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The Relationship between Energy Consumption, CO_2 Emissions and GDP per Capita: A Revisit of the Evidence from Turkey

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ABSTRACT

In this study, the relationship between total energy consumption and carbon dioxide (CO2) emissions is measured in the Environmental Kuznets Curve (EKC) framework. Based on the data in Turkey between the years of 1960-2015, the relationship is analyzed for long term through ARDL-bounds test. In this context, CO2 emissions, gross domestic product per capita, total energy consumption and some other related variables such as capital, labor, openness and population are considered.

In the long-run equilibrium CO2 emissions and energy use appear to be both output elastic where the results indicate that output is a significant determinant of emissions and energy use. In accordance with these results of the inverted U-shaped relationships of both emissions–income and energy consumption–income imply that both environmental damage and energy consumption firstly increase with income, then stabilize, and eventually decline. Various policy recommendations about the estimated income elasticity of carbon emissions and energy consumption are presented with additional analyses of adverse effects. The overall results indicates that EKC is valid, besides, energy conservation policies and controlling CO2 emissions, are likely to have adverse effect on the real output growth of Turkey.

Keywords: Carbon dioxide emission, Energy consumption, Environmental Kuznets Curve

Enerji Tüketimi, CO_2 Emisyonu ve Kişi Başına GSYİH Arasındaki İlişkiye Yönelik Türkiye'den Kanıt

ÖZ

Bu çalışmada enerji tüketimi ve karbon dioksit (CO2) emisyonları arasındaki ilişki Çevresel Kuznets Eğrisi (ÇKE) çerçevesinde ölçülmüştür. İlişki ARDL-sınır testi aracılığıyla Türkiye 1960-2015 verileri için uzun dönemli olarak ele alınmıştır. Bu bağlamda CO2 emisyonları, kişi başı gayri safi yurt içi hasıla ve toplam enerji tüketiminin yanında sermaye, işgücü, ticari açıklık ve popülasyon gibi başka değişkenlere de yer verilmiştir.

Uzun dönem dengesinde CO2 emisyonlarının ve enerji kullanımının çıktıya göre elastik olduğu görülmektedir. Sonuçlar çıktının enerji kullanımı ve emisyon için anlamlı bir belirleyici olduğunu göstermektedir. Emisyon-çıktı ve enerji tüketimi-çıktı arasındaki ters-U biçimindeki ilişkiye ait bulgular çevresel bozulmanın ve enerji tüketiminin çıktı ile birlikte arttıktan sonra azalmaya başladığına işaret etmektedir. Karbon emisyonlarının ve enerji tüketiminin gelire göre tahmin edilen esneklikleri ve ilave olarak bu değişkenler arasındaki ters yönlü etkileşim için çeşitli politika önerileri sunulmuştur. Tüm sonuçlar Türkiye için ÇKE'nin geçerli olduğuna ve enerjiyi koruma politikalarının yanında CO2 emisyonlarını kontrol altında tutmanın da büyüme üzerinde ters yönlü etkisinin olduğuna işaret etmektedir.

Anahtar Kelimeler: Karbon dioksit emisyonu, Enerji tüketimi, Çevresel Kuznets Eğrisi

1. Introduction

One of the major input of the economic development for a country is energy. It's always in demand and the usage of it is growing. Investing in energy while earning income shape the future either for developing countries or the developed ones. Therefore energy sector has a critical importance for economic growth.

Energy can be classified into several types within some different criterion. Primary and Secondary, Renewable and Non-Renewable energy are the main classification for the types of use. Primary energy sources are those that are either found or stored in nature like coal, oil, natural gas, and biomass. These can be convertible for industrial needs such as coal, oil or gas converted into steam and electricity where we define it as secondary energy sources. Especially non-renewable energy such as fossil fuels comes from sources that will run out or will not be replenished for thousands or even millions of years and can be stored, piped, or shipped anywhere in the world. Thus, it is an inexpensive and preferred way for usage. However non-renewable energy takes part as one of an air pollutant and it is harmful for the environment. When fossil fuels are heated, they release carbon dioxide (CO2) into the atmosphere. In brief the extraction and processing of nonrenewable resources creates a great deal of pollution and air, water and land pollution are all consequences of using fossil fuels. Therefore, governments give incentives and support investing in renewable energy programs in order to find nonpolluting alternatives to fossil fuels.

This paper surveys the interaction among energy consumption, carbon dioxide (CO2) emissions and gross domestic product (GDP) per capita in the basis of Environmental Kuznets Curve (EKC) hypothesis. The paper is organized as follows. In Section 2 we provide a brief information about the relation between CO2 emissions-GDP and energy consumption-GDP. We define summarize recent experiences in several countries. Section 3 empirically examines the long term relationship between CO2 emissions, energy consumption and GDP through the channel of Kuznets framework by applying bounds test derived from autoregressive distributed lagged (ARDL) model. Section 4 sets out the main conclusions.

2. Analytical Framework

The objective of the empirical analysis is to examine the relationship between CO2 emissions as an environmental pollutant and energy consumption in Kuznet's framework. In order to carry out the relationship, first the relationship between CO2 emissions and its determinants especially GDP is handled in this frame. The general environmental Kuznet's equation form which describes a rela-tionship between economic growth and pollutants is as follows;

$$Pollution\ level = f\left(gdp,\ gdp2\right) \tag{1}$$

Eq.1 above gives the environmental degradation level conditional to gdp level which is assumed as an inverted U-shaped relationship between national income and environmental degradation. Second degree of polynomial gives the shape as a curve therefore it is known as EKC. Moreover, Kuznet's name attached to the curve by Grossman and Kruger (1991) first. However it was first pointing out the phenomena of the relationship between income inequality and development (Dasgupta et al, 2002). In EKC the expectation of the parameters are positive and negative respectively as have two major explanations as follows: (i) use of environment as a major source of inputs increases at the first stage of economic growth because people are more interested in income than environmental quality, communities correspond weak for environmental regulation. (ii) as a country grows richer, greater environment protection takes place, people value the environment more highly, regulatory institutions become more effective which results in cleaner industrial sector. Shortly, the balance shifts as income rises and the status of environmental quality changes from a luxury to a necessary good as an economy develops. (Dinda et al, 2000).

It is known that EKC is sensitive to functional form, data and the sample of countries used and the sampling duration. Therefore power of the polynomial in GDP per capita is in relation with the income level. Generally it is investigated that high income countries has cubic functional form instead of quadratic in GDP per capita which points out that environmental degradation starts to increase again at high levels of GDP (Magnani, 2000). This is called N-type EKC.

EKC hypothesis may also depend on some other factors, such as industrial structures, technological progresses and environmental policies, etc. Therefore, according to Shen (2006), estimating the EKC hypothesis without testing other important determinants of pollution generally leads to a biased result. However many studies in the literature estimated EKC in a single equation model. Some of the leading theoretical models which aim to explain the EKC generally focus on the emissions of SO_2, NO_x, and CO_2. The results indicate that either emissions of CO_2 or the other pollutants generally dependent on income whereas the pollutants follow an EKC pattern. Selden and Song (1994) focused exclusively on air pollutants in their examination of possible EKC relationships. A more extensive overview about models of EKC can be found in Andreoni and Levinson (2001). Other leading studies on EKC is listed in Table.1 below.

Author(s)	**Time period**	**Country**	**Methodology**	**Result**
Lebe (2016)	1960-2010	Turkey	Bounds Test, Granger Causality	EKC is Valid (inverted U-type)
Sahli, Rejeb (2015)	1996-2013	MENA countries	Dynamic Panel Time Series	EKC is Valid (inverted U-type)
Ergün, Polat (2015)	1980-2010	30 OECD countries	Panel Time Series, VECM	EKC is Valid (inverted U-type)
Bozkurt, Okumuş (2015)	1966-2011	Turkey	Cointegration	EKC is Valid (inverted U-type)
Artan et al. (2015)	1981-2012	Turkey	Time Series	EKC is Valid (inverted U-type)
Lau et al. (2014)	1970–2008	Malaysia	ARDL ve VECM Granger	EKC is Valid (inverted U-type)
Dam et al. (2014)	1960-2010	Turkey	Dynamic LS	EKC is Valid (inverted U-type)
Koçak (2014)	1960-2010	Turkey	ARDL Bounds Test	EKC is Valid (inverted U-type)
Aytun (2014b)	1971-2010	10 Developing countries	Panel Time Series	EKC is Valid (inverted U-type)
Akın (2014)	2001-2011	BRICS	Panel data analysis HEKK,SE,RE	EKC is Valid (inverted U-type)
Urataş, Uysal (2014)	1992-2010	BRICT	Panel Time Series	EKC is Valid (inverted U-type)

Author(s)	Time period	Country	Methodology	Result
Gündüz (2014)	1960–2008	18 OECD countries	Panel Time Series	EKC is Valid (inverted U-type)
Aytun (2014a)	1981-2010	83 Country	Panel Time Series	EKC is valid (N-type)
Şahinöz, Fotourehchi (2013)	1994-2010	26 OECD countries	Panel Time Series	EKC is valid (N-type)
Erol et al. (2013)	1995-2011	10 rising country	Panel Time Series	EKC is Valid (inverted U-type)
Çınar et al.(2012)	1985-2009	8 developing 6 developed	Panel Time Series	U type in developing and inverted-U type in developed countries
Karaca (2012)	1980-2007	37 Country	Panel Time Series	EKC is valid (N-type)
Güriş , Tuna (2011)	1971–2008	88 countries	Panel Time Series	EKC is Valid (inverted U-type)
Saatçı , Dumrul (2011)	1950-2007	Turkey	Cointegration	EKC is Valid (inverted U-type)
Pao, Tsai (2011)	1980–2007	Brazil	Panel Time Series	EKC is Valid (inverted U-type)
Wang et al. (2011)	1995-2007	China	Panel time Series, VECM	EKC is Valid (inverted U-type)
Arı , Zeren (2011)	2000–2005	17 Mediterranean	Panel Time Series	EKC is valid (N-type)
Aslan (2010)	1968-2005	Turkey	Panel Time Series	EKC is valid (N-type)
Lean, Smyth (2010)	1980-2006	ASEAN	Panel time Series, VECM	EKC is Valid (inverted U-type)
Akyıldız (2008)	1990-2000	Turkey	Panel time Series	EKC is valid (N-type)
Tokatlıoğlu, Atan (2007)	1923-2005	Turkey		EKC is Valid (inverted U-type)
Başar , Temurlenk (2007)	1950-2000	Turkey	Time Series	EKC is valid (inverted N-type)
Martinez, Bengochea(2004)	1975-1998	22 OECD countries	Panel Time Series	EKC is valid (N-type)
Kaufmann et al. (1998)	1974-1989	23 Country	Panel Time Series	EKC is Valid (inverted U-type)
Torras, Boyce (1998)	1977-1991	42 Country	Panel Time Series	EKC is valid (N-type)
Panayotou(1993)	1982-1994	30 Country	Panel Time Series	EKC is Valid (inverted U-type)

Table 1. Literature Review (Güllü,*et al.*, 2017)

According to World Development Indicators (2017) of The World Bank, Turkey's share of CO2 emissions in the world is 77th place and the share of Turkey in the total world carbon emissions is below 1% in 2017. If we focus on the literature which is summarized for Turkey in Table 2, relationship between energy consumption and pollutants, we see that it is considered in two groups. The first one is studies which use the EKC pattern in which the dependent variable is the pollutant variable. And the second approach is concerning the energy consumption as dependent variable. The studies about these relationships are presented in Table 2 where the empirical investigations conducted within causality approach or by regression analyses.

The second approach is generally tested and synthesized by four hypotheses which are named as neutrality, conservation, growth and feedback hypothesis. Growth hypothesis becomes valid if energy consumption is a cause of economic growth. If the direction of causality becomes adverse, this unidirectional causality supports conservation hypothesis oppositely. If energy consumption is ineffective on economic growth and vice versa, neutrality hypothesis becomes valid. The fourth hypothesis is feedback hypothesis where the direction of causality relationship is bidirectional between energy consumption and economic growth. According to those hypothesis which is based on the direction of causalities between energy consumption and economic growth, Table 2 gives the empirical literature of the studies related with Turkey with the conclusion of direction of causalities.

Authors	**Period**	**Variables**	**Methodology**	**Conclusion**
Soytas et al. (2007)	1960–1995	Energy consumption; GDP	Granger causality; VEC; JJ cointegration	EC → GDP
Soytas and Sari (2003)	1950–1992	Energy consumption; GDP	Granger causality; VEC; JJ cointegration	EC → GDP
Altinay and Karagol (2004)	1950–2000	Energy consumption; GDP	Hsiao causality; Zivot Andrews structural break test	EC ≠GDP
Say and Yucel (2006)	1970–2002	GNP, total energy consumption, Carbon emissions, population	OLS	EC has positive effect on GDP CO2 emissions have positive effect on EC
Lise and Monfort (2007)	1970–2003	Energy consumption; GDP	Granger causality; VEC; JJ cointegration	GDP →EC
Jobert and Karanfil (2007)	1960–2003	Energy consumption; GDP	Granger causality; VAR.	EC ≠GDP
Erdal et al. (2008)	1970–2006	Energy consumption; GDP	Granger causality; VEC; JJ cointegration	EC↔GDP
Halicioglu (2009)	1960–2005	Carbon emissions; Energy consumption; GDP; Foreign Trade	Granger causality ARDL cointegration	EC↔CO2 CO2↔GDP FT ≠CO2
Soytas and Sari (2009)	1960–2000	Energy consumption; carbon emissions; Labor; gross fixed capital investment; GDP	TY causality	EC ≠GDP CO2≠GDP CO2→EC EM→EC

Notes: → , ↔ and ≠ represent unidirectional causality, bidirectional causality, and no causality, respectively. Abbreviations are defined as follows: VAR: vector autoregressive model, VEC: vector error correction model, JJ: Johansen–Juselius, TY: Toda–Yamamoto, OLS: ordinary least squares, ARDL: autoregressive distributed lag, GDP: real gross domestic product, EC: energy consumption, CO2: carbon dioxide, FT: foreign trade, EM: employment ratio.

Table 2. Summary of causality test results with related earlier studies for Turkey (Öztürk and Acaravcı, 2010)

3. Empirical Analysis

In this section, we analyze the relationships among pollution, GDP per capita, and energy consumption variables, which are, CO2_2010$_GDP; carbon dioxide emissions, GDPPC_C_2010$; GDP per capita, ENRGY; energy consumption. Moreover we use some additive variables which are; EMP_AGGR; employment in agriculture, EMP_IND, employment in industry and POP; population, in order to increase the model information. All the variables are in logarithmic form. The analysis period covers 1960-2015 for Turkey and the econometric analysis consists of bounds test based on ARDL (autoregressive distributed lag) model. The source of the data is World Development Indicators- 2016.

In order to analyze causality relationship between the variables, we run two different model groups in ARDL models that are:

- First model group consists of variables CO2 emission, GDP per capita and energy consumption as dynamic regressors and in addition to that, population and employment in agriculture and industry as fixed regressors. In this group CO2 emission is considered as dependent variable in order to analyze the causal relationship from energy to CO2 emissions. The models which contain the GDP per capita and its square has the form of EKC.

- Second model group consists of variables as the first model group where the dynamic and fixed regressors are the same without employment of agriculture in fixed regressors. In this group energy consumption is considered as dependent variable in order to analyze the causal relationship from CO2 emissions to energy consumption. EMP_AGGR is excluded from fixed regressors to prevent decrease in model information. GDP per capita included in some models in this group in order to analyze the relationship in the context of conservation hypothesis . Moreover the square of GDP per capita is included in order to regulate the analyses in the pattern of Kuznet's curve.

ARDL methodology is used in which the relevant variables may be I(0) or I(1) which avoids classification of the variables into stationary or integrated in order one. For this procedure there is no need for unit root pre-testing, unlike standard cointegration tests. According to the variables y, x and z where y and x are dynamic regressors in which y is the dependent variable, and z represents the fixed regressors, an information criterion is used to determine the lag length. The Akaike, Hannan-Quinn and/or Schwartz criterion tend to favor general specifications with many lags (up to 4 in the tests) to choose the most parsimonious model. For a specification with one lag, the equation for an ARDL (1,1) model is as follows;

$$Y = f\left(Y_{t-1},\ X_t,\ X_{t-1},\ Z_t\right) \tag{2}$$

A test for cointegration as suggested by Pesaran, Shin, and Smith (2001) can be performed which is conditional on the chosen lag length in Eq.2, and the specification for the model where the test statistic estimated is as follows in Eq.3 where D represents first differenced variable.

$$DY = f\left(Y_{t-1},\ X_{t-1},\ DX_t,\ Z_t\right) \tag{3}$$

In Eq.3 bounds test is conducted with an F-statistic which is estimated by restriction of Yt-1 and Xt-1 in Eq.3. If the estimated F-statistic is smaller than the lower bound than null of no cointegration is not rejected. If it is higher than the upper bound then null is rejected which means that there is a long run relationship between Y and X which is represented in Eq.4.

$$Y = f\left(X_t,\ Z_t\right) \tag{4}$$

Eq.4 is the estimated long run solution. Moreover an error correction model (ECM) can be estimated from the long run relationship where et-1 represents equilibrium error (or disequilibrium term) occurred in the previous period (lagged) which is derived from Eq.4.

$$DY = f\left(DY_{t-1},\ DX_{t-1},\ DZ_t,\ e_{t-1}\right) \tag{5}$$

According to the ECM, the change in one variable is related to the change in another variable, as well as the gap between the variables in the previous period. All the variables in the ECM are stationary, and therefore, the ECM has no spurious regression problem.

Dependent Variable	**MODEL-1**	**MODEL-2**	**MODEL-3**	**MODEL-4**
CO2_2010$_GDP	**ARDL(1,1)**	**ARDL(2,1)**	**ARDL(1,1)**	**ARDL(1,0)**
CO2_2010$_GDP(-1)	0,14	0,47*	0,15	-0,09
CO2_2010$_GDP(-2)		0,42*		
ENRGY	1,01*	0,42*	1,00**	1,09
ENRGY(-1)	-0,22*	-0,43*	-0,23*	
GDPPC_C_2010$	6,93*		6,84*	
GDPPC_C_2010$^2	-0,43*		-0,42*	
EMP_AGGR				0,03
EMP_IND				0,02
POP			0,03	
C	-34,02*	-0,05*	-3,40*	-6,16
R-sq,	**0,98**	**0,97**	**0,98**	**0,89**
F stat	**508,55***	**324,49***	**415,70***	**30,65***
D,W, stat	**1,80**	**1,78**	**1,81**	**1,57**
Akaike info criterion	**-4,36**	**-3,93**	**-4,32**	**-5,36**
Schwarz criterion	**-4,14**	**-3,74**	**-4,06**	**-5,04**
Hannan-Quinn criter	**-4,27**	**-3,86**	**-4,22**	**-5,26**
*,** and *** indicates significance about %1, %5 and %10 respectively				

Table 3. ARDL Models with Dynamic and Fixed Regressors for CO2 Model

According to the first model group in our framework is carry out whether the effect of energy consumption on CO2 emissions is significant as expected or not. Focusing on the current literature carries out that the effect of energy consumption on CO2 emissions is generally positive however such an empirical study focusing on the bilateral interaction does not exist. Therefore a point of view of the interaction from CO2 emissions to energy consumption is considered in the second model group.

In the first model group where the interaction from energy consumption to CO2 emissions is investigated, the estimated coefficients are shown in Table.2 above. The signs for energy consumption is positive and the coefficients for all models are significant as expected. When we focus on the other variables considered, we see that EKC pattern is valid for CO2 emissions in Turkey. For both Model-1 and Model-3 GDP per capita has positive and square of GDP per capita has negative signs with both in significance which indicate that air pollution follows the EKC pattern in Turkey. The estimated signs about the other variables employments in agriculture and industry and population are positive as expected however the coefficients are insignificant which means that there is no evidence that employment either in industry or in agriculture has not have an influence in air pollution as population.

Dep. Var.: D(CO2_2010$_GDP)	**MODEL-1**	**MODEL-2**	**MODEL-3**	**MODEL-4**
D(CO2_2010$_GDP(-1))		-0,418*		
D(ENRGY)	1,013*	0,420*	1,004*	
GDPPC_C_2010$	6,929*		6,844*	1,418
GDPPC_C_2010$^2	-0,428*		-0,424*	-0,093
EMP_AGGR				0,073***
EMP_IND				0,222
POP			0,031*	

Dep. Var.: D(CO2_2010$_GDP)	MODEL-1	MODEL-2	MODEL-3	MODEL-4
C	-34,019*	-0,046*	-3,403*	-8,516
ENRGY(-1)	0,793*	-0,009*	0,771*	0,216
CO2_2010$_GDP(-1)	-0,857*	-0,115*	-0,852*	-0,908*
R-sq	**0,682**	**0,503**	**0,683**	**0,550**
F stat	**20,148***	**11,885***	**16,485***	**4,686***
D,W, stat	**1,804**	**1,779**	**1,808**	**1,971**
Akaike info criterion	**-4,361**	**-3,930**	**-4,325**	**-4,129**
Schwarz criterion	**-4,137**	**-3,742**	**-4,065**	**-3,802**
Hannan-Quinn criter,	**-4,275**	**-3,858**	**-4,225**	**-4,024**
Bounds Test F stat	**18,91**	**8,72**	**17,34**	**7,66**

*,** and *** indicates significance about %1, %5 and %10 respectively
I(0) Bound (5% signif): 3,62
I(1) Bound (5% signif):4,16

Table.4 Equations for Bounds Tests Pesaran, Shin, and Smith (2001)

ARDL models in Table.3 are estimated in order to determine the lag lengths. However the parsimonious models can also be used in interpretation also. Therefore, as a result for Table.3 it can be seen that there is an interaction from GDP and energy consumption to CO2 emissions which can be defined in EKC pattern. Peseran, Shin and Smith (2001) methodology to estimating Eq.3 consists of three steps.

First, existence of the long-run relationship among CO2, and energy consumption is tested with GDP and its square with also employment in agriculture and industry and population under the null hypothesis of “non-existence of cointegration” by the bounds test which is tested by F-statistic. The asymptotic distribution of this F-statistic which is presented under the Table 4 is non-standard irrespective of whether the variables are stationary or I(1). There are two critical values considered as upper and lower bound which assume that all variables are I(1) and second assumes I(0) for all respectively. These bounds cover all possible classifications of the variables into I(0) and I(1) or even fractionally integrated. According to the bounds test, the F-statistic is calculated above the upper level of the bound, thus, the null is rejected which indicate cointegration all four models. Technically, excluding the lagged level of variables ENRGY(-1) and CO2_2010$_GDP(-1) increases the model information statistically.

	MODEL-1	MODEL-2	MODEL-3	MODEL-4
ENRGY	0,93*	-0.082610*	0.904871*	1,00*
GDPPC_C_2010$	8,09*		8,04*	0.386119
GDPPC_C_2010$^2	-0,50*		-0.497539*	-0.073348
EMP_AGGR				0.026416
EMP_IND				0.019971
POP			0.036486	
C	-39,70*	-0.404540*	-39,96	-5,67

*,** and *** indicates significance about %1, %5 and %10 respectively

Table 5. Long Run Relationship for CO2_2010$_GDP

Table 5 is related with the second step drawing the cointegration relationship between CO2 and energy consumption with the external variables considered in four models which gives the results for those estimations. Kuznets approximation requires a priori information on various parameters which is presented in Eq.1.

However consideration of energy consumption makes the model more complex. According the results presented in Table 5, EKC hypothesis is supported in Model-1 and Model-3 with positive signs for GDP and negative for the square of it. In these models, the long-term coefficients of energy consumption are also positive which point out that energy consumption dominates CO2 emission level.

	MODEL-1	MODEL-2	MODEL-3	MODEL-4
D(CO2_2010$_GDP(-1))		-0.418244*		
D(ENRGY)	1,23*	0.419601*	1,20*	1,10*
D(GDPPC_C_2010$)	6,94*		6,46*	1,66*
D(GDPPC_C_2010$ ^ 2)	-0,45*		-0.421320*	-0.152494*
D(EMP_AGGR)				0.056053*
D(EMP_IND)				0.167188*
D(POP)			0.176452	
CointEq(-1)	-0,64*	-0.114881*	-0.629247*	-1,01*
*,** and *** indicates significance about %1, %5 and %10 respectively				

Table 6. Error Correction Model fort the Long Run Relationships

In spite of the fact that, the second step for Peseran, Shin and Smith's methodology is drawing the long-run relationship, the third step carries out the lagged error correction term (CointEq(-1)) which represents the short-run relation presented in Table 6. The sign for the error correction term is negative as expected is highly significant in all cases except Model-4 in which either the long-run coefficients statistically, or the short-run coefficients are economically insignificant. As a result for the EKC hypothesis we see that Model 1 and Model 3 are appropriate models where the considered significant variables are CO2 emissions, energy consumption and GDP. According to the results combined both long run and short run, we see that energy consumption has a positive and significant role in CO2 emissions and the pattern of the inverted-U shape is also valid for Turkey. The significant lagged error-correction terms obtained from Model 1 and Model 3 also support the long run relation among relevant variables. As Kremers et al. (1992) indicated, significant error correction terms is a more efficient way of establishing long-run relationship. Thus, we conclude that CO2 emissions and energy consumption in the EKC model do have a long-run relationship.

	MODEL-5	MODEL-6	MODEL-7
	ARDL(1,0)	ARDL(1,1)	ARDL(1,1,3)
CO2_2010$_GDP(-1)			-0,116
CO2_2010$_GDP(-2)			-0,174**
CO2_2010$_GDP(-3)			0,109
CO2	0.5119*	0,248*	0,611*
ENRGY(-1)	0.275*	0,423*	0,441**
GDPPC_C_2010$	-2.765*	0,77*	0,831*
GDP(-1)		-0,251**	-0,353**
GDPPC_C_2010$^2	0.1922*		
EMP_IND			0,057**
POP			0,043
C	14.901*	-0,368*	-0,928
R-sq,	**0,99**	**0,99**	**0,99**

	MODEL-5	MODEL-6	MODEL-7
	ARDL(1,0)	ARDL(1,1)	ARDL(1,1,3)
F stat	6239*	5450*	1378*
D,W.* stat	1,54	1,66	2,14
Akaike info criterion	-5,1062	-4,9713	-6,02008
Schwarz criterion	-4.920388	-4.785475	-5.553018
Hannan-Quinn criter	-5.034785	-4.899872	-5.870666
*,** and *** indicates significance about %1, %5 and %10 respectively			

Table 7. ARDL Models with Dynamic and Fixed Regressors for Energy Consumption Model

In order to carry out the bilateral interaction among energy consumption and CO2 emission, the interaction from CO2 emissions to energy consumption is considered in the second model group. Therefore second research strand in our framework is to carry out whether the effect of CO2 emissions and GDP on energy consumption is significant and is adapted to Kuznets form or not. In the second model group where the interaction from CO2 emissions to energy consumption is investigated, the estimated coefficients of several ARDL models are shown in Table.7 above. These three model are conducted in order to determine model information by corresponding the lag lengths and the dynamic and fixed regressors.

For Model-5, the dependent variable energy consumption is followed by dynamic regressor CO2 emissions. GDP and square of GDP are defined as fixed regressors. For Model-6, the dependent variable energy consumption is followed by dynamic regressor GDP. CO2 emissions is defined as fixed regressor. Moreover in Model-7 dynamic regressors are GDP and CO2 emissions whereas fixed ones are employment in industry and population.

The signs for dynamic regressors CO2 emissions and GDP in all three models are positive and significant as expected. However in Model-5 the Kuznets curve pattern seems to be U shape instead of inverted-U shape as in EKC pattern for energy consumption which means that in the first stages of GDP the relation between energy and GDP is negative before a local minimum (threshold) point. After that stage the relation becomes positive as expected. Before threshold level of GDP, an increase in GDP level reduces energy consumption and vice versa after the threshold. It gives an evidence that, conservation hypothesis is valid when the economy grows rapidly. According to model-6, we consider just GDP without GDP square where the coefficient of GDP seems to be positive significant independent from local a threshold level for GDP. It points out that GDP positively contribute to energy consumption and conservation hypothesis is valid for the general economy. Model-7 gives the model results where all corresponded variables are included. The results are the same as the first two models as expected. However an important results different from other findings employment in industry positive and significantly contribute the dependent variable energy consumption while population has no effect.

Dep. Var.: D(LENERGY)	MODEL-5	MODEL-6	MODEL-7
D(GDPPC_C_2010$)		0,7707*	0,8316*
GDPPC_C_2010$	-2,7653*		
GDPPC_C_2010$^2	0,1922*		
GDPPC_C_2010$(-1)		0,5190*	0,4779*
D(CO2_2010$_GDP)			0,6111*

Dep. Var.: D(LENERGY)	**MODEL-5**	**MODEL-6**	**MODEL-7**
D(CO2_2010$_GDP(-1))			0,0653
D(CO2_2010$_GDP(-2))			-0,1094
EMP_IND			0,0570**
POP			0,0433
C	14,901*	-0,3679**	
ENRGY(-1)	-0,7247*	-0,5767*	-0,5582*
CO2_2010$_GDP	0,5119*	0,2479*	
CO2_2010$_GDP(-1)			0,4292*
Bounds Test F stat	**67,5149**	**17,6671**	**2,8177**
*,** and *** indicates significance about %1, %5 and %10 respectively I(0) Bound (5% signif): 3,62 I(1) Bound (5% signif):4,16			

Table 8. Equations for Bounds Tests Pesaran, Shin, and Smith (2001)

Table 8 represents Eq.3 results for the second strand of the framework. Bounds test F-statistic is carried out from Peseran, Shin and Smith's methodology. First, cointegration is tested by restricting first lagged dynamic variables in level. Upper and lower bound where upper bound assumes that all variables are I(1) and lower bound assumes I(0) are presented at the bottom of Table-8. According to the bounds cointegration test, F-statistics are calculated above the upper level of the bound for model 5 and model 6 which point out that the null is rejected indicating cointegration for those. However the null cannot be rejected for model 7. Although model information seems to be better. Thus, model 5 and model 6 is corresponded in order to carry out the long run relationship among energy consumption, CO2 emissions and GDP. Table 9 gives the long run relationship coefficients for these models.

	MODEL-1	**MODEL-2**
CO2	0,706*	
GDPPC_C_2010$		0.899*
C	20,559*	-0.637**
*,** and *** indicates significance about %1, %5 and %10 respectively		

Table 9. Long Run Relationships for Energy Consumption Model

According to the second research strand which draws the long-run relationship coefficients where energy consumption is dependent while CO2 emissions and GDP per capita are corresponded as internal variables, model-1 and model-2 gives significant and positive coefficients contributing energy consumption for both CO2 emissions and GDP per capita respectively. This result is consistent with the ARDL models which are presented in Table 7. Significant coefficient of GDP in model 2 also supports causality from GDP to energy consumption which means that economic growth dominates energy consumption for Turkish economy and moreover conservation or feedback hypothesis is valid.

	MODEL-5	**MODEL-6**
GDPPC_C_2010$	-2,6333*	
GDPPC_C_2010$^2	0,1819*	
D(GDPPC_C_2010$)		0,7707*
CO2_2010$_GDP		0,2479*
CointEq(-1)	-0,6969*	-0,5767*

	MODEL-5	MODEL-6
R-sq,	0,58	0,78
D,W.* stat	2,07	1,66
Akaike info criterion	-4,3888	-5,0468
Schwarz criterion	-4,2772	-4,9353
Hannan-Quinn criterion	-4,3459	-5,0039

Table 10. Error Correction Model for Energy Consumption

Table 10 represents the error correction model derived from the system of cointegrated variables of energy consumption model. The lagged error correction terms, the short-run relation coefficients are statistically significant and also have the expected sign in all cases which means that the error correction mechanism is working. It points out that the variables in the error-correction representation adequately capture short-run expectations. The estimated coefficients -0,6969 and -0,5767 indicate that about 69 percent and 57 percent of disequilibrium is corrected between 1 year for model 5 and model 6 respectively.

According to the results combined both long run and short run, we see that CO2 emissions and national income has a positive and significant role energy consumption for Turkey. The significant lagged error-correction terms obtained from Model 5 and Model 6 also support the long run relation among relevant variables. Thus, we conclude that CO2 emissions and national income have a significant and positive impact on energy consumption which makes the feedback hypothesis valid for Turkey.

4. Conclusion

The paper examined the linkage between environmental degradation, energy consumption and national income in the framework of three research strands which are handled in literature by Ozturk and Acaravci (2010), Ang (2007), Ang (2008) , Soytas et al. (2007), Soytas and Sari (2009), Zhang and Cheng (2009). The first strand focuses on the environmental degradation and output in the EKC pattern which assumes an inverted-U shaped relationship between pollutants and GDP. The phenomena is examined via literature surveys by Stern et al. (1996), Borghesi (1999), Stagl (1999), Dinda (2004), Bo (2011) and Nahman and Antrobus (2005). Additionally, Stern (2004) had a critique on EKC. The second strand of the research focuses the causal relationship between energy consumption and GDP where the direction of the causality provides the validity of neutrality, conservation, growth and feedback hypothesis. Growth hypothesis points out that energy consumption causes economic growth. The adverse direction supports conservation hypothesis. The bidirectional causality points out feedback hypothesis. No causal relation between energy consumption and economic growth supports neutrality hypothesis. Ozturk (2010) provide literature review on the empirical results from causality tests between energy consumption and national income per capita. Additionally, Payne (2010) considered such a survey for electricity consumption. The third strand combines first two approaches which carry out the relationship among national income, environmental degradation and energy consumption.

In first group of models the impact of energy consumption to CO2 emissions is investigated in the EKC framework. According to the cointegration analysis derived from ARDL models the linear combinations of CO_2 emissions, energy consumption and GDP are cointegrated. EKC pattern has found to be valid for CO_2 emissions in Turkey with the information from the model that energy consumption also stimulates air pollution in a significant level. However there is no evidence that employment and population have an influence in air pollution. According to the long run relationships and error correction models, a positive and significant role of energy consumption on CO_2 emissions has found following the pattern of EKC for Turkey. This implies that with the increase in the energy consumption CO_2 emissions also increases. Second research strand in our framework carried out the positive effect of CO_2 emissions and GDP on energy consumption which points out that CO_2 emissions increase energy use. Therefore the relation between energy consumption, CO_2 emissions and national income are found to be positive among each other. Additionally GDP seems to be the dominator of both CO_2 emissions and energy consumption. Significant coefficient of GDP in model 2 also supports conservation or feedback hypothesis for Turkish economy.

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