Does financial development improve environmental quality in Turkey? An application of endogenous structural breaks based cointegration approach

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Abstract

Purpose – The purpose of this paper is to investigate the long-run effect of financial sector development, energy use and economic growth on carbon emissions for Turkey, in presence of possible regime shifts over a period of 1960-2013.

Design/methodology/approach – Along with the conventional unit root tests, Zivot-Andrews unit root test with structural break has been employed to check the stationarity of variables. The cointegrating relationship between variables is investigated by using the autoregressive distributed lag bounds test and Hatemi-J threshold cointegration test.

Findings – The results confirm a cointegrating relationship between the variables. The long-run relationship between the variables has gone through two endogenous structural breaks in 1976 and 1986. Development of financial sector improves environmental quality whereas energy use and economic growth degrade it. The results challenge the validity of environmental Kuznets curve hypothesis in Turkish economy.

Research limitations/implications – The study uses domestic credit to private sector as a proxy for development of financial sector. The model can be improved by constructing an index of financial development instead of using a single determinant as a proxy for financial development.

Practical implications – The study may pave the way for policy makers to capture important environmental pollutants in better way and develop effective and efficient energy and economic policies. This may make significant contribution to curbing CO₂ emissions while sustaining economic growth.

Originality/value – This is the only study to examine long-run impact of financial sector development on carbon emissions, using the threshold cointegration approach. Hence, the study is a gentle request to reduce the possible omitted variable econometric estimation bias and fill the gap in the existing literature.

Keywords Turkey, Environmental Kuznets curve, Structural break, Carbon emissions, Cointegration, Financial development

Paper type Research paper

1. Introduction

Environmental degradation and global warming (greenhouse gas emissions) are currently major global issues. Since the start of industrial revolution, countries are making efforts to achieve the maximum possible economic growth. This race has led to an unprecedented rise in the greenhouse gas emissions in general and carbon emissions in particular, which resulted in global warming and ozone depletion. The effects of climate change, global warming and environmental degradation are already visible in escalating the occurrence of severe weather events, increased intensity of storms, changing rainfall patterns and an ever increasing sea level. Such changes have sufficiently great impact on the proper working of ecosystems, the sustainability of forests and the human well-being (Boutabba, 2014).
Various scientific studies have warranted for the policies of sustained reductions in CO₂ emissions by countries (Lamb et al., 2014). The concerns of environmental degradation and global warming have turned out to be an essential part of domestic and international policy debates in the recent past. The increasing environmental threats are the concern for general public and a part of political, social and economic choice (Ayeche et al., 2016). A key strategic objective of worldwide efforts to alleviate the harmful effects of climate change is to cut back worldwide CO₂ emissions; see Tamazian and Bhaskara Rao (2010).

The peril of environmental degradation and climate change has directed the attention of researchers on the causal interactions between environmental pollutants and various macroeconomic variables. Thus, many researchers find it interesting to explore the determinants of CO₂ emissions and the strength of relationship between them. Economic growth, energy use, volume of trade, urbanization and foreign investment (FDI) are found to be the most common determinants of carbon emissions (Sharif Hossain, 2011; Sharma, 2011; Rault et al., 2015; Tang and Tan, 2015). But the research in this research strand, using the conventional econometric methodology, is now overstudied (Al-mulali et al., 2015; Dar and Asif, 2017).

The development of financial sector in a country plays an important role in achieving a higher growth of income and significantly affects the environmental quality (Jalil and Feridun, 2011). Consequently, many researchers have extended their analysis for development of financial sector. An efficient financial intermediation may make it easier and convenient for consumers to buy consumer durables and emit more greenhouse gases (Zhang, 2011). This may bring increased levels of energy-prone economic activities, and may affect the quality of environment. However, some authors have opposed the above arguments and stated that financial development may improve the quality of environment. For instance, financial development helps listed companies to enhance energy efficiency and cut the carbon emissions intensity significantly. Tamazian et al. (2009) has further pointed out that the omission of financial sector development from the determinants of environmental degradation may lead to flawed results. Despite its relevance, the financial development-environment nexus has not received much attention in case of Turkey. Hence, we find it interesting to study the nature of relationship between carbon emissions and financial development because proper and sustainable environmental policies can be framed after understanding the nature of relationship between the two, along with the conventional determinants of CO₂ emissions.

In the last three decades, Turkey has implemented various financial and economic reforms to liberalize the economy in general, and financial sector in particular (Gokmenoglu et al., 2015). In the last decade, the financial sector in Turkey has experienced a considerable development due to the efficient functioning and sound growth of its banking system. Turkey’s industrial production depends heavily on the consumption of fossil fuels. World Bank reports that fossil fuel consumption constitutes more than 90 percent of Turkey’s energy use. The climate change performance index (Bals et al., 2013) ranks Turkey 51st in performance of climate protection performance index among 61 countries, emitting 90 percent of greenhouse gases in the world. Ediger et al. (2006) has pointed out that Turkey suffers from the lack of energy policies and inferior energy efficiency in comparison with other countries. Turkey has witnessed impressive growth in output and development of banking system, in the last decade. The yearly growth rate of CO₂ emissions was 4 percent in 2010, which increased from 0.5 percent in 1960 (Ozturk and Acaravci, 2013). The criticism for Turkey’s weak climate protection performance and the debate on the relationship between development of financial sector of an economy and its environmental quality makes the study interesting.

Recently, some attempts have been made to study the impact of financial development on environmental quality in Turkey. Ozturk and Acaravci (2013) examined the impact of financial development on CO₂ emissions in Turkey, using autoregressive distributed lags.
model for an annual data set of 1960-2007. The authors found no long-run relationship
between the two variables. On the same note, Gokmenoglu et al. (2015) studied the Turkish
data for a period 1960-2010, using Johansen and Juselius (1990) and Engle and Granger
(1987) tests and found that air pollution in Turkey is driven by financial development.
The estimation techniques used in the above two studies assumed linear a cointegrating
relationship between the variables. However, the application of such tests may lead to
misspecification of cointegration if the structural breaks are unknown (Gregory and Hansen,
1996). This study proposes the application of Gregory et al.'s (1996) and Hatemi-J (2008) tests
which study the cointegrating relationship between variable in presence of one and two
endogenous structural breaks respectively. These tests are more recent and more robust
when determining the exact break dates (Charfeddine and Ben Khediri, 2016).

This study extends the available literature further by including financial development as
one of the important determinants of quality of environment and using more advanced
estimation techniques. The extensive literature review has found that no attempt has been
made so far to examine cointegration between carbon emissions and financial development,
using multiple endogenous structural breaks based cointegration approach for Turkey.
The current study tries to fulfill this gap and it may substantially reduce the omitted
variable econometric estimation bias. The study may pave the way for policy makers to
capture the important environmental pollutants in a better way and develop effective and
efficient energy and economic policies. This may make a significant contribution to curbing
CO₂ emissions while sustaining economic growth.

The rest of this study is prepared as follows: the literature review is presented in Section 2,
and Section 3 describes the econometric methodology and data used. The empirical results
and discussion are covered in Section 4, while section 5 concludes the study and presents some
policy recommendations.

2. A brief review of literature
Over the last six decades, the association between CO₂ emissions and its determinants has
been investigated in numerous studies. In the literature, there are three major strands of
research. The first area studies the nexus of causal interactions between economic
development and environmental quality, and focuses on examining the validity of EKC
hypothesis for different countries (Grossman and Krueger, 1991; Shafik, 1994; Heil and
Selden, 1999; Friedl and Getzner, 2003; Dinda and Coondoo, 2006; Managi and Jena, 2008).
The results of these studies are found to be conflicting with each other. The second research
stream examines the connection between economic development and energy use. In this
research area, many other researchers including (Yang, 2000; Wolde-Rufael, 2006;
Narayan et al., 2008; Ozturk et al., 2010; Lau, 2011) followed the illustrious study of Kraft and
Kraft. However, the studies in this area of research have also produced controversial results
across time and countries (Kanjilal and Ghosh, 2013). The third stream of research combines
the first two and tests the dynamic relationship between CO₂ emissions, energy
consumption and economic growth simultaneously. Soytas et al. (2007), Zhang and Cheng
(2009), Apergis and Payne (2010), Alam et al. (2011), Tiwari (2011) and Dar and Asif (2017),
among others, are some of the studies in this research strand. Even these studies show
a large range of contradictory results.

In the recent past, following Grossman and Krueger (2008), researchers have gained
attention in examining the relationship between development of financial sector and
environmental degradation. Several studies have found strong evidence of financial sector
development causing increased carbon emissions (Bello and Abimbola, 2010; Sadorsky,
2010; Zhang, 2011; Boutabba, 2014; Gokmenoglu et al., 2015; Sehrawat et al., 2015; Dar and
Asif, 2017). The studies found following reasons responsible for a positive effect of financial
sector development on CO₂ emissions. First, the development of stock markets may help the
listed companies to enhance their financial channels, reduce financing cost, minimize the operating risk, make new investments and hence increase energy use and CO₂ emissions. Second, financial development may increase environmental pollution via increased levels of foreign direct investment inflows. Lastly, a developed financial system in a country may make it easier for customers to buy consumer durables and hence may lead to increased levels of carbon emissions (Zhang, 2011).

However, some researchers have established that financial development enhances the energy efficiency and performance of industries, thus helping reduce energy consumption and emission of carbon (Tamazian et al., 2009; Tamazian and Bhaskara Rao, 2010; Jalil and Feridun, 2011; Shahbaz et al., 2013; Al-mulali et al., 2015).

Recently, some authors made attempts to study the environmental significance of financial development for Turkey also. Ozturk and Acaravci (2013), using the ARDL bounds testing cointegration approach, found no significant impact of development of financial sector on CO₂ emissions. Other studies used Johansen and Juselius (1990) and Engle and Granger (1987) tests and found that air pollution in Turkey is driven by financial development (Gokmenoglu et al., 2015). It is a common practice that researchers do cointegration analysis with augmented Dickey-Fuller test with the assumption that there is no regime shift in the cointegrating vector. However, the standard Augmented Dickey-Fuller (ADF) test may lead to false conclusions in presence of any structural break in the time series data (Gregory and Hansen, 1996). The power of standard ADF falls sharply in presence of any possible regime shift (Gregory et al., 1996). This problem can be reduced significantly by applying the tests which allow for possible regime shifts. So far, no study on the nexus of cointegration between development of financial sector and environmental quality in Turkey has incorporated structural breaks in the estimation procedure. This is the only study to examine long-run impact of financial sector development on carbon emissions, using the threshold cointegration approach. Hence, the study is a gentle request to reduce the possible omitted variable econometric estimation bias and fill the gap in the existing literature.

3. Data collection and econometric modeling

The data on per capita carbon emissions (metric tons), energy use per capita (kg of oil equivalent) and GDP per capita (constant 2010 US$) have been taken from the World Development Indicators 2015, available on the official website of the World Bank. Domestic credit to private sector (% of GDP) has been used as a proxy for development of financial sector and, its data have been collected from Global Financial Development Index 2016. The study covers the time span of 1960-2013.

3.1 The model

This paper aims to explore the long-run effect of financial development, energy use and economic growth in greenhouse gas emissions for Turkey. In line with the existing literature, we find various approaches applied to test the nexus of relationship among these variables. Following these studies, we use carbon emissions, financial development and economic growth in a multivariate framework for Turkey and the relationship has been specified as follows:

\[ CE_t = f \left( EC_t, FD_t, Y_t, Y_t^2 \right) \]  (1)

The log-linear specification has been used to investigate the above relationship because log-linear specification has been found to be superior to simple linear specification in terms of providing more accurate results by considerably reducing dispersion in data. Hence, we formulate the following empirical model:

\[ LCE_t = \theta_0 + \Phi_{01} LEC_t + \Phi_{02} LFD_t + \Phi_{03} LY_t + \Phi_{04} LY_t^2 + \epsilon_t \quad t = 1, 2, \ldots, n \]  (2)
where $LCE$ is the natural log of per capita carbon emissions, $LEC$ stands for the natural log of per capita energy use, $LFD$ denotes natural log of financial development, $LY$ represents the natural log of $GDP$ per capita and $\varepsilon$ is the white noise error term.

The financial sector may affect environment through various interactions. A developed financial sector may act as an investor and supply the required investment for energy-prone manufacturing activities. The development of stock markets may help the listed companies to enhance their financial channels, reduce financing cost, minimize the operating risk, make new investments and hence increase energy use and CO$_2$ emissions. Financial development in an economy may also increase environmental pollution via increased levels of foreign direct investment inflows. Further, Zhang (2011) states that a developed financial system in a country may make it easier for customers to buy consumer durables and hence may lead to increased levels of carbon emissions. In contrast to the above arguments, the financial sector may act as an innovator by stimulating technological advancement in energy efficiency and reduce greenhouse gas emissions (Shahbaz et al., 2013). A mature financial sector monitors and funds projects for environmental sustainability whereas the sole purpose of an immature financial sector is profit maximization[1]. Hence, the impact of development of financial sector on environmental quality is ambiguous, subject to the scale of development achieved by the financial sector and the sign of $\Phi_{02}$ can go either way.

A priori, rise in energy use is anticipated to increase the emissions of greenhouse gasses, including CO$_2$ emissions, hence $\Phi_{01} > 0$. Furthermore, persistent economic growth is expected to increase emission of greenhouse gases, $\Phi_{03} > 0$. The sign of $\Phi_{04}$ is ambiguous as it can go either way; positive and negative signs of $\Phi_{04}$ reflect the evidence against and in favor of the prevalence of environmental Kuznets curve, respectively.

### 3.2 Estimation techniques

Usually, researchers use ADF test for cointegration analysis and go on if the null hypothesis of no long-run relationship is rejected. However, if the selected variables have a cointegrating relationship with a regime shift, the conventional ADF test may fail to reject the null hypothesis (Gregory and Hansen, 1996). Indeed, Gregory et al. (1996) have argued that power of ADF test may decrease in presence of a regime shift. On the other hand, if the tests which allow for possible regime shifts are used, there may be a better chance of specifying a correct model.

#### 3.2.1 The ARDL bounds testing cointegration approach

The ARDL bounds test (Pesaran et al., 2001) is employed to test whether cointegration exists between the variables or not. This approach has been found to have some advantages over other cointegration techniques. First, the short-run parameters and long-run parameters can be calculated simultaneously. Second, the ARDL bounds procedure can be employed even if the variables are integrated in different order. Thirdly, this cointegration test has been found more efficient when dealing with small samples. An ARDL model uses the dependent variable lag terms and contemporaneous independent variable values to directly estimate the short-run coefficients and indirectly estimate the long-run parameters (Kanjilal and Ghosh, 2013). Equation (2) can be represented in an ARDL form as follows:

$$
\Delta LCE_t = \delta_0 + \sum_{i=1}^{p} \gamma_{1i} \Delta LCE_{t-i} + \sum_{i=1}^{p} \gamma_{2i} \Delta LEC_{t-i} + \sum_{i=1}^{p} \gamma_{3i} \Delta LFD_{t-i} + \sum_{i=1}^{p} \gamma_{4i} \Delta LY_{t-i}
+ \sum_{i=1}^{p} \gamma_{5i} \Delta LY^2_{t-i} + \lambda_1 LCE_{t-1} + \lambda_2 LEC_{t-1} + \lambda_3 LFD_{t-1} + \lambda_4 LY_{t-1}
+ \lambda_5 LY^2_{t-1} + \varepsilon_{1t}
$$

(3)
where $\Delta$ is the difference operator, $\delta_0$ is the intercept and $\varepsilon_{1t}$ is the IID(2) error term. $\gamma$s indicate the short-run parameters while long-run parameters are indicated by the $\lambda$s. For the selection of optimum lag length, Akaike information criteria has been used, and $F$-test is employed to test the presence of cointegration among the variables. The hypothesis of no cointegration is $H_0$: $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$ against the hypothesis of presence of cointegrating relationship among the variables $H_1$: $\lambda_1 \neq \lambda_2 \neq \lambda_3 \neq \lambda_4 \neq \lambda_5 \neq 0$, denoted as $F_{LCE}$ ($LCE$, $LEC$, $LFD$, $LY$, $LY_i^2$). Pesaran et al. (2001) and Narayan (2005) have given upper bound and lower bound $F$ critical values for large samples and small samples (30-80), respectively. Cointegration among variables exists if the calculated $F$ value is greater than the critical upper bound value, and no cointegration exists among the variables if the calculated $F$ value falls below the lower bound critical value. However, if the calculated $F$ value lies between the two bounds, then the inference remains inconclusive.

3.2.2 Threshold cointegration approach. The possible endogenous structural breaks can be tested by considering “Level Shift (C),” “Level Shift with Trend (C/T)” and “Regime Shift (C/S)” models (Gregory et al., 1996; Hatemi-J, 2008). We follow Kanjilal and Ghosh (2013) and consider the regime shift model for both Gregory-Hansen (GH) and Hatemi-J (HJ) cointegration tests[3]. The regime shift representation of Equation (2) is defined as:

**GH test:**

$$LCE_t = \Psi_0 + \Psi_1 D_{1t} + \chi_{01} LEC_t + \chi_{11} D_{1t} LEC_t + \chi_{02} LFD_t + \chi_{12} D_{1t} LFD_t + \chi_{03} LY_t + \chi_{13} D_{1t} LY_t + \chi_{04} LY_t^2 + \chi_{14} D_{1t} LY_t^2 + u_t$$  

(4)

**HJ test:**

$$LCE_t = \Psi_0 + \Psi_1 D_{1t} + \Psi_2 D_{2t} + \chi_{01} LEC_t + \chi_{11} D_{1t} LEC_t + \chi_{21} D_{2t} LEC_t + \chi_{02} LFD_t + \chi_{12} D_{1t} LFD_t + \chi_{22} D_{2t} LFD_t + \chi_{03} LY_t + \chi_{13} D_{1t} LY_t + \chi_{23} D_{2t} LY_t + \chi_{04} LY_t^2 + \chi_{14} D_{1t} LY_t^2 + \chi_{24} D_{2t} LY_t^2 + u_t$$  

(5)

where $\Psi_0$ is an intercept common to Equations (4) and (5).

$\Psi_1$ represents the differential intercept over common intercept $\Psi_0$ with a single structural break for Equation (4) but, for Equation (5), it represents the differential intercept over $\Psi_0$ for first sub-sample of the break. $\Psi_2$ is the differential intercept over $\Psi_0$ for the next sub-sample of the break for Equation (5).

$\chi_{0i}$ is the slope coefficient of $i$th explanatory variable; $i = 1-4$. $\chi_{1i}$ represents differential slope parameter over $\chi_{0i}$ (base slope coefficient) with a single structural break for Equation (4), but, for Equation (5), it represents the differential slope coefficient over $\chi_{0i}$ for first sub-sample of structural break. On the same note, $\chi_{2i}$ ($i = 1-4$) represents the differential slope coefficient over $\chi_{0i}$ for the second sub-sample of structural break for Equation (5).

$D_{1t}$ is a dummy variable for Equation (4) at time $t$ ($t = 1-n$). For Equation (5), $D_{1t}$ is a dummy variable representing the first unknown structural break and $D_{2t}$ is a dummy variable signifying the second unknown structural break at time $t$ ($t = 1-n$):

$$D_{1t} = 0; \text{ if } t < [n\tau_1]$$

$$= 1; \text{ if } t \geq [n\tau_1]$$  

(6)

$$D_{2t} = 0; \text{ if } t < [n\tau_2]$$

$$= 1; \text{ if } t \geq [n\tau_2]$$  

(7)
where $\tau_1$ and $\tau_2$ are the known parameters of $D_{t1}$ and $D_{t2}$, respectively, belonging to set $(0, 1)$ and indicating the relative points of two unknown structural breaks. The bracket represents the integer part. In general, to test the hypothesis of no cointegration for models like Equations (4) and (5), in absence of the structural breaks based dummies, researchers use the Engle and Granger (1987) residual-based approach. However, when such tests are employed on regression errors, they may lead to flawed conclusions on cointegrating relationship in presence of endogenous structural breaks (Gregory and Hansen, 1996). The bias-corrected modified $ADF^*$, $Z^*_a$ and $Z^*_t$ have been proposed for testing cointegration among the underlying variables:

$$ADF^* = \inf ADF(\tau), \quad (\tau) \in T$$

$$Z^*_a = \inf Z_a(\tau), \quad (\tau) \in T$$

$$Z^*_t = \inf Z_t(\tau), \quad (\tau) \in T$$

For testing the hypothesis of no cointegrating relationship the regression of Equations (4) and (5) for each possible structural break $(\tau) \in T = (0.15, 0.85)$ in case of GH test and $(\tau_1) \in T_1 = (0.15, 0.70)$ and $(\tau_2) \in T_2 = (0.15 + \tau_1, 0.85)$ for HJ test is run, and then Equation (8)-(10) are applied for the errors of regression of each unknown structural break. The lowest value of Equation (8)-(10) is chosen for the comparison purpose, to reject or accept the hypothesis of no long-run association between the variables.

### 4. Empirical results and discussion

Table I presents the basic statistical description of variables used (without log) in our study. The results show that income-square variable is most volatile whereas income is least volatile. Jarque-Bera statistic also makes it evident that CO2 emissions, energy use and income are normally distributed but financial development and income-square do not follow normal distribution. However, ARDL captures the non-linearities in time series data and solves the problem of non-normality.

Before proceeding to test cointegrating relationships between variables, the first step is to check their order of integration. Although, the autoregressive distributive lag bounds testing cointegration approach can be employed even if the variables are integrated of

<table>
<thead>
<tr>
<th>Variables</th>
<th>CE</th>
<th>EC</th>
<th>FD</th>
<th>Y</th>
<th>$Y^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2.3841</td>
<td>895.9238</td>
<td>21.6583</td>
<td>6254.6300</td>
<td>44262024</td>
</tr>
<tr>
<td>Median</td>
<td>2.3761</td>
<td>875.5474</td>
<td>17.8343</td>
<td>5862.1342</td>
<td>34396176</td>
</tr>
<tr>
<td>Maximum</td>
<td>4.4031</td>
<td>1561.8354</td>
<td>70.0998</td>
<td>11102.6563</td>
<td>123000000</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.6105</td>
<td>384.3461</td>
<td>12.6731</td>
<td>2996.5806</td>
<td>8979490</td>
</tr>
<tr>
<td>SD</td>
<td>1.0998</td>
<td>340.2685</td>
<td>11.4109</td>
<td>2288.8079</td>
<td>31738469</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>46.1306</td>
<td>37.9796</td>
<td>52.6860</td>
<td>36.5938</td>
<td>71.7058</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.1332</td>
<td>0.2668</td>
<td>2.7085</td>
<td>0.5179</td>
<td>0.9654</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>1.9352</td>
<td>2.0272</td>
<td>9.9737</td>
<td>2.2593</td>
<td>2.9645</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>2.7109</td>
<td>2.7724</td>
<td>175.4466</td>
<td>36.793</td>
<td>8.9199</td>
</tr>
<tr>
<td>Probability</td>
<td>0.2578</td>
<td>0.2503</td>
<td>0.0000</td>
<td>0.1589</td>
<td>0.0115</td>
</tr>
</tbody>
</table>

Table I. Descriptive statistics

Notes: CE, EC, FD and Y are actual values of carbon emissions, energy consumption, financial development and income, respectively

Source: Calculated by authors
different order, i.e. $I(1)$ or $I(0)$, the computed $F$-statistic of Pesaran et al. (2001) becomes invalid in presence of higher order integrated variables, i.e. $I(2)$ and beyond. Hence, it is a prerequisite to make it sure that none of our variables is $I(2)$ or beyond. In doing so, ADF, PP and KPSS tests have been used to test the variables for order of integration[4]. In addition, we have also tested the variables for a unit root, in presence of a possible endogenous structural break, using Zivot and Andrews unit root test.

ADF and PP tests are based on the null hypothesis that the variable has a unit root. However, the null hypothesis of KPSS test is that the variable is stationary. Schwarz information criterion has been used to automatically select the optimum lag length for ADF test. For PP and KPSS tests, the automatic Bandwidth selection criterion of Newey and West has been applied. The unit root results of variables are presented in Table II. As apparent from the results, all the variables are level non-stationary and stationary at the first difference.

Table III presents the results of Zivot-Andrews unit root test. This test is based on the null hypothesis that the variable has a unit root in presence of a structural break. Following Alam et al. (2011), we consider an unknown structural break in intercept for a variable at level, and unknown structural break in intercept and trend for a variable when taken at first difference. As evident from the results, Zivot-Endrews test reinforces the conclusions drawn from conventional unit root tests. Hence, the series are $I(1)$ and we may proceed with the cointegration tests.

The study uses the ARDL bounds test to investigate the presence of cointegration. The ARDL cointegration test results, given in Table IV, reveal that there exists a highly significant (at 1 percent level) long-run cointegrating relationship between CO2 emissions, energy consumption, financial sector development and economic growth in case of Turkey. In order to test the ARDL model for stability, various diagnostic checks have also been conducted. The standard statistical inferences ($R^2$, adjusted $R^2$ and $F$-statistic) are valid.

<table>
<thead>
<tr>
<th>Intercept/trend</th>
<th>Variables</th>
<th>ADF</th>
<th>PP</th>
<th>KPSS</th>
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<tr>
<td><strong>At level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>$LCE_t$</td>
<td>-3.0268</td>
<td>-4.5051*</td>
<td>0.9747*</td>
</tr>
<tr>
<td></td>
<td>$LEC_t$</td>
<td>-1.2806</td>
<td>-1.3460</td>
<td>0.8711*</td>
</tr>
<tr>
<td></td>
<td>$LFD_t$</td>
<td>1.0683</td>
<td>1.0403</td>
<td>0.5254**</td>
</tr>
<tr>
<td></td>
<td>$LY_t$</td>
<td>-0.4925</td>
<td>-0.4712</td>
<td>1.0021*</td>
</tr>
<tr>
<td></td>
<td>$LY_t^2$</td>
<td>-0.5549</td>
<td>-0.5403</td>
<td>0.58948*</td>
</tr>
<tr>
<td>Intercept and trend</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$LCE_t$</td>
<td>-2.4443</td>
<td>-2.5281</td>
<td>0.2159**</td>
</tr>
<tr>
<td></td>
<td>$LEC_t$</td>
<td>-2.3497</td>
<td>-2.3493</td>
<td>0.1670**</td>
</tr>
<tr>
<td></td>
<td>$LFD_t$</td>
<td>-0.2141</td>
<td>-0.4317</td>
<td>0.1513**</td>
</tr>
<tr>
<td></td>
<td>$LY_t$</td>
<td>-3.0474</td>
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<td>0.0781</td>
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<tr>
<td></td>
<td>$LY_t^2$</td>
<td>-3.0907</td>
<td>-3.0908</td>
<td>0.0774</td>
</tr>
<tr>
<td><strong>At first difference</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>$\Delta LCE_t$</td>
<td>-6.9972*</td>
<td>-6.9961**</td>
<td>0.5843**</td>
</tr>
<tr>
<td></td>
<td>$\Delta LEC_t$</td>
<td>-6.9616*</td>
<td>-6.9508*</td>
<td>0.1377</td>
</tr>
<tr>
<td></td>
<td>$\Delta LFD_t$</td>
<td>-6.1437*</td>
<td>-6.1380*</td>
<td>0.4785**</td>
</tr>
<tr>
<td></td>
<td>$\Delta LY_t$</td>
<td>-7.4719*</td>
<td>-7.4881*</td>
<td>0.0430</td>
</tr>
<tr>
<td></td>
<td>$\Delta LY_t^2$</td>
<td>-7.5364*</td>
<td>-7.5531*</td>
<td>0.0426</td>
</tr>
<tr>
<td>Intercept and trend</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\Delta LCE_t$</td>
<td>-7.9413*</td>
<td>-7.9291*</td>
<td>0.0838</td>
</tr>
<tr>
<td></td>
<td>$\Delta LEC_t$</td>
<td>-7.0518*</td>
<td>-7.0709*</td>
<td>0.0411</td>
</tr>
<tr>
<td></td>
<td>$\Delta LFD_t$</td>
<td>-6.2841*</td>
<td>-6.2837*</td>
<td>0.1112</td>
</tr>
<tr>
<td></td>
<td>$\Delta LY_t$</td>
<td>-7.4014*</td>
<td>-7.4251*</td>
<td>0.0427</td>
</tr>
<tr>
<td></td>
<td>$\Delta LY_t^2$</td>
<td>-7.4830*</td>
<td>-7.4953*</td>
<td>0.0318</td>
</tr>
</tbody>
</table>

**Notes:** * **Significant at 1 and 5 percent levels, respectively**

**Source:** Calculated by authors
The model is free from serial correlation and heteroscedasticity, and the residuals follow standard normal distribution.

The results of structural breaks based cointegration tests are presented in Table V. For both GH test and HJ test, the hypothesis of no cointegrating relationship is rejected by modified ADF* and $Z_t^*$ at 1 percent level of significance. Hence, the threshold cointegration tests establish a long-run relationship among carbon emissions, energy consumption, financial development and income, with a couple of endogenous structural breaks. The first break point of HJ test (late 1976) almost overlaps the break point of GH test (early 1977), and the timing of second endogenously determined structural break is 1986.

The timing of the two regime shifts is very much expected within the period of study. In 1976-1977, Turkey was entering its third and most severe post-war economic crisis. The country faced external debt crisis (about $10 billion), foreign exchange crisis, trade deficit ($4 billion) and an inflation rate of more than 26 percent. Ecevit[5] tried to control the

<table>
<thead>
<tr>
<th>Variables</th>
<th>$t$-statistic</th>
<th>At level</th>
<th>Break year</th>
<th>Decision</th>
<th>$t$-statistic</th>
<th>At first difference</th>
<th>Break year</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>$LCE$</td>
<td>-3.1023(0)</td>
<td>1970</td>
<td>Non-stationary</td>
<td>-8.8751*(0)</td>
<td>1982</td>
<td>Stationary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$LEC$</td>
<td>-3.7191(0)</td>
<td>1971</td>
<td>Non-stationary</td>
<td>-7.5532*(0)</td>
<td>1978</td>
<td>Stationary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$LFD$</td>
<td>-1.8719(2)</td>
<td>2005</td>
<td>Non-stationary</td>
<td>-7.0058*(1)</td>
<td>2004</td>
<td>Stationary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$LY$</td>
<td>-4.0052(0)</td>
<td>1979</td>
<td>Non-stationary</td>
<td>-7.7451*(0)</td>
<td>2003</td>
<td>Stationary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$LY^2$</td>
<td>-4.0050(0)</td>
<td>1979</td>
<td>Non-stationary</td>
<td>-7.7441*(0)</td>
<td>2003</td>
<td>Stationary</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Numbers in parenthesis denote the lag length selected; The critical values can be found in Zivot and Andrews. *Significant at 1 percent level

Source: Calculated by authors
crisis through foreign exchange adjustments and various fiscal measures. In this regard, Lira[6] was devalued by more than 28 percent, various subsidies were eliminated and government deficit was considerably reduced. In late 1980s also, Turkey faced a very high rate of inflation (around 65 percent). To control inflation various economic reforms in the form of nominal anchoring and monetary tightening were implemented. Macroeconomic policies were directed to attract external flows (Erçel, 2006).

The estimates of ARDL long-run parameters are presented in panel I of Table VI. The results indicate that elasticity of carbon emissions with respect to energy use is 1.15 which is in line with our expectation that increased energy consumption leads to falling environmental standards. The results show a strong negative relationship (−1.73) between financial development and CO₂ emissions. This result indicates that development of financial sector in Turkey has helped in carbon mitigation. However, in contrast to the expectation, the model did not find any statistical evidence of long-run association between income and carbon emissions. This result is very interesting. The reason may be that increase in income encourages energy-prone economic activities and energy efficiency simultaneously, making overall economic growth indifferent for environment. Also, the model does not support prevalence of environmental Kuznets curve in Turkey. The diagnostic checks of the ARDL model, presented in panel II of Table VI, support the reliability of the model. The results of CUSUM test, given in Figure 1, support the stability of ARDL parameters.

The results of single endogenous structural breaks based long-run parameter values are presented in panel-I of Table VII. As expected, the results show a substantial positive effect of energy use on carbon emissions (1.46). Financial development is found to be reducing carbon emissions (−0.39). In contrast to the ARDL results and in line with our expectation, the GDP growth is found to be positively contributing to carbon emissions. The model does not find any evidence of existence of EKC in Turkey. The diagnostic test results presented in panel II of Table VI show that the model is statistically reliable, and the CUSUM test results presented in Figure 2 prove the parameter stability of the model.

Table VIII presents the parameter estimates with two endogenous structural breaks. The results indicate that energy use has a positive significant and dominant impact on carbon emissions, though in the post-break period, the strength of relationship seems to be diminishing. Other things remaining constant, a 1 percent rise in energy consumption leads to 1.08 percent rise in CO₂ emissions. The results suggest some concrete action to limit energy-prone activities to sustain the environment. This can be done by limiting the fossil fuel subsidies and promoting renewable and green energy consumption. The result

<table>
<thead>
<tr>
<th>Panel I: long-run coefficients</th>
<th>Panel II: diagnostic tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Coefficient</td>
</tr>
<tr>
<td>Constant</td>
<td>$-7.8651^*$</td>
</tr>
<tr>
<td>$LEC_t$</td>
<td>$1.1510^*$</td>
</tr>
<tr>
<td>$LFD_t$</td>
<td>$-1.7319^{**}$</td>
</tr>
<tr>
<td>$LY_t$</td>
<td>$-0.0401$</td>
</tr>
<tr>
<td>$LY_t^2$</td>
<td>5.9515**</td>
</tr>
</tbody>
</table>

**Notes:** Values in parenthesis represent the probability values. *,**,** Significant at 1 and 5 percent levels, respectively

**Source:** Calculated by authors

Table VI. Long-run coefficients based on ARDL
supports the findings of Friedl and Getzner (2003), Ang (2007) and Halicioglu (2009). Further, the results show that financial development has a significant negative impact on carbon emissions in Turkey. A 1 percent improvement in the development of financial sector is associated with 0.18 percent reduction in the volume of carbon emissions. This finding is in line with those of Tamazian et al. (2009), Tamazian and Bhaskara Rao (2010), Jalil and Feridun (2011), Shahbaz et al. (2013) and Al-mulali et al. (2015). Turkish policymakers can use financial reforms as means of carbon mitigation policy. Since Turkish financial sector suffers from a low penetration ratio, the policymakers can focus on improving the ratio for CO2 mitigation. Growth in real income (real GDP) has a positive impact on carbon emissions. A 1 percent rise in per capita real income is linked with a rise in CO2 emissions by 0.16 percent. This result is in agreement with the findings of Song et al. (2008), Halicioglu (2009), Lean and Smyth (2010), and Shahbaz et al. (2012). Since the coefficient of square of income is non-negative, our empirical evidence fails to establish the prevalence of environmental Kuznets curve in Turkey, even when we incorporate two endogenous structural breaks. Hence, carbon emissions do not fall at higher levels of income. An interesting result we found from the test is that the coefficients of $Y$ and $Y^2$
have negative sign in the base period and positive sign for the first and second sub-sample (though not statistically significant). This result indicates that the impact of economic growth increases exponentially during the base period and decreases exponentially after the two break years (1976 and 1986). The reasons for such surprising result might be that in the post-break periods, the economic reforms done by Turkish policymakers to neutralize the external debt crisis and high rate of inflation discouraged the energy-prone economic activities. The monetary tightening also helped the cause. The diagnostic test results, given in Table VII, show that the model has successfully passed all diagnostic tests. Further, the results of CUSUM (stability test), presented in Figure 3, show that the parameter values are stable. This confirms our estimates to be reliable and consistent.

### Table VIII

<table>
<thead>
<tr>
<th>Dependent variable = $LCE_t$</th>
<th>Base</th>
<th>First sub-sample ($D_1$)</th>
<th>Second sub-sample ($D_2$)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-15.9501* (-20.2245)</td>
<td>4.7454** (2.4510)</td>
<td>5.0049* (2.7750)</td>
<td>-6.1998</td>
</tr>
<tr>
<td>$LEC_t$</td>
<td>0.7619* (4.4442)</td>
<td>0.3828 (0.9654)</td>
<td>-0.0610 (-0.1510)</td>
<td>1.0837</td>
</tr>
<tr>
<td>$LFD_t$</td>
<td>-9.0819** (-3.8416)</td>
<td>7.5950** (2.1754)</td>
<td>1.3051 (0.5019)</td>
<td>-0.1818</td>
</tr>
<tr>
<td>$LY_t$</td>
<td>1.3919* (6.0919)</td>
<td>-0.7151*** (-1.8750)</td>
<td>-0.5220 (-1.1036)</td>
<td>0.1548</td>
</tr>
<tr>
<td>$LY_t^2$</td>
<td>24.5214* (3.7717)</td>
<td>-20.2315** (-2.0721)</td>
<td>-3.6551 (-0.5039)</td>
<td>0.6348</td>
</tr>
</tbody>
</table>

**Diagnostic tests**

- $R^2$: 0.9981
- Adjusted $R^2$: 0.9975
- F-statistic: 1895.4927 (0.0000)
- Durbin-Watson: 2.0931
- Jarque-Bera: 2.5115 (0.2850)
- Breusch-Godfrey LM test ($F$): 1.3025 (0.2813)
- ARCH LM test ($F$): 0.5165 (0.3712)

**Notes:** The values in parenthesis are the respective $t$-ratios of the parameters. ***, ****Significant at 1, 5 and 10 percent levels, respectively.

**Source:** Calculated by authors
5. Conclusion and policy implications

The study is engaged in establishing an empirical research model to examine the impact of energy use, financial sector development and economic growth for Turkey in period of 1960-2013. The ARDL bounds testing cointegration approach, GH one endogenous structural breaks based cointegration test and HJ two endogenous structural breaks based cointegration test have been applied to test the variables for long-run relationship. All the three approaches confirm long-run association between the variables. However, the threshold cointegration technique (GH test and HJ test) reveal that the long-run cointegrating relationship has gone through two endogenous structural breaks during the period of study, in 1976 and 1986. The timing of the regime shifts is reasonably expected as Turkey faced severe post-war economic crisis in 1976-1977 and a very high rate of inflation in 1986-1987. This study reduces possible omitted variable econometric estimation bias and fills the gap in the existing literature as no other study has incorporated the threshold cointegration technique in the estimation procedure of nexus of cointegration between financial sector development and environmental quality in case of Turkey.

The results reveal that development of financial sector has a negative impact on CO2 emissions in Turkey, suggesting that the development in financial sector has not taken place at the cost of environmental quality. Financial development has led to improvement in environmental quality. The signs of long-run coefficients of per capita income ($LY_t$) and per capita energy use ($LEC_t$) are in line with our expectation. However, the positive sign of the parameter estimate of income square ($L{Y_t}^2$) indicates that the EKC hypothesis does not hold good in Turkey. Also, the elasticity of CO2 emissions per capita with respect to real GDP per capita and energy consumption per capita are 0.16 and 1.08, respectively. As the results reveal that energy consumption and economic growth make significant contribution in deterioration of environment, we may propose cuts in economic activities and quantum of energy consumption.

As seen from the results, the carbon mitigation policies based on energy use and income alone may not prove to be fruitful as financial development is an integral part of the greenhouse gas mitigation policy. Financial development is found to improve environmental quality in Turkey. The policy implication may be to use the financial sector, through the banking system, to encourage energy-efficient investments. Monetary policy can be framed to offer lower interest rates and other discounts for eco-friendly production techniques by companies. However, Turkish financial sector has a low penetration ratio and has a very long way to go before reaching its optimum level. The authors suggest continued economic
normalization, revenue reforms and other reforms for enhancing financial inclusion to further increase the penetration ratio. A developed and more inclusive financial sector will play a significant role in improving environmental quality by providing incentives to adopt environmental friendly production techniques.

Among other determinants, energy consumption (fossil fuels in particular) plays a dominant role in deteriorating the environment. So, the obvious policy should be some cuts in economic activities and quantum of energy consumption. But in reality, oil and coal consumption (contributing 28 and 47 percent, respectively, to the total energy use in Turkey) enjoy a huge amount of subsidies in Turkey (Oil Change International, 2015). These market distorting subsidies keep Turkey in a vicious circle of technical, institutional and legal structure dependent on fossil fuels and hampers development of renewable energy. If the external costs of environmental impact are considered, then solar and wind energy are already cheaper than fossil fuels (GSI and IISD, 2015). Hence, we strongly recommend Turkey to cut back subsidies on fossil fuels and develop mitigation strategies. The G20 commitment to phase out all subsidies to fossil fuels needs to be implemented with immediate effect. The social and environmental costs of fossil fuel consumption should be considered for making energy policies. Further, the renewable and clean energy use should be promoted through various monetary and fiscal measures. Turkey needs to invest heavily in energy-related research and development to diffuse cleaner technology in future. This will pave the way for Turkey to achieve green growth and develop a climate friendly and secure energy system based on sustainable principles.

Finally, this study extends the scope for research in future as researchers can use our methodology to get better insight into the financial development-environmental quality nexus in countries other than Turkey. Further, our model can be improved by constructing an index of financial development instead of using a single determinant as a proxy for financial development. The study has used the aggregate emissions data; however, testing the nexus of relationship between financial development and emissions intensity at disaggregate level (industry wise) may give better insights. This might help policy makers to formulate eco-friendly financial policies.

Notes
1. It should be noted that the sign of $\Phi_{02}$ can be used as an indicator of level of maturity of a financial sector. If $\Phi_{02} > 0$, then the financial sector is said to have achieved maturity, otherwise not.
2. IID is a series of independent and identically distributed random variables.
3. GH and HJ stand for Gregory-Hansen and Hatemi-J tests, respectively. GH has taken a single structural break whereas HJ has included two structural breaks.
4. ADF, PP and KPSS stand for Augmented Dickey and Fuller test, Phillips and Perron Test and Kwiatkowski-Phillips-Schmidt-Shin test, respectively.
5. Mustafa Bülent Ecevit served as the Prime minister of Turkey four times between 1974 and 2002.
6. Lira is the official currency of Turkey.

References


Further reading


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