−1.65/−2.94/0.5971	−8.57/−2.94/0.0000*
	ecol_foot	−0.90/−2.94/0.7741	−7.85/−2.94/0.0000*

"*" and "**" terms indicate the UR test results of the series implemented in the estimation process, 1 and 5% importance levels, respectively. Bold values demonstrate ADF test statistic. ADF: Augmented Dickey Fuller

Table 4: PP unit root test results for Northern European countries from 1980 to 2018

Countries	Series	Series at I (0) (nonstationarity) *t*-stat/crit-val %5/*P*	After converting from I (0) to I (1) (stationarity) *t*-stat/crit-val %5/*P*
Denmark	*trd_opn*	−0.00/−2.94/0.9533	−6.49/−2.94/0.0000*
	indus_const_dev	−0.49/−2.94/0.8808	−5.97/−2.94/0.0000*
	gdp	−0.34/−2.94/0.9086	−5.35/−2.94/0.0001*
	energy_cons	−1.89/−2.94/0.5112	−17.64/−2.94/0.0001*
	ecol_foot	−2.06/−2.94/0.2575	−8.37/−2.94/0.0000*
Finland	*trd_opn*	−0.99/−2.94/0.7451	−5.76/−2.94/0.0000*
	indus_const_dev	−1.09/−2.94/0.7072	−5.24/−2.94/0.0000*
	gdp	−0.58/−2.94/0.8612	−4.98/−2.94/0.0002*
	energy_cons	−1.12/2.94/0.7128	−28.94/−2.94/0.0001*
	ecol_foot	−1.83/−2.94/0.3588	−7.56/−2.94/0.0000*
Netherlands	*trd_opn*	0.45/−2.94/0.9826	−7.67/−2.94/0.0000*
	indus_const_dev	−0.85/−2.94/0.7928	−4.91/−2.94/0.0003*
	gdp	−0.26/−2.94/0.9206	−5.11/−2.94/0.0002*
	energy_cons	−1.53/−2.94/0.4871	−9.25/−2.94/0.0000*
	ecol_foot	−1.20/−2.94/0.6625	−7.75/2.94/0.0000*
Norway	*trd_opn*	−0.99/2.94/0.7156	−7.21/−2.94/0.0000*
	indus_const_dev	−0.93/−2.94/0.7669	−5.22/−2.94/0.0001*
	gdp	−0.44/−2.94/0.8907	−4.59/−2.94/0.0007*
	energy_cons	−1.21/−2.94/0.6532	−55.22/−2.94/0.0001*
	ecol_foot	−1.50/−2.94/0.4936	−7.32/−2.94/0.0000*
Sweden	*trd_opn*	−0.91/−2.94/0.7724	−5.29/−2.94/0.0001*
	indus_const_dev	−0.74/−2.94/0.8236	−6.13/−2.94/0.0000*
	gdp	−0.38/−2.94/0.9024	−5.61/−2.94/0.0000*
	energy_cons	−1.32/−2.94/0.6734	−18.78/−2.94/0.0000*
	ecol_foot	−1.38/−2.94/0.6279	−14.35/−2.94/0.0000*

"*" and "**" terms indicate the PP test results of the series implemented in the estimation process, 1 and 5% importance levels, respectively. Bold values demonstrate PP test statistic

Table 5: Augmented Dickey Fuller unit root test results for Latin American countries from 1980 to 2018

Countries	Series	Series at I (0) (nonstationarity) *t*-stat/crit-val %5/*P*	After converting from I (0) to I (1) (stationarity) *t*-stat/crit-val %5/*P*
Argentina	*trd_opn*	−1.60/−2.94/0.4696	−6.82/−2.94/0.0000*
	indus_const_dev	−0.89/−2.94/0.7787	−6.60/−2.94/0.0000*
	gdp	−0.68/−2.94/0.8373	−6.02/−2.94/0.0000*
	energy_cons	−1.18/−2.94/0.5129	−7.43/−2.94/0.0000*
	ecol_foot	−1.79/−2.94/0.3760	−9.13/−2.94/0.0000*
Brazil	*trd_opn*	−1.35/−2.94/0.5959	−5.70/2.94/0.0000*
	indus_const_dev	−0.98/−2.94/0.7505	−4.78/−2.94/0.0004*
	gdp	0.01/−2.95/0.9535	−3.55/−2.95/0.0124**
	energy_cons	−1.70/−2.94/0.3975	−6.49/−2.94/0.0000*
	ecol_foot	−1.20/−2.94/0.6634	−5.66/−2.94/0.0000*
Chile	*trd_opn*	−1.53/−2.94/0.5052	−5.51/−2.94/0.0000*
	indus_const_dev	−0.03/−2.94/0.9491	−4.70/−2.94/0.0005*
	gdp	0.45/−2.94/0.9825	−3.42/−2.94/0.0164**
	energy_cons	−1.38/2.94/0.6324	−9.41/−2.94/0.0000*
	ecol_foot	−0.67/−2.94/0.8401	−7.07/−2.94/0.0000*
Colombia	*trd_opn*	−1.59/−2.94/0.4736	−7.17/−2.94/0.0000*
	indus_const_dev	1.31/−2.96/0.9981	−4.60/−2.96/0.0010*
	gdp	2.20/−2.96/0.9999	−4.97/−2.97/0.0005*
	energy_cons	−2.87/−2.94/0.0578	−13.49/−2.94/0.0000*
	ecol_foot	−1.49/−2.94/0.5245	−7.14/−2.94/0.0000*
Uruguay	*trd_opn*	−1.95/−2.94/0.3055	−6.27/−2.94/0.0000*
	indus_const_dev	−0.78/−2.94/0.8111	−3.94/−2.94/0.0043*
	gdp	0.25/−2.94/0.9723	−3.59/−2.94/0.0106**
	energy_cons	−1.01/−2.94/0.7589	−12.47/−2.94/0.0000*
	ecol_foot	−1.40/−2.94/0.5676	−7.71/−2.94/0.0000*

"*" and "**" Terms indicate the UR test results of the series implemented in the estimation process, 1 and 5% importance levels, respectively. Bold values demonstrate ADF test statistic. ADF: Augmented Dickey Fuller

structural break. In Zivot-Andrews (2002) unit root test with structural break, three models were designed that allow a single break at Model A level, Model B for single break at slope, and Model C for single break both in slope and level.

Model A:

$$Y_t = \alpha_0 + \alpha_1 DU_t + d(DTB)_t + \beta_t + py_{t-1} + \sum_{i=1}^{p}\phi_i \Delta y_{t-i} + \varepsilon_t \quad (5)$$

Table 6: PP unit root test results for Latin American countries from 1980 to 2018

Countries	Series	Series at I (0) (nonstationarity) *t*-stat/crit-val %5/*P*	After converting from I (0) to I (1) (stationarity) *t*-stat/crit-val %5/*P*
Argentina	*trd_opn*	−1.60/−2.94/0.4696	−6.82/−2.94/0.0000*
	indus_const_dev	−0.83/−2.94/0.7971	−6.60/−2.94/0.0000*
	gdp	−0.65/−2.94/0.8465	−6.03/−2.94/0.0000*
	energy_cons	−1.83/−2.94/0.3529	−12.46/−2.94/0.0000*
	ecol_foot	−1.42/−2.94/0.5610	−17.64/−2.94/0.0001*
Brazil	*trd_opn*	−1.39/−2.94/0.5745	−5.67/−2.94/0.0000*
	indus_const_dev	−1.22/−2.94/0.6539	−4.84/−2.94/0.0003*
	gdp	−0.79/−2.94/0.8077	−4.70/−2.94/0.0005*
	energy_cons	−1.76/−2.94/0.3985	−10.77/−2.94/0.0000*
	ecol_foot	−1.21/−2.94/0.6583	−5.64/−2.94/0.0000*
Chile	*trd_opn*	−1.61/−2.94/0.4634	−5.52/−2.94/0.0000*
	indus_const_dev	0.19/−2.94/0.9689	−3.48/−2.94/0.0142**
	gdp	0.91/−2.94/0.9946	−3.11/−2.94/0.0337**
	energy_cons	−1.72/2.94/0.4879	−24.78/−2.94/0.0001*
	ecol_foot	−0.47/−2.94/0.8861	−7.29/−2.94/0.0000*
Colombia	*trd_opn*	−1.54/−2.94/0.4985	−7.63/−2.94/0.0000*
	indus_const_dev	−0.63/−2.94/0.8504	−3.69/−2.94/0.0084*
	gdp	−0.05/−2.94/0.9475	−4.09/−2.94/0.0029*
	energy_cons	−1.05/−2.94/0.5987	−35.79/−2.94/0.0001*
	ecol_foot	−1.28/−2.94/0.6266	−7.91/−2.94/0.0000*
Uruguay	*trd_opn*	−1.96/−2.94/0.3023	−6.27/−2.94/0.0000*
	indus_const_dev	−0.63/−2.94/0.8497	−3.94/−2.94/0.0043*
	gdp	0.81/−2.94/0.9929	−3.60/−2.94/0.0104**
	energy_cons	−1.25/−2.94/0.6327	−44.65/−2.94/0.0001*
	ecol_foot	−1.07/−2.94/0.7159	−8.07/−2.94/0.0000*

"*" and "**" Terms indicate the PP test results of the series implemented in the estimation process, 1 and 5% importance levels, respectively. Bold values demonstrate PP test statistic

Model B:

$$Y_t = \alpha_0 + \gamma DT_t^* + \beta_t + py_{t-1} + \sum_{i=1}^{p} \phi_i \Delta Y_{t-i} + \varepsilon_t \quad (6)$$

Model C:

$$Y_t = \alpha_0 + \alpha_1 DU_t + d(DTB)_t + \gamma DT_t + \beta_t + py_{t-1} + \sum_{i=1}^{p} \theta_i \Delta Y_{t-i} + \varepsilon_t \quad (7)$$

According to Models A, B and C above, Δ represents the first difference, ε_t indicates the variance of the white noise error term. The expression ΔY_{t-i} is added to the model in order to eliminate the autocorrelation in the error term. The dummy variable is indicated as DU_t and the constant term shows the changes in level, and the changes in the slope in terms of the break time which is symbolized as DT_t and TB.

If the calculated statistic of α is greater than the ZA critical value in absolute value after the date of the break is determined, the basic hypothesis showing the existence of a unit root without a structural break which is rejected. If the calculated t statistic is less than the ZA critical value in absolute value, the alternative hypothesis showing that the series is trend stationary with a structural break in the trend function is rejected. All series must be stationary at I(1) before starting FMOLS, DOLS, and CCR analyses.

3.1. Northern European Countries From 1980 to 2018

According to results of Tables 3-8, all series are stationary at I(1) which can proceed to Westerlund co-integration test, FMOLS, DOLS, and CCR analysis in order to test the long-run relationship between variables for two group of countries including Denmark, Finland, Netherlands, Norway, Sweden, Argentina, Brazil, Chile, Colombia, and Uruguay from 1980 to 2018.

FMOLS test is a method introduced by Christopoulos and Tsionas (2004) for estimating panel data. The FMOLS method takes into account the internality relationship among the independent variables, the error term, and the autocorrelation considering the error terms to get rid of the problems caused by the long-term correlation in co-integrated equations. In this context, FMOLS method corrects the problems arising from the endogenity and autocorrelation in the developed function (Phillips and Hansen, 1990).

3.2. Latin American Countries From 1980 to 2018

The DOLS method is developed by Stock and Watson (1993) to investigate the long-run relationship between dependent and independent variables. Dynamic elements are taken into account in the long-run linkage equation established in the DOLS method stands out as one of the strengths of the test. The results of the estimations for each panel using FMOLS and DOLS methods are shown in Tables 1 and 2.

The results in Table 9 show that the null hypothesis is rejected and there is a long-term co-integrated relationship between the series according to the four tests based on group averages.

Table 7: Zivot-Andrew unit root test results for Northern European countries from 1980 to 2018

Countries	Series	Level I (0)	First difference I (1)	Model Selection	Decision
Denmark	*trd_opn*	−2.2364 (**−4.2116**)	−6.1423* (**−2.1281**)	C/T	I (1)
	indus_const_dev	−2.1653 (**−4.1217**)	−8.1359* (**−2.2613**)		
	Gdp	−0.6317 (**−2.9148**)	−5.1227* (**−2.3471**)		
	energy_cons	−1.4365 (**−5.1254**)	−4.2611* (**−3.1267**)		
	ecol_foot	−1.3153 (**−6.1324**)	−7.2678* (**−1.7824**)		
Finland	*trd_opn*	−2.2356 (**−5.2418**)	−8.1329* (**−3.4590**)	C/T	I (1)
	indus_const_dev	−1.9523 (**−4.2687**)	−5.8874* (**−3.7214**)		
	Gdp	−2.4739 (**−6.2344**)	−8.2741* (**−3.3167**)		
	energy_cons	−3.7615 (**−7.2346**)	−9.1259* (**−4.5789**)		
	ecol_foot	−4.5799 (**−5.2794**)	−8.2583* (**−5.2793**)		
Netherlands	*trd_opn*	−1.7214 (**−5.1763**)	−7.2335* (**−3.5287**)	C/T	I (1)
	indus_const_dev	−1.6247 (**−2.9476**)	−6.3719* (**−3.7241**)		
	Gdp	−0.8274 (**−4.3258**)	−5.6278* (**−2.8753**)		
	energy_cons	−3.2678 (**−3.8513**)	−3.8165** (**−2.9728**)		
	ecol_foot	−5.2563 (**−6.2459**)	−6.1478* (**−3.8765**)		
Norway	*trd_opn*	−0.8236 (**−4.3137**)	−8.2573* (**−4.4126**)	C/T	I (1)
	indus_const_dev	−2.2147 (**−4.7238**)	−7.6831* (**−4.1267**)		
	Gdp	−1.3271 (**−4.2177**)	−5.8332* (**−2.7255**)		
	energy_cons	−2.3416 (**−4.7218**)	−5.5261* (**−2.8167**)		
	ecol_foot	−1.7256 (**−3.8245**)	−7.2426* (**−3.5211**)		
Sweden	*trd_opn*	−0.8170 (**−3.7126**)	−7.4150* (**−4.3142**)	C/T	I (1)
	indus_const_dev	−1.4514 (**−4.7167**)	−7.1328* (**−3.5216**)		
	Gdp	−0.9238 (**−3.9178**)	−5.3724* (**−3.2421**)		
	energy_cons	−3.2213 (**−3.4173**)	−3.5214** (**−2.8623**)		
	ecol_foot	−0.8136 (**−3.5147**)	−9.2614* (**−3.7226**)		

The statement "*" describes the UR test results for the series performed in the estimation process for 1% importance level. Statements in parentheses are 1% significance, respectively. Besides, it indicates the critical value and structural break dates for the level. The results show that the variables performed in the model are stationary I (1) in the first difference.
C/T: Demonstrates structural break together in constant trend

Table 8: Zivot-Andrew unit root test results for Latin American countries from 1980 to 2018

Countries	Series	Level I (0)	First difference I (1)	Model Selection	Decision
Argentina	*trd_opn*	0.6347 (**−3.1423**)	−8.2561* (**−3.7864**)	C/T	I (1)
	indus_const_dev	0.6215 (**−4.2783**)	−6.3471* (**−2.8123**)		
	Gdp	0.4595 (**−3.7132**)	−5.2412* (**−3.7013**)		
	energy_cons	0.8143 (**−3.7682**)	−5.2176* (**−3.7173**)		
	ecol_foot	−2.1338 (**−3.6723**)	−6.0332* (**−3.5987**)		
Brazil	*trd_opn*	−1.2458 (**−3.7126**)	−4.6231** (**−2.9856**)	C/T	I (1)
	indus_const_dev	−1.3624 (**−3.6173**)	−6.1452* (**−3.2114**)		
	Gdp	−2.8113 (**−3.2178**)	−3.6256** (**−3.2124**)		
	energy_cons	−3.1422 (**−4.1237**)	−5.8163* (**−3.9242**)		
	ecol_foot	−1.1457 (**−4.1263**)	−6.1628* (**−4.1114**)		
Chile	*trd_opn*	−3.1036 (**−4.6142**)	−8.5245* (**−4.3156**)	C/T	I (1)
	indus_const_dev	−2.5278 (**−4.321**)	−8.3256* (**−4.2156**)		
	Gdp	−0.6174 (**−3.6215**)	−6.8253* (**−3.4215**)		
	energy_cons	−1.7835 (**−3.4223**)	−6.2413* (**−3.4127**)		
	ecol_foot	−2.3416 (**−3.8521**)	−6.5123* (**−3.6321**)		
Colombia	*trd_opn*	−1.8572 (**−5.1623**)	−7.1632* (**−4.7567**)	C/T	I (1)
	indus_const_dev	−2.8457 (**−6.3162**)	−8.8143* (**−4.7162**)		
	Gdp	−3.3216 (**−4.6254**)	−7.7214* (**−4.6346**)		
	energy_cons	−2.5123 (**−4.2681**)	−8.4113* (**−3.7136**)		
	ecol_foot	−2.2156 (**−2.8223**)	−7.6129* (**−3.6152**)		
Uruguay	*trd_opn*	−1.9163 (**−3.6128**)	−6.5142* (**−2.8127**)	C/T	I (1)
	indus_const_dev	−1.4752 (**−4.3265**)	−5.2317* (**−2.5632**)		
	Gdp	−1.8142 (**−4.2168**)	−7.8263* (**−3.6127**)		
	energy_cons	−1.7426 (**−3.2457**)	−6.2356* (**−3.1252**)		
	ecol_foot	−1.3567 (**−2.6243**)	−6.2618* (**−3.6217**)		

The statement "*" describes the UR test results for the series performed in the estimation process for 1% importance level. Statements in parentheses are 1% significance, respectively. Besides, it indicates the critical value and structural break dates for the level. The results show that the variables performed in the model are stationary I (1) in the first difference.
C/T: Demonstrates structural break together in constant trend

After these findings regarding the existence of a co-integrated relationship, long-term coefficients should be estimated in order to determine the direction and size of the relationship between trade openness, industrial and construction development, energy consumption, economic growth and ecological footprint.

Table 9: Results of westerlund co-integration test

Statistics	Value	Z	P
Group-t	−3.147	−2.825	0.021**
Group-a	−11.265	−1.925	0.011**
Panel-t	−12.178	−2.734	0.004*
Panel-α	−10.874	1.428	0.001*

*,** and *** demonstrates the significance level at 1%, 5% and 10% significance level, respectively

The long-term relationship between the all series has been established, according to Westerlund's (2007) statistic results. Therefore, it is significant to estimate the coefficients of long-term series by employing various and more powerful approaches. An influential test carried out by Pedroni (2001, 2004) is performed to correct the bias of the estimator to remove the pseudo coefficients caused by the "ordinary least squares" (OLS) tool.

FMOLS is one of these crucial methods of estimation that take into account a parametric approach. This method ensures for the correction of endogeneity components in the regressors and elimination of the impact of serial correlation. In addition, long-term estimates are also made performing the dynamic OLS (DOLS), a parametric estimating approach developed by Mark and Sul (2003).

Park (1992) developed the "Canonical Cointegrating regression" (CCR) method, which is founded on a non-parametric correction that is analogous to the FMOLS method of estimation but the CCR model removes the bias of non-centrality in a different form (Kurozumi and Hayakawa 2009). The forecasted coefficients of the long-term are calculated for the individuals and countries.

The empirical model is estimated with the group mean FMOLS and DOLS models, while the lag length is determined according to the Schwarz information criterion in Tables 1 and 2. When the FMOLS and DOLS model estimation results are examined on the basis of panels and countries, results that partially consistent with each other.

Considering the FMOLS, DOLS, and CCR test results of Northern European countries the EKC hypothesis is not confirmed for Finland, Norway and Sweden except Denmark and Netherlands. There is a long-run relationship among industrial and construction development, economic growth, and ecological footprint for both Denmark and Netherlands which verifies the EKC hypothesis from 1980 to 2018.

According to Table 1, the P-values of Denmark and Netherlands are <0.05 which indicates that these values are within the 5% confidence interval. When the remaining countries are examined, the results are the opposite.

There is no long-run relationship among relevant variables for Finland, Denmark, and Sweden from 1980 to 2018. Besides, there is no effect of industrial and construction development, economic growth, energy consumption, and trade openness on ecological footprint for Finland, Denmark, and Sweden from 1980 to 2018. The P-value of all independent variables is more than 0.05 at Table 1.

The EKC hypothesis is not confirmed for Latin American countries including Argentina, Brazil, Chile, Colombia, and Uruguay at Table 2. The P-value of Argentina for trade openness is 0.1231, industrial and construction development is 0.9607, economic growth is 0.4287, and energy consumption is 0.0821 in terms of FMOLS results.

Similar results are obtained by using the same variables and models including FMOLS, DOLS, and CCR for all Latin American countries. Considering the periods of 1980 to 2018, ecological footprint is selected as dependent varible for Northern European (Denmark, Finland, Netherlands, Norway, and Sweden) and Latin American Countries (Argentina, Brazil, Chile, Colombia, and Uruguay).

Economic growth, energy consumption, trade openness, industrial and construction development affect the ecological footprint which verifies the lineer relations between variables from 1980 to 2018, for Netherlands.

If other countries are taken into account (1980 to 2018), non-lineer relations emerged among series and whole independent varibles do not have impact on ecological footprint for Finland, Norway, Sweden, Argentina, Brazil, Chile, Colombia, and Uruguay (Tables 1 and 2).

4. CONCLUSION

In this study, it has been tried to examine the effects of economic growth, energy consumption, trade openness, industrial and construction development on ecological footprint, which are closely related to world economies. In this context, FMOLS, DOLS, and CCR analysis reveal the long-term linkage among trade openness, industrial and construction development, economic growth, energy consumption, and ecological footprint from 1980 to 2018 which is verified the EKC hypothesis for Netherlands and Denmark. Furthermore, the impact of independent variables including trade openness, industrial and construction development, economic growth, energy consumption on ecological footprint is indicated via FMOLS, DOLS, and CCR models which are also confirmed the EKC hypothesis for Netherlands. Thus, all econometric models of this manuscript reveal that industrial and construction development and economic growth from 1980 to 2018 cause environmental degradation for Denmark and Netherlands. The EKC hypothesis is not confirmed for remaining northern countries including Finland, Norway, and Sweden at Table 1. The EKC hypothesis is not confirmed for Latin American countries at Table 2 as well. The pollution problem in question is of particular concern to developed countries. Because these countries are forced to use heavy industry, which is far from the nano-technological industry structure and has high environmental degradation.

Finland's green energy consumption and use of environmentally friendly technology in terms of industry and construction coincide with the empirical findings of this article, especially in Table 1. In this sense, Finland is a highly developed country in the fields of forest, metal, electronics and chemical industries. It also has expertise in the use of environmental technology in these industries.

Firms in Finland are investing in new competitive technologies that encourage environmentally responsible activities. Technological knowledge in this field is seen as an opportunity for international companies that focus on environmental factors. In the production and use of bioenergy, which is one of the most important environmental technologies, Finland is one of the leading countries as a result of its geographical location, climate, energy-intensive industries, effective cooperation between the government, research institutions and companies. Bioenergy consumption accounts for 25% of Finland's total energy consumption. Finland has expertise in bioenergy use, particularly in biomass energy technologies, combined heat and power generation. Biomass is the conversion of organic materials such as garbage, wood and agricultural and animal waste into useful energy by combustion. These are the factors that make energy production efficient and reduce the use of fossil fuels.

For instance, the laying a tax on a new carbon dioxide in Norway and Sweden has been achieved in certain sectors by reducing existing energy taxes. The environmental effects of these measures may vary depending on both the tax burden of the total taxed fuel and whether there are substitute goods. This type of tax was introduced in Sweden in 1991. New environmental taxes have been imposed on properties including, carbon, sulfur, nitrogen oxides. Sweden initially reimbursed the industry 75% in carbon tax, which was later reduced to 50%. Norway started implementing the carbon dioxide tax on mineral fuels in 1991 and then expanded it to coal and cola drinks. In 2000, the CO_2 tax on gasoline, heavy fuels and coal increased. Due to such tax revenues, income tax reductions were made, and tax advantages were provided for energy-saving investments and reusable energy resources. As a result of doubling the taxes on waste water in Norway from 1987 to 1993, wastewater in houses decreased by 16%, in construction by 64%, and in other works by 22%. On the other hand, industrial wastewater increased by 8% despite the tax. These applied policies clearly support the empirical findings of the article.

It is a well-known fact that a large part of the world's energy consumption originates from residential construction. 21% of the world's carbon emissions originate from industrial development and 6% from the construction sector. As a result of the climate changes and the gradual depletion of natural energy resources, efforts have been made to make conscious production in the construction sector, and in this context, the principles of sustainable production and resource conservation have emerged.

Denmark should build an artificial island as a precaution against the climate crisis. The other important solution is to impose deterrent taxes to reduce environmentally harmful energy consumption for both Denmark and Netherlands. Another main recommendation is Dutch government should build hydrogen heated homes in order to wage a fight against air pollution. Because, Hydrogen is obtained in a sustainable way which is the new alternative to natural gas and it is produced only from water and electricity. Hydrogen does not release carbon dioxide when burning. For this reason, it is known as an "environmentally friendly" fuel.

When Latin American countries are examined, the series are not co-integrated in terms of economic growth, energy consumption, trade openness, industrial and construction development, and ecological footprint which are demonstrated empirically at Table 2. In this article, the achievements of Latin American countries in environmental issues have been empirically proven. Brazil has supported the production and use of ethanol as it is an environmentally friendly energy source. It has led to the implementation of environmental protection decisions to prevent new sugarcane plantings and establishment of ethanol production facilities for ethanol production. The subject of criticism about Brazil in terms of environmental pollution is Madeira dam which were built in 2013. However, Roberto Smeraldi states that (member of the Friends of the World Environment Organization) every dam project in the Amazon Valley is delayed by 60% to 120% of the planned construction time. As a precautionary measure, fossil fuel thermal power plants through extremely low carbon dioxide emissions should be included in the system until the dams are put into operation.

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