Interactions among Financial Services, Informal Economies and Environmental Performance: Evidence from Developing Countries

Barış Memduh Eren

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Finance

Eastern Mediterranean University
September 2019
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Prof. Dr. Ali Hakan Ulusoy
Acting Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy in Finance.

Prof. Dr. Nesrin Özataç
Chair, Department of Banking and Finance

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Doctor of Philosophy in Finance.

Assoc. Prof. Dr. Korhan Gökmenoğlu
Co-Supervisor

Prof. Dr. Salih Katırcıoğlu
Supervisor

Examining Committee

1. Prof. Dr. Murat Donduran
2. Prof. Dr. Salih Katırcıoğlu
3. Prof. Dr. Nesrin Özataç
4. Prof. Dr. Sevin Uğural
5. Prof. Dr. Çağatay Ünüsan

ABSTRACT

This study conducts an empirical examination about the roles of financial development, informal economy, fossil fuel and renewable energy consumption on global environmental degradation. Turkey and India are selected as the sample countries to carry out a comparative analysis in the framework of Environmental Kuznets Hypothesis. To this aim, time series procedures are carried out by taking multiple structural breaks into account. Moreover, the study applied the Granger causality test under a vector error correction model to estimate the existence and direction of causality between the variables. The estimated results produced supporting evidence toward the validation of the Environmental Kuznets Curve (EKC) hypothesis. Coefficient estimates indicated that fossil fuel energy consumption, financial development and informal economy in both countries transmit a deteriorating impact on environmental well-being. Conversely, the presented evidence determined that the renewable energy consumption improves the environmental performance by reducing the CO2 emissions. The causality test results suggest that renewable energy consumption is financial development driven in the long run for Turkey and India. Based on the acquired results, this study provides a number of policy recommendations that can be considered to design more efficient economic and financial system in order to achieve energy security and sustainable global environment.

Keywords: EKC hypothesis, Financial development, Informal economy, Renewable energy consumption, Environmental degradation, Time series analysis

ÖZ

Bu çalışma, finansal gelişim, kayıt dışı ekonomi, fosil yakıt tüketimi ve yenilenebilir enerji tüketimi değişkenlerinin küresel çevre dezenformasyonu üzerindeki etkileri üzerine ampirik bir inceleme yürütmektedir. Çevresel Kuznets Eğrisi hipotezi çerçevesinde karşılaştırmalı bir analiz yapmak için Türkiye ve Hindistan örnek ülkeler olarak seçilmiştir. Bu amaçla, zaman serisi prosedürleri birden fazla yapısal kırılma göz önünde bulundurularak uygulanmıştır. Ayrıca, değişkenler arasındaki nedensellik ilişkisini ve yönünü tahmin etmek için bir vektör hata düzeltme modeli altında Granger nedensellik testi uygulamıştır. Elde edilen sonuçlar Çevresel Kuznets Eğrisi hipotezini destekleyici kanıtlar sunmaktadır. Katsayı tahminleri, her iki ülkede de fosil yakıt enerji tüketimi, finansal gelişme ve kayıt dışı ekonominin çevresel refah üzerinde kötüleşen bir etki gösterdiğini işaret etmektedir. Buna karşılık, sunulan kanıtlar yenilenebilir enerji tüketiminin CO2 emisyonlarını azaltarak çevresel performansı iyileştirdiğini de göstermektedir. Nedensellik testi sonuçları, yenilenebilir enerji tüketiminin Türkiye ve Hindistan için uzun vadede finansal gelişime bağlı olarak değişkenlik gösterdiğini tespit etmiştir. Elde edilen sonuçlara dayanarak, bu çalışma, enerji güvenliğini ve sürdürülebilir küresel ortamı sağlamak için daha verimli bir ekonomik ve finansal sistem tasarlanabilmesi üzerine bir dizi politika önerisi sunmaktadır.

Anahtar Kelimeler: Çevresel Kuznets Eğrisi hipotezi, Finansal gelişim, Kayıt dışı ekonomi, Yenilenebilir enerji tüketimi, Çevresel dezenformasyon, Zaman serisi analizi

To My Family and Friends

ACKNOWLEDGMENT

Firstly, I would like to express my sincere gratitude to my supervisors Prof. Salih Katırcıoğlu and Prof. Korhan Gökmenoğlu for the continuous support of my Ph.D study and related research, for their patience, motivation, and immense knowledge.

Besides my supervisors, I would like to thank Prof. Nesrin Özataç for the endless support and encouragement that she showed throughout my academic journey at Eastern Mediterranean University. I will always be grateful not only for her tremendous academic support, but also for giving me so many wonderful opportunities.

This study might have never happened without the employment opportunities of the Banking and Finance Department. I was privileged to be hired as a research assistant since the beginning of my Ph.D education. During my time at the department, I was surrounded by excellent professors and learned a lot from their academic experiences. I was also lucky enough to work with brilliant fellow researchers and we constantly shared our knowledge to contribute on each other's studies. I thank them all for their guidance and support.

I wish to give special thanks to my fiancée Dr. Nigar Taspinar for putting her faith in me. Even when I doubted from myself, she was right beside me and kept me strong with her love and support. Thank you for bearing with me during the time of this study. I owe you a lot.

Last but not the least, I deeply thank my parents; Ünal, Elif and Onur Eren for their unconditional trust, timely encouragement, and endless patience.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADF-GLS	Augmented Dickey Fuller – Generalized Least Squares
AIC	Akaike Information Criterion
AMG	Augmented Mean Group
ARCH	Autoregressive Conditional Heteroscedasticity
ARDL	Autoregressive Distributed Lag
BP	British Petroleum
BRIC	Brazil, Russia, India and China
CD	Cross-Sectional Dependence
CO_2	Carbon Dioxide
CUSUM	Cumulative Sum
DBC	Deposit Money Bank Assets to Central Bank Assets
DC	Domestic Credit
DOLS	Dynamic Ordinary Least Squares
DW	Durbin Watson
ECM	Error Correction Model
ECT	Error Correction Term
EKC	Environmental Kuznets Curve
EN	Fossil Fuel Energy Consumption
FD	Financial Development
FDI	Foreign Direct Investments
FMOLS	Fully Modified Ordinary Least Squares
GDP	Gross Domestic Product
GHG	Greenhouse Gas Emissions

GLS	Generalized Least Squares
INF	Informal Economy
IPCC	Intergovernmental Panel on Climate Change
LM	Lagrange Multiplier
NSDP	Per Capita Net State Domestic Product
OECD	Organization for Economic Co-operation and Development
REN	Renewable Energy Consumption
VAR	Vector Autoregressive
VECM	Vector Error Correction Model
ZA	Zivot-Andrews

Chapter 1

INTRODUCTION

Environmental degradation has been an important issue since the industrial era of economic activities. The atmosphere's inability to maintain excessive amount of greenhouse gas (GHG) emissions has already produced unwanted climate changes and it is expected to cause further ecological damages in the near future. According to the World Meteorological Organization (WMO) (2018), total GHG emission levels have increased by 175% compared to pre-industrial economic era. Heat-trapping nature of these gasses has led to rapid rises in the global temperature that used to be constantly stable for the last couple of thousands years. The records tracked by National Aeronautics and Space Administration (NASA) revealed that the mean surface temperature of Earth has increased by 0.9 degrees Celsius since the late 19^{th} century (GISTEMP Team, 2018). Reported figures further showed that the hottest surface temperature levels since the mid-1880s have been recorded in the last 35 years. Extreme weather changes, water scarcity, ocean/sea level rises, and lower human mortality rate are some of the permanent damages that 'global warming' will cause unless it can be mitigated soon (IPCC, 2018). The substantial evidence regarding the catastrophic consequences of global warming has produced international concerns and fighting against climate change has become an ambitious goal for many nations. As of January 2019, 194 parties (states and countries) who are responsible from 87% of the global GHG emissions signed the Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC) to stop further global temperature rises (UNFCCC, 2019).

Although global warming is a natural phenomenon, GHG emissions are primarily produced by human activities which accelerated the process to alerting levels (IPCC, 2018). The Worldbank (2017) has reported that overall energy consumption around the world has increased by 44% from 1971 to 2014 and 78.4% of the total energy consumption is based on fossil fuel resources. Excessive combustion of fossil fuel adds inordinate amounts of carbon dioxide (CO2) emissions into the atmosphere, which leads to detrimental environmental effects. Dependence on fossil fuel consumption on a large scale brings the risk of energy insecurity for importing countries. As of 2017, oil is the most used fuel in the world, making up one-third of total energy consumption. Organization of the Petroleum Exporting Countries (OPEC) holds 71.5% of total oil reserves, while others mostly rely on the producing countries (BP, 2017). Long-term energy security is necessary for viable investments to keep the energy supply in line with economic prosperity and development. In the short term, energy security requires uninterrupted availability of the demanded energy source and stable prices to make it affordable (IEA, 2017). However, highly volatile nature of fossil fuel markets places importing countries at risk of energy insecurity. The disruption of the supply-demand balance of energy is expected to generate severe economic consequences. Therefore, energy-based economies are vulnerable to conservation policies that limit the usage of energy consumption (Eggoh, Bangake and Rault, 2011; Shahbaz, Khan and Tahir, 2013; Alshehry and Belloumi, 2015; Tang, Tan and Ozturk, 2016). As the concerns regarding the global environmental degradation, energy insecurity and their economic consequences are considered, understanding the dynamics between economic activities and environmental quality became a vital study field among academics and practitioners. Renewable energy stands as a potential tool to achieve energy diversification. Less dependency on fossil fuel resources implies a stronger resistance against energy market shocks. Moreover, green energy production might prevent further environmental degradation. However, transitioning from fossil fuel based energy to renewable energy production can be challenging. One of the primary difficulties toward adapting renewable energy is the cost. There are number of financial obstacles to overcome compared to fossil fuel based energy investments; these include higher infrastructure, start-up and operating costs. In this context, it is essential to have a solid financial system to provide an efficient way of price discovery and funding, market liquidity and risk management. Moreover, financial markets enhance the capital allocation. Highly developed financial system increases investments made in growing industries, while an underdeveloped financial system decreases investments made in declining industries (Wurgler, 2000). Therefore, in an environment where renewable energy investments are highly encouraged, the role of financial development can be substantial. Among the energy literature, there is a growing interest in investigating the factors that derive the usage of renewable energy consumption.

Empirical literature of the environmental economics has generated a vast amount of studies that are focusing on the economy-energy-pollutants linkages (Tiris, Atagunduz, and Dincer, 1994; Hawdon and Pearson, 1995; ZhiDong, 2003; Oliveira and Antunes, 2004; Price and Keppo, 2017). However, the relationship between economic growth, energy consumption and environmental degradation remains inconclusive due to mixed empirical evidences. Conflicting empirical outcome on the nexus is usually associated with the omitted variable bias (Frankel and Romer, 1999; Lundgren, 2003). To prevent a possible omitted variable bias, particular segments of the economy have included in the constructed empirical models. For instance, Frankel and Romer (1999) argued that as the countries reach into higher levels of financial development, economic growth escalates through higher local and international investment activities which in turn affect the environmental quality. In this extent, financial development has become an increasingly examined factor in terms of its constructive or destructive environmental impacts. In addition, various other factors such as urbanization, industrialization, foreign direct investments, renewable energy and electricity consumption are taken into consideration by many researchers to reveal the true determinants of environmental degradation.

It should be noted that big majority of the existing studies do not include the share of unrecorded economic activities into their estimation processes. Especially in developing countries, the size of the informal economy reaches into significant levels which might lead to changes in environmental quality. Although the diverse measurement approaches make the informal economy hard to define, the phenomenon can be referred as "market-based production of goods and services, whether legal or illegal, that escapes detection in the official estimates of GDP" (Smith, 1997).[1] Schneider and Enste (2000) presented a detailed overview regarding the size and consequences of the unofficial economy on the official one. They stressed that despite the estimation differences and complexity of measurements, the informal economic activities had reached an enormous size in most transition and OECD countries since the 1970s. In the aspect of environmental quality, the informal

[1] The shortcomings of such a broad definition have discussed broadly by Schneider and Enste (2000). Their study has emphasized that size of an informal economy might show differences depending on the estimation methodologies.

economy may have hazardous influences. Unlike the firms who operate under the authority of governments, unregistered firms tend to evade environmental regulations and might cause higher pollution (Baksi and Bose, 2010). For Latin American countries, Loayza (1999) demonstrated that as the share of the underground economy rises, public services quality falls due to inefficient use of the existing facilities. In other words, some of the most essential services of general interests such as electricity distribution, environmental protection practices, public transportation, and waste management are expected to function poorly in the existence of the informal economy.

Based on the given theoretical and empirical linkages for the economic growth-environment nexus, this study focuses on the Environmental Kuznets Curve (EKC) framework by investigating the interactions between environmental degradation, renewable energy consumption, fossil fuel consumption, financial development and informal economic activities. Inspired from the pioneering study of Kuznets (1955) which examined the long-run shifts between unequal distribution of income and economic growth, EKC hypothesis argues that environmental degradation increases as a result of high economic growth until a point where increasing economic activities starts to improve environmental quality by reducing the degradation of the environment (Agras and Chapman, 1999). Such a relationship between economic growth and environmental degradation is referring to an inverted U-shaped curve in which the variables of environmental degradation can be modeled as functions of income growth (Dinda, 2004). Theoretically, the EKC hypothesis can be explained by the economic stage shifts that countries experience over their growth processes. According to that, during their rapid economic growth periods, nations initially move from agriculture to the industrial stage in which they generate a high amount of pollution. Subsequently, the pollutant-induced industrial stage is expected to be followed by the state of technologically advanced and efficient industrial production which economic activities start to improve the quality of environment (Stern, 2004; Tao, Zheng and Lianjun, 2008).

The contribution of this study is twofold. First, it examines the potential relevance of financial sector development on global environmental degradation. Second, it takes the role of the informal economy in empirical modelling process of the EKC hypothesis. By being relevant to the modelling procedure of the current study, Turkey and India are selected as the sample countries. As an emerging economy aiming to achieve a higher level of economic growth with a sustainable environment, Turkey is a compelling case to study. According to the Climate Change Performance Index (CCPI) (2019), Turkey is ranked as the 50^{th} out of 61 countries in managing the GHG emissions. World Bank (2017) reported that the CO2 emissions of the country increased at a fast pace in the last three decades. Also, the figures showed that the total energy consumption of the country which mostly contains fossil based energy, increased by 50% in the last decade. That being said, Turkey introduced a number of policies towards achieving sustainable economic growth in the process of its European Union membership accession. Throughout its economic past, Turkey went through economic liberalization policies, experienced severe economic crises and performed successful recoveries. During this volatile process, Turkey abounded the fixed exchange rate regime in 2001 and liberalized its financial market by letting free capital movements (Gokmenoglu, Kirikkaleli, and Eren, 2018). Throughout its transition period of being a market economy, Turkey introduced numerous economic reforms and carried out institutional structural changes to promote the private business sector. The economic survey of the OECD (2018) stated that these promotions helped Turkey in accelerating the production at official level. However, it is showed that the country continues to struggle with the informality as the size of its unrecorded economy makes up 27% of the total GDP (Savasan, 2003; Schneider and Savasan, 2007).

According to BP (2017), India's total energy consumption growth is expected to increase by 129% by the year 2035. It is worth mentioning that this number is more than double the non-OECD countries' average (52%) and it is also significantly higher than other BRICS countries as China (47%), Brazil (41%) and Russia (2%). It is further reported that by 2035, India will reach 9% share of the world's total energy consumption. Due to its high population growth and rapid rise in industrial output, India will become the fastest growing energy consuming country by 2035. Although the energy consumption is heavily dependent on the fossil fuel, India is the fifth country in the world in renewable energy consumption. The Indian government continues to support the research of alternative energy sources; as a result, renewable energy investments continue to take place. Since India is a developing economy and facing a high energy demand, studying the country can yield important outcomes for the energy literature. Renewable energy in India is composed of hydroelectricity, non-hydroelectric renewables, solar, tide, wave, fuel cell, wind and, biomass and waste. The biggest proportion of renewable energy is hydroelectricity with an increasing trend between the period of 2005-2015 (see figure 1).

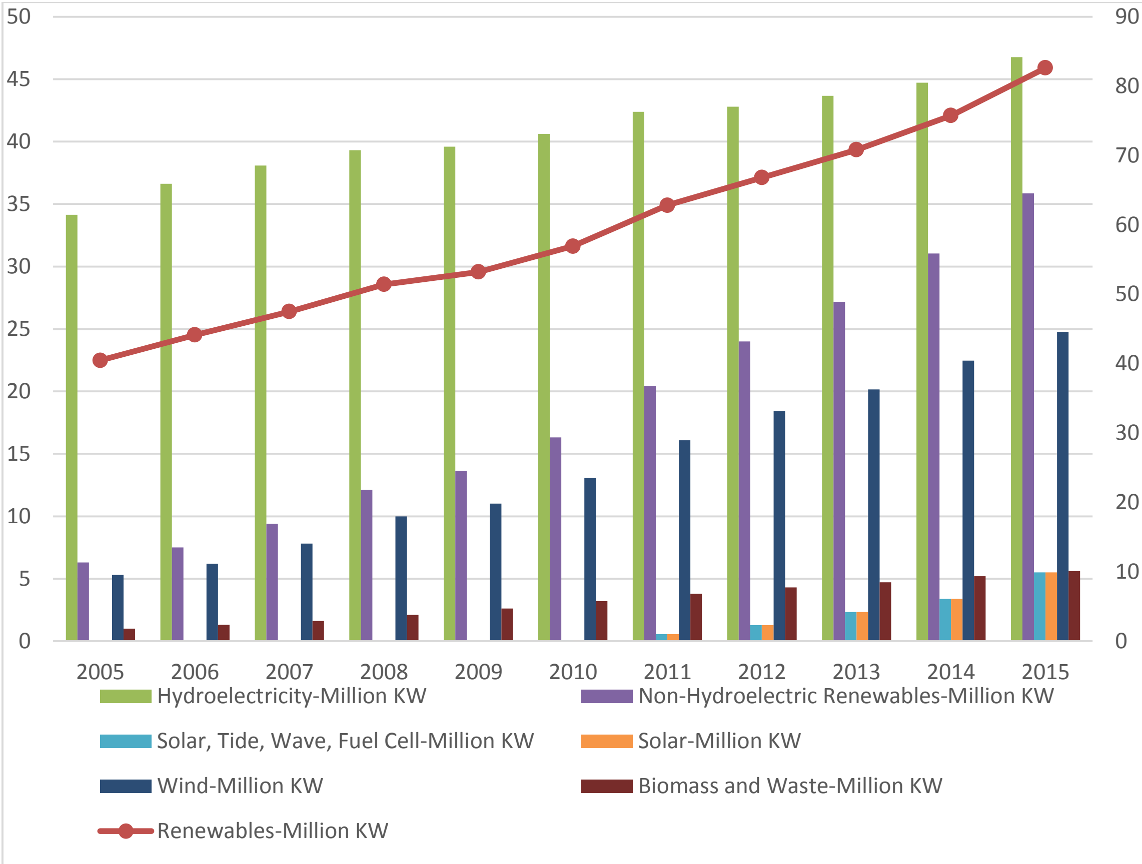

Figure 1. Composition of Renewable Energy Consumption in India
Source: U.S. Energy Information Administration (2018)

It is well documented that informal economic activities are making up a significant proportion of the Indian economy. According to India Labor Merket Update (2016), unregistered labor force composes around 80% of the total workforce in the country. It is further highlighted that the informal sector in India is more dominant than formal sector and it has a very limited contribution to the national income.

Given the fact that developing economies experience market shocks more often than developed economies, it is very likely to encounter some unexpected changes in developing countries' statistical parameters. Therefore, empirical studies that follow a series of econometrics procedures should carefully examine the structural stability of their tests. In order to avoid estimation errors and biased empirical outcome, this study employs appropriate tests that take structural breaks into account. First, Carrion-i-Silvestre, *Kim*, and Perron (2009) unit root test which allows five structural breaks in the series is utilized to determine the stationarity properties of the examined variables. Second, Maki (2012) cointegration test is employed under five structural breaks to confirm the equilibrium relationship. Finally, the obtained structural breaks are included from the cointegration test in the long-run coefficient estimation process.

The rest of the study is organized as follows: Section 2 provides a literature review on the subject; section 3 highlights the sample data and methodology, section 4 presents the empirical findings and finally, section 4 presents the conclusion and policy implications.

Chapter 2

LITERATURE REVIEW

Many number of studies examined the determinants of environmental degradation for both developed and developing economies. Due to its high influence in creating unwanted level of `greenhouse` effects, majority of the empirical investigations used CO2 emissions as the indicator of global pollution. Considering the tremendous increase of CO2 emissions after the industrial advancements, two parallel strands of literature have emerged among the practitioners. The first group of studies has mainly focused on the relationship between the GHG emissions and economic growth. In particular, the EKC hypothesis has received significant attention as the global pollution and the economic growth variables may not have a monotonic relationship with each other. Although there are alternative ways to produce energy such as nuclear and renewables, fossil fuel based energy consumption is the dominating source of energy. Based on the argument that excessive fossil fuel consumption leads to producing more CO2 emissions, the second group of studies has been concentrating on the relationship between energy consumption and economic growth.

The EKC hypothesis was initially confirmed by the study of Grossman and Krueger (1991) and it became a well-studied empirical phenomenon for the economic growth-pollution nexus. The studies of Panayotou (1993), Selden and Song (1994), Moomaw and Unruh (1997), Lindmark (2002), Managi and Jena (2008), Ozturk and Acaravci

(2010), Pao and Tsai (2011), Apergis and Ozturk (2015), Aslan, Destek and Okumus (2018), Gokmenoglu and Taspinar (2018) and Katircioglu, Gokmenoglu and Eren (2018) are among the ones that have provided evidence for the EKC hypothesis by revealing the inverted U-shaped relationship between economic growth and environmental degradation. Many other studies, on the other hand, failed to demonstrate such a relationship and argued that the hypothesis is not valid (Zilio and Recalde, 2011; Arouri, Youssef and M'henni, 2012; Chandran, 2013; Ozcan, 2013; Al-Mulali, Weng-Wai, Sheau-Ting and Mohammed, 2015; Baek, 2015; Ganda, 2019).

Following the introduction by the study of Kraft and Kraft (1978), the relationship between energy consumption and economic growth has got a lot of attention. Kraft and Kraft (1978) found that economic growth is the main driver of energy consumption and there is a unidirectional causality running from economic growth to energy consumption. This finding implies that energy conservation policies will have a minor or no adverse effect on economic growth. This phenomenon is referred as *conservation hypothesis*. The conservation hypothesis has been confirmed by many other studies (Abosedra and Baghestani, 1989; Cheng and Lai, 1997; Magazzino, 2016; Destek and Sarkodie, 2019). However, there are significant numbers of studies those provide conflicted outcomes with that of *conservation hypothesis*. In this context, three additional hypotheses have been put forward to explain the energy – economic growth nexus. First one is the *growth hypothesis* which suggests that energy use is a determinant of economic growth and any energy conservation policy will result in deterioration of economic growth. A finding of a unidirectional causality running from energy consumption to economic growth supports this hypothesis (Rafiq and Salim, 2011; Stern, 1993; Soytas, Sari and Ozdemir, 2001;

Tang et al., 2016; Bekun, Emir and Sarkodie, 2019). Next is the *feedback hypothesis* which argues that energy consumption and economic growth are interrelated and is represented by a bi-directional causality between these variables (Hwang and Gum, 1991; Glasure, 2002; Wang, Li, Fang and Zhou, 2016; Liu and Hao, 2018). According to this hypothesis, energy conservation policies are likely to cause economic disruption and similarly changes in economic growth are expected to alter the level of energy consumption. At last, the *neutrality hypothesis* denies the existence of a relationship between energy consumption and economic growth. Nonexistence of a causal relationship between energy consumption and economic growth is supported by some studies as well (Eden and Jin, 1992; Ozturk and Acaravci, 2010; Rafiq and Salim, 2009).

As the renewable energy usage continues to increase, economic consequences of adapting renewable energy remain its importance. As a result, the relationship between renewable energy and economic growth has garnered significant attention and has been intensively investigated over the past decade. However, the studies produced conflicting results. Sadorsky (2009a, b), Menyah and Wolde-Rufael (2010), Tiwari (2011) and Dong, Sun and Dong (2018) supported the conservation hypothesis between renewable energy consumption and economic growth. Their studies argued that policy decisions to conserve energy cause little or no adverse impact on the economic growth of the examined countries. Subsequently, Yildirim, Sarac and Aslan (2012), Bilgili (2015), Bilgili and Ozturk (2015), Ozturk and Bilgili (2015), Hamit-Haggar (2016), Inglesi-Lotz (2016), Destek and Aslan (2017), Adams, Klobodu and Apio (2018) and Balsalobre-Lorente, Shahbaz, Roubaud and Farhani (2018) presented empirical evidence to support the growth hypothesis and discussed how policies toward energy conservation and direct or indirect energy restrictions in the investigated economies would adversely affect their GDPs. Another group of studies supported the feedback hypothesis. The works of Apergis and Payne (2010a, b), Apergis, Payne, Menyah and Wolde-Rufael (2010), Apergis and Payne (2011), Apergis and Payne (2012), Pao and Fu (2013), Al-mulali, Fereidouni and Lee (2014), Lin and Moubarak (2014), Shahbaz, Loganathan, Zeshan and Zaman (2015), Shahbaz, Rasool, Ahmed and Mahalik (2016), Kahia, Aissa and Lanouar (2017), Amri (2017) and Pao and Chen (2018) revealed renewable energy consumption and economic growth are interdependent. It is discussed that policy implications regarding renewable energy consumption will lead to changes in the economic growth of countries and likewise, the economic growth changes are expected to impact the level of renewable energy consumption. Finally, Payne (2009), Bowden and Payne (2010), Menegaki (2011), Ocal and Aslan (2013) and Dogan (2015) showed there is no causal relationship between renewable energy and economic growth. In other words, nations can target reductions of renewable energy consumption through conservation policies or increase it without worrying about the economic outcomes of such policies.

Regardless of the differing opinions on economic impact, one aspect remains steadily true: the level of financial sector development can be a significant factor in renewable energy consumption. Renewable energy projects by nature are very expensive. They require high startup costs, long-term debt repayment and consistent investments in research and development (Sonntag-O'Brien and Usher, 2006). A developed financial system can channel credits to a renewable energy industry in an efficient way. In contrast, an underdeveloped financial system may prevent new projects from emerging, even if there is a demand for them. Unfortunately, studies investigating the role of financial development in renewable energy are quite limited.

Brunnschweiler (2010) was first to examine the issue empirically. She confirmed in her panel of non-OECD countries that financial sector development has a significant and positive effect on the amount of renewable energy production. In their attempt of determining the factors that most influence renewable electricity consumption in China, Lin, Omoju and Okonkwo (2016) found that renewable electricity consumption and financial development are cointegrated. They also confirmed that financial development has positive long run effect on renewable electricity consumption. Hassine and Harrathi (2017) investigated the causal interactions between renewable energy consumption, real GDP, trade and financial development for the Gulf Cooperation Council countries during the period 1980-2012. They found a unidirectional causality running from renewable energy consumption to private sector credit, which is used as the proxy of financial development. The study further showed that long run coefficients from renewable energy to financial development are significant and positive. In a panel setting of 12 Commonwealth of Independent States, Rasoulinezhad and Saboori (2018) explored the causal interactions between renewable and non-renewable energy consumption and economic growth by considering the roles of trade intensity and financial openness. Their panel causality test results revealed a unidirectional linkage from financial openness to renewable energy. By dividing 19 Asia Cooperation Dialogue countries into three income groups, Ali, Khan and Khan (2018) investigated the dynamics between financial development, tourism, trade sanitation, renewable energy and total reserves. The outcome of panel Granger causality under VECM provided evidence that financial development and renewable energy variables have a bidirectional relationship for low, middle and high income Asian countries.

Frankel and Romer (1999) argued that as the countries reach into higher levels of financial development, economic growth escalates through higher local and international investment activities which in turn affect the environmental quality. In this extent, financial development has become an increasingly examined factor in terms of its constructive or destructive environmental impacts. According to Lundgren (2003) and Ma and Stern (2008), financial development can stimulate technological enhancements in industrial goods and services production of the companies. Such improvements in technology help enterprises to achieve economies of scale and as a consequence, environmental degradation decreases by reduced waste and resource pollution. Although financial sector development can generate an expansion in industrial production level and conveys economic growth, failing to adopt technological innovations might leave a deteriorating impact on the environment. Sadorsky (2011) indicated that financial development enables easy access to capital for businesses to expand their operations and help individuals to afford big ticket items such as cars and houses. As a result, energy consumption is expected to rise to the degree that energy conservation policies might fail to reach their targets if they do not include the impact of financial development. Katircioglu and Taspinar (2017) highlighted that increased financial development might lead to environmental pollution through higher energy consumption unless sustainable growth transition can be achieved.

By investigating the link between financial development and environmental degradation, Tamazian and Rao (2010) found empirical evidence showing that financial sector development promotes capital mobility toward green investment projects and contributes to CO2 emission reductions. Jalil and Feridun (2011) suggested an inverse relationship between financial development and environmental pollution for China. For the case of Indonesia, Shahbaz, Hye, Tiwari, and Leitao (2013) determined a unidirectional causality running from financial sector development to CO_2 emissions. They emphasized the supportive role of financial sector development for businesses to adopt advanced green energy technologies. Similarly, Shahbaz, Tiwari, and Nasir (2013) revealed the mitigating role of banking sector development in reducing CO_2 emissions in South Africa as financial reforms are introduced in the country. Bekhet, Matar, and Yasmin (2017) identified the financial development as an essential determinant of energy emissions reduction for Gulf Cooperation Council countries. Katircioglu and Taspinar (2017) tested the direct and moderating effects of the financial sector development. The test results confirmed the short and long-term effects of the financial development on the EKC framework through the channels of energy use and economic growth. Moreover, Tamazian and Rao (2010), and Saidi and Mbarek (2017) presented empirical outcome about financial sectors' mitigating role of GHG emissions. On the other hand, Abbasi and Riaz (2016) and Shahzad, Kumar, Zakaria, and Hurr (2017) showed for the case of Pakistan that financial development increases the level of global environmental degradation due to its pre-mature structural transformation in the economy. Finally, Ozturk and Acaravci (2013) reported that financial development is not a statistically significant variable for the changes in CO_2 emissions in the long-run.

2.1 A Summary of the EKC Studies Carried Out for Turkey

The linkage between economic growth and global environmental pollution in Turkey has been subject to a lot of empirical studies. Mixed evidence about the validity of the EKC hypothesis has made Turkey one of the most examined case studies in the empirical literature (see Table 1). Lise (2006) demonstrated that the carbon intensity in Turkey has been increasing at a fast pace over the period 1980 – 2003. The decomposition analysis of the study revealed that CO2 emissions in the country are economic growth driven. The results also showed that the conventional EKC hypothesis in which, the emitter variable is regressed with GDP and GDP squared, is not significant. Akbostanci, Turut-Asik and Tunc (2009) carried out two staged empirical analyses to test the relationship between global pollution and income for Turkey. In the first stage of their examination, a time series approach is used over the period 1968 – 2003 and CO2 emissions are taken as the relevant proxy for the pollution. The second stage of their analysis is used particulate matter and sulfur dioxide emissions for 58 Turkish provinces under a series of panel data procedures. Their estimations confirmed cointegration between the variables and the long-run coefficient results failed to support an inverted U-shaped trend. It is demonstrated that the global pollutants are increasing (decreasing) monotonically with a decreasing (increasing) level of economic growth. Ozturk and Acaravci (2010) employed the Autoregressive Distributed Lag (ARDL) (Peseran and Shin, 1999) cointegration methodology in order to test the EKC hypothesis. In addition to conventional variables of GDP, GDP^2 and energy consumption, the authors also included the impact of the employment. After confirming the long-term relationship between the variables, they conducted the two-step Granger causality (Engle and Granger, 1987) to show directional effects. According to their estimations, the EKC hypothesis was not valid for the case of Turkey. Katircioglu and Katircioglu (2018) tested the EKC hypothesis by modelling it with the consideration of urban development in the country. The econometric methodology is followed by taking possible structural breaks in the series for the period 1960 – 2013. The long-run cointegration relationship is confirmed through the Maki (2012) test under five structural breaks and coefficient estimations are extracted by the ARDL approach. The authors showed a U-shaped relationship between CO2 emissions and other explanatory variables and therefore, the EKC hypothesis cannot be validated. Besides the studies that are failed to produce an empirical evidence to validate the EKC hypothesis, some others supported the hypothesis for Turkey. For example, Yavuz (2014) confirmed long-term equilibrium relation between the variables of CO2 emissions, energy consumption and economic growth by the tests of Gregory and Hansen (1996) test under structural breaks Johansen (1991). Furthermore, FMOLS and DOLS tests are employed to capture the long-term coefficients and the results supported the inverted U-shaped relationship.

Table 1: A Summary of the EKC Studies Carried Out for Turkey

Studies	Independent Variables	Methodology	Conclusion
Lise, W. (2006)	GDP, energy supply per technology, energy consumption per technology.	Decomposition analysis.	EKC is not confirmed
Akbostancı, E., Türüt-Aşık, S., and Tunç, G. İ. (2009)	GDP per capita, population density.	VAR analysis (first model), pooled EGLS regression (second model).	EKC is not confirmed
Ozturk, I., and Acaravci, A. (2010)	GDP per capita, energy consumption, employment.	ARDL, Granger causality.	EKC is not confirmed
Ozturk, I., and Acaravci, A. (2013)	GDP, GDP^2, energy consumption, trade openness, financial development.	ADF-GLS and ADF-WS unit root tests, Bounds test, ARDL, Granger causality.	EKC is confirmed
Shahbaz, M., Ozturk, I., Afza, T., and Ali, A. (2013)	GDP per capita, GDP^2 per capita, energy intensity per capita, globalization index.	Zivot Andrews (1992) unit root test, bounds test, Johansen cointegration test, Gregory-Hansen (1996) cointegration test, VECM Granger causality test.	EKC is confirmed
Yavuz, N. C. (2014)	GDP, GDP^2, energy consumption.	ADF, PP and Zivot Andrews (1992) unit root tests, Johansen and Gregory-Hansen (1996)	EKC is confirmed

		cointegration test.	
Bölük, G., and Mert, M. (2015)	GDP, GDP^2, energy consumption.	Bounds test, ARDL error correction model.	EKC is not confirmed (U-shaped)
Seker, F., Ertugrul, H. M., and Cetin, M. (2015)	GDP, GDP^2, energy consumption, foreign direct investment.	ADF, PP and Ng-Perron unit root tests, Bounds test, Hatemi-J (2008) cointegration test, ARDL.	EKC is confirmed
Dogan, N. (2016)	GDP, GDP^2, energy consumption, agriculture growth.	Bounds test, ARDL.	EKC is confirmed
Gökmenoğlu, K., and Taspinar, N. (2016)	GDP, energy consumption, foreign direct investment.	Zivot Andrews (1992) unit root test, Bounds test, ARDL error correction model, Toda-Yamamoto (1995) causality test .	EKC is confirmed
Gozgor, G., and Can, M. (2016)	GDP, GDP^2 per capita, energy consumption, export product diversification.	Strazicich et al. (2004) unit root test, Maki (2012) cointegration test, DOLS regression.	EKC is confirmed
Katircioglu, S. T., and Taspinar, N. (2017)	GDP, GDP^2, financial development.	Maki (2012) cointegration test, DOLS regression Granger causality/block exogeneity Wald test.	EKC is confirmed
Katircioglu, S., and Katircioglu, S. (2018).	GDP, urbanization, energy consumption	Carrion-i-Silvestre et al. (2009) unit root test, Maki (2012). cointegration test, ARDL.	EKC is not confirmed
Ozcan, B., Apergis, N., and Shahbaz, M. (2018).	GDP, ecological footprint.	Hacker-Hatemi-J (2006) bootstrap Granger causality.	EKC is not confirmed
Pata, U. K. (2018)	GDP, financial development, trade openness, industrialization, urbanization, coal and noncarbohydrate energy consumption.	Bounds test, ARDL.	EKC is confirmed

It should be noted that countries are inherited with different sociological, governmental and economic backgrounds. Therefore, employing standardized empirical models without acknowledging a relevant variable for a particular country or case might produce biased outcomes. Based on this argument and inconclusive empirical findings, recent studies started extent the EKC modelling by adding new variables to produce robust outcomes. For instance, Seker, Ertugrul and Cetin (2015) investigated the hypothesis by including the foreign direct investments (FDIs) into their empirical modelling. They argued that rapidly growing FDI inflows into the Turkey may have significant impacts on the environmental quality and excluding this variable may lead to biased conclusions about validity of the EKC hypothesis. Hatemi-J (2008) cointegration test under structural breaks confirmed the long-term relationship between the variables and the ARDL model confirmed the existence of the hypothesis. Similarly, Gokmenoglu and Taspinar (2016) examined the impacts of GDP, energy consumption and FDI inflows on CO2 emissions for Turkey. The outcome of the ARDL methodology indicated that an increase in GDP leads to an increase in the global pollution level at the short-run while an increase in GDP leads to a decrease at the long-run. In addition, the Toda-Yamamoto (1995) causality test results revealed a bi-directional relationship FDI and CO2 emissions. Agricultural sector makes up a big share of total GDP of Turkey. Dogan (2016) suggested that the sector may create global pollution and it may be a significant variable for the environment. Covering the period 1968 – 2010, the study found evidence which supports the EKC hypothesis. Ozturk and Acaravci (2013) pointed that GDP may not be the sole reason for the changes in global pollution level. The authors emphasized the fast growth rate of the financial sector development and they discussed that financial development may promote the usage of fossil fuel based products which in return causes higher CO2 emissions. Although the results supported the EKC hypothesis for Turkey, the authors concluded that the financial development has no significant impact on the global pollution. Katircioglu and Taspinar (2017) investigated the role of financial development on environmental degradation. The authors constructed two different models to examine the EKC hypothesis. In the first model, three moderating variables are created by taking the interactions between financial development, GDP, GDP^2 and energy consumption. The second model is excluded these interaction variables to conduct a robustness check with the first model. The second generation time series analyses revealed that financial development in Turkey has a negative influence on the CO2 emissions. It is also showed that the financial sector alters the global emissions indirectly through the variables of GDP, GDP^2 and energy consumption.

As the renewable energy sources become a viable substitute for fossil fuel based energy, some studies tested their relationship with the global environmental well-being. In the context of Turkey, Boluk and Mert (2015) tested impact of electricity consumption produced from renewables on CO2 emissions. The result of the carried out ARDL test showed an inverted U-shaped association by having statistically significant and positive at GDP and negative at GDP^2 variables. It is also shown that increasing the electricity consumption by using renewable energy sources transmits a negative impact on the greenhouse gas emissions. Bilgili, Kocak and Bulut (2016) investigated the role of renewable energy usage under the EKC modelling for 17 OECD countries. The study employed panel FMOLS and panel DOLS estimations to identify short and long-term coefficients. The results revealed that regardless of the income levels of the countries, EKC hypothesis is valid under the panel setting. It is highlighted that for the case of Turkey there is an inverted U-shaped relationship between CO2 emissions, GDP and GDP^2. Another highlight of the study was the negative effect of the renewable energy consumption on the CO2 emissions. It is discussed that although the renewable energy makes up a relatively small percentage of the total energy consumption in all of the examined countries, it is still a vital factor in reducing the global pollutants. Pata (2018) examined the role of renewable energy consumption on CO2 emissions in three separate models. Financial development and urbanization variables were used in all of the constructed models in order to capture their contributions on GHG emissions. The impacts of renewable energy use, hydropower energy and other alternative renewable energy sources were tested separately to avoid a multicollinearity problem. The long-term relationships among the variables were tested through the ARDL bounds testing and coefficients were acquired by FMOLS and DOLS. It is found that both fınancial sector development and urbanization have an increasing effect on the global pollution level. In all three models, renewable energy consumption variables turned out to be insignificant which contradicts with the findings of Boluk and Mert (2015).

The role of the informal economy has only covered by limited studies in the relevant literature. Elgin and Oztunali (2014) examined the link between the informal sector and environmental degradation by using both local and global pollutants for the case of Turkey. Conducted time series procedures demonstrated an inverse U-shaped relationship between the pollutants and the size of the informal sector. Recently, Imamoglu (2018) studied the impacts of informal economy and financial development on environmental quality. The test results of the ARDL methodology showed a significant and positive impact of the informal economy on environmental pollution for Turkey. Besides, the study pointed out that financial development has a contributing impact on the environmental performance and it decreases the pollution in the country.

2.2 A Summary of the EKC Studies Carried Out for India

India is one of the fastest growing developing economies with a high population count. The country requires consistent flow of energy to support its industrialized economic activities. Similar to the rest of the world, India’s main source of energy is based on fossil fuel. Based on this, sustainable economic growth of India became an important study area for researchers. Investigating the relationship between the economic growth and environmental degradation, EKC hypothesis is well studied phenomenon for the case of India (see Table 2). As it was discussed for the case of Turkey, practitioners paid special attention for some specific variables that might affect the environmental performance of India. For example, Jayanthakumaran and Liu (2012) extended the conventional EKC model by adding international trading activities. It is argued that trade liberalization process of the country can be a vital factor in terms of changing the level of greenhouse gas emission. Long-term relationship between the variables is tested through the Bounds testing procedure and coefficient estimations are predicted by the ARDL methodology. The empirical results provided evidence for the validity of the EKC hypothesis. In addition, the authors emphasized that structural transformation of international trade in India is an ambiguous variable and its impact on the CO2 emissions cannot be identified with confidence. High influence of the informal economic activities in the country is showed as the main reason for such inconclusive result. In response to these inconclusive findings between the international trade and CO2 emissions, Kanjilal and Ghosh (2013) suggested that `regime shifts` regarding the international trade laws shouldn’t be ignored in constructed empirical models. Therefore, they employed structural break points during the modelling process of their analyses. The empirical findings of the ARDL bounds test for the long-term interactions and coefficient estimates confirmed the EKC hypothesis. In opposition to the results of Jayanthakumaran and Liu (2012), international trade variable is found to be a statistically significant variable. By being an energy importer country, India's trading activities are found to have a negative effect on the global environmental pollution. Coal consumption in India constitutes a great share in the country's total energy consumption. Shahbaz, Hye and Tiwari (2013) examined the role of coal consumption on CO2 emissions also by including trade openness into the EKC setting. Their empirical methodology considered possible structural breaks for the tested series and supported inverted U-shaped relationship between the variables of CO2, GDP and GDP^2. The estimated coefficient parameters presented that both coal consumption and trade openness lead to produce more GHG emissions. Finally Granger causality test under Vector Error Correction Model (VECM) employed in the study to observe the directional relationship between the variables. The reported estimations showed a bi-directional causal relationship between coal consumption and CO2 emissions as well as between GDP and CO2 emissions. Boutabba (2014) studied the aspect of financial sector development in terms of the environmental degradation. In addition to the financial development, the constructed model also contained economic growth, energy consumption and trading activities under the VECM framework. The obtained results revealed a long-term equilibrium relationship among the variables and it is found that financial sector makes a positive contribution to global pollution. The causality tests identified that unidirectional causality exists form GDP to CO2 emissions. Sehrawat, Giri and Mohapatra (2015) highlighted the economic and financial liberalization process of India and discussed the possible outcome of this transition in terms of the global environmental well-being. The authors suggested that financial sector development might provide people to have an easier access to `big ticket items` which in turn might lead to consuming more energy. In this context, the impacts of economic growth, energy consumption and financial development on CO2 emissions are investigated through time series procedures for the case of India. The cointegration analysis of the bounds test methodology presented a long-term movement among the variables under investigation. Moreover, long-run estimations revealed that GDP is statistically significant and positive, while GDP^2 statistically significant and negative in respect to CO2 emissions. This indicates an initial increase in the level of CO2 emissions with the economic growth until a threshold point after which the emissions level starts to decrease. In addition to supported evidence towards the EKC, directional relationship between the variables is identified. The Granger causality test determined bi-directional causality between GDP and CO2 emissions in addition to unidirectional causality running from CO2 emissions to energy usage, GDP, GDP^2 and financial sector development.

Table 2: A Summary of the EKC Studies Carried Out for India

Studies	Independent Variables	Methodology	Conclusion
Alam, M. J., Begum, I. A., Buysse, J., Rahman, S., & Van Huylenbroeck, G. (2011)	GDP, total labor forces, the gross fixed capital formation.	ARCH-LM test, White test, Ramsey RESET, CUSUM test, granger causality	EKC is not confirmed
Mythili, G., & Mukherjee, S. (2011)	Per capita NSDP, Urbanization, Industry Category Dummy, GDP per capita,GDP^2	OLS regression	EKC is confirmed (S shaped)
Jayanthakumaran, K., Verma, R., & Liu, Y. (2012)	per capita, per capita energy consumption, trade openness.	Bounds test, ARDL.	EKC is confirmed
Govindaraju, V. C., & Tang, C. F. (2013).	GDP per capita, per capita coal consumption.	Bayer and Hanck (2010) cointegration test, VECM granger causality.	EKC is not confirmed
Kanjilal, K., & Ghosh, S. (2013)	GDP per capita, trade openness, per capita	ARDL, GH and HJ cointegration tests	EKC is confirmed

	energy use.		
Tiwari, A. K., Shahbaz, M., & Hye, Q. M. A. (2013)	GDP per capita, coal consumption, trade openness	Narayan and Popp (2010) unit root test, ARDL, VECM granger causality .	EKC is confirmed
Shahbaz, M., Mallick, H., Mahalik, M. K., & Loganathan, N. (2015)	GDP per capita, energy consumption, financial development, economic globalization.	Bayer–Hanck cointegration, VECM granger causality .	EKC is confirmed
Ahmad, A., Zhao, Y., Shahbaz, M., Bano, S., Zhang, Z., Wang, S., & Liu, Y. (2016)	GDP per capita, GDP^2 per capita, oil consumption, gas consumption, use of electricity, coal consumption	ADF, PP, Johansen cointegration test, ARDL, VECM granger causality.	EKC is confirmed
Alam, M. M., Murad, M. W., Noman, A. H. M., & Ozturk, I. (2016)	GDP per capita, energy consumption, population growth.	OLS, Wald test, ARDL	EKC is not confirmed
Ertugrul, H. M., Cetin, M., Seker, F., & Dogan, E. (2016)	per capita GDP, per capita energy consumption, trade openness.	ZA, ARDL, VECM Granger causality.	EKC is confirmed
Sinha, A., & Bhattacharya, J. (2016)	city level income, city specific effect, population	Fixed and random effect panel regressions	EKC is confirmed
Solarin, S. A., Al-Mulali, U., & Ozturk, I. (2017)	Real GDP, hydroelectricity consumption, urbanization.	ARDL, Granger causality.	EKC is confirmed
Pal, D., & Mitra, S. K. (2017)	GDP per capita, use of coal in electricity generation, energy import, trade openness.	ARDL	EKC is confirmed
Sinha, A., & Shahbaz, M. (2018)	GDP, renewable energy generation, electric power consumption, international trade, total factor productivity.	Bounds test, ARDL	EKC is confirmed

As the energy demand of India grew with its economic activities, energy diversification has become a vital policy for the governmental authorities. Although the fossil fuel based energy still plays a dominating role in the country, renewable energy investments continue to take place. In the last decade, environmental economics literature has generated increasing number of studies focusing on the impact of the renewables on global pollution in India. For example, Sinha and Shahbaz (2018) conducted a multivariate structured analysis where multiple structural breaks are taken into account. They tested the influence of the renewable energy on CO2 emissions along with other explanatory variables; GDP, GDP^2, international trade and total factor productivity. Their empirical outcome presented supporting evidence towards the existence of the EKC hypothesis. It is showed that the positive impact of the GDP variable in the linear model becomes negative when it is tested within the quadratic function. Furthermore, renewable energy consumption is found to be having a negative effect on the environmental degradation. By applying panel series procedures into seven regions around the world, Al-Mulali, Ozturk and Solarin (2016) tested the validity of the EKC hypothesis. Economic growth, financial development, trade openness and renewable energy use variables are examined in order to identify their influences on the global pollution. The empirical outcome of the research confirmed the equilibrium relationship between the variables by the Pedroni (1999) panel cointegration test. DOLS and VECM Granger causality tests underlined the negative impact of renewable energy consumption on CO2 emissions for five regions including South Asia. It is discussed that for India and the rest of the countries in those regions must design appropriate policy making tools since the renewable energy stands as an important factor to achieve better environmental and economic conditions. Dong, Sun and Hochman (2017) investigated the roles of natural gas and renewable energy consumption on the performance of CO2 emissions. The study carried out a panel data analysis for the so called BRICS (Brazil, Russia, India China and South Africa) countries whose share a similar economic development pattern. Due to the cross-sectional dependency among the groups in the panel, the study employed second-generation panel methodology. Westerlund (2005) cointegration test confirmed long-term relationship between the variables and the Augmented Mean Group (AMG) approach is used to provide the coefficient estimations in the model. Including India the results turned out to be in favor of the EKC hypothesis. It is further showed that in all five countries, natural gas and renewable energy decrease the level of global pollution. The VECM panel causality test specified a bi-directional causal relationship between renewable energy and CO2 emissions as well as between natural gas and CO2 emissions.

Chapter 3

DATA AND EMPIRICAL METHODOLOGY

3.1 Data

The present study covers the annual sample period of 1960-2013 for Turkey and 1971-2011 (due to data availability) for the case of India to construct a multivariate EKC model which captures the impacts of economic growth, fossil fuel based energy consumption, renewable energy consumption, financial development, and informal economic activities on CO2 emissions[2]. The variables that are used to model the given relationship include; carbon dioxide emissions (CO2) (total amount of kiloton), fossil fuel energy consumption (EN) (percent of total), renewable energy consumption (REN) (percent of total final energy consumption), economic growth proxy (GDP) (constant 2010 US$), financial development index (FD) and the volume of the informal economy (INF). Except the INF variable, all other variables are collected from the World Bank (2017). The INF variable was collected from the study of Elgin and Oztunali (2012) in which a two-sector dynamic general equilibrium model is used to estimate the size of the informal economy for 161 countries around the world[3].

[2] The specified time period is determined based on data availability of all the variables that are employed during the estimation procedure.
[3] In response to our request, the updated data for the informal economy has been sent by the courtesy of the authors.

3.2 Construction of the Composite Financial Development Index

Studies in the empirical literature propose several alternatives for the proxy preference of financial development. Based on the discussions of Beck, Demiguc-Kunt and Levine (1999), Levine, Loayza and Beck (2000) and Ang (2009), three main determinants of financial development are identified to quantify the financial sector development. These determinants are size of money in financial markets measured by the broad money in the system (M2), financial intermediation measured by the domestic credits provided by the financial sector (DC), and commercial bank effectiveness measured by the ratio of deposit money bank assets to central bank assets (DBC). Many studies have employed only one of these given indicators which might result in not capturing the full aspect of financial development. Hence, the present study constructs a composite financial development index (FD) which aims to reflect the development of the financial sector completely.

The functional representation of the financial development proxy which is used in this study can be written as follows:

$$\mathrm{FD} = f\,(\mathrm{M2}, \mathrm{DC}, \mathrm{DBC}) \tag{1}$$

The components of the index are collected from the World Bank (2017). All of the variables are represented in percentage numbers by taking the GDP% of the M2 and DC variables. The principal component analysis is implemented to calculate the index whose formula can be written as follows:

$$FD\ \text{Index} = \sum_{\mathrm{k}=1}^{\mathrm{k}} \mathrm{w}_{\mathrm{k}} \times S_k \tag{2}$$

The FD index is calculated by the ratio of variance by each financial component and the equivalent factor scores of each component (S_k). w_k designates the weight of each k[th] factor for the financial development determinant and it can be calculated as;

$$w_k = \left(\frac{\text{var}_k}{\sum_{k=1}^{n} v_k} \right) \times 100 \tag{3}$$

where var_k is the explained variance by each k[th] factor and n represents the number of factors (Chen, 2010).

3.3 Theoretical Setting and Specification of the Models

Empirical investigation of the EKC hypothesis started with examining the impacts of the initial and later stages of economic growth variables (GDP and GDP^2) on the global emissions level. This examination is also referred as the conventional EKC framework in the literature.

$$CO_{2_t} = f(GDP, GDP^2) \tag{4}$$

In parallel with the given functional relationship, many studies have included the variable of fossil energy consumption (EN) and renewable energy consumption (REN) into the conventional EKC to capture the impacts of fossil fuel and renewable energy consumption separately.

$$CO_{2_t} = f(GDP, GDP^2, EN, REN) \tag{5}$$

Equation 5 can be written in the form of a double logarithmic regression equation which appropriately represents the impact estimations of the regressors on CO_2 emissions.

$$\ln CO_{2_t} = \alpha_0 + \alpha_1(\ln GDP_t) + \alpha_2(\ln GDP_t^2) + \alpha_3(\ln EN_t) + \alpha_4(\ln REN_t)\varepsilon_t \quad (6)$$

Conventional EKC modelling has extended by including various economic sectors throughout the literature. By being one of the most crucial economic sector variables, financial development is included in the EKC estimation procedure by this study.

$$\ln CO_{2_t} = \alpha_0 + \alpha_1(\ln GDP_t) + \alpha_2(\ln GDP_t^2) + \alpha_3(\ln EN_t) + \alpha_4(\ln REN_t) + \alpha_5(\ln FD_t) + \varepsilon_t \quad (7)$$

Finally, the informal economy variable is added to the model to observe the environmental effects of underground activities.

$$\ln CO_{2_t} = \alpha_0 + \alpha_1(\ln GDP_t) + \alpha_2(\ln GDP_t^2) + \alpha_3(\ln EN_t) + \alpha_4(\ln REN_t) + \alpha_5(\ln FD_t) + \alpha_6(\ln INF_t) + \varepsilon_t \quad (8)$$

Equation 8 demonstrates the main model of this study where the effects of economic growth (GDP, GDP^2), fossil fuel energy consumption (EN), renewable energy consumption (REN), financial development (FD) and informal economic activities (INF) on carbon dioxide emissions (CO2) can be estimated for the case of Turkey and India.

Renewable energy is one of the most important factors that improve environmental quality for the countries. In parallel with the literature, economic growth and financial development are the main determinants of renewable energy consumption for emerging economies. Therefore, another model is constructed to capture the impacts of economic growth and financial development on renewable energy consumption for the case of Turkey and India. The functional relationship among renewable energy consumption, economic growth and financial development can be represented as follows:

$$lnREN_t = \beta_0 + \beta_1 lnFD_t + \beta_2 lnGDP_t + \varepsilon_t \quad (9)$$

where $lnREN_t$, $lnFD_t$ and $lnGDP_t$ are the logarithmic forms of renewable energy consumption, financial development and economic growth respectively.

3.4 Empirical Methodology

3.4.1 Unit Root Test

The empirical investigation of this study starts with determining the stationarity properties of the variables presented in equation 8 and 9. Unlike the many numbers of available tests, the unit root test of Carrion-i-Silvestre et al. (2009) allows multiple structural breaks to be included. Specifically, the test allows up to five structural breaks by employing the quasi-GLS procedure proposed by Elliot, Rothenberg, and Stock (1996). Carrion-i-Silvestre et al. (2009) discuss that similar other unit root procedures assume the occurrence of a break point under the alternative hypothesis of stationarity only. Not allowing a break under the null hypothesis leads test statistics to diverge or not being invariant to break parameters. Also, it is quite likely that such tests suffer from having low power as a result of failing to fully utilize the information about the structural break. The methodology of Carrion-i-Silvestre et al. (2009) overcomes the mentioned issues by allowing the structural breaks under both null (series are not stationary) and alternative (series are stationary) hypotheses. The test calculates five test statistics under multiple structural breaks; Gaussian point optimal statistics (P_t), modified feasible point optimal statistic (MP_t) and three M-type optimum statistics (MZα, MZ_t, and MSB). The simulation runs of the test demonstrated that it is suitable to be applied in small sample cases. Therefore, the unit root test of Carrion-i-Silvestre et al. (2009) is applied in the present study.

3.4.2 Cointegration Test

Conventional cointegration tests that identify the long-run equilibrium relationship between variables such as Engle and Granger (1987) and Johansen (1991) are often criticized for not taking possible structural breaks into account. In response, Gregory and Hansen (1996) introduced a new cointegration test which allows series to contain a single structural break. Hatemi-J (2008) improved these tests by enabling two structural breaks to be included in each series. According to Maki (2012), the main problem behind the mentioned tests is the necessity to include a specified number of breaks without having any priori information about the number of breaks. In other words, if a series is supposed to contain more than two breaks due to its volatile past values, then both Gregory and Hansen (1996) and Hatemi-J (2008) cointegration tests would perform poorly. Hence, Maki (2012) proposes a residual based cointegration test which allows series to have structural breaks up to five. Monte Carlo simulations confirmed that when there are more than three structural breaks for a given cointegration relationship, the test of Maki (2012) performs better than the others. The test can be conducted under four models which are written in a general regression equation as follows:

$$y_t = \lambda + \sum_{i=1}^{b} \lambda_i P_{i,t} + \alpha' x_t + \varepsilon_t \qquad (10)$$

$$y_t = \lambda + \sum_{i=1}^{b} \lambda_i P_{i,t} + \alpha' x_t + \sum_{i=1}^{b} \alpha_i' x_t P_{i,t} + \varepsilon_t \qquad (11)$$

$$y_t = \lambda + \sum_{i=1}^{b} \lambda_i P_{i,t} + \gamma^t + \alpha' x_t + \sum_{i=1}^{b} \alpha_i' x_t P_{i,t} + \varepsilon_t \qquad (12)$$

$$y_t = \lambda + \sum_{i=1}^{b} \lambda_i P_{i,t} + \gamma^t + \sum_{i=1}^{b} \gamma_i t P_{i,t} + \alpha' x_t + \sum_{i=1}^{b} \alpha_i' x_t P_{i,t} + \varepsilon_t \qquad (13)$$

where y_t and x_t denote variables with their first differences, b gives the maximum number of breaks and $P_{i,t}$ equals to 1 if t is larger than the time period of the breaks. Equation 10 presents level shifts (model 0), equation 11 presents regime shifts model (model 1), equation 12 presents regime shifts model with trend (model 2), and equation 13 presents structural breaks of levels, trends, and regressors (model 3). Given that Turkey and India had experienced frequent economic downturns and recoveries in its past, it is expected that the series of the country contain a high number of structural breaks. Therefore, this study employs Maki (2012) cointegration test under the null hypothesis of no cointegration for equations 8 and 9.

3.4.3 Estimations of the Long-Run Coefficients

After the long-run equilibrium relationship is identified, the long-run coefficient estimations are utilized by employing the Fully-Modified Ordinary Least Squares (FMOLS) technique. The FMOLS approach has initially proposed by Phillips and Hansen (1990) to address the issues associated with the statistical inference in integrated processes. By modifying the Wald statistics through semiparametric corrections for serial correlation and endogeneity, the test statistics of the FMOLS corrects the cointegrated models by removing the nuisance parameter dependencies. This methodology also asymptotically removes the sample bias as long as the variables in a cointegration system are integrated at order one (Narayan, 2005). The econometric equation model of FMOLS can be written as:

$$y_t = \delta_0 + \delta_1^{'} X_t + \varepsilon_t, \qquad t = 1,2,....,n \tag{14}$$

where y_t is a variable with an order of integration one and X_t is a (kx1) vector of non-cointegrating regressors.

During the long-run coefficient estimation of this study, the structural breaks obtained from the Maki (2012) cointegration test are inserted into the FMOLS as dummy variables.

3.4.4 Causality Test

In this study, Granger causality test through the VECM is applied in order to investigate the directions of possible long-run equilibrium relationship among variables. The Granger causality test suggests the estimation of the following ECMs for the models 8 and 9, respectively:

$$\begin{bmatrix} \Delta lnCO2 \\ \Delta lnGDP \\ \Delta lnGDP2 \\ \Delta lnEN \\ \Delta lnREN \\ \Delta lnFD \\ \Delta lnINF \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \\ \mu_6 \\ \mu_7 \end{bmatrix}$$

$$+ \begin{bmatrix} \partial_{11,1} & \partial_{12,1} & \partial_{13,1} & \partial_{14,1} & \partial_{15,1} & \partial_{16,1} & \partial_{17,1} \\ \partial_{21,1} & \partial_{22,1} & \partial_{23,1} & \partial_{24,1} & \partial_{25,1} & \partial_{26,1} & \partial_{27,1} \\ \partial_{31,1} & \partial_{32,1} & \partial_{33,1} & \partial_{34,1} & \partial_{35,1} & \partial_{36,1} & \partial_{37,1} \\ \partial_{41,1} & \partial_{42,1} & \partial_{43,1} & \partial_{44,1} & \partial_{45,1} & \partial_{46,1} & \partial_{47,1} \\ \partial_{51,1} & \partial_{52,1} & \partial_{53,1} & \partial_{54,1} & \partial_{55,1} & \partial_{56,1} & \partial_{57,1} \\ \partial_{61,1} & \partial_{62,1} & \partial_{63,1} & \partial_{64,1} & \partial_{65,1} & \partial_{66,1} & \partial_{67,1} \\ \partial_{71,1} & \partial_{72,1} & \partial_{73,1} & \partial_{74,1} & \partial_{75,1} & \partial_{76,1} & \partial_{77,1} \end{bmatrix} \begin{bmatrix} \Delta lnCO2_{t-1} \\ \Delta lnGDP_{t-1} \\ \Delta lnGDP2_{t-1} \\ \Delta lnEN_{t-1} \\ \Delta lnREN_{t-1} \\ \Delta lnFD_{t-1} \\ \Delta lnINF_{t-1} \end{bmatrix}$$

$$+ \cdots + \begin{bmatrix} \partial_{11,i} & \partial_{12,i} & \partial_{13,i} & \partial_{14,i} & \partial_{15,i} & \partial_{16,i} & \partial_{17,i} \\ \partial_{21,i} & \partial_{22,i} & \partial_{23,i} & \partial_{24,i} & \partial_{25,i} & \partial_{26,i} & \partial_{27,i} \\ \partial_{31,i} & \partial_{32,i} & \partial_{33,i} & \partial_{34,i} & \partial_{35,i} & \partial_{36,i} & \partial_{37,i} \\ \partial_{41,i} & \partial_{42,i} & \partial_{43,i} & \partial_{44,i} & \partial_{45,i} & \partial_{46,i} & \partial_{47,i} \\ \partial_{51,i} & \partial_{52,i} & \partial_{53,i} & \partial_{54,i} & \partial_{55,i} & \partial_{56,i} & \partial_{57,i} \\ \partial_{61,i} & \partial_{62,i} & \partial_{63,i} & \partial_{64,i} & \partial_{65,i} & \partial_{66,i} & \partial_{67,i} \\ \partial_{71,i} & \partial_{72,i} & \partial_{73,i} & \partial_{74,i} & \partial_{75,i} & \partial_{76,i} & \partial_{77,i} \end{bmatrix} \begin{bmatrix} \Delta lnCO2_{t-i} \\ \Delta lnGDP_{t-i} \\ \Delta lnGDP2_{t-i} \\ \Delta lnEN_{t-i} \\ \Delta lnREN_{t-i} \\ \Delta lnFD_{t-i} \\ \Delta lnINF_{t-i} \end{bmatrix}$$

$$+\begin{bmatrix}\varphi_1\\ \varphi_2\\ \varphi_3\\ \varphi_4\\ \varphi_5\\ \varphi_6\\ \varphi_7\end{bmatrix}\times ECT_{t-1}+\begin{bmatrix}\varepsilon_{1,t}\\ \varepsilon_{2,t}\\ \varepsilon_{3,t}\\ \varepsilon_{4,t}\\ \varepsilon_{5,t}\\ \varepsilon_{6,t}\\ \varepsilon_{7,t}\end{bmatrix}$$

(15)

$$\begin{bmatrix}\Delta lnREN\\ \Delta lnGDP\\ \Delta lnFD\end{bmatrix}=\begin{bmatrix}\mu_1\\ \mu_2\\ \mu_3\end{bmatrix}+\begin{bmatrix}\partial_{11,1} & \partial_{12,1} & \partial_{13,1}\\ \partial_{21,1} & \partial_{22,1} & \partial_{23,1}\\ \partial_{31,1} & \partial_{32,1} & \partial_{33,1}\end{bmatrix}\begin{bmatrix}\Delta lnREN_{t-1}\\ \Delta lnGDP_{t-1}\\ \Delta lnFD_{t-1}\end{bmatrix}+\cdots+$$

$$\begin{bmatrix}\partial_{11,i} & \partial_{12,i} & \partial_{13,i}\\ \partial_{21,i} & \partial_{22,i} & \partial_{23,i}\\ \partial_{31,i} & \partial_{32,i} & \partial_{33,i}\end{bmatrix}\begin{bmatrix}\Delta lnREN_{t-i}\\ \Delta lnGDP_{t-i}\\ \Delta lnFD_{t-i}\end{bmatrix}+\begin{bmatrix}\varphi_1\\ \varphi_2\\ \varphi_3\end{bmatrix}\times ECT_{t-1}+\begin{bmatrix}\varepsilon_{1,t}\\ \varepsilon_{2,t}\\ \varepsilon_{3,t}\end{bmatrix}$$

(16)

where Δ indicates the differences of the variables. The ECT_{t-1} suggests lagged form of error correction term of the long-run model. $\varepsilon_{1,t}$, $\varepsilon_{2,t}$, $\varepsilon_{3,t}$, $\varepsilon_{4,t}$, $\varepsilon_{5,t}$, $\varepsilon_{6,t}$ and $\varepsilon_{7,t}$ are serially independent random errors with a mean of zero and a finite covariance matrix. Each dependent variable is regressed in the multivariate VECM with its and other independent variables' lagged values. Statistically significant t-ratios for ECT_{t-1} in the Granger causality test trough ECM indicates the presence of long-run causalities, while statistically significant F-ratios suggest the presence of short-run causalities among variables (Narayan and Smyth, 2004).

Chapter 4

EMPIRICAL RESULTS

4.1 Unit Root Test Results

The integration orders of variables are examined by the Carrion-i-Silvestre et al. (2009) unit root test. Table 3 and Table 4 present the outcome of the unit root test under five structural breaks for the case of Turkey and India respectively. The upper panel of the table shows that the null hypothesis of non-stationarity cannot be rejected when the series are tested at their level forms. The series are tested one more time after their first differences are taken. In this case, it is revealed that the null hypothesis can be rejected for all series as the test statistics of P_t, MP_t, MZ_{α}, MBT and MZ_t turn out to be statistically significant at five percent. Hence, it is concluded that the variables under investigation are integrated order one, I(1).

Table 3: The Quasi-GLS Based Unit Root Tests under Multiple Structural Breaks for Turkey.

Variable	Levels					Break Points
	P_T	MP_T	MZ_{α}	MSB	MZ_t	
lnGDP	18.36 [8.55]	17.29 [8.55]	-22.06 [-44.03]	0.14 [0.10]	-3.30 [-4.69]	1977; 1982; 1990; 2000; 2007
$lnGDP^2$	18.67 [8.55]	17.54 [8.55]	-21.76 [-44.03]	0.15 [0.10]	-3.28 [-4.69]	1977; 1982; 1990; 2000; 2007
lnEN	18.90 [8.58]	17.29 [8.58]	-23.07 [-45.65]	0.14 [0.10]	-3.39 [-4.77]	1965; 1978; 1993; 1998; 2007

lnREN	16.94 [8.17]	15.58 [8.17]	-23.46 [-43.03]	0.14 [0.10]	-3.36 [-4.63]	1977; 1989; 1994; 2001; 2007
lnFD	24.59 [9.01]	21.50 [9.01]	-19.34 [-45.81]	0.16 [0.10]	-3.11 [-4.77]	1973; 1980; 1985; 1997; 2002
lnINF	17.54 [8.84]	16.80 [8.84]	-24.86 [-46.10]	0.14 [0.10]	-3.51 [-4.80]	1968; 1978; 1993; 1998; 2007
lnCO2	20.10 [8.45]	17.07 [8.45]	-22.14 [-43.79]	0.14 [0.10]	-3.30 [-4.66]	1977; 1987; 1994; 1999; 2004
First Differences						
ΔlnGDP	3.98* [5.54]	3.81* [5.54]	-25.69* [-17.32]	0.13* [0.16]	-3.53* [-2.89]	-
$\Delta lnGDP^2$	3.95* [5.54]	3.84* [5.54]	-25.77* [-17.32]	0.13* [0.16]	-3.53* [-2.89]	-
ΔlnEN	3.61* [5.54]	3.53* [5.54]	-25.85* [-17.32]	0.13* [0.16]	-3.59* [-2.89]	-
ΔlnREN	4.23* [5.54]	4.26* [5.54]	-25.82* [-17.32]	0.13* [0.16]	-3.46* [-2.89]	-
ΔlnFD	3.95* [5.54]	4.04* [5.54]	-23.00* [-17.32]	0.14* [0.16]	-3.37* [-2.89]	-
ΔlnINF	3.50* [5.54]	3.61* [5.54]	-25.62* [-17.32]	0.13* [0.16]	-3.57* [-2.89]	-
ΔlnCO2	3.85* [5.54]	3.67* [5.54]	-25.72* [-17.32]	0.13* [0.16]	-3.56* [-2.89]	-

Note: Structural break points are obtained through using the quasi GLS-based unit root tests of Carrion-i-Silvestre et al. (2009). * denotes the rejection of the null hypothesis of a unit root at the customary 0.05 significance level. Numbers in brackets are critical values from the bootstrap approach by Carrion-i-Silvestre et al. (2009).

Table 4: The Quasi-GLS Based Unit Root Tests under Multiple Structural Breaks for India

	Levels					Break Years
	P_T	MP_T	MZ_α	MSB	MZ_t	
lnGDP	21.21 [9.09]	20.00 [9.09]	-21.43 [-46.59]	0.15 [0.10]	-3.27 [-4.81]	1975; 1980; 1994; 2001; 2007
$lnGDP^2$	21.72 [8.99]	21.58 [8.99]	-19.69 [-46.69]	0.15 [0.10]	-3.13 [-4.81]	1974; 1978; 1986; 1990; 2001
lnEN	24.25 [9.17]	23.60 [9.17]	-18.63 [-46.56]	0.16 [0.10]	-3.01 [-4.82]	1977; 1988; 1994; 2000; 2007
lnREN	17.55 [8.47]	17.08 [8.47]	-21.94 [-43.81]	0.15 [0.10]	-3.30 [-4.66]	1975; 1980; 1985; 1990; 2010
lnFD	22.74 [9.28]	22.72 [9.28]	-19.54 [-47.04]	0.15 [0.10]	-3.12 [-4.83]	1975; 1980; 1989; 1994; 2008
lnINF	22.27 [9.15]	22.33 [9.15]	-19.70 [-47.13]	0.15 [0.10]	-3.11 [-4.84]	1974; 1980; 1992; 1998; 2003
lnCO2	19.52 [8.53]	19.18 [8.53]	-19.72 [-43.96]	0.15 [0.10]	-3.13 [-4.68]	1984; 1988; 1995; 2001; 2007
	First differences					
ΔlnGDP	4.64* [5.54]	4.37* [5.54]	-20.88* [-17.32]	0.15* [0.16]	-3.22* [-2.89]	-
$\Delta lnGDP^2$	5.02* [5.54]	4.94* [5.54]	-18.71* [-17.32]	0.15* [0.16]	-3.04* [-2.89]	-
ΔlnEN	5.46* [5.54]	5.11* [5.54]	-18.49* [-17.32]	0.15* [0.16]	-3.00* [-2.89]	-
ΔlnREN	4.44* [5.54]	4.65* [5.54]	-19.61* [-17.32]	0.15* [0.16]	-3.13* [-2.89]	-
ΔlnFD	4.73* [5.54]	4.94* [5.54]	-18.43* [-17.32]	0.16* [0.16]	-3.03* [-2.89]	-
ΔlnINF	4.74* [5.54]	4.96* [5.54]	-18.33* [-17.32]	0.15* [0.16]	-3.06* [-2.89]	-
ΔlnCO2	4.52* [5.54]	4.74* [5.54]	-19.35* [-17.32]	0.16* [0.16]	-3.10* [-2.89]	-

Note: [i]Break years are obtained through using the quasi GLS-based unit root tests of Carrion-i-Silvestre et al. (2009). [ii]* denotes the rejection of the null hypothesis of a unit root at the customary 0.05 significance level. [iii]Numbers in brackets are critical values from the bootstrap approach by Carrion-i-Silvestre et al. (2009).

4.2 Cointeration Test Results

After identifying the stationarity properties of the series, Maki (2012) cointegration test is employed to detect possible equilibrium relationship among the variables. The test is conducted for the models that are indicated in equation 8 and 9 for Turkey and India. Table 5 and 6 present the test statistics, critical values and structural break points for each model specification of Maki (2012). The results of the cointegration test provide evidence for long-run equilibrium relationship for both models since the null hypothesis of no cointegration can be rejected in favor of the alternative hypothesis of cointegration under five structural breaks.

Table 5: Maki (2012) Cointegration Test under Multiple Structural Breaks for Turkey

Number of Break Points		Test Statistics [Critical Values]	Break Points
Model : $lnCO_2$ = f ($lnGDP$, $lnGDP^2$, lnEN, lnREN, lnFD, lnINF)			
$T_B \leq 5$			
	Model 0	-6.80 [-6.31]*	1971; 1978; 1988; 1995; 2001
	Model 1	-7.97 [-7.05]*	1971; 1978; 1988; 1999; 2005
	Model 2	-12.09 [-9.44]*	1966; 1969; 1980; 1992; 2002
	Model 3	-12.57 [-10.08]*	1971; 1978; 1984; 1993; 2005
Model : lnREN = f (lnFD, lnGDP)			
$T_B \leq 5$			
	Model 0	-5.63 [-5.491]*	1974; 1979; 1987; 2000; 2008
	Model 1	-5.85 [-5.722]*	1979; 1986; 1990; 1994; 2007
	Model 2	-8.76 [-6.976]*	1978; 1984; 1990; 1995; 2011
	Model 3	-9.47 [-7.811]*	1989; 1990; 2001; 2007; 2011

Notes: Numbers in corner brackets are critical values at 0.05 level from Table 1 of Maki (2012). * denotes statistical significance at 0.10 level.

Table 6: Maki (2012) Cointegration Test under Multiple Structural Breaks for India

Number of Break Points	Test Statistics [Critical Values]	Break Points
Model : $lnCO_2$ = f (lnGDP, $lnGDP^2$, lnEN, lnREN, lnFD, lnINF)		
$T_B \leq 5$		
Model 0	-8.53 [-6.31]*	1981; 1985; 1988; 2007; 2009
Model 1	-9.78 [-7.05]*	1973; 1985; 1988; 2004; 2007
Model 2	-9.94 [-9.44]*	1982; 1990; 1995; 1998; 2006
Model 3	-10.20 [-10.08]*	1977; 1980; 1990;1997; 2000
Model : lnREN = f (lnFD, lnGDP)		
$T_B \leq 5$		
Model 0	-5.53 [-5.491]*	1975; 1978; 1992; 1998; 2007
Model 1	-4.25 [-5.722]	1978; 1986; 1989; 1992; 2003
Model 2	-8.36 [-6.976]*	1973; 1979; 1990; 1995; 2010
Model 3	-9.50 [-7.811]*	1979; 1989; 1995; 2002; 2010

Notes: Numbers in corner brackets are critical values at 0.05 level from Table 1 of Maki (2012).* denotes statistical significance at 0.10 level.

4.3 FMOLS Coefficient Estimates

After revealing the long-run equilibrium relationship between variables, long-run coefficients are estimated by the FMOLS estimation technique. Structural breaks that are obtained from the Maki (2012) cointegration test are added to the long-run models as dummy variables. According to table 7 and 8, FMOLS test results show that long run coefficients of GDP and GDP^2 are positive and negative respectively which means EKC hypothesis is valid for the case of Turkey and India. Also, results indicate that both financial development and informal economy variables contribute the CO2 emissions positively. It can be inferred that the financial sector improvement in Turkey and India is not environmentally efficient and the accessible funds through the financial market are invested in carbon intensive projects. This outcome is in line with the results of Pata (2018), but it is contradictory to the findings of Dogan and Seker (2016) since a negative coefficient estimated between financial development and CO2. It is also found that the informal economy has a deteriorating effect on the environment. The operations of underground companies are not subject to any environmental rules and regulations of the governments. Production of pollution intensive goods and services such as metals, chemicals, and illegal urban transportation might be among the reasons behind the estimated coefficient.

Table 7: Estimation of Long-run Coefficients by FMOLS Approach for Turkey

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP	3.777355	1.811663	2.085020	0.0428
LNGDP2	-0.174014	0.138826	-1.253470	0.0165
LNREN	0.367617	0.095406	3.853194	0.0004
LNFD	0.102416	0.047997	2.133825	0.0383
LNINF	1.965017	0.558918	3.515751	0.0010
LNEN	0.737311	0.231260	3.188234	0.0026
C	-10.10339	4.825701	-2.093664	0.0420
TREND	0.053309	0.008018	6.648518	0.0000
R-squared	0.999157			
Adjusted R-squared	0.999026			
S.E. of regression	0.025426			
Long-run variance	0.000914			

Table 8: Estimation of Long-run Coefficients by FMOLS Approach for India

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP	4.084497	0.419067	9.746641	0.0000
LNGDP2	-0.245305	0.033768	-7.264410	0.0000
LNREN	-0.014395	0.115800	-0.124312	0.0018
LNFDEV	0.050063	0.014116	3.546649	0.0012
LNINF	1.644341	0.196062	8.386843	0.0000
LNEN	1.036433	0.035568	29.13928	0.0000
C	-4.443950	1.560121	-2.848465	0.0076
TREND	0.011303	0.001869	6.046672	0.0000
R-squared	0.992880			
Adjusted R-squared	0.991322			
S.E. of regression	0.060689			
Long-run variance	2.90E-05			

FMOLS estimation results in Table 9 and 10 suggest that economic growth and financial development have statistically significant and positive long-run impacts on renewable energy consumption for the case of Turkey and India. When economic growth and financial development increase by 1%, renewable energy consumption in India and Turkey increases by 0.110%, 0.179% and 1.137%, 0.980% in the long run, respectively. This outcome is in parallel with the findings of Brunnschweiler (2010) and Hassine and Harrathi (2017). FMOLS estimation results reveal that higher economic growth and financial development is essential to use higher renewable energy by creating financial incentives to invest more in clean energy projects and R&D activities. Lack of financial resources is an obstacle for the renewable energy usage and increased financial development help firms to access financial resources to adopt clean energy.

Table 9: Estimation of Long-run Coefficients by FMOLS Approach for Turkey

Dependent Variable	Regressors								
	lnGDP	lnFD	Constant	Trend	D1	D2	D3	D4	D5
lnREN	1.13* (0.00)	0.98* (0.00)	0.054 (0.982)	-0.059* (0.000)	-0.004 (0.446)	-0.002* (0.007)	0.006 (0.41)	-0.02** (0.048)	-0.00 (0.400)
R-squared	0.999								
S.E. of Regression	0.009								
Long-run Variance	0.001								

Note: Optimum lag length is selected by Schwarz information criteria and long-run covariance is estimated by Bartlett Kernel and Newey-West fixed bandwidth, which is 3. Numbers in parentheses show prob. values. * denotes the significance level of 1%.

Table 10: Estimation of Long-run Coefficients by FMOLS Approach for India

Dependent Variable	Regressors								
	lnGDP	lnFD	Constant	Trend	D1	D2	D3	D4	D5
lnREN	0.129* (0.000)	0.214* (0.000)	10.062* (0.000)	0.007* (0.000)	-0.01* (0.004)	-0.002 (0.447)	0.004 (0.51)	-0.01** (0.038)	-0.00 (0.300)
R-squared	0.999								
S.E. of Regression	0.007								
Long-run Variance	0.001								

Note: Optimum lag length is selected by Schwarz information criteria and long-run covariance is estimated by Bartlett Kernel and Newey-West fixed bandwidth, which is 3. Numbers in parentheses show prob. values. * denotes the significance level of 1%.

4.4 Causality Test Results

Directions of the relationships between variables are estimated by the Granger causality test under VECM model. Causality test results in Table 11 and 12 suggest unidirectional relationships running from financial development to GDP and renewable energy consumption, which means renewable energy consumption and economic growth in Turkey and India are financial development driven in long-run.

A change in financial development leads to changes in renewable energy consumption and economic growth. This finding indicates the importance of sustainable financial development for achieving higher economic growth and renewable energy consumption for the case of Turkey and India. Unidirectional causality between renewable energy consumption and financial development highlights the importance of the financial system for renewable energy consumption of the host country. Expansion in financial resources increases investments on clean energy projects. Thus, greater financial resources in the host country contribute to renewable energy consumption.

Table 11: Granger Causality Test under VECM for Turkey

Dependent Variable	ΔLNGDP	ΔLNFD	ΔLNREN	χ^2-stat (prob) for ECT_{t-1}
ΔLNGDP	--	4.334575 (0.0059)	0.427270 (0.7879)	1.80927*** (0.07833)
ΔLNFD	1.146662 (0.3509)	--	1.584812 (0.2000)	-0.03562 (0.97179)
ΔLNREN	0.822125 (0.5199)	7.956098 (0.0001)	--	1.74777*** (0.08927)

Table 12: Granger Causality Test under VECM for India

	F-statistics (probability values)			
Dependent Variable	ΔlnGDP	ΔlnFD	ΔlnREN	χ^2-stat (prob) for ECT_{t-1}
ΔlnGDP	--	1.386 (0.266)	1.256 (0.306)	1.797** (0.082)
ΔlnFD	2.902** (0.051)	--	0.155 (0.925)	0.151 (0.880)
ΔlnREN	0.317 (0.812)	0.396 (0.756)	--	-3.794* (0.000)

Note: * and** indicate the rejection of null hypothesis at 1% and 10% level of significance, respectively.

There is also a long-run bidirectional relationship between economic growth and renewable energy consumption. This finding is compatible with many other studies such as; Apergis and Payne (2012), Shahbaz et al. (2016). Therefore, when there is a change in economic growth, it causes a change in renewable energy consumption and vice versa, meaning that the feedback hypothesis is valid for the case of Turkey and India. Bidirectional causality between renewable energy consumption and economic growth highlights the importance of renewable energy usage for economic growth for both countries. Expansion in renewable energy usage causes increases in the demand for clean energy investments. Thus, greater clean energy investments in the host country contribute to economic growth with increased economic activities.

Table 13: Granger Causality Test under VECM for Turkey

Dependent Variable	ΔLNGDP	ΔLNGDP2	ΔLNEN	ΔLNREN	ΔLNFD	ΔLNINF	ΔLNCO2	χ^2-stat (prob) for ECT_{t-1}
ΔLNGDP	--	1.064 (0.307)	1.012 (0.320)	0.119 (0.731)	9.033* (0.001)	0.318 (0.575)	1.943 (0.170)	-0.639 (0.525)
ΔLNGDP2	0.756 (0.389)	--	1.093 (0.301)	0.152 (0.698)	9.225* (0.001)	0.448 (0.506)	1.728 (0.195)	-0.650 (0.518)
ΔLNEN	0.396 (0.532)	0.227 (0.635)	--	0.457 (0.502)	0.786 (0.380)	0.021 (0.883)	3.513 (0.067)	-1.033 (0.307)
ΔLNREN	1.095 (0.301)	0.967 (0.330)	0.003 (0.956)	--	6.289** (0.016)	4.190** (0.046)	0.704 (0.405)	-0.014 (0.988)
ΔLNFD	0.017 (0.895)	0.008 (0.928)	0.008 (0.928)	0.285 (0.596)	--	0.100 (0.753)	0.055 (0.815)	1.254 (0.216)
ΔLNINF	0.222 (0.639)	0.168 (0.683)	0.115 (0.735)	0.686 (0.411)	0.700 (0.407)	--	0.048 (0.827)	-0.734 (0.466)
ΔLNCO2	0.072 (0.789)	0.123 (0.726)	0.099 (0.753)	0.022 (0.882)	5.690** (0.021)	0.037 (0.848)	--	-1.781*** (0.081)

Note: *, ** and*** indicate the rejection of null hypothesis at 1%, 5% and 10% level of significance, respectively.

Granger Causality under VECM model test results for equation 15 are presented in table 13 and 14 for the case of Turkey and India respectively. According to Granger causality test results, there are long run unidirectional causalities running form economic growth, fossil fuel energy consumption, renewable energy consumption, financial development and informal economy to CO_2 emissions. These findings support the estimated long run coefficients of the variables meaning that changes in regressors in the conducted models cause changes in the air pollution level for both countries. Moreover, there are some short run causalities running from financial development to CO_2 emissions, from financial development and informal economy to renewable energy consumption and from financial development to economic growth for the case of Turkey. Unidirectional causalities between financial development, economic growth and CO2 emissions reveal the importance of stable financial system for the growth and financing of renewable energy projects.

Table 14: Granger Causality Test under VECM for India

Dependent Variable	ΔLNGDP	ΔLNGDP2	ΔLNEN	ΔLNREN	ΔLNFD	ΔLNINF	ΔLNCO2	χ^2-stat (prob) for ECT_{t-1}
ΔLNGDP	--	0.530 (0.471)	4.227** (0.048)	15.368* (0.001)	1.598 (0.215)	6.688** (0.014)	0.187 (0.667)	-1.272 (0.212)
ΔLNGDP2	1.201 (0.281)	--	3.580*** (0.068)	17.455* (0.001)	1.187 (0.284)	7.311** (0.011)	0.127 (0.723)	-1.141 (0.262)
ΔLNEN	1.788 (0.191)	1.678 (0.205)	--	0.144 (0.706)	0.010 (0.920)	0.189 (0.666)	0.034 (0.853)	0.415 (0.680)
ΔLNREN	0.105 (0.748)	0.102 (0.751)	0.223 (0.639)	--	1.221 (0.277)	1.438 (0.239)	0.023 (0.879)	0.146 (0.884)
ΔLNFDEV	1.627 (0.211)	1.247 (0.272)	0.217 (0.644)	14.364* (0.001)	--	0.004 (0.946)	0.265 (0.609)	-0.505 (0.616)
ΔLNINF	3.988*** (0.055)	4.174** (0.049)	0.257 (0.615)	0.246 (0.623)	0.001 (0.990)	--	0.4815 (0.493)	0.3819 (0.705)
ΔLNCO2	5.877** (0.022)	6.637** (0.015)	0.123 (0.727)	0.003 (0.995)	1.953 (0.172)	9.013* (0.005)	--	-3.487* (0.001)

Note: *, ** and*** indicate the rejection of null hypothesis at 1%, 5% and 10% level of significance, respectively.

There are also short run causal relationships among variables for the case of India as reported in table 14. There are unidirectional causal relationships running from GDP and informal economy to CO_2 emissions, from renewable energy to financial development, from fossil fuel energy, renewable energy consumption and informal economy to GDP in short run. These causal relationships confirm that changes in economic growth and informal economy cause changes in CO_2 emissions level in India.

Chapter 5

CONCLUSION

This study adopts time series methodologies to investigate the long run equilibrium relationship between economic growth, fossil fuel energy consumption, renewable energy consumption, financial development and informal economy under EKC framework for the case of India and Turkey. Moreover, this study investigates the impact of financial development and economic growth on renewable energy consumption in India and Turkey. Results of the study confirm the existence of EKC hypothesis for both countries and indicate that financial development and informal economy have significant long run positive impacts on CO_2 emissions. Results also confirm the negative long run impact of renewable energy consumption on CO_2 emissions. Therefore, another model is constructed to examine the determinants of renewable energy consumption in India and Turkey. Our results suggest that financial development and economic growth contribute to renewable energy consumption in long run meaning that stable financial development and economic growth are important long run determinants of renewable energy consumption for emerging economies.

Based on the produced empirical outcome in this study, several policy prescriptions can be suggested for the countries under examination. Targeting to achieve higher usage of the renewable sources, new projects and investments in renewable systems should be supported by providing incentives. In this regard, selective taxation procedures can be applied under fiscal policy. In order to expand the deployment of renewable energy systems, tax credits can be granted to investors in the stages of purchasing, installation and production. In addition, imposing a carbon tax on non-renewable energy might shift the production of energy in favor of the renewables. Similarly, tax exemption policies for certain fuels such as biomasses can bring a competitive advantage to renewable market. That being said, the transition process of energy supply from non-renewable to renewable alternatives should be implemented gradually in order to avoid disrupting the existent market for non-renewables. For example, direct government interventions which result in a sharp rise on carbon prices might cause premature retirement of facilities at use. Early shutdowns of such facilities can create a high economic cost due to the generation of inordinate amount of stranded assets. Hence, instead of following an aggressive strategy to cut down fossil fuel usage, efficient way of producing renewable energy can be achieved by alternative policy tools such as fee bates and subsidized loans for green energy power plants.

Considering the mature and dominating role of non-renewable energy sector, encouraging new researches in renewable technologies can have benefits in the long-run. Promotion of technological advancements can aid renewable energy sector to reach economies of scale in manufacturing and construction. As the cost is reduced, investments can be taken by a larger group of entrepreneurs and more employment can be created by the renewable energy market. As the empirical evidence highlights, both Turkish and Indian authorities should be aware about the role of financial sector in their policy designs. Unlike the fossil fuel projects, renewable energy investments require high initial costs and have lengthy payback periods. Therefore, financial intermediaries may not always be willing to provide credits for such projects. To make sure that funds will flow into feasible projects, government guarantees and bank risk taking incentives can be granted to investors. In addition, financial market of both countries should be more prominently promoted as it is an important driver of renewable energy consumption as well as the economic growth. When the risk mitigation and cost reduction functions of the financial instruments are considered, financial market development can attract private investors who would normally avoid investing into renewable energy projects. Among instruments of financial markets, equity enables public and private institution partnerships with the investing companies who pursue green energy business ventures. As an alternative to equity, debt financing holds a great potential for the promotion of renewable energy investments. Mostly issued by government owned entities, rapid growth of Green bonds market promises a higher credit rating and commitment in bond repayments. Therefore, in emerging markets where renewable energy investments are financial development driven, the local authorities should evaluate the benefits of a bonds market for financing green energy projects.

As the test results of the current study have highlighted, unrecorded economic activities lead to higher CO2 emissions. The authorities might approach this issue by formulating tailor-made environmental rules and regulations at the industrial level. For instance, the tax burden of energy intensive industries can be relieved by a tax subsidy mechanism which may attract the previously unregistered firms into the official system (Chen, Hao, Li and Song, 2018). Labor regulations can also be effective in preventing incentives for firms to operate informally. Improving the existent employment protection laws, charging deterring penalties to employers who violate the labor rights and determinant enforcement of law might increase the number of workers participating in the official economy.

REFERENCES

Abbasi, F., & Riaz, K. (2016). CO2 emissions and financial development in an emerging economy: An augmented VAR approach. *Energy Policy*, *90*, 102-114.

Abosedra, S., & Baghestani, H. (1989). New evidence on the causal relationship between United States energy consumption and gross national product. *The Journal of Energy and Development*, 285-292.

Adams, S., Klobodu, E. K. M., & Apio, A. (2018). Renewable and non-renewable energy, regime type and economic growth. *Renewable Energy*, *125*, 755-767.

Agras, J., & Chapman, D. (1999). A dynamic approach to the environmental Kuznets curve hypothesis. *Ecological Economics*, *28*(2), 267-277.

Ahmad, A., Zhao, Y., Shahbaz, M., Bano, S., Zhang, Z., Wang, S., & Liu, Y. (2016). Carbon emissions, energy consumption and economic growth: An aggregate and disaggregate analysis of the Indian economy. *Energy Policy*, *96*, 131-143.

Akbostancı, E., Türüt-Aşık, S., & Tunç, G. İ. (2009). The relationship between income and environment in Turkey: is there an environmental Kuznets curve?. *Energy policy*, *37*(3), 861-867.

Alam, M. J., Begum, I. A., Buysse, J., Rahman, S., & Van Huylenbroeck, G. (2011). Dynamic modeling of causal relationship between energy consumption, CO2 emissions and economic growth in India. *Renewable and Sustainable Energy Reviews*, *15*(6), 3243-3251.

Alam, M. M., Murad, M. W., Noman, A. H. M., & Ozturk, I. (2016). Relationships among carbon emissions, economic growth, energy consumption and population growth: Testing Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia. *Ecological Indicators, 70,* 466-479.

Ali, Q., Khan, M. T. I., & Khan, M. N. I. (2018). Dynamics between financial development, tourism, sanitation, renewable energy, trade and total reserves in 19 Asia cooperation dialogue members. *Journal of Cleaner Production*, *179*, 114-131.

Al-mulali, U., Fereidouni, H. G., & Lee, J. Y. (2014). Electricity consumption from renewable and non-renewable sources and economic growth: Evidence from Latin American countries. *Renewable and Sustainable Energy Reviews*, *30*, 290-298.

Al-Mulali, U., Ozturk, I., & Solarin, S. A. (2016). Investigating the environmental Kuznets curve hypothesis in seven regions: The role of renewable energy. *Ecological indicators*, *67*, 267-282.

Al-Mulali, U., Weng-Wai, C., Sheau-Ting, L., & Mohammed, A. H. (2015). Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation. *Ecological Indicators*, *48*, 315-323.

Alshehry, A. S., & Belloumi, M. (2015). Energy consumption, carbon dioxide emissions and economic growth: The case of Saudi Arabia. *Renewable and Sustainable Energy Reviews*, *41*, 237-247.

Amri, F. (2017). Intercourse across economic growth, trade and renewable energy consumption in developing and developed countries. *Renewable and Sustainable Energy Reviews*, *69*, 527-534.

Ang, J. B. (2009). CO2 emissions, research and technology transfer in China. *Ecological Economics*, *68*(10), 2658-2665.

Apergis, N., & Ozturk, I. (2015). Testing environmental Kuznets curve hypothesis in Asian countries. *Ecological Indicators*, *52*, 16-22.

Apergis, N., & Payne, J. E. (2010a). Renewable energy consumption and growth in Eurasia. *Energy Economics*, *32*(6), 1392-1397.

Apergis, N., & Payne, J. E. (2010b). Renewable energy consumption and economic growth: evidence from a panel of OECD countries. *Energy policy*, *38*(1), 656-660.

Apergis, N., & Payne, J. E. (2011). The renewable energy consumption–growth nexus in Central America. *Applied Energy*, *88*(1), 343-347.

Apergis, N., & Payne, J. E. (2012). Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model. *Energy Economics*, *34*(3), 733-738.

Apergis, N., Payne, J. E., Menyah, K., & Wolde-Rufael, Y. (2010). On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. *Ecological Economics*, *69*(11), 2255-2260.

Arouri, M. E. H., Youssef, A. B., M'henni, H., & Rault, C. (2012). Energy consumption, economic growth and CO2 emissions in Middle East and North African countries. *Energy policy*, *45*, 342-349.

Aslan, A., Destek, M. A., & Okumus, I. (2018). Bootstrap rolling window estimation approach to analysis of the environment Kuznets curve hypothesis: Evidence from the USA. *Environmental Science and Pollution Research*, *25*(3), 2402-2408.

Baek, J. (2015). Environmental Kuznets curve for CO2 emissions: The case of Arctic countries. *Energy Economics*, *50*, 13-17.

Baksi, S., & Bose, P. (2010). Environmental regulation in the presence of an informal sector. *University of Winnipeg Department of Economics Working Paper*, *3*.

Balsalobre-Lorente, D., Shahbaz, M., Roubaud, D., & Farhani, S. (2018). How economic growth, renewable electricity and natural resources contribute to CO 2 emissions?. *Energy Policy*, *113*, 356-367.

Beck, T., Demirgüç-Kunt, A., & Levine, R. (1999). *A new database on financial development and structure*. The World Bank.

Bekhet, H. A., Matar, A., & Yasmin, T. (2017). CO2 emissions, energy consumption, economic growth, and financial development in GCC countries: Dynamic simultaneous equation models. *Renewable and Sustainable Energy Reviews*, *70*, 117-132.

Bekun, F. V., Emir, F., & Sarkodie, S. A. (2019). Another look at the relationship between energy consumption, carbon dioxide emissions, and economic growth in South Africa. *Science of The Total Environment*, *655*, 759-765.

Bilgili, F. (2015). Business cycle co-movements between renewables consumption and industrial production: A continuous wavelet coherence approach. *Renewable and sustainable energy reviews*, *52*, 325-332.

Bilgili, F., & Ozturk, I. (2015). Biomass energy and economic growth nexus in G7 countries: Evidence from dynamic panel data. *Renewable and Sustainable Energy Reviews*, *49*, 132-138.

Bilgili, F., Koçak, E., & Bulut, Ü. (2016). The dynamic impact of renewable energy consumption on CO2 emissions: a revisited Environmental Kuznets Curve approach. *Renewable and Sustainable Energy Reviews*, *54*, 838-845.

Bölük, G., & Mert, M. (2015). The renewable energy, growth and environmental Kuznets curve in Turkey: An ARDL approach. *Renewable and Sustainable Energy Reviews, 52*, 587-595.

Boutabba, M. A. (2014). The impact of financial development, income, energy and trade on carbon emissions: Evidence from the Indian economy. *Economic Modelling*, *40*, 33-41.

Bowden, N., & Payne, J. E. (2010). Sectoral analysis of the causal relationship between renewable and non-renewable energy consumption and real output in the US. *Energy Sources, Part B: Economics, Planning, and Policy*, *5*(4), 400-408.

BP. (2017). *Statistical review of world energy: June 2017.* London, United Kingdom. Retrieved from. https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf

Brunnschweiler, C. N. (2010). Finance for renewable energy: an empirical analysis of developing and transition economies. *Environment and Development Economics*, *15*(3), 241-274.

Carrion-i-Silvestre, J. L., Kim, D., & Perron, P. (2009). GLS-based unit root tests with multiple structural breaks under both the null and the alternative hypotheses. *Econometric theory*, *25*(6), 1754-1792.

CCPI. (2019). Climate change performance index: Results 2019. Retrieved from https://www.climate-change-performance-index.org/sites/default/files/documents/ccpi-2019-results-190614-web-a4.pdf

Chandran, V. G. R., & Tang, C. F. (2013). The impacts of transport energy consumption, foreign direct investment and income on CO2 emissions in ASEAN-5 economies. *Renewable and Sustainable Energy Reviews*, *24*, 445-453.

Chen, M. H. (2010). The economy, tourism growth and corporate performance in the Taiwanese hotel industry. *Tourism Management*, *31*(5), 665-675

Cheng, B. S., & Lai, T. W. (1997). An investigation of co-integration and causality between energy consumption and economic activity in Taiwan. *Energy economics*, *19*(4), 435-444.

Chontanawat, J., Hunt, L. C., & Pierse, R. (2008). Does energy consumption cause economic growth?: Evidence from a systematic study of over 100 countries. *Journal of policy modeling*, *30*(2), 209-220.

Destek, M. A., & Aslan, A. (2017). Renewable and non-renewable energy consumption and economic growth in emerging economies: Evidence from bootstrap panel causality. *Renewable Energy*, *111*, 757-763.

Destek, M. A., & Sarkodie, S. A. (2019). Investigation of environmental Kuznets curve for ecological footprint: the role of energy and financial development. *Science of The Total Environment*, *650*, 2483-2489.

Dinda, S. (2004). Environmental Kuznets curve hypothesis: A survey. *Ecological economics*, *49*(4), 431-455.

Dogan, E. (2015). The relationship between economic growth and electricity consumption from renewable and non-renewable sources: A study of Turkey. *Renewable and Sustainable Energy Reviews*, *52*, 534-546.

Dogan, E., & Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. *Renewable and Sustainable Energy Reviews*, *60*, 1074-1085.

Dogan, N. (2016). Agriculture and environmental Kuznets curves in the case of Turkey: Evidence from the ARDL and bounds test. *Agricultural Economics*, *62*(12), 566-574.

Dong, K., Sun, R., & Dong, X. (2018). CO 2 emissions, natural gas and renewables, economic growth: Assessing the evidence from China. *Science of The Total Environment*, *640*, 293-302.

Dong, K., Sun, R., & Hochman, G. (2017). Do natural gas and renewable energy consumption lead to less CO2 emission? Empirical evidence from a panel of BRICS countries. *Energy*, *141*, 1466-1478.

Eden, S. H., & Jin, J. C. (1992). Cointegration tests of energy consumption, income, and employment. *Resources and Energy*, *14*(3), 259-266.

Eggoh, J. C., Bangaké, C., & Rault, C. (2011). Energy consumption and economic growth revisited in African countries. *Energy Policy*, *39*(11), 7408-7421.

Elgin, C., & Oztunali, O. (2012). Shadow economies around the world: Model based estimates. *Bogazici University Department of Economics Working Papers*, *5*(2012), 1-48.

Elgin, C., & Öztunalı, O. (2014). Environmental Kuznets curve for the informal sector of Turkey (1950-2009). *Panoeconomicus*, *61*(4), 471-485.

Elliot, B. E., Rothenberg, T. J., & Stock, J. H. (1996). Efficient tests of the unit root hypothesis. *Econometrica*, *64*(8), 13-36.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, 251-276.

Frankel, J. A., & Romer, D. H. (1999). Does trade cause growth?. *American Economic Review*, *89*(3), 379-399.

Ganda, F. (2019). Carbon emissions, diverse energy usage and economic growth in South Africa: Investigating existence of the environmental Kuznets curve (EKC). *Environmental Progress & Sustainable Energy*, *38*(1), 30-46.

GISTEMP Team, 2018: GISS surface temperature analysis (GISTEMP). NASA Goddard Institute for Space Studies. Retrieved from. https://data.giss.nasa.gov/gistemp.

Glasure, Y. U. (2002). Energy and national income in Korea: further evidence on the role of omitted variables. *Energy economics*, *24*(4), 355-365.

Gokmenoglu, K. K., & Taspinar, N. (2018). Testing the agriculture-induced EKC hypothesis: The case of Pakistan. *Environmental Science and Pollution Research*, *25*(23), 22829-22841.

Gökmenoğlu, K., & Taspinar, N. (2016). The relationship between CO2 emissions, energy consumption, economic growth and FDI: the case of Turkey. *The Journal of International Trade & Economic Development*, *25*(5), 706-723.

Gokmenoglu, K., Kirikkaleli, D., & Eren, B. M. (2018). Time and frequency domain causality testing: The causal linkage between FDI and economic risk for the case of Turkey. *The Journal of International Trade & Economic Development*, 1-19.

Gregory, A. W., & Hansen, B. E. (1996). Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics*, *70*(1), 99-126.

Grossman, G. M., & Krueger, A. B. (1991). *Environmental impacts of a North American free trade agreement* (No. w3914). National Bureau of Economic Research.

Hamit-Haggar, M. (2016). Clean energy-growth nexus in sub-Saharan Africa: Evidence from cross-sectionally dependent heterogeneous panel with structural breaks. *Renewable and Sustainable Energy Reviews*, *57*, 1237-1244.

Hassine, M. B., & Harrathi, N. (2017). The Causal Links between Economic Growth, Renewable Energy, Financial Development and Foreign Trade in Gulf Cooperation Council Countries. *International Journal of Energy Economics and Policy*, *7*(2). 76-85.

Hatemi-j, A. (2008). Tests for cointegration with two unknown regime shifts with an application to financial market integration. *Empirical Economics*, *35*(3), 497-505.

Hawdon, D., & Pearson, P. (1995). Input-output simulations of energy, environment, economy interactions in the UK. *Energy economics*, *17*(1), 73-86.

Hwang, D. B., & Gum, B. (1991). The causal relationship between energy and GNP: the case of Taiwan. *The Journal of Energy and Development*, 16(2), 219-226.

IEA. (2017). What is energy security. Retrieved from https://www.iea.org/topics/energysecurity/subtopics/whatisenergysecurity

Imamoglu, H. (2018). Is the informal economic activity a determinant of environmental quality?. *Environmental Science and Pollution Research*, *25*(29), 29078-29088.

India Labour Market Update, (2016). ILO country office for India: July 2016. Retrieved from. https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---sro-new_delhi/documents/publication/wcms_496510.pdf

Inglesi-Lotz, R. (2016). The impact of renewable energy consumption to economic growth: A panel data application. *Energy Economics*, *53*, 58-63.

IPCC, (2018). Summary for policymakers: October 2018. Retrieved from. https://www. ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_version_stand_alone_LR.pdf.

Jalil, A., & Feridun, M. (2011). The impact of growth, energy and financial development on the environment in China: A cointegration analysis. *Energy Economics*, *33*(2), 284-291.

Jayanthakumaran, K., Verma, R., & Liu, Y. (2012). CO2 emissions, energy consumption, trade and income: a comparative analysis of China and India. *Energy Policy*, *42*, 450-460.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica: Journal of the Econometric Society*, 1551-1580.

Kahia, M., Aissa, M. S. B., & Lanouar, C. (2017). Renewable and non-renewable energy use-economic growth nexus: The case of MENA Net Oil Importing Countries. *Renewable and Sustainable Energy Reviews*, *71*, 127-140.

Kanjilal, K., & Ghosh, S. (2013). Environmental Kuznet's curve for India: Evidence from tests for cointegration with unknown structuralbreaks. *Energy Policy*, *56*, 509-515.

Katircioğlu, S. T., & Taşpinar, N. (2017). Testing the moderating role of financial development in an environmental Kuznets curve: Empirical evidence from Turkey. *Renewable and Sustainable Energy Reviews*, *68*, 572-586.

Katircioglu, S., & Katircioglu, S. (2018). Testing the role of urban development in the conventional environmental Kuznets curve: Evidence from Turkey. *Applied Economics Letters*, *25*(11), 741-746.

Katircioglu, S., Gokmenoglu, K. K., & Eren, B. M. (2018). Testing the role of tourism development in ecological footprint quality: Evidence from top 10 tourist destinations. *Environmental Science and Pollution Research*, *25*(33), 33611-33619.

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development*, 401-403.

Kuznets, S. (1955). Economic growth and income inequality. *The American economic review*, 1-28.

Lee, C. C., & Chang, C. P. (2005). Structural breaks, energy consumption, and economic growth revisited: evidence from Taiwan. *Energy Economics*, *27*(6), 857-872.

Levine, R., Loayza, N., & Beck, T. (2000). Financial intermediation and growth: Causality and causes. *Journal of monetary Economics*, *46*(1), 31-77.

Lin, B., & Moubarak, M. (2014). Renewable energy consumption–Economic growth nexus for China. *Renewable and Sustainable Energy Reviews, 40,* 111-117.

Lin, B., Omoju, O. E., & Okonkwo, J. U. (2016). Factors influencing renewable electricity consumption in China. *Renewable and Sustainable Energy Reviews*, *55*, 687-696.

Lindmark, M. (2002). An EKC-pattern in historical perspective: Carbon dioxide emissions, technology, fuel prices and growth in Sweden 1870-1997. *Ecological economics*, *42*(1-2), 333-347.

Lise, W. (2006). Decomposition of CO2 emissions over 1980–2003 in Turkey. *Energy Policy*, *34*(14), 1841-1852.

Liu, Y., & Hao, Y. (2018). The dynamic links between CO2 emissions, energy consumption and economic development in the countries along "the Belt and Road". *Science of The Total Environment*, *645*, 674-683.

Loayza, N. (1999). *The economics of the informal sector: A simple model and some empirical evidence from Latin America*. The World Bank.

Lotfalipour, M. R., Falahi, M. A., & Ashena, M. (2010). Economic growth, CO2 emissions, and fossil fuels consumption in Iran. *Energy*, *35*(12), 5115-5120.

Lundgren, T. (2003). A real options approach to abatement investments and green goodwill. *Environmental and Resource Economics*, *25*(1), 17-31.

Ma, C., & Stern, D. I. (2008). Biomass and China's carbon emissions: A missing piece of carbon decomposition. *Energy Policy*, *36*(7), 2517-2526.

Magazzino, C. (2016). The relationship between CO2 emissions, energy consumption and economic growth in Italy. *International Journal of Sustainable Energy*, *35*(9), 844-857.

Maki, D. (2012). Tests for cointegration allowing for an unknown number of breaks. *Economic Modelling*, *29*(5), 2011-2015.

Managi, S., & Jena, P. R. (2008). Environmental productivity and Kuznets curve in India. *Ecological Economics, 65*(2), 432-440.

Menegaki, A. N. (2011). Growth and renewable energy in Europe: a random effect model with evidence for neutrality hypothesis. *Energy Economics*, *33*(2), 257-263.

Menyah, K., & Wolde-Rufael, Y. (2010). CO 2 emissions, nuclear energy, renewable energy and economic growth in the US. *Energy Policy*, *38*(6), 2911-2915.

Moomaw, W. R., & Unruh, G. C. (1997). Are environmental Kuznets curves misleading us? The case of CO 2 emissions. *Environment and Development Economics*, *2*(4), 451-463.

Mythili, G., & Mukherjee, S. (2011). Examining Environmental Kuznets Curve for river effluents in India. *Environment, Development and Sustainability*, *13*(3), 627-640.

Narayan, P. K. (2005). The saving and investment nexus for China: Evidence from cointegration tests. *Applied economics*, *37*(17), 1979-1990.

Narayan, P. K., & Smyth, R. (2004). Temporal causality and the dynamics of exports, human capital and real income in China. *International Journal of Applied Economics*, *1*(1), 24-45.

Ocal, O., & Aslan, A. (2013). Renewable energy consumption–economic growth nexus in Turkey. *Renewable and Sustainable Energy Reviews*, *28*, 494-499.

Oliveira, C., & Antunes, C. H. (2004). A multiple objective model to deal with economy - energy - environment interactions. *European Journal of Operational Research*, *153*(2), 370-385.

Ozcan, B. (2013). The nexus between carbon emissions, energy consumption and economic growth in Middle East countries: A panel data analysis. *Energy Policy*, *62*, 1138-1147.

Ozcan, B., Apergis, N., & Shahbaz, M. (2018). A revisit of the environmental Kuznets curve hypothesis for Turkey: new evidence from bootstrap rolling window causality. *Environmental Science and Pollution Research*, *25*(32), 32381-32394.

Ozturk, I., & Acaravci, A. (2010). CO2 emissions, energy consumption and economic growth in Turkey. *Renewable and Sustainable Energy Reviews*, *14*(9), 3220-3225.

Ozturk, I., & Acaravci, A. (2013). The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. *Energy Economics*, *36*, 262-267.

Ozturk, I., & Bilgili, F. (2015). Economic growth and biomass consumption nexus: Dynamic panel analysis for Sub-Sahara African countries. *Applied Energy*, *137*, 110-116.

Pal, D., & Mitra, S. K. (2017). The environmental Kuznets curve for carbon dioxide in India and China: Growth and pollution at crossroad. *Journal of Policy Modeling*, *39*(2), 371-385.

Panayotou, T. (1993). *Empirical tests and policy analysis of environmental degradation at different stages of economic development* (No. 992927783402676). International Labour Organization.

Pao, H. T., & Chen, C. C. (2018). Decoupling strategies: CO2 emissions, energy resources, and economic growth in the Group of Twenty. *Journal of Cleaner Production*, *206*, 907-919.

Pao, H. T., & Fu, H. C. (2013). Renewable energy, non-renewable energy and economic growth in Brazil. *Renewable and Sustainable Energy Reviews*, *25*, 381-392.

Pao, H. T., & Tsai, C. M. (2011). Modeling and forecasting the CO2 emissions, energy consumption, and economic growth in Brazil. *Energy*, *36*(5), 2450-2458.

Pata, U. K. (2018). Renewable energy consumption, urbanization, financial development, income and CO2 emissions in Turkey: Testing EKC hypothesis with structural breaks. *Journal of Cleaner Production*, *187*, 770-779.

Payne, J. E. (2009). On the dynamics of energy consumption and output in the US. *Applied Energy*, *86*(4), 575-577.

Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and statistics*, *61*(S1), 653-670.

Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, *94*(446), 621-634.

Phillips, P. C., & Hansen, B. E. (1990). Statistical inference in instrumental variables regression with I(1) processes. *The Review of Economic Studies*, *57*(1), 99-125.

Price, J., & Keppo, I. (2017). Modelling to generate alternatives: A technique to explore uncertainty in energy-environment-economy models. *Applied energy*, *195*, 356-369.

Rafiq, S., & Salim, R. (2011). The linkage between energy consumption and income in six emerging economies of Asia: an empirical analysis. *International Journal of Emerging Markets*, *6*(1), 50-73.

Rafiq, S., & Salim, R. A. (2009). Temporal causality between energy consumption and income in six Asian emerging countries. *Applied Economics Quarterly*, *55*(4), 335-350.

Rasoulinezhad, E., & Saboori, B. (2018). Panel estimation for renewable and non-renewable energy consumption, economic growth, CO 2 emissions, the composite trade intensity, and financial openness of the commonwealth of independent states. *Environmental Science and Pollution Research*, 1-17.

Sadorsky, P. (2009a). Renewable energy consumption, CO 2 emissions and oil prices in the G7 countries. *Energy Economics, 31*(3), 456-462.

Sadorsky, P. (2009b). Renewable energy consumption and income in emerging economies. *Energy policy*, *37*(10), 4021-4028.

Sadorsky, P. (2011). Financial development and energy consumption in Central and Eastern European frontier economies. *Energy policy*, *39*(2), 999-1006.

Saidi, K., & Mbarek, M. B. (2017). The impact of income, trade, urbanization, and financial development on CO2 emissions in 19 emerging economies. *Environmental Science and Pollution Research*, *24*(14), 12748-12757.

Savasan, F. (2003). Modeling the underground economy in Turkey: Randomized response and MIMIC models. *The Journal of Economics*, *29*(1), 49-76.

Say, N. P., & Yücel, M. (2006). Energy consumption and CO2 emissions in Turkey: empirical analysis and future projection based on an economic growth. *Energy policy*, *34*(18), 3870-3876.

Schneider, F., & Enste, D. H. (2000). Shadow economies: Size, causes, and consequences. *Journal of economic literature*, *38*(1), 77-114.

Schneider, F., & Savasan, F. (2007). Dymimic estimates of the size of shadow economies of Turkey and of her neighbouring countries. *International Research Journal of Finance and Economics*, *9*(5), 126-143.

Sehrawat, M., Giri, A. K., & Mohapatra, G. (2015). The impact of financial development, economic growth and energy consumption on environmental degradation: Evidence from India. *Management of Environmental Quality: An International Journal*, *26*(5), 666-682.

Seker, F., Ertugrul, H. M., & Cetin, M. (2015). The impact of foreign direct investment on environmental quality: a bounds testing and causality analysis for Turkey. *Renewable and Sustainable Energy Reviews*, *52*, 347-356.

Selden, T. M., & Song, D. (1994). Environmental quality and development: Is there a Kuznets curve for air pollution emissions?. *Journal of Environmental Economics and management*, *27*(2), 147-162.

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., & Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. *Renewable and Sustainable Energy Reviews*, *25*, 109-121.

Shahbaz, M., Khan, S., & Tahir, M. I. (2013). The dynamic links between energy consumption, economic growth, financial development and trade in China: fresh evidence from multivariate framework analysis. *Energy economics*, *40*, 8-21.

Shahbaz, M., Loganathan, N., Zeshan, M., & Zaman, K. (2015). Does renewable energy consumption add in economic growth? An application of auto-regressive distributed lag model in Pakistan. *Renewable and Sustainable Energy Reviews*, *44*, 576-585.

Shahbaz, M., Rasool, G., Ahmed, K., & Mahalik, M. K. (2016). Considering the effect of biomass energy consumption on economic growth: fresh evidence from BRICS region. *Renewable and Sustainable Energy Reviews*, *60*, 1442-1450.

Shahbaz, M., Tiwari, A. K., & Nasir, M. (2013). The effects of financial development, economic growth, coal consumption and trade openness on CO2 emissions in South Africa. *Energy Policy*, *61*, 1452-1459.

Shahzad, S. J. H., Kumar, R. R., Zakaria, M., & Hurr, M. (2017). Carbon emission, energy consumption, trade openness and financial development in Pakistan: A revisit. *Renewable and Sustainable Energy Reviews*, *70*, 185-192.

Solarin, S. A., Al-Mulali, U., & Ozturk, I. (2017). Validating the environmental Kuznets curve hypothesis in India and China: The role of hydroelectricity consumption. *Renewable and Sustainable Energy Reviews*, *80*, 1578-1587.

Sinha, A., & Bhattacharya, J. (2016). Environmental Kuznets curve estimation for NO2 emission: a case of Indian cities. *Ecological indicators*, *67*, 1-11.

Sinha, A., & Shahbaz, M. (2018). Estimation of Environmental Kuznets Curve for CO2 emission: Role of renewable energy generation in India. *Renewable energy*, *119*, 703-711.

Smith, P. M. (1997). Assessing the size of the underground economy: The statistics Canada perspective. *The underground economy: Global evidence of its size and impact*, 11-37.

Sonntag-O’Brien, V., & Usher, E. (2006). Mobilizing finance for renewable energies. *Renewable Energy: A Global Review of Technologies, Policies and Markets*, 169-195.

Soytas, U., Sari, R., & Ozdemir, O. (2001). Energy consumption and GDP relation in Turkey: a cointegration and vector error correction analysis. In *Economies and Business in Transition: Facilitating Competitiveness and Change in the Global*

Environment Proceedings (Vol. 1, pp. 838-844). New York: Global Business and Technology Association.

Stern, D. I. (1993). Energy and economic growth in the USA: a multivariate approach. *Energy economics*, *15*(2), 137-150.

Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. *World Development*, *32*(8), 1419-1439.

Tamazian, A., & Rao, B. B. (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. *Energy Economics*, *32*(1), 137-145.

Tang, C. F., Tan, B. W., & Ozturk, I. (2016). Energy consumption and economic growth in Vietnam. *Renewable and Sustainable Energy Reviews*, *54*, 1506-1514.

Tao, S., Zheng, T., & Lianjun, T. (2008). An empirical test of the environmental Kuznets curve in China: A panel cointegration approach. *China Economic Review*, *19*(3), 381-392.

Tiris, M., Atagunduz, G., & Dincer, I. (1994). Energy, economy and environment modelling: Applications for Turkey. *Energy*, *19*(9), 1005-1009.

Tiwari, A. K. (2011). A structural VAR analysis of renewable energy consumption, real GDP and CO2 emissions: evidence from India. *Economics Bulletin*, *31*(2), 1793-1806.

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of econometrics*, *66*(1-2), 225-250.

UNFCCC, (2019). Understanding the UN climate change regime: October 2018. Retrieved from. https://unfccc.int/resource/bigpicture/#content-the-paris-agreemen.

Wang, S., Li, Q., Fang, C., & Zhou, C. (2016). The relationship between economic growth, energy consumption, and CO 2 emissions: empirical evidence from China. *Science of the Total Environment*, *542*, 360-371.

Westerlund, J. (2005). New simple tests for panel cointegration. *Econometric Reviews*, *24*(3), 297-316.

WMO, (2018). Greenhouse gas bulletin: November 2018. Retrieved from. https://library.wmo.int/index.php?lvl=notice_display&id=3030#.XLcHCIkzbcd.

World Bank. (2017). World development indicators. (2017). Retrieved from http://databank.worldbank.org

Wurgler, J. (2000). Financial markets and the allocation of capital. *Journal of financial economics*, *58*(1), 187-214.

Yavuz, N. Ç. (2014). CO2 emission, energy consumption, and economic growth for Turkey: Evidence from a cointegration test with a structural break. *Energy Sources, Part B: Economics, Planning, and Policy*, *9*(3), 229-235.

Yildirim, E., Saraç, Ş., & Aslan, A. (2012). Energy consumption and economic growth in the USA: Evidence from renewable energy. *Renewable and Sustainable Energy Reviews*, *16*(9), 6770-6774.

ZhiDong, L. (2003). An econometric study on China’s economy, energy and environment to the year 2030. *Energy policy*, *31*(11), 1137-1150.

Zilio, M., & Recalde, M. (2011). GDP and environment pressure: the role of energy in Latin America and the Caribbean. *Energy Policy*, *39*(12), 7941-7949.