

THE EFFECTS OF ECONOMIC GROWTH AND ENERGY CONSUMPTION ON ECOLOGICAL FOOTPRINT AND CARBON EMISSIONS: EVIDENCE FROM TURKEY

Ekonomik Büyüme ve Enerji Tüketiminin Ekolojik Ayak İzi ve Karbon Emisyonları Üzerindeki Etkisi: Türkiye Örneđi

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Abstract

The aim of this paper is to explore the relationship between energy use, economic growth, and environmental pollution in Turkey for the period from 1968 to 2016 by using ARDL bounds test approach. Test findings show that an increase in economic growth and trade openness cause environmental degradation in all models. Although the energy consumption coefficient is positive in all models, it is statistically significant only in the model where the ecological footprint indicator is the dependent variable. Thus, while determining a positive relationship between environmental pollution and economic growth in Turkey, also it can be said that the energy consumption increases ecological footprint. The findings indicate that there is a need to consider not only pollution emissions but also the ecological footprint for environmental degradation. These results raise a number of policy recommendations for Turkey. The existence of an inverted-U shaped relationship between environmental degradation and economic growth actually demonstrate the successful long run sustainable growth in Turkey.

Keywords:

Ecological Footprint, CO2 Emissions, Growth, Energy, ARDL, Turkey

JEL Codes:

B23, C22, K32, N1

Özet

Bu çalışmanın amacı, 1968-2016 yılları arasında Türkiye’de ekonomik büyüme enerji tüketimi ve çevre kirliliđi arasındaki ilişkiyi ARDL sınır testi yaklaşımını kullanarak incelemektir. Bulgular ekonomik büyüme ve dış ticaret açıklığındaki artışın tüm modellerde çevresel bozulmaya neden olduğunu göstermektedir. Enerji tüketim katsayısı tüm modellerde pozitif olmakla birlikte, sadece ekolojik ayak izi göstergesinin bağımlı deđişken olduğu modelde istatistiksel olarak anlamlıdır. Böylece Türkiye’de çevre kirliliđi ve ekonomik büyüme arasında pozitif bir ilişki belirlenirken, enerji tüketiminin ekolojik ayak izini artırdığı söylenebilir. Bulgular yalnızca kirlilik emisyonlarını deđil aynı zamanda çevresel bozulma için ekolojik ayak izini de dikkate almanın gerekli olduğunu gösterir. Bu sonuçlar Türkiye için birçok politika önerisini gündeme getiriyor. Çevresel bozulma ile ekonomik büyüme arasında ters U şeklinde bir ilişkinin varlığı, aslında Türkiye’deki başarılı uzun vadeli sürdürülebilir büyümeyi göstermektedir.

Anahtar Kelimeler:

Ekolojik Ayak İzi, CO2 salınımı, Büyüme, Enerji, ARDL, Türkiye

JEL Kodları:

B23, C22, K32, N1

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1. Introduction

For the last decades, economic development effects on environmental pollution have become one of the most vital areas for academicians because of climate change and also global warming. So, the researchers focused on the environmental Kuznets curve (EKC) hypothesis to analyze the linkage between income level and environmental pollution. It is clear that the carbon dioxide CO₂ emissions and other pollution factors have a high correlation with human activity and also economic growth and energy consumption Stern (2007). Therefore, it is critical to explore the EKC hypothesis for sustainable development strategies. Accordingly, this study examined the EKC hypothesis validity by analyzing the relationship among energy demand, growth, and environmental pollution in Turkey via applying the ARDL bounds test approach.

The EKC hypothesis supports that environmental pollution rises with economic growth to a maximum point and in the second stage of economic growth leads to environmental recovery with environmental improvement therefore there is an inverted U-shaped linkage between environmental pollution and economic growth Panayotou (1993). Turkey has practiced economic growth, lowered destitution, and developed welfare over the past 30 years. These improvements sometimes made an increase in environmental pressure. Also, almost all human activity causes climate change and global warming and threaten the planet.

In literature, there are lots of studies on the EKC hypothesis in several countries for the different periods with using various analysis models. Most of these studies have used CO₂ emissions as an indicator of environmental pollution. But CO₂ emissions can't compensate for environmental degradation because it is only a portion of pollution. Over the last years, the ecological footprint (EF) has received much attention as an exhaustive variable to determine the environmental degradation. Wackernagel and Rees (1996) explain the EF as "...a measure of the load imposed by a given population on nature, it represents the land area necessary to sustain current levels of resources consumption and waste discharge by that population...". Also, it can be said that all over the world consumers who use the nature's outputs and services affect the Earth. These effects correspond to the amount of nature they get to live. These are, a measurable amount of natural capital they need to function.

The EF is meant to supply research of the using resources that can be referred to final consumption. Wackernagel and Rees (1996) discussions demonstrate the EF can be viewed as both a conceptive model and a calculation method. The analysis of EF is recommended to help assign the human appropriation of ecological production, measured in area units. The power of this method is the fact that all human operation of resources and environment is reduced to a sole dimension Van den Bergh and Verbruggen (1999). The ecological footprint can supply a more complete view of environmental degradation. Based on these reasons, this paper aims to investigate the effect of energy consumption, economic growth, financial development, trade openness, and urbanization rates on the ecological carbon footprint, ecological footprint, and carbon dioxide emissions as proxies of environmental degradation for the period 1968–2016 in Turkey. GDP in Turkey has expanded over the %5 average rate for the last fifty years. Therefore, Turkey economic growth experience suggests that one of the most important countries to be examined to show its role in environmental degradation.

This study contributions to the present literature. In order to investigate the relationship among CO₂ emissions, ecological carbon footprint and ecological footprint as proxies of environmental pollution in Turkey for 1968 to 2016 data period. While the basic explanatory

variables in each model are GDP and energy use, financial development, trade openness, and urbanization rate are used as control variables. ARDL bounds testing and Granger VECM causality tests are applied for each model. This paper fills a striking research gap in the present literature, as it attempts to analyze the EKC for Turkey's ecological footprint by employing these indicators and models. Therefore, it is revealed whether the validity of EKC hypothesis changes according to the environmental degradation indicator in Turkey.

Section 2 provides a literature survey relevant to the EKC hypothesis. Section 3 shows data details, model, and econometric method. Section 4 gives the findings, and section 5 gives the conclusions of the study. Ethics of research and publication were followed in this study, which does not require permission from the ethics committee and / or legal / special permission.

2. Literature Review

Grossman and Krueger (1991) firstly examined the EKC hypothesis. Following this study, there are numerous studies that have investigated this relationship and found complexity results for a great variety of countries by using different econometric models over different periods. Although these studies generally adopt CO₂ emissions as the dependent variable (for example Apergis and Ozturk, 2015; Aslan, Destek and Okumus, 2018; Atici, 2009; Azam and Khan; 2016; Balsalobre-Lorente, Shahbaz, Roubaud and Farhani, 2018; Friedl and Getzner, 2003; Jebli, Youssef and Ozturk, 2016; Kais and Sami, 2016; Nasir and Rehman, 2011; Pablo-Romero and De Jesús, 2016; Pata, 2018; Shahbaz, Mahalik, Shah and Sote, 2016; Shahbaz, Solarin, Hammoudeh and Shahzad, 2017; Soytas, Sari and Ewing, 2007) the ecological footprint is used as an important indicator of environmental degradation, recently. The problem with the literature using CO₂ emissions as an environmental pollution indicator to test the EKC hypothesis is that CO₂ emissions alone do not fully represent environmental degradation. For all countries, the analyses of the ecological footprint are vital to reduce environmental degradation. Therefore, this section focuses on current studies investigating the existence of EKC with a particular focus on the ecological footprint.

Al-Mulali and Ozturk (2015), explored the relationship among energy consumption, ecological footprint, urbanization, industrial development, trade openness and political stability for 14 MENA countries over the period 1996-2012. The results showed that these variables cause the environmental degradation in the long and short run. For 93 countries over the period from 1980 to 2008, Al-Mulali, Choong, Sheau-Ting and Mohammed (2015) examined the EKC hypothesis by employing GMM model and empirical results suggested the validity of EKC in upper-middle-and high-income countries. Using a similar model for 144 countries, Ozturk, Al-Mulali and Saboori (2016) tested the validity of the EKC hypothesis for the period 1988 to 2008 by using the ecological footprint variable as an environment indicator and found the same results with Al-Mulali et al. (2015). Mrabet and Alsamara (2017) tested the validity of the EKC in Qatar for the 1980-2011 data period by using GDP, financial development, energy use and trade openness as independent variables and ecological footprint and CO₂ emissions as dependent variables. ARDL bounds test results illustrated that the EKC hypothesis is valid for ecological footprint but invalid for CO₂ emissions. Bello, Solarin and Yen (2018) examined the relationship among environmental degradation and GDP, GDP square and urbanization over the period 1971 to 2016 for Malaysia. The empirical findings suggested the validity of EKC hypothesis. Acar and Asııcı (2017) tested the EKC hypothesis for Turkey over the period from

1961 to 2008 by utilizing the ecological footprint and income variables. Empirical findings support an inverted U-shaped for production footprint and income relationship but not for consumption, import and export footprints. Charfeddine and Mrabet (2017) examined the EKC hypothesis for the period from 1975 to 2017 by utilizing ecological footprint, and results suggested the validity of EKC in 15 countries. Uddin, Salahuddin, Alam and Gow (2017) explored the linkage between economic growth and environmental impact with ecological footprint and GDP, trade openness, financial development variables for the 27 developed and developing countries over the period of 1991-2012. The empirical results showed that real income has a positive effect on ecological footprint in some countries. Destek and Sarkodie (2019), test the validity of EKC hypothesis by using energy use, GDP, financial development, and ecological footprint over the period from 1977 to 2013 and the findings suggested the existence of EKC hypothesis. Dogan, Taspinar and Gokmenoglu (2019) examined the relationship among ecological footprint, GDP, renewable energy consumption, fossil fuel energy consumption, imports and exports of goods and services, urban population and domestic credits provided by the financial sector by utilizing ARDL method in Mexico, Indonesia, Nigeria and Turkey for the period from 1971 to 2013. The empirical results support the validity of EKC hypothesis for each country. Ulucak and Bilgili (2018) investigated the EKC hypothesis in 46 countries for the period from 1961 to 2013 by using the ecological footprint indicator and findings demonstrated the validity of EKC. The validity of EKC found by Sharif, Baris-Tuzemen, Uzuner, Ozturk and Sinha (2020). They studied for Turkey by using quantile ARDL approach. Their analysis includes renewable and non-renewable energy. Another study determining the validity of EKC using the ecological footprint is Bulut (2020).

In addition to studies using the ecological footprint as an indicator of environmental degradation and concluding that EKC hypothesis is valid, there are also studies in the related literature that confirm the invalidity of this hypothesis. Wang, Kang, Wu and Xiao (2013) investigated growth-ecological footprint relationship for a global panel dataset by using a spatial framework, and empirical results showed that EKC hypothesis is invalid. The same result found by Bagliani, Bravo and Dalmazone (2008). They tested the EKC hypothesis for 141 countries by using OLS and WLS analysis by using 2001 ecological footprint data. Destek, Ulucak and Dogan (2018) tested the EKC hypothesis for EU countries over the period of 1980-2013 by utilizing ecological footprint, the real income, its squared term, non-renewable energy demand, renewable energy demand, trade openness variables. Findings of the study does not indicate the validity of EKC. Also, Aydin, Esen and Aydin (2019) test the EKC hypothesis for 26 EU countries in the period 1990 to 2013 by utilizing panel smooth transition regression (PSTR) model and findings not show the validity of EKC. Another study of Aşıcı and Acar (2018), which investigates the relationship between income and footprints for 87 countries for the period of 2004 to 2010, and results do not support the EKC hypothesis validity.

3. Data, Model Specification, and Methodology

3.1. Data

In this paper, it is used ecological footprint and carbon emissions to investigate the relationship between economic growth and environmental pollution in Turkey. CO₂ emissions, ecological carbon footprint and ecological footprint are used as proxies of environmental degradation. GDP per capita and energy use are main explanatory variables. Trade openness,

financial development and urbanization are used as control variables. All variables present in Table 1. The annually dataset used in this paper covers the period from 1968 to 2016.

Table 1. Data Describes

Variable	Describe	Measure	Source
Ecological footprint (log_ef)	The ecological footprint measures how much people demand resources from ecosystem.	Global hectares per person	Global Footprint Network
Ecological carbon footprint (log_ecf)	Ecological carbon footprint refers to the forest area required to keep CO ₂ emissions. CO ₂ emissions are resulted from the	Global hectares per person	Global Footprint Network
Carbon emissions (log_co2)	Burning of fossil fuels and the manufacture of cement.	Metric tons per capita	WDI
Economic growth (log_gdp)	Gross Domestic Product	Per capita (constant 2010 US\$)	WDI
Energy use (log_eu)	Energy demand of primary energy before transformation to other end-use fuels, calculated as indigenous production plus imports and stock changes,	kg of oil equivalent per capita	WDI
Trade openness (log_tra)	Sum of exports and imports of goods and services	% of GDP	WDI
Urbanization (log_urb)	Population living in urban areas as a share of total population	% of total population	WDI
Financial development (log_fd)	Domestic credit provided by financial sector.	% of GDP	WDI

3.2. Model Specification

Since the linkage between ecological degradation and economic growth are examined in Turkey by using variables of ecological carbon footprint and ecological footprint for the first time in this paper, taking into consideration Charfeddine (2017). In this context, we adopt the linear models given in the equations:

$$\begin{aligned} \log_ef_t = & \beta_0 + \beta_1 \log_gdp_t + \beta_2 \log_gdp2_t + \beta_3 \log_eu_t + \beta_4 \log_tra_t + \\ & \beta_5 \log_urb_t + \beta_6 \log_fd_t + \varepsilon_t \end{aligned} \quad (1)$$

$$\begin{aligned} \log_ecf_t = & \beta_0 + \beta_1 \log_gdp_t + \beta_2 \log_gdp2_t + \beta_3 \log_eu_t + \beta_4 \log_tra_t + \\ & \beta_5 \log_urb_t + \beta_6 \log_fd_t + \varepsilon_t \end{aligned} \quad (2)$$

$$\begin{aligned} \log_co2_t = & \beta_0 + \beta_1 \log_gdp_t + \beta_2 \log_gdp2_t + \beta_3 \log_eu_t + \beta_4 \log_tra_t + \\ & \beta_5 \log_urb_t + \beta_6 \log_fd_t + \varepsilon_t \end{aligned} \quad (3)$$

where t denotes time series (1968-2016). Each β represents the slope coefficient of the corresponding variable and finally ε_t indicates the estimation residual. All variables are logarithmically analysed.

3.3. Methodology

3.3.1. Unit Root Test

Time series analysis first step is examining the series stationary. The series stability is tested by the ADF unit root test, proposed by Dickey and Fuller (1979):

$$\Delta Y_t = \alpha + \delta Y_{t-1} + \sum_{i=1}^z \theta_i \Delta Y_{t-i} + \mu_t \quad t=1, \dots, T \quad (4)$$

Y_t is the series which used, Δ is the first difference, t is a time trend, μ_t is the error term and the last z measures the lag of the dependent variable. Akaike Information Criteria determine the lag length. The null hypothesis of ADF test shows that series are not stationary. Testing unit root procedure depends of the statistical significance of the δ parameter. Another unit root test used in the study is the Phillips-Perron (PP) test. The PP test is basically deviating from ADF test in order to deal with the sequence correlation and variance problems in the errors.

3.3.2. Cointegration Test

After the unit root tests, the ARDL bounds test approach is used to determine whether there is a cointegration linkage among the variables in the long run and to estimate the coefficient if there is a cointegration relationship. ARDL test developed by Pesaran, Shin and Smith (1996, 2001), has an advantageous over other test without investigating whether the variables are integrated of $I(0)$ or $I(1)$. This test equation can be specified as follows (Pesaran et al., 2001):

$$\Delta Y_t = \alpha + \sum_{i=1}^n \beta_{1i} \Delta(Y)_{t-i} + \sum_{i=0}^n \beta_{2i} \Delta(X)_{t-i} + \beta_3 Y_{t-1} + \beta_4 X_{t-1} + \mu_t \quad (5)$$

where Δ denotes the difference between dependent (Y) and explanatory variables (X). The difference between each lag in variables indicates the short run dynamics and the dynamics that may exist in the left-hand-side variable. The error correction model used to obtain short run dynamics can be formulated as follows:

$$\Delta(Y)_t = \alpha + \sum_{i=1}^n \beta_{1i} \Delta(Y)_{t-i} + \sum_{i=1}^n \beta_{2i} \Delta(X)_{t-i} + \beta_{3i} ECT_{t-1} + \mu_t \quad (6)$$

The negative and significant coefficient of ECT_{t-1} means that the imbalances that exist in the short run will come to equilibrium in the long run.

3.3.3. Causality Tests

In the case of a cointegration relationship between variables, causality relations should be determined via Vector Error Correction Model (VECM) Granger (1988). VECM is generally specified as follows:

$$\Delta y_t = \phi_0 + \sum_{i=1}^z \phi_{1i} \Delta y_{t-1} + \sum_{i=1}^z \phi_{2i} \Delta x_{t-1} + \sum_{i=1}^z \phi_{3i} \Delta ECT_{t-z} + u_t \quad (7)$$

The long-run dynamics depend on the ECT coefficient (ϕ_{3i}) whereas the short-run causality is based on the Wald test.

4. Empirical Results

4.1. Unit Root Test Results

In the analysis part of this paper, firstly, it is investigated whether the series are stationary by using ADF and PP unit root tests. The lag selection considers the Akaike Information Criterion (AIC).

Table 2. Unit Root Test Results

Variable	ADF	ADF (1 st Diff.)	PP	PP (1 st Diff.)
log_ef	-0.870801(0.788)	-7.031242(0.000)*	-1.435021(0.557)	-16.09674(0.000)*
log_ecf	-1.615295(0.467)	-8.846883(0.000)*	-1.645058(0.4522)	-8.846883(0.000)*
log_co2	-1.937662(0.312)	-6.274046(0.000)*	-2.043172(0.268)	-6.253643(0.000)*
log_gdp	0.583227 (0.987)	-6.575075(0.000)*	0.625590 (0.989)	-6.574720(0.000)*
log_gdp2	0.770837(0.992)	-6.527217(0.811)	0.825926(0.993)	-6.527250(0.000)*
log_eu	-0.916862(0.314)	-0.796069(0.000)*	-1.746742(0.401)	-6.359666(0.000)*
log_tra	-2.125274(0.236)	-5.741413(0.000)*	-2.120873(0.237)	-5.701056(0.000)*
log_urb	-1.650213(0.449)	-4.501110(0.000)*	-2.490280(0.124)	-4.536111(0.000)*
log_fd	0.518026 (0.985)	-5.200447(0.000)*	-0.398219(0.980)	-5.095110(0.000)*

Note: * denotes %1 statistically significance level.

Both test results are presented in Table 2. The results indicate that all variables are stationary in the first difference. That is, all variables are integrated in I(1), which is one of the suitable stationarity conditions for using the ARDL method.

4.2. Cointegration Test Results

ARDL cointegration results for each model are given in Table 3. The results of all models indicate that the F-statistic value is statistically significant at 1% significance level.

Table 3. Cointegration Test Results

	F-statistic	I(0)	I(1)
Model 1 (dependent variable: log_ef)	23.833076	2.88	3.99
Model 2 (dependent variable: log_ecf)	7.0371626	2.88	3.99
Model 3 (dependent variable : log_co2)	20.59490	2.88	3.99

Long run coefficients are obtained after the existence of the cointegration relationship for each model. First of all, the validity of the EKC hypothesis is verified in all models. This finding is same in line with Al-Mulali et al. (2015), Ozturk et al. (2016), Bello et al. (2018), Acar and Ařıcı (2017), Charfeddine and Mrabet (2017), Destek and Sarkodie (2019), Ulucak and Bilgili (2018), Sharif et al. (2020) and Bulut (2020). The results differ slightly in terms of other variables. One of the striking results is that energy consumption reduces the ecological footprint. On the other hand, although the energy consumption coefficient in the other two

models is negative, it is insignificant in terms of both coefficient and probability values. Therefore, it can be said that the measures taken by Turkey for sustainability in terms of energy composition is insufficient for carbon-reducing. While trade positively affects ecological carbon footprint and CO₂ emissions, it has a negative effect on ecological footprint. This result highlights the carbon-enhancing effect of international trade. Although urbanization have a statistically insignificant effect on EF and CO₂, it is observed that it has a negative impact on ECF. Finally, while the financial development coefficient is positive in all models, it is statistically significant only in Model 3.

Table 4. Long-run Coefficient Estimation Results

	Variable	Coefficient	t-statistics(prob)
Model 1	log_gdp	11.52903	5.244865(0.000)
	log_gdp2	-1.359802	-5.033936(0.000)
	log_eu	-0.374190	-2.567810(0.014)
	log_tra	-0.077298	-2.364073(0.023)
	log_urb	-0.042128	-0.2600296(0.796)
	log_fd	0.038109	1.26788(0.212)
	C	-22.55350	-5.454686(0.000)
	Variable	Coefficient	t-statistics(prob)
Model 2	log_gdp	18.85189	7.492025(0.000)
	log_gdp2	-2.248590	-7.102031(0.000)
	log_eu	-0.002450	-0.385474(0.702)
	log_tra	0.087911	1.939120(0.060)
	log_urb	-0.782252	-3.155415(0.003)
	log_fd	0.057757	1.405621(0.168)
	C	-37.98716	-7.941085(0.000)
	Variable	Coefficient	t-statistics(prob)
Model 3	log_gdp	14.87431	7.642699(0.000)
	log_gdp2	-1.805583	-7.307437(0.000)
	log_eu	-0.007475	-1.329180(0.191)
	log_tra	0.071063	1.926288(0.061)
	log_urb	0.060578	0.305289(0.761)
	log_fd	0.095838	2.639898(0.011)
	C	-30.36408	-8.178038(0.000)

The short run results indicate that the error correction coefficient is negative and statistically significant in all models. Also, EKC hypothesis is valid in all models in the short run as well as in the long run. Besides, short run estimation results for all other variables are in line with long run results.

Table 5. Short-run Coefficient Estimation Results

	Variable	Coefficient	t-statistics(prob)
Model 1	log_gdp(-1)	12.62993	5.983154(0.000)
	log_gdp2(-1)	-1.489646	-5.645937(0.000)
	log_eu(-1)	-0.409921	-3.140644(0.000)
	log_tra(-1)	-0.084679	-2.283863(0.028)
	log_urb(-1)	-0.046151	-0.260763(0.795)
	log_fd(-1)	0.041748	1.250795(0.218)
	ECT(-1)	-1.095489	-15.02621(0.000)
	Variable	Coefficient	t-statistics(prob)
Model 2	log_gdp(-1)	19.93734	4.845441(0.000)
	log_gdp2(-1)	-2.378058	-4.743744(0.000)
	log_eu(-1)	-0.002591	-0.388189(0.700)
	log_tra(-1)	0.092973	1.927552(0.062)
	log_urb(-1)	-0.827292	-2.803562(0.008)
	log_fd(-1)	0.061083	1.399451(0.170)
	ECT(-1)	-1.057577	-8.219291(0.000)
	Variable	Coefficient	t-statistics(prob)
Model 3	log_gdp(-1)	11.32270	6.064654(0.000)
	log_gdp2(-1)	-1.374455	-5.906541(0.000)
	log_eu(-1)	-0.005690	-1.335892(0.189)
	log_tra(-1)	0.054095	2.037335(0.048)
	log_urb(-1)	0.046113	0.302784(0.763)
	log_fd(-1)	0.072954	2.659732(0.011)
	ECT(-1)	-0.761225	-13.91374(0.000)

Whether the models contain an econometric problem is tested with the serial correlation, heteroskedasticity and stability tests in Table 6. Diagnostic tests support that there are not any econometric problems in established models.

Table 6. Diagnostic Test Results

	Model 1	Model 2	Model 3
Test	F.statistic(prob.)	F.statistic(prob.)	F.statistic(prob.)
Breusch-Godfrey Serial Corr. LM Test	0.592(0.558)	1.093(0.346)	2.053(0.142)
Heteroskedasticity Test	0.775(0.639)	1.493(0.178)	0.328(0.936)
Ramsey Reset Test	0.009(0.923)	0.205(0.653)	1.183(0.283)

4.3. Causality Test Results

Table 6 presents the results of Granger causality that based on a VEC model. log_ed denotes log_ef for Model 1, log_ecf for Model 2 and log_co2 for Model 3, respectively. According to the Granger causality test results, there is a unidirectional causality from financial development to GDP, from GDP to urbanization and from trade to urbanization in model 1. Also, there is unidirectional causality running from urbanization to ecological carbon footprint

and to GDP, from financial development to ECF, to GDP and to urbanization, from energy consumption to GDP and from trade to urbanization in model 2. Finally, in model 3, there is unidirectional causality from financial development to CO₂ emissions, to GDP, from CO₂ emissions to urbanization, from energy consumption to urbanization and from trade to urbanization.

Table 7. VEC Granger Causality/Bloc Exogeneity Wald Tests Results

	Model 1		Model 2		Model 3	
Dep. Var. : d(log_ed)	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
d(log_gdp)	0.477	0.787	0.414	0.812	0.836	0.658
d(log_gdp2)	0.452	0.797	0.452	0.797	0.869	0.647
d(log_eu)	1.026	0.598	2.610	0.271	0.023	0.988
d(log_tra)	0.458	0.795	3.689	0.158	0.550	0.759
d(log_urb)	0.612	0.736	6.608	0.036	0.416	0.811
d(log_fd)	2.462	0.292	6.791	0.033	5.207	0.074
Dep. Var. : d(log_gdp)	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
d(log_ed)	1.861	0.394	3.720	0.155	0.112	0.945
d(log_gdp2)	0.382	0.826	6.153	0.046	0.259	0.878
d(log_eu)	3.952	0.138	6.223	0.044	0.410	0.814
d(log_tra)	2.883	0.236	6.432	0.040	1.676	0.432
d(log_urb)	2.761	0.251	7.353	0.025	1.603	0.448
d(log_fd)	6.749	0.034	16.345	0.000	7.992	0.018
Dep. Var. : d(log_gdp2)	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
d(log_ed)	1.968	0.373	3.706	0.156	0.099	0.951
d(log_gdp)	0.363	0.833	6.029	0.049	0.365	0.832
d(log_eu)	4.090	0.129	6.246	0.044	0.477	0.787
d(log_tra)	2.966	0.226	6.333	0.042	1.687	0.430
d(log_urb)	2.686	0.261	7.075	0.029	1.503	0.471
d(log_fd)	6.628	0.036	16.016	0.000	8.056	0.017
Dep. Var. : d(log_eu)	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
d(log_ed)	0.074	0.963	2.644	0.266	1.747	0.417
d(log_gdp)	0.850	0.653	0.074	0.963	2.743	0.253
d(log_gdp2)	0.913	0.633	0.078	0.961	2.780	0.249
d(log_tra)	1.545	0.461	0.507	0.775	1.520	0.467
d(log_urb)	0.361	0.834	0.762	0.683	0.195	0.906
d(log_fd)	0.105	0.948	1024	0.599	0.485	0.784
Dep. Var. : d(log_tra)	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
d(log_ed)	2.173	0.337	0.174	0.916	3.043	0.218
d(log_gdp)	0.007	0.996	0.075	0.962	0.734	0.692
d(log_gdp2)	0.019	0.990	0.063	0.968	0.680	0.711
d(log_eu)	1.453	0.483	0.366	0.832	1.211	0.545
d(log_urb)	1.256	0.533	1.345	0.510	1.340	0.511
d(log_fd)	1.500	0.472	0.893	0.639	0.396	0.820

Table 7...

Dep. Var. : d(log_urb)	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
d(log_ed)	0.002	0.998	2.480	0.289	7.252	0.026
d(log_gdp)	5.474	0.064	0.580	0.748	0.746	0.688
d(log_gdp2)	5.345	0.069	0.558	0.756	0.793	0.672
d(log_eu)	3.322	0.189	0.366	0.832	4.756	0.092
d(log_tra)	23.596	0.000	11.122	0.003	32.640	0.000
d(log_fd)	3.968	0.137	1.335	0.513	0.550	0.759
Dep. Var. : d(log_fd)	Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
d(log_ed)	1.808	0.404	2.731	0.255	0.041	0.979
d(log_gdp)	1.021	0.600	0.529	0.767	2.241	0.326
d(log_gdp2)	1.086	0.580	0.555	0.757	2.398	0.301
d(log_eu)	0.822	0.662	2.664	0.263	0.606	0.738
d(log_tra)	0.392	0.821	2.677	0.262	0.313	0.855
d(log_urb)	0.667	0.716	1.787	0.409	0.136	0.934

5. Conclusion

This study investigated evidence of short- and long-run relationship between growth, environmental degradation and energy use in Turkey over the period 1968-2016. We used ecological carbon footprint, ecological footprint and CO₂ emissions as proxies of environmental pollution. While the basic explanatory variables in each model are economic growth and energy consumption, trade openness, financial development and urbanization rates are used as control variables. ARDL bounds test approach and Granger VECM causality tests are applied for each model.

The short and long run results confirmed the validity of EKC hypothesis in all models. This result indicates the existence of the EKC in Turkey regardless of the environmental degradation variable. In the long run, energy consumption has a negative impact on the ecological footprint, but this coefficient is statistically insignificant in other models. While trade openness positively affects ecological carbon footprint and CO₂ emissions, it has a negative effect on ecological footprint. Urbanization have a statistically insignificant effect on EF and CO₂, but it has a negative impact on ECF. Finally, while the financial development coefficient is positive in all models, it has statistically significant impact on CO₂ emissions.

Results raises a number of policy recommendations for Turkey. The existence of an inverted-U shaped relationship between environmental degradation and economic growth actually demonstrate the successful long run sustainable growth in Turkey. However, the negative impact to appear as soon as possible depends on the policies likely to be implemented. In particular, spreading renewable energy consumption in production processes with some incentives and subsidies and allocating resources to green transformation projects should be a priority target in policy-making progresses. Although, according to results, energy consumption reduces the ecological footprint, it is actually a carbon-reducing effect expected from energy consumption. Therefore, the use and production of renewable energy sources should be guaranteed. Also, for reduce the carbon-enhancing impact of trade openness, in the production of export products, productivity should be increased with capital-intensive production techniques. Thus, by obtaining maximum output with minimum input, many cost advantages, especially energy savings, are achieved. Results for financial development imply that financial

sector is not ensure the use of clean and environmentally friendly technologies in Turkey. Therefore, using the financial sector as a tool to finance environmentally friendly investments should be one of the primary goals of this country.

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