Elektronik Sosyal Bilimler Dergisi® www.esosder.org
Electronic Journal of Social Sciences® ISSN:1304-0278
Nisan/April(2024) - Cilt/Volume:23 - Sayı/Issue:90 (437-448)

THE ECOLOGICAL FOOTPRINT AND TRADE OPENNESS NEXUS: A CASE OF G-7 COUNTRIES

EKOLOJİK AYAK İZİ VE TİCARİ AÇIKLIK BAĞLANTISI: G7 ÜLKELERİ ÖRNEĞİ

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Abstract

The ecological footprint basically aims to measure the impact of humans on the ecosystem. The measurements include the area required to produce the materials consumed in terms of the consumption footprint and the area required to absorb the carbon dioxide emissions. No distinction is made between domestic and foreign producers in the production by the countries. The countries with the most developed industry and the highest impact on the ecosystem in this sense appear as the countries with the highest footprint in the ecosystem. This study, based on the ecological footprint data of seven industrialized countries (G7) between 1984 and 2019, aims to reveal the effect of ecological footprints on trade openness. Panel data analysis and ARDL Boundary Test / PMG method was used to obtain the results. DOLS and FMOLS methods were also used to compare both economic and empirical results and for consistency. As a result of the analysis, as the impact of industrialized countries on the ecosystem increases, their trade openness also increases in the short and long term. This effect could be seen most clearly in the United States (USA), which has the most developed industry. This research paper points out these important issues.

Keywords: International trade, ecological footprint, trade openness, ARDL

Jel Classifications: C50, F14, F18

Öz

Ekolojik ayak izi, temelde insanların ekosisteme etkisini ölçmeyi amaçlamaktadır. Yapılan ölçümler tüketim ayak izi cinsinden tüketilen malzemeleri üretmek için gereken alanı ve karbondioksit emisyonlarını emmek için gereken alanı içermektedir. Ülkeler açısından, yapılan üretimde yerli veya yabancı üretici ayrımı gözetilmemektedir. Sanayisi en gelişmiş ve ekosisteme bu anlamda en yüksek etkisi bulunan ülkeler ekosistemde ayak izi en yüksek olan ülkeler olarak karşımız çıkmaktadır. Sanayileşmiş 7 ülke ve bu ülkelerin 1984 - 2019 yılların arasındaki ekolojik ayak izi verilerine dayanarak ekolojik ayak izlerinin ticari dışa açıklıklarına etkisi incelendiği bu çalışmada, Panel veri analizinden yararlanılmış ve ARDL Sınır Testi/ PMG yöntemi kullanılmıştır. DOLS ve FMOLS yöntemleri de hem ekonomik hem ampirik sonuçların karşılaştırılması ve tutarlılık için kullanılmıştır. Yapılan analiz sonucunda, sanayileşmiş ülkelerin ekosisteme etkisi arttıkça ticari açıklıkları da kısa ve uzun dönemde artmaktadır. En gelişmiş sanayiyi sahip Amerika Birleşik Devletleri'nde (ABD) bu etki en açık şekilde görülebilmektedir.

Anahtar Kelimeler: Uluslararası Ticaret, ekolojik ayak izi, ticari açıklık, ARDL

Jel Sınıflandırması: C50, F14, F18

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Makale Türü: Araştırma Makalesi – Geliş Tarihi: 05.09.2023 – Kabul Tarihi: 23.02.2024

DOI:10.17755/esosder.1355174

Atıf için: Elektronik Sosyal Bilimler Dergisi, 2024;23(90): 437448

1. Introduction

The G7 countries[3] were established among the seven industrialized countries of the world after the 1973 oil crisis. According to 2018 World Bank (WB) data, The G7 countries produces 58% of the world's total gross domestic product (GDP). At the same time, the G7 countries not only own 46% of the total wealth, but also manage 15% of the world's land with 20 million square meters (World Bank [WB], 2019). While the G7 countries realize nearly half of the world production, the cost of the damage these countries cause to the environment is also measured by the ecological footprint. Since it includes the concept of carbon footprint and is a broader expression, the concept of ecological footprint is accepted as a better indicator in measuring the damage to the environment. The concept of ecological footprint, developed by Mathis Wackernagel and William Rees in 1996, is generally defined as the sum of many concepts used in the literature, such as carbon footprint, agricultural footprint, forest footprint, structured area footprint, fishing field footprint and grassland footprint in which the effects left on nature are measured, and is defined as the area used to support the consumption of a population. In other words, it reveals how much biologically productive space is needed for a particular population to produce the resources it consumes and to destroy the relevant waste generated as a result of this production using the dominant technology (Wackernagel & Silverstein, 2000: 392).

Waste left to nature should provide a sustainable trade environment. It also has a great importance in ensuring the ecological balance. Trade openness has become one of the most important determinants of the ecological environment as a result of the efforts of countries with ecological deficits to close these deficits through trade. For this reason, it should be examined in detailed (Aktürk & Gültekin, 2023: 8). The concept of trade openness is a criterion used to express the extent to which countries will take part in bilateral trade with the world. Trade openness is expressed as the removal of visible and invisible barriers to trade between countries. The most general trade openness criterion for countries is to express their imports and exports by their share of GDP (İlter & Doğan 2018: 90). There is no consensus on the criteria of trade openness for countries. Due to its ease of calculation, the most widely used measure of trade openness in the literature is expressed as the ratio of exports and imports to gross domestic product. This ratio is also a ratio that measures a country's dependence on foreign trade (Seyidoğlu, 2013).

Research studies are done to investigate the impact of the ecological footprint, which is broadly defined in the upper part, on the trade openness. By this purpose, the aim of the research is to examine the impact of ecological footprint from the studies in the literature in terms of the period it covers and to examine the effect of seven industrialized countries. In the study, firstly, a literature search was conducted that explores the concept of ecological footprint and trade openness. Brief evaluations were made about the academic findings obtained as a result of this screening. Consequently of the evaluations, it is determined that there is a close connection between the ecological footprint and the trade openness of the seven industrialized countries, these two concepts strongly affect each other due to industrialization, and the industrialization rates of the countries with a high ecological footprint are similarly high. In addition, it has been concluded that the ecological footprints of the country's leading industrialization affect their trade openness at a higher rate. In the following sections, analysis was made depending on the data set used and the results obtained were evaluated. In the conclusion part, based on the findings that the ecological footprint is generally high in industrialized countries, the share of

[3]G7 countries: United Kingdom (GBR), United States of America (USA), Canada (CAN), Japan (JPN), Italy (ITA), France (FRA), Germany (DEU)

imports and exports from the GDP of the countries with industrialization is the same high, and the trade openness is a result of industrialization; it has been obtained that ecological footprint has a positive effect on trade openness both in the short and long term and this effect increases the trade openness by 25% on average in two periods. This situation can inform researchers that the ecological footprint in general increases trade openness. Again, as a result of the study, policy recommendations are made to increase trade openness and thus to enable countries to do more international trade.

2. Literature Review

As stated in the previous section, the relationships between trade openness, ecological footprint and other macroeconomic variables are frequently encountered in the literature. In this part of the study, literature studies addressing the relationship between ecological footprint and trade openness for countries will be included. Literature review is important for a better understanding of the study. The literature review related to the study is given in Table 1.

Table 1. Literature Review

Author/Year	Country/ Period	Variables	Method	Result
Yilanci et al. (2019)	25 OECD 1961-2013	Ecological Footprint (EF)	Panel Data Analysis	It has been concluded that the shocks applied by policy makers in OECD countries only have a lasting effect on the ecological footprint caused by fisheries.
Destek and Sinha (2020)	OECD 1980-2014	Ecological Footprint (EF), Real Gross Domestic Product (GDP), Real Non-Renewable Energy Consumption (REC) and Trade Openness (TO).	Panel Data Analysis	From the applied analysis, 8 OECD countries can achieve economic growth and environmental sustainability, while for 16 OECD countries, these countries need to improve a few environmental regulation standards primarily in renewable energy technologies.
Dumrul and Kılıçarslan (2020)	Türkiye 1961-2014	Ecological Footprint (ECF), Energy Consumption (EC), Gross Domestic Product (GDP) and Trade Openness (TRADE)	Johansen Cointegration Test and Vector Error Correction (VECM)	In the policies to be formed for the environmental effects of international trade in Türkiye, the effects of the ecological footprint should be taken into account.
Lu (2020)	Asian Countries 1973-2014	Ecological Footprint Per Capita (EF), The Real Income Per Capita (GDP), Trade (TRD) and Energy Consumption Per Capita (EU).	Panel Data Analysis/ (Pooled Average Group) PMG	Ecological footprint and macroeconomic indicators are related to each other. Higher funding of renewable energy and increased efficiency are essential for governments in the context of economic growth.

Gülmez et al. (2021)	G7 Countries 1971-2015	Ecological Footprint (eko), Energy Consumption (ek), Trade Openness (da) and Gros Domestic Product Per Capita (kbgysh)	Panel Cointegration Analysis	The values that emerged as a result of the tests are that the variables of economic growth, trade openness and energy use all increase the ecological footprint.
Bucak and Saygılı (2022)	G7 and Türkiye 1998-2017	Ecological Footprint (EF), Gross Domestic Prododuct (GDP), Trade Openness (OPEN), Renewable Energy (REC) and Population (PD)	Panel Data Analysis	It has been concluded that openness and growth increase the ecological footprint, while renewable energy consumption reduces the ecological footprint.
Chu and Tran (2022)	27 OECD 1990-2015	Ecological Footprint (EF), Environmental Policy Stringency (EPS), Trade Openness (OPE), Energy Intensity (ENE), Renewable Energy Consumption (REN), and Gross Domestic Product Per Capita (GDP)	Panel Data Analysis	Continuous implementation of environmental policy plays an important role in reducing the ecological footprint in the product and service produced.
Güzel and Oluç (2022)	Türkiye 1962-2014	Ecological Footprint (EF), Export Product Diversification (DIV), Energy Consumption (EC), Renewable Energy (REC) and Gross Domestic Product (GDP)	The Fully Modified Least Squares Method (FMOLS)	It has been concluded that the ecological footprint of the exported products will increase if the diversity of the products increases and economic growth is achieved.
Okelele et al. (2022)	23 Sub-Saharan African countries 1990-2015	Ecological Footprint of Consumption (EcFP), Gross Domestic Product Per Capita (PCGDP), Renewable Energy Consumption (REEN), The Ratio of The Sum of Imports and Exports to gdp (TROP), The Ratio of Urban to Total Population (URBAN) and Net Inflows of fdi (FDI).	Panel Data Analysis	There is a relationship between ecological footprint and real GDP per capita. This relationship is an inverted U-shaped relationship.
Adebayo et al. (2023)	Mexico, Indonesia, Nigeria, Türkiye (MINT) 1961-2018	Ecological Footprint (ECF), Trade Openness (TO), Import (IMP) and Export (EXP)	Panel Data Analysis	While a positive relationship can be mentioned for Mexico and Indonesia, a very strong effect cannot be mentioned for Turkey and Nigeria.
Aktürk and Gültekin (2023)	Türkiye 1990-2018	Logarithm of Total Ecological Footprint (logeto), Income inequality (eşit), Trade Openness (tic), Gross Domestic Product (gsyih), Renewable Energy Consumption (yen), Logarithm of Population (lognüf), Population Growth (nüf) and Food Production Index (gıda)	The Autoregressive Distributed Lag (ARDL)	Trade openness and income inequality have a reducing effect on the ecological footprint. On the contrary, renewable energy and GDP have an increasing effect.

Previous studies mostly examine the impact of different macroeconomic variables on the ecological footprint. The results show that the ecological footprint, including the carbon footprint, increases with economic developments such as real income increase, improvement in income distribution, economic development, increases in foreign trade, which are some of the results of the industrialization of countries. In other words, economic development increases the rate of waste released to nature. As can be seen in the following sections, the results of this study show parallelism with the studies in the literature.

3. Data and Methodology

The relationship between ecological footprint and trade openness was examined in this study by using annual data from seven industrialized countries for the period 1984-2019. The reason for the limited period of the study is that the data of the Covid-19 Pandemic period is not included in this study and selected data set from 1984 to keep up to date of the study.

When the literature study examined deeply, the relationship between trade openness and ecological footprint has been investigated together with many other macroeconomic variables. Although there are many variables that can be used for the model, two important variables required in the model such as GDP of the countries and the real effective exchange rate to make the model significate (Ngouhouo, Nchofoung & Kengdo, 2021; Tahir, Hasnu & Estrada, 2018;Tsaurai, 2021; Suleman, Thaker, Ariff & Cheong, 2023) . Ecological footprint preferred as a control variable for this research. The model used is thus in the form of $TO = f(EFP, GDP, CURR)$. Indicators, codes of variables, their usage patterns and the sources of data were obtained are also presented in Table 2.

Table 2. A Brief Synopsis of Criteria

Indicators	Codes	Log./Orig.	Source
Ecological Footprint	EFP	Logarithmic	Footprint Network
Trade Openness	TO	Original	Penn World Table
Gross Domestic Product	GDP	Original	World Bank & OECD
Reel Effective Exchange Rate	CURR	Logarithmic	OECD – US Dollar

Panel data analysis has preferred in the study. The model used in the analysis is as in equation 1:

$$TO_{it} = \beta_0 + \beta_1 \Delta EFP_{it} + \beta_2 GDP_{it} + \beta_3 \Delta CURR_{it} + \varepsilon_{it} \quad (1)$$

From the model, trade openness (TO) is the dependent variable and indices on model i represent cross sections, indices t represent the time dimension and ε_{it} represent the error term[4].

Cross-Sectional Dependence

Checking the cross sectional dependence is important to make estimation with series before unit root test. These results need to be consistent to get correct test. Unit root tests suitable for series are divided into first generation and second generation unit root tests. Which generation unit root tests should be selected while performing the tests is learned by cross-

[4] Eviews 10 and Stata 14 softwares selected for performing econometric analysis.

sectional dependence. The cross-section dependency of the series necessitates one of the second generation unit root tests. Otherwise, unitary generation unit root tests should be preferred.

Cross-sectional dependence in the series is determined by the Pesaran (2004) CD test and the Breusch Pagan (1980) LM test. These tests are preferred when the cross-section dimension is smaller than the time dimension (N<T). The reason of these two tests has been selected, since the time dimension is 35 and the cross-sectional dimension is 7.

Breusch Pagan (1980) The LM test statistic is as in equation 2:

$$LM = \sum_{i=1}^{N-1} \sum_{J=i+1}^{N} T_i \hat{\rho}_{ij}^2 \sim \frac{\chi^2_{N(N-1)}}{2} \quad (2)$$

$T_i \hat{\rho}_{ij}^2$, i and j represent the correlation coefficient between the coefficients of the units. The null hypothesis of the test is that there is no relationship between the horizontal sections, and if the null hypothesis is rejected, it is concluded that there is a cross-section dependency and second generation unit root tests are used (Breusch & Pagan, 1980: 240).

Pesaran (2004), test statistic LM_{CD} is as in equation 3:

$$LM_{CD} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T_i \hat{\rho}_{ij}^2 - 1\right) \sim N(0,1) \quad (3)$$

In the equation, it is generally understood by N and T whether there is a horizontal section in the panel. It is assumed that there is no cross-section as N and T go to infinity (Pesaran, 2004).The results of these tests are as in Table 3:

Table 3. Cross-Section Independence Test

Tests	Statistics	P-Value
$\boldsymbol{LM}$	204.7	0.0000
$\boldsymbol{LM}_{\boldsymbol{adj}}$	88.23	0.0000
$\boldsymbol{LM}_{\boldsymbol{CD}}$	12.21	0.0000

Probability values in Table 3 are evaluated according to 1% and 5% significance levels. According to the results obtained, the hypothesis of "H_0: There is no cross-section dependence" is rejected and the hypothesis of "H_1: There is a cross-section dependency" is accepted. In other words, it is concluded that there is a cross-section dependency. According to this result, a shock that occurs in countries affects other countries as well. This result allows to perform the second generation panel unit root test. In the next section, the stationarity of the series will be tested with the second generation unit root test.

Panel Unit Root Test

After obtaining the cross-sectional dependency, CIPS unit root test was selected for this study which is developed by Pesaran (2007) and it is one of the second generation unit root test.

$$CIPS\ (N,T) = N^{-1}\sum_{i=1}^{N} t_i(N,T) \quad (4)$$

Equation 4 shows that the horizontal sections of the null hypothesis in the panel unit root test contain unit root, and unit roots are not stationary (Pesaran, 2007: 269). In Table 4, if the critical values of the calculated values are less than the absolute value, it is understood that the series contain a unit root and are not stationary. After took the first difference of unit roots, it is seen that the series become stationary. CIPS unit root test results are given in Table 4.

Table 4. CIPS Panel Unit Root Test Results (Level)

	Panel CIPS Value			
	Constant	**Critical Value**	**Trend**	**Critical Value**
TO	-2.19	-2.33	-2.81	-3.06
ΔEFP	-2.09	-2.33	-2.99	-3.06
GDP	-3.73	-2.33	-3.60	-3.06
ΔCURR	-1.71	-2.33	-1.84	-3.06

Note: The critical value represents the 5% significance level. The latency value is determined as 4 according to the Akaike Information Criteria (AIC)

As seen in Table 4, all series except GDP contain unit root. For this reason, it is necessary to perform the stationarity test again by taking the first differences. The test results of the retested series are given in Table 5.

Table 5. CIPS Panel Unit Root Test Results (First-differences)

	Constant	**Critical Value**	**Trend**	**Critical Value**
TO	-4.39	-2.33	-4.57	-3.06
ΔEFP	-5.88	-2.33	-6.05	-3.06
GDP	-	-	-	-
ΔCURR	-3.90	-2.33	-4.05	-3.06

Note: The critical value represents the 5% significance level. The latency value is determined as 4 according to the Akaike Information Criteria (AIC)

As can be seen in Table 5, all series become stationary when first difference is taken. GDP is stationary only at level. In this case, the conditions required for the selected test method are fulfilled.

Westerlund (2005) panel cointegration test was chosen as the next step. While the null hypothesis of the test expresses the existence of cointegration, the alternative hypothesis states that there is no cointegration. The results of the test are given in Table 6.

Table 6. Westerlund (2005) Panel Cointegration Test Results

Tests	**Statistic**	**Z-Statistic**	**P-Value**
$\boldsymbol{G_t}$	-24.360	-67.157	0.000
$\boldsymbol{G_a}$	-5.043	1.054	0.854
$\boldsymbol{P_t}$	-7.364	-3.418	0.000
$\boldsymbol{P_a}$	-6.949	-1.495	0.067

When the results obtained in Table 6 is investigated, it is seen that there is a cointegration relationship between the series, and there is a long-term balance relationship between trade openness and ecological footprint. After applying the cointegration tests, the DOLS and FMOLS methods that developed by Pedroni (2000 and 2001) were used to test the consistency of the estimators within the framework of expectations to estimate the final

unbiased coefficients of this relationship (Gülmez &Yardımcıoğlu, 2012: 347). When the long-term coefficients obtained by using DOLS and FMOLS approaches in the study are evaluated in this context, it is seen that the long-term effect of ecological footprint on trade openness is strong. Obtained results are given in Table 7.

Table 7. Panel Short and Long Term Results

Long Term Coefficient (Dependent Variable: TO)			
	PMG	**FMOL**	**DOLS**
ΔEFP	30.6875**	-31.7850**	13.5133
GDP	-2.0932**	-1.0743	11.6002**
ΔCURR	-202.6419	-4.4629	1.6779**
Short Term Coefficient (Dependent Variable: TO)			
ΔEFP	24.2610***	-	-
GDP	0.3942***	-	-
ΔCURR	7.0650***	-	-
ECM	-0.0504**	-	-

Note: *, ** and *** indicate the relevant coefficient that is significant at 10%, 5% and 1% significance levels, respectively. **ECM**: Error correction term.

PMG estimator proposed by the Panel ARDL method, which does not take into account the inter-unit correlation, will be applied. Since the PMG estimator dominates the DFE estimator and allows heterogeneity in the short-run coefficients and Hausman test statistical probability value is greater than 0.05 (0.6385), decided that PMG is the effective estimator for both cases (Mehmood et al., 2014:416). A similar situation is valid for MG and the Hausman test statistical probability value is obtained as 0.9055. All these results allow the use of the PMG estimator. In Table 8, the results of the short and long term analysis for the G7 countries are given. In the next section, the results and recommendations of the study are given according to Table 7 and Table 8.

Table 8. Short and Long Term Forecast Results of Countries

Dependent Variable: TO			GBR	USA	CAN	JPN	ITA	FRA	DEU
Long Run	ΔEFP	PMG	30.6875 (**)	30.6875 (**)	30.6875 (**)	30.6875 (**)	30.6875 (**)	30.6875 (**)	30.6875 (**)
	GDP		-2.0932 (**)	-2.0932 (**)	-2.0932 (**)	-2.0932 (**)	-2.0932 (**)	-2.0932 (**)	-2.0932 (**)
	ΔC		-202.6419	-202.6420	-202.6421	-202.6422	-202.6423	-202.6424	-202.6425
Short Run	ΔEFP		-5.5880	14.4362 (**)	7.0392	31.0967 (***)	30.6320 (***)	31.0629 (***)	61.1482 (***)
	GDP		0.2734	0.3716 (**)	0.5985 (**)	0.4125 (*)	0.4125 (*)	0.4763 (**)	0.4765 (***)
	ΔC		12.2006 (**)	-	15.9226 (*)	5.9764	5.9764	8.5526 (**)	0.3026
	ECM		-0.0258	-0.1902 (***)	-0.0169	-0.0228	-0.0228	-0.0386	-0.0248

Note: *, ** and *** indicate the relevant coefficient that is significant at 10%, 5% and 1% significance levels, respectively. **ECM**: Error correction term.

4. Conclusion

In this study, it is aimed to test the short and long term relationships between trade openness and ecological footprint of seven industrialized countries within the framework of panel data approach. The panel set of the study covers the data between 1984-2019. The short- and long-run relationship between ecological footprint and trade openness was analyzed by CIPS unit root test and Westerlund panel cointegration tests. DOLS and FMOLS approaches that developed by Pedroni (2000 and 2001) were used to estimate the long-term coefficients. Estimation of both the long- and short-run relationship between trade openness and ecological footprint is made with the PMG estimator.

The existence of a long-term relationship between trade openness and ecological footprint has been proven by the applied cointegration test. It has also been determined that the long-term data are homogeneous with the PMG estimator, which allows to reach both long and short-term results and is selected according to the Hausman test. In this direction, it has been revealed that the long-term coefficient obtained from the PMG estimator is approximately 30.68, and an increase of 0.1% that may occur in the ecological footprint will cause an increase of approximately 3% in trade openness. In the short term, the ecological footprint coefficient was found to be positive and statistically significant. This result shows that there is a causal relationship between ecological footprint and trade openness in the short run. In addition, it was determined that the error correction coefficient obtained from the PMG approach was

approximately -0.05 and the relevant coefficient confirmed the long-term equilibrium relationship between the variables in line with the expectations.

Based on these results, it can be concluded that there is a significant relationship between ecological footprint and trade openness. The previous research also supports these findings (Cole, 2004; Al-Mulali & Ozturk, 2015; Wen & Dai, 2020). It can be said that the countries (USA, Japan, Germany, Italy, France) which are at the top of the ranking of ecological footprint value adopt a more open economic structure, and that the increase in ecological footprint values can make these countries produce more, and therefore they can tend to more international trade. According to results, only the error correction term coefficient of the USA is statistically significant with a negative sign which is expected. Thus, the effects of a shock will disappear in the long run. The coefficient of the error correction term is -0.19, which indicates that the effect of a shock will stabilize at a rate of 19% in the first year. This result can also be explained by the fact that the USA is the largest economy in the world. Considering the relationship between ecological footprint and trade openness, it can be concluded that the findings obtained from the study provide significant information to both policy makers and investors.

Contribution Rate Statement

The contribution rates of the authors in the study are equal.

Conflict of Interest Statement

There is no conflict of interest with any institution or person within the scope of the study.

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