Environmental Kuznets Curve: The Roles of Financial Development and FDI for the Case of Turkey

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ABSTRACT

The aim of this thesis is to investigate the roles of financial development and foreign direct investments on conventional environmental Kuznets curve (EKC) for the case of Turkey. To this aim, thesis divided into two sections. In the first section, moderating role of financial development in conventional EKC is investigated by employing second-generation econometric procedures that consider multiple structural breaks in the series. First section includes two separate models for this purpose: (1) the main effects model and (2) the interaction effects model. The results of this investigation suggest a long-term equilibrium relationship between financial development and the EKC in Turkey, using both model options. Financial development has been found to moderate the effect of real output on carbon dioxide emissions in the shorter periods negatively, which signifies successful environmental performance and energy management. In comparison, financial development moderates the effect of real output on carbon dioxide emissions in the longer periods positively, and in which this finding again signifies that policies for energy savings and green house targets need to be established to target longer periods and energy management policies at higher levels of economic activity. The present thesis did not confirm a significant moderating effect of financial development on the impact of energy consumption on carbon dioxide emissions in the case of Turkey.

In the second section, the relevance of the environmental Kuznets curve (EKC) hypothesis is investigated in Turkey for the period 1974–2010 using carbon dioxide (CO2) emissions, energy consumption, economic growth, and foreign direct investment (FDI) variables. The long-run equilibrium relationship among CO2 emissions, energy consumption, economic growth, and FDI is revealed using the bounds test. The error correction model under autoregressive-distributed lag mechanism suggests that CO2 emissions converge to their long-run equilibrium level by a 49.2% speed of adjustment every year by the contribution of energy consumption, economic growth, and FDI. The Toda–Yamamoto (1995) causality test results imply that carbon emissions and FDI, energy consumption, and CO2 emissions have bidirectional causal relationships. On the other hand, there are unidirectional causal relationships running from economic growth and energy consumption to FDI and from economic growth to energy consumption. Findings of this thesis provide evidence of the validity of the pollution haven hypothesis, in addition to the scale effect, and the EKC in the case of Turkey.

Keywords: Air pollution, financial development, foreign direct investments, moderating role, causality.

ÖZ

Bu tezin amacı Türkiye'de finansal gelişim ve yabancı doğrudan yatırımların geleneksel çevresel Kuznets eğrisi üzerindeki etkisini incelemektir. Bu amaçla tez, iki bölümden oluşmaktadır. Birinci bölümde, finansal gelişimin çevresel Kuznets eğrisi üzerindeki aracı rolü, ikinci nesil yapısal kırılmalı ekonometrik metodlar uygulanarak incelenmektedir. Bu amaç doğrultusunda birinci bölümde ana etkiler modeli ve aracı etkiler modeli olmak üzere iki ayrı model uygulanmıştır. Analizler sonucunda Türkiye'de finansal gelişim ve çevresel Kuznets eğrisi arasında uzun dönem denge ilişkisi bulunmuştur. Kısa dönemlerde finansal gelişimin gelir düzeyi üzerinden karbon emisyonlarına aracı etkisi negatiftir. Bu da kısa dönemlerde Türkiye'nin çevresel performans ve enerji yönetiminin başarılı olduğunu göstermektedir. Bunun karşılığında uzun dönemlerde, finansal gelişimin gelir düzeyi üzerinden karbon emisyonlarına aracı etkisi pozitiftir. Bu da enerji yönetim politikalarının daha uzun dönemler için de planlanması gerektiğini göstermektedir. Bunun yanında finansal gelişimin enerji tüketimi üzerinden karbon emisyonlarına istatistiksel olarak anlamlı bir aracı etkisi olmadığı gözlemlenmiştir.

İkinci bölümde, Türkiye'de 1974-2010 yılları arasında yabancı doğrudan yatırımların tetiklediği çevresel Kuznets eğrisinin varlığı, karbon emisyonları, enerji tüketimi, ekonomik gelişim ve yabancı doğrudan yatırımlar kullanılarak incelenmiştir. Karbon emisyonları, enerji tüketimi, ekonomik gelişim ve yabancı doğrudan yatırımlar arasında uzun dönemli denge ilişkisi bounds yöntemi ile kanıtlanmıştır. ARDL mekanizması altında uygulanan hata düzeltme modeli, karbon emisyonlarının uzun dönemli denge seviyesine, enerji tüketimi, ekonomik gelişim ve yabancı doğrudan

yatırımların yıllık katkısıyla % 49.2 hızla ulaştığını göstermektedir. Toda-Yamamoto nedensellik testi sonuçları karbon emisyonları ile yabancı doğrudan yatırımlar ve enerji tüketimi arasında çift yönlü nedensellik ilişkisi olduğunu göstermektedir. Diğer yandan, ekonomik gelişim ve enerji tüketiminden yabancı doğrudan yatırımlara ve ekonomik gelişimden enerji tüketimine doğru tek yönlü nedensellik ilişkisi olduğu saptanmıştır. Bu tezin sonuçları, Türkiye'de kirlilik cenneti hipotezinin, ölçek etkisinin ve çevresel Kuznets eğrisinin varlığını kanıtlamaktadır.

Anahtar Kelimeler: Hava kirliliği, finansal gelişim, yabancı doğrudan yatırımlar, aracı etkisi, nedensellik.

To My Mom and Dad

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LIST OF ABBREVIATIONS

AIC	Akaike information criterion
ARDL	Autoregressive distributed lag
ASEAN	Association of Southeast Asian Nations
BRIC	Brazil, Russia, India and China
CO_2	Carbon dioxide
CUSUM	Cumulative sum
CUSUMSQ	Cumulative sum of squares
DOLS	Dynamic ordinary least squares
DRC	Democratic Republic of the Congo
D-W	Durbin Watson
ECM	Error correction model
ECT	Error correction term
EKC	Environmental Kuznets Curve
EU	European Union
FD	Financial Development
FDI	Foreign direct investments
FMOLS	Fully Modified Ordinary Least Squares

GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GHGE	Greenhouse gas emissions
GLS	Generalized least squares
IPCC	Intergovernmental Panel on Climate Change
MENA	Middle East and North Africa region
MWALD	Modified Wald stat
OECD	Organization for Economic Co-operation and Development
R&D	Research and Development
SO_2	Sulfur dioxide
VAR	Vector Autoregressive

Chapter 1

INTRODUCTION

Environmental degradation is one of the biggest concerns for policy makers of developing countries while they are trying to reach higher levels of economic growth. The Intergovernmental Panel on Climate Change (IPCC) (2013) reports that mostly developing countries contribute to the green house gas emissions while they are trying to increase their production in order to achieve higher levels of economic growth and better standard of living. That's why, investigating the reasons behind environmental degradation is very important for policy makers in order to create efficient environmental policies. The relationship between economic growth and environmental degradation has been investigated widely in the literature by investigating the Environmental Kuznets Curve (EKC) hypothesis. The common point of these studies that examine the interactions between environmental quality and economic growth, quality of environment starts to decline at the initial levels of growth and it starts to increase in the later stages of development (Dinda, 2004). As environmental degradation increases faster than income at initial stages of development and it gets slower in the later stages, the relationship between environmental quality and income is an inverted U-shaped (Dinda, 2004). Kuznets (1955) suggests the inverted U-shaped relationship between distribution of income inequality and level of income for the first time and EKC name is derived from Kuznets' (1955) study. The reason behind the negative relationship between higher economic development and environmental degradation is explained by Panayotou

(1993). At later stages of economic development, structural changes are observed in the industries and services towards more information-based industries. In addition, increased public awareness, technological changes, higher government expenditures on environmental problems and stricter regulations on environmental issues cause decreases in environmental degradation (Stern, 1998). Dasgupta et al. (2002) also state that in the early stages of industrialization, environmental quality decreases rapidly because of the priority given only to the output rather than the material input. People also are more concerned with the income and availability of jobs than environmental quality.

Financial development might correlate either positively or negatively to environmental pollution. Several recent papers studied the environmental effects of financial sector development (Ozturk and Acaravci, 2013; Jalil and Feridun, 2011; Shahbaz et al., 2013a). First, expansion in financial services results in higher energy demand; therefore, it is expected that financial development will positively influence the energy consumption process. On the other hand, with only a few exceptions, it is well documented that financial development generally results in a higher economic growth rate in the involved countries. Indeed, it is well recognized that financial development is crucial for economic growth (Calderon and Liu, 2003). Furthermore, it is a necessary condition for achieving a high rate of economic growth (Chang, 2002; Mazur and Alexander, 2001). Nonetheless, some studies, such as by Gregorior and Guidotti (1995), found that financial development significantly reduces economic growth for some countries (especially in Latin America) experiencing relatively high inflation rates. Consequently, this causal relationship generally remains unclear (Jenkins and Katircioglu, 2008; Calderon and Liu, 2003). As a result of financial development, economic activity will increase mainly through credit expansion, investments, and stock markets. Foreign direct investments (FDI) and foreign trade are important channels through which financial development can contribute positively to the economy (Jalil and Feridun, 2011). In a healthy financial environment, part of the credit will go to foreign-based investments, which will attract foreign direct inflows to the economy. Alfaro et al. (2009) argue that well-functioning financial markets contribute to lowering the costs of conducting transactions and ensuring that the capital is allocated to the projects that yield the highest returns, and therefore enhance growth rates. In this respect, FDI can be a source of valuable technology and expertise that also fosters linkages with local firms and thus helps to jump-start an economy (Alfaro et al., 2009). Ang (2009) finds that the impact of FDI on output is enhanced through financial development. Therefore, it can be easily assumed that the financial sector is the main channel in which capital moves from abroad into the domestic economies. Hermes and Lensink (2003) suggest that a developed financial system contributes positively to the process of technological diffusion associated with FDI. In the case of tourism, Zhang and Jensen (2007) suggest that multinational tour operators and hotel chains have important advantages over the others in terms of reputation, branding, and the product recognition to attract tourists to the countries where they invest. Frankel and Romer (1999) suggest that financial development may attract FDI and higher degrees of research and development (R&D), which result in an increase in the level of economic growth.

Candau (2012) found that in liberalizing from high trade costs, countries could attract capital as well as labor; however, after a threshold of trade costs, opening trade generates return migration toward the periphery while capital remains agglomerated in the core. A well-functioning financial system will attract not only FDI, but higher foreign trading activities as well, which all result in economic growth. Therefore, it can be easily inferred that energy consumption in an economy will increase because of economic growth, which is stimulated by financial development. This might ultimately lead to an increase in the level of greenhouse gas emissions (GHG).

A second perspective is that financial development might result in better environmental performance since it will encourage investments in environmental projects (Jalil and Feridun, 2011; Tamazian et al., 2009). In this case, financial development might negatively influence the level of environmental pollution, while it may lead to a reduction in pollution levels through investments in environmental projects. Claessens and Feijen (2007) regard a well-developed financial sector as a mechanism for carbon trading to provide incentives to mitigate GHG.

Foreign direct investment (FDI) plays a vital role in the economic growth of developing economies that do not have sufficient capital for investing. FDI contributes to the economic growth of developing countries not only with capital financing, but it also helps those countries to increase their productivity via transferring advanced production technology, managerial skills, and know-how to modernize the economy and encourage innovation. FDI also creates new job alternatives and encourages entrepreneurship and competitiveness, which are the most important tools for the rapid growth of developing countries (Mallampally and Sauvant, 1999; Hermes and Lensink, 2003; Batten and Vo, 2009; Reiter and Steensma, 2010; Fernandes and Paunov, 2012; Lee, 2013).

FDI can affect CO_2 emissions and environmental degradation in several contradictory ways, and there have been ongoing discussions about the net effect of

FDI on environmental pollution. According to some researchers, aside from being harmful FDI contributes to environmental protection. FDI in the form of efficient technology for production can be transferred and can help countries reduce air pollution (Stretesky and Lynch, 2009). On the other hand, many other researchers argue that FDI contributes to air pollution. According to them, FDI stimulates economic growth by increasing productivity, which leads to higher energy consumption. More CO_2 emissions as a result of higher energy usage result in environmental pollution. In addition, polluting firms may choose to invest in developing countries that have insufficient environmental regulations in order to minimize production costs, which also causes increases in energy consumption in the country (Jensen, 1996; Acharyya, 2009; Lau et al., 2014). Thus, insufficient environmental regulations that enable firms to increase their level of CO_2 emissions may attract foreign investors and thus the amount of FDI inflow. This relationship is formalized by the pollution haven hypothesis.

Given the importance of the effect of FDI and financial development on economic growth, energy consumption, and CO_2 emissions, the aim of this thesis is to examine the long run equilibrium relationship between CO_2 emissions, economic growth, energy consumption, financial development and FDI in Turkey, which is an energy-dependent emerging economy.

The climate change performance index (2015) ranks Turkey 51st of 61 countries worldwide in terms of climate change protection and criticizes the country for its lack of national policies to prevent climate change. Energy-related CO_2 emissions in the country began to increase rapidly during the 1990s. International Energy Agency statistics (2014) show a 138.3% change in CO_2 emissions in Turkey between 1990 and 2012. On the other hand, Turkey has been an attractive country for FDI starting in 2004 as a result of its economic stability and high earning rates compared to many developing countries. In addition, Turkey has managed to promote financial sector successfully and managed to stabilize financial markets. Therefore, increases in FDI and higher investments via financial development may be a driving force of higher energy consumption by enhancing the growth rate of the Turkish economy and thus contribute to CO_2 emissions. These aspects make Turkey an interesting case in terms of examining the interactions among CO_2 emissions, energy consumption, economic growth, financial development and FDI inflows and discussing effective national policies governing climate change.

The rest of the thesis is structured as follows; chapter 2 reviews the relevant literature, chapter 3 tests the validity of financial development-induced EKC, chapter 4 examines the existence of FDI-induced EKC and chapter 5 concludes the thesis.

Chapter 2

LITERATURE REVIEW

The relationship between air pollution, energy consumption and economic growth with different types of indicators has been investigated intensively in the last decade. Several researchers investigate the relationship between these variables by testing the existence of EKC hypothesis. The EKC hypothesis states that when a country's income level increases, environmental degradation of the country increases at the first stage of development, then after a certain point it starts to decline (Dinda, 2004). Ang (2007) tests the existence of EKC hypothesis in France by adopting ARDL bounds testing approach and results of the study confirm the existence of the long-run relationship between CO2 emissions, energy consumption and economic growth. Fodha and Zaghdoud (2009) examine the relationship between economic growth and pollutant indicators of CO_2 emissions and sulfur dioxide (SO_2) emissions on the basis of EKC hypothesis for the case of Tunisia. Cointegration analysis is adopted for the years 1961-2004 and the long run relationship between two pollution indicators and economic growth is revealed. Lean and Smyth (2010) investigate the relationship between CO_2 emissions, electricity consumption as an energy consumption indicator and economic growth in a panel setting for five ASEAN countries for the years of 1980-2006. Results of their study support the existence of EKC hypothesis for ASEAN countries. According to estimations of their study, there is a positive relationship between electricity consumption and CO_2 emissions. Jaunky (2011) tests the existence of EKC hypothesis for 36 high-income countries by adopting Narayan and Narayan's (2010) approach and state that EKC is valid for the case of Greece, Malta, Oman, Portugal and United Kingdom for the period of 1980-2005. Recently, Heidari et al. (2015) examine the existence of EKC hypothesis by investigating the interactions between CO_2 emissions, economic growth and energy consumption for ASEAN countries. Results of their study are compliant with the results of Lean and Smyth (2010) which confirm the validity of EKC for the case of five ASEAN countries. Apergis and Ozturk (2015) investigate the validity of EKC hypothesis for 14 Asian countries for the period of 1990-2011 by adopting panel data methodology and results support the existence of inverted U-shaped relationship between CO_2 emissions and income per capita. Jula et al. (2015) test the existence of EKC hypothesis for the case of Romania over the period 1960-2010. Existence of the EKC hypothesis is confirmed by investigating the long run relationship between income growth per capita and CO_2 emissions per capita. On the other hand, Magazzino (2014) fails to confirm the long run relationship between CO_2 emissions, economic growth and energy consumption for the case of Italy for the period of 1970-2006. Therefore, Toda-Yamamato causality test is applied in order to examine the directions of the variables. Causality test results reveal a feedback relationship between CO_2 emissions and economic growth and also between CO_2 emissions and energy consumption for the case of Italy. Validity of Kuznets curve in Vietnam is examined by Al-Mulali et al. (2015a) for the period of 1981-2011. Results of the study indicate a positive relationship between air pollution and economic growth both in the short and the long run which means that the EKC hypothesis is not valid in Vietnam. Robalino-Lopez et al. (2015) use a different technique to investigate the existence of EKC hypothesis for the case of Venezuela. Their study is different than the current literature in a way that EKC hypothesis is tested not only with historical data but also predictions about future for the years 1980-2025. According to the predictions of their study, EKC hypothesis is not existed in Venezuela but stabilization in environmental degradation is expected in the medium term by the help of increases in renewable energy usage due to economic growth.

EKC hypothesis has been investigated extensively by several researchers for the case of Turkey. Lise and Montfort (2007) investigate the long run relationship between energy consumption and economic growth between the period of 1970-2003 for the case of Turkey. Results of the study reveal that energy consumption and economic growth are cointegrated between the sample period. Lise and Montfort (2007) examined also the EKC hypothesis in their study but their results suggest nonexistence of EKC for the case of Turkey. Akbostanci et al. (2009) examine the long run equilibrium relationship between environmental degradation and income by adopting time series and panel data analysis. Their findings support the results of Lise and Montfort (2007) and do not suggest the existence of EKC hypothesis for the case of Turkey. Halicioglu (2009) uses ARDL bounds testing approach for investigating the long-run equilibrium relationship between carbon emissions, energy consumption and growth and concludes that environmental Kuznets curve exists for the case of Turkey. On the other hand, Ozturk and Acaravci (2010) examine the EKC for the same country between the years of 1968-2005, in contrast to Halicioglu (2009), claim that EKC hypothesis is not valid for their sample period. The existence of EKC hypothesis is confirmed by Ozturk and Acaravci (2013) for Turkey by investigating the relationship between financial development, trade, economic growth, energy consumption and CO_2 emissions. Shahbaz et al. (2013b) examine the relationship between emissions, energy intensity, economic growth and globalization over the period of 1970-2010 in Turkey by applying unit root test and cointegration methods under the existence of structural breaks. Empirical Findings also confirm the existence of EKC hypothesis in Turkey and indicate bidirectional causality between CO_2 emissions and economic growth. Yavuz (2014) also investigates the long run equilibrium relationship between CO_2 emissions per capita, energy consumption per capita and income per capita for the period of 1960-2007 under existence of a single structural break by adopting Gregory-Hansen cointegration test. Gregory-Hansen cointegration test results reveal the long run equilibrium relationship between the variables conducted in the empirical model of the study. Also, the validity of EKC is examined and findings indicate the validity of EKC hypothesis in the long run for the case of Turkey. Vita et al. (2015) examine the EKC hypothesis in a tourism development context for the case of Turkey and their results indicate the long run equilibrium relationship between CO_2 emissions, income growth, squared income growth, energy consumption and international tourist arrivals. Their findings also support the existence of EKC hypothesis in a tourism development context.

In the energy economics literature, investigating the relationship between CO2 emissions, energy consumption, economic growth for sub-segments of the economy and testing the validity of EKC hypothesis with the existence of different economic indicators deserves attention (Katircioglu et al., 2014). Several studies use different indicators such as trade openness, tourism development, urbanization and technological improvement in order to test the effect of these variables on the EKC (Al-Mulali et al., 2015b). Jalil and Mahmud (2009) examine the impact of international trade on EKC for the period of 1975-2005 in China. Results of the study reveal that there is a quadratic relationship between GDP and CO_2 emissions which implies the validity of EKC hypothesis in China. Atici (2009) also examines the interactions between air pollution, energy usage and trade openness in the Central and Eastern Europe over the period 1980-2002. Results of the study support the existence of EKC hypothesis for Turkey, Hungary, Bulgaria and Romania and suggest that air pollution decreases when economic growth increases in the region. Nasir and Rehman (2011) study the relationship between air pollution, energy consumption, economic growth and trade openness for the case of Pakistan, a developing country, for the period of 1972-2008 and suggest that these variables have long-run equilibrium relationship. On the other hand, Du et al. (2012) examine the interactions between carbon emissions, economic growth, urbanization, energy usage, technological improvement and trade openness for the case of China as well for the period of 1995-2009 and, in contrast to Jalil and Mahmud (2009), conclude that EKC hypothesis does not exist for the case of Chinese economy. The relationship between CO_2 emissions, energy consumption, economic growth, trade openness and population growth is investigated by Onafowora and Owoye (2014) for the case of several countries including China, Egypt, Brazil, Japan, Nigeria, South Korea, Mexico and South Africa in EKC hypothesis context. Results of the study suggest that EKC hypothesis exists in an inverted-U shaped in Japan and South Korea. In other host countries, the estimated relationship is N-shaped. Moreover, Granger causality test results indicate that changes in energy usage causes changes in both CO_2 emissions and economic growth for all countries. Katircioglu (2014) examines the long run equilibrium relationship between tourism development and air pollution by testing the existence of EKC hypothesis with the contribution of tourism sector in Singapore. Results of this study indicate a negative impact of tourism development on air pollution and also tourism development-induced EKC is valid for the host country. Recently, Kasman and Duman (2015) study the causal interactions between economic growth, energy usage, carbon emissions, urbanization and trade openness for the case of new EU member and candidate countries by employing panel data analysis between the period of 1992-2010. Results of panel data analysis suggest the existence of EKC hypothesis and indicate an inverted-U shaped relationship between environmental degradation and economic growth for the countries in the sample. Moreover, error correction analysis suggest that trade, urbanization, energy usage and economic growth are the determinants of CO_2 emissions in long run. On the other hand, Ozturk and Al-Mulali (2015) investigate the effect of better governess and corruption control on the N-shaped relationship between income and CO_2 emissions in Cambodia for the period of 1996-2012 and state that EKC hypothesis does not exist for the case of Cambodia. Begum et al. (2015) also suggest invalidity of EKC hypothesis by investigating the interactions between CO_2 emissions, economic growth, energy consumption and population growth for the case of Malaysia. According to the results of the study, economic growth and energy usage in the host country has positive effects on CO_2 emissions while population growth has no significant effect on emissions.

Financial development is one of the crucial sectors for a country's economic growth (Calderon and Liu, 2003). Therefore, the effect of financial development on environmental degradation has been investigated by several researchers over the last decades. Jalil and Feridun (2011) examine the interactions between carbon emissions, economic growth, energy consumption, international trade and financial development in China for the period of 1953-2006. Results confirm the long-run equilibrium relationship among variables used in the study and suggest relevance of the EKC hypothesis. Findings also show that financial development affects air pollution negatively which means financial development of China causes a decrease in carbon emissions level. Shahbaz et al. (2013c) investigate the interactions between financial development, economic growth, trade openness, coal consumption and environmental quality for the case of South Africa by employing time series econometric procedures. Their results suggest that increases in CO_2 emissions are observed when there is an increase in economic growth but CO_2 emissions decline when there is an increase in the level of financial development. Also, EKC hypothesis is confirmed by the results of the study for the case of South Africa. Shahbaz et al. (2013a) investigate the relationship among economic growth, energy consumption, financial development, trade openness and CO_2 emissions in Indonesia by adopting ARDL bounds testing approach. Empirical findings indicate that economic growth has a positive effect on CO_2 emissions in the short-run as well as in the long run which means EKC hypothesis is not valid in Indonesia. Boutabba (2014) examines the relationship between CO_2 emissions, financial development, GDP growth and energy consumption in India. Results of their study indicate that financial development increases the environmental degradation because it leads to increases in economic growth and energy consumption. Results of Boutabba (2014) are supported by Farhani and Ozturk (2015) that financial development has a positive impact on CO_2 emissions for the case of Tunisia by adding financial development, trade openness and urbanization variables in the conventional EKC model. Moreover, findings of Farhani and Ozturk (2015) do not support the EKC hypothesis for the case of Tunisia. Also, Lee et al. (2015) investigate the relationship between EKC and financial development for the case of OECD countries by employing panel data analysis for the years 1971-2007. Results of the study do not support the EKC hypothesis and financial development has negative significant impact on CO_2 emissions for eight OECD countries. Negative impact of financial development is revealed also by the study of Salahuddin et al. (2015) for the case of Gulf Cooperation Council (GCC) for the period of 1980-2012. The long run relationship is examined between the carbon emissions, electricity consumption, economic growth and financial development. According to the results of the study, economic growth and electricity consumption accelerate emissions in the long run. Any short run interaction is not observed among the variables in the conducted model. On the other hand, Al-Mulali et al. (2015c) test the effect of GDP, renewable energy consumption and financial development on air pollution between the years of 1980-2010 for the Latin America and Caribbean countries by applying the Fully Modified OLS (FMOLS). FMOLS results indicate that EKC hypothesis exists for the case of Latin America and Caribbean countries. EKC hypothesis and the interactions between CO_2 emissions, financial development, trade and economic growth is examined for the case of MENA countries by Omri et al. (2015). Their results confirm the existence of EKC hypothesis for the period of 1990-2011 and bidirectional relationships are observed between carbon emissions, trade and economic growth. Recently, Javid and Sharif (2016) investigate the impact of financial development on air pollution for the case of Pakistan, a developing country, and conclude that EKC hypothesis is valid for the period of 1972-2013. Results of the study also suggest that financial development is one of the key contributors to air pollution in Pakistan.

In the existing literature, there are various studies which examine the impact of FDI, which is an important economic indicator for economic growth, on air pollution or environmental degradation trough the increased energy consumption or economic growth (Hao and Liu, 2015). Hoffmann et al. (2005) investigate the relationship between FDI and air pollution for 112 countries by using panel data approach. According to Granger causality test results, carbon emissions in low-income economies Granger cause FDI and FDI Granger causes carbon emissions in middle-income economies. In other words, countries with low-income and high levels of emissions attract more FDI and middle-income countries with high level of FDI produce more emissions. A similar study is conducted by Acharyya (2009) for the case of India and results reveal a positive relationship between both FDI and growth and FDI and CO_2 emissions in the long-run. Pao and Tsai (2011) investigate the causal relationship between air pollution, GDP, energy consumption and FDI for BRIC countries. Bi-directional causal relationship is observed between air pollution and FDI. Also, unidirectional causal relationship is found which runs from the growth to FDI. Blanco et al. (2013) examine the effect of FDI on CO_2 emissions in Latin American countries for the period of 1980-2007. Results of Granger Causality test exhibit that, a change in FDI inflows in pollution intensive sectors leads to a change in CO_2 emissions. Kivriyo and Arminen (2014) also apply the Granger causality analysis for Sub Saharan African countries in order to check the causal relationships between CO_2 emissions, energy consumption, economic growth and FDI. EKC hypothesis is supported by the results for the case of Democratic Republic of the Congo (DRC), Kenya and Zimbabwe. In addition, FDI increases environmental degradation in some of these countries while it causes a decrease in pollution level in some other countries. Recently, Tang and Tan (2015) test the existence of EKC in Vietnam and their results support the existence of EKC as the relationship between energy consumption, GDP and emissions is positive while the relationship between GDP squared and emissions is negative. Moreover, bi-directional relationships between emissions and GDP and between FDI and emissions are observed in the mentioned study. The study of Linh and Lin (2015) support the pollution haven hypothesis for Asian countries which states that when environmental regulations are not strong enough, more foreign direct investors are attracted to the countries. Therefore, FDI inflows do not contribute to the environmental pollution of the 12 sample Asian countries but environmental pollution contributes to the FDI inflows of the host countries.

Chapter 3

TESTING FINANCIAL DEVELOPMENT-INDUCED EKC: THE CASE OF TURKEY

3.1 Introduction

The investigation of the relationships between energy consumption, greenhouse gas emissions (GGE), and economic growth have attracted significant attention in the energy economics literature of the last three decades. Although previous literature typically focused on the connection between economic growth, energy, and GGE, the results are still inconclusive (see, for example, Kraft and Kraft, 1978; Akarca and Long, 1980; Erol and Yu, 1987; Stern, 1993; Asafu-Adjaye, 2000; Coondoo andDinda, 2002; Narayan and Smyth, 2007; Wolde-Rufael, 2009). Some studies investigate the relationship between energy consumption and real income growth (Kraft and Kraft, 1978; Lise and Montfort, 2007; Jobert and Karanfil, 2007; Odhiambo, 2009), while others test the existence of the EKC hypothesis, which examines the interactions among GHGE and income growth (Grossman and Krueger, 1991; Coondoo and Dinda, 2002; Stern, 2004; Dinda, 2004; Luzzati and Orsini, 2009). Still others investigate the joint relationship between energy consumption, carbon emissions, and economic growth in the existing literature (Zhang and Cheng, 2009; Ang, 2007; Say and Yucel, 2006; Richmond and Kaufmann, 2006). It is noteworthy that carbon dioxide emissions have been used extensively to proxy for GGE in the energy economics literature. However, the relationship of energy and emissions with the particular segments or sectors of the economy, specifically the financial sectors, which is the focus of the current thesis, have been widely ignored in the related literature in this field.

Although rare, some recent studies have examined the empirical connections among financial development, energy consumption, and carbon dioxide emissions. Jalil and Feridun (2011) investigated the impact of financial development, economic growth, and energy consumption on environmental pollution in China and found that financial development leads to a decrease in the environmental pollution level through mediating the roles of energy usage, growth of income, and trade openness. The findings of Jalil and Feridun (2011) thus confirmed the finance-induced EKC hypothesis in China. Again, in the Chinese context, Shahbaz et al. (2013) confirm the existence of the feedback relationship between energy consumption and financial development. In contrast, Ozturk and Acaravci (2013) find that financial development does not exert a statistically significant impact on carbon dioxide emissions in the long run of the Turkish economy under the Environmental Kuznets Curve framework. To proxy for a financial development variable, Ozturk and Acaravci (2013) used the volume of domestic credits provided to the private sector as the percent to the gross domestic product in Turkey.

As mentioned previously, since development in the financial or services sector comes with an increased demand of energy for various functions, the importance of energy for this sector is beyond debate. In this respect, examining the empirical relationships between energy, GGE, and financial development with contemporary econometric approaches and the effective use of available variables and data is of interest to researchers; moreover, the conclusions drawn from such investigations are of more effective and efficient interest to policy makers and practitioners. It is expected that as the financial sector develops, it will start relying more on energy, which might lead to increases in the GGE levels. Therefore, the methodology used in measuring the financial development variable deserves attention from researchers. Numerous studies have used various proxies for financial development. As Ang (2009) also argued, the selection of key variables to proxy financial services, and therefore financial development, and measuring the extent and efficiency of financial intermediation are the major problems in the empirical economics literature. Levine et al. (2000) maintain that constructing measures to reflect the ability of different financial systems should be essential for researchers. Beck et al. (1999) constructed a database for various measures of financial development, which has subsequently shed light for researchers. To investigate the role of economic sectors, such as finance, in the relationships between real income, energy usage, and air pollution, or simply in the traditional EKC of countries, it is also important that new alternative econometric models receive attention from researchers.

Against this backdrop, the present thesis introduces a new mechanism for investigating the moderating role of the financial sector in the traditional EKC for the case of Turkey. Previous studies estimated extended versions of the EKC under growth or simple regressions. In the statistical theory, moderation occurs when the interaction between two variables also depends on a third variable. Therefore, the third variable is called the “moderator” (Baron and Kenny, 1986). The moderating role of variables is introduced through constructing and adapting interaction variables. To investigate the moderating role of financial development in the traditional EKC of Turkey, the present thesis contributes to the literature by adapting interaction variables into time series data for the first time, to the best of the author’s knowledge.

Turkey has an emerging economy, which has been volatile throughout its history. Hitherto, financial markets have shown a similar trend. Since the 1980s, Turkey has had to adopt several stabilization programs to stabilize price levels and achieve sustainable growth during the liberalization processes (Gungor et al., 2014). Throughout a highly volatile era of almost 30 years, Turkey attracted foreign investors (multinational companies) using certain policy tools, as documented in Gungor et al. (2014). This resulted in good subsequent foreign direct investment (FDI) inflows. In 2000, FDI inflows increased from 817 million USD to 1,719 million USD, by a total of 5,328 foreign capital firms (Deichmann et al., 2003).

Recent developments in both domestic political stability and the EU relationship created a positive climate that led to non-stop growth of output in 23 consecutive quarters between 2001 and 2008. Many observers assume the EU relationship as either an anchor or a commitment and credibility device for Turkey's restructuring and development (Tsarouhas, 2009). Throughout the last three decades, Turkey has managed to promote its financial system, which has also contributed to its economic sectors, including industry, FDI, and trade. Therefore, it would be interesting to examine the role of financial development in environmental performances in countries such as Turkey. Although numerous recent studies examine conventional EKC under both panel and time series settings, the debate provides mixed results since heterogeneity is high across countries. With this consideration, to receive better estimations and provide better policy implications, it would be better to focus on single country cases rather than a panel of countries (Jalil and Feridun, 2011).

3.2 Theoretical Setting

Over the years, the validity of EKC hypothesis tested widely in the related field of literature. The variables of GDP and GDP^2 (and sometimes GDP^3 in the literature) are regressors in the conventional EKC model, as presented in equation (1) and in per capita (P) terms:

$$\frac{CO_2}{P} = f\left(\frac{GDP}{P}, \frac{GDP^2}{P}\right) \tag{1}$$

Energy consumption (E) has been included extensively in the conventional EKC model to estimate the effects of energy on CO_2 emissions, as formulated in equation (2):

$$\frac{CO_2}{P} = f\left(\frac{GDP}{P}, \frac{GDP}{P}^2, \frac{E}{P}\right) \tag{2}$$

Equation (2) can be written in the linear equation form to estimate the effects of regressors on CO_2 emissions, as presented in equation (3):

$$\frac{CO_{2_t}}{P_t} = \beta_0 + \beta_1\left(\frac{GDP_t}{P_t}\right) + \beta_2\left(\frac{GDP_t^2}{P_t}\right) + \beta_3\left(\frac{E_t}{P_t}\right) + \varepsilon_t \tag{3}$$

Equation (3) can be re-written in the double logarithmic form to capture growth effects of regressors on the dependent variable (Katircioglu, 2010):

$$\ln\frac{CO_{2_t}}{P_t} = \beta_0 + \beta_1\left(\ln\frac{GDP_t}{P_t}\right) + \beta_2\left(\ln\frac{GDP_t^2}{P_t}\right) + \beta_3\left(\ln\frac{E_t}{P_t}\right) + \varepsilon_t \tag{4}$$

This thesis proposes that financial development might have a moderating role in the EKC for Turkey. Specifically, financial development might moderate the effects of

(1) GDP, (2) GDP^2, and (3) energy consumption on CO_2 emissions. The moderating effects in Figure 1 can be tested by introducing interaction variables (Cohen and Cohen, 1983), similar to the work of Chen and Myagmarsuren (2013). As it has been advised in the literature, focusing on the moderating effects, two different models can be offered: First, the model with the main effects is presented in equation (5), where a proxy of financial development (lnFD) is added as a regressor to equation (4):

$$\ln\frac{CO_{2_t}}{P_t} = \beta_0 + \beta_1\left(\ln\frac{GDP_t}{P_t}\right) + \beta_2\left(\ln\frac{GDP_t^2}{P_t}\right) + \beta_3\left(\ln\frac{E_t}{P_t}\right) + \beta_4\left(\ln FD_t\right) + \varepsilon_t \quad (5)$$

Second, the model for estimating the moderating effects of financial development can then be developed by including interaction variables, as shown in Figure 1, and presented in equation (6):

$$\ln\frac{CO_{2_t}}{P_t} = \beta_0 + \beta_1\left(\ln\frac{GDP_t}{P_t}\right) + \beta_2\left(\ln\frac{GDP_t^2}{P_t}\right) + \beta_3\left(\ln\frac{E_t}{P_t}\right) + \beta_4\left(\ln FD_t\right)$$
$$+ \beta_5\left[\left(\ln\frac{GDP_t}{P_t}\right)\times\left(\ln FD_t\right)\right] + \beta_6\left[\left(\ln\frac{GDP_t^2}{P_t}\right)\times\left(\ln FD_t\right)\right]$$
$$+ \beta_7\left[\left(\ln\frac{E_t}{P_t}\right)\times\left(\ln FD_t\right)\right] + \varepsilon_t \quad (6)$$

Where the financial development (FD) variable has been added to equation (6), as both alone and through interaction variables with GDP, GDP^2, and E. The interaction variables in equation (6) are expected to be statistically significant to confirm the existence of moderating roles (Cohen and Cohen, 1983).

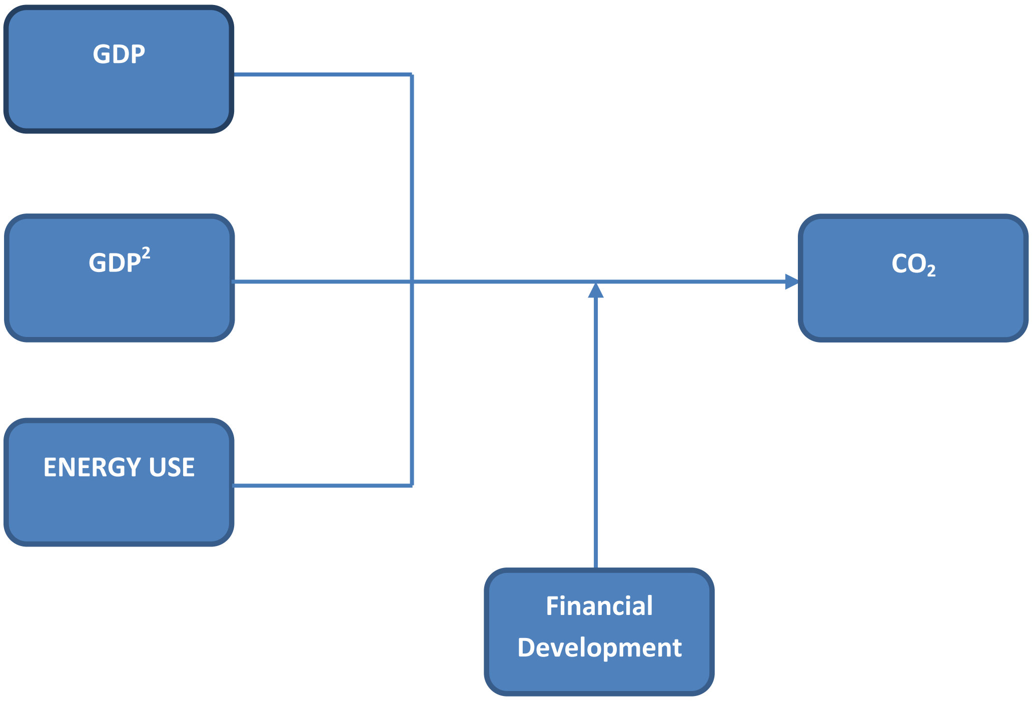


Figure 1: Moderating Role of Financial Development in Environmental Kuznets Curve

The regressand in equation (6) may not be adjusted to its long run equilibrium level because of the changes in its determinants. Thus, the speed of adjustment among the short run and long run values of the regressand in equation (6) can be estimated by the ECM as follows (Katircioglu, 2010):

$$\Delta \ln \frac{CO_{2_t}}{P_t} = \beta_0 + \sum_{i=1}^{n} \beta_1 \left(\Delta \ln \frac{CO_{2t-j}}{P_{t-j}} \right)_t + \sum_{i=0}^{n} \beta_2 \left(\Delta \ln \frac{GDP_{t-j}}{P_{t-j}} \right) + \sum_{i=0}^{n} \beta_3 \left(\Delta \ln \frac{GDP^2_{t-j}}{P_{t-j}} \right)$$

$$+ \sum_{i=0}^{n} \beta_4 \left(\Delta \ln \frac{E_{t-j}}{P_{t-j}} \right) + \sum_{i=0}^{n} \beta_5 \left(\Delta \ln FD_{t-j} \right) + \sum_{i=0}^{n} \beta_6 \left[\left(\Delta \ln \frac{GDP_{t-j}}{P_{t-j}} \right) \times \left(\Delta \ln FD_{t-j} \right) \right]$$

$$+ \sum_{i=0}^{n} \beta_7 \left[\left(\Delta \ln \frac{GDP^2_{t-j}}{P_{t-j}} \right) \times \left(\Delta \ln FD_{t-j} \right) \right] + \sum_{i=0}^{n} \beta_8 \left[\left(\Delta \ln \frac{E_{t-j}}{P_{t-j}} \right) \times \left(\Delta \ln FD_{t-j} \right) \right]$$

$$+ \beta_9 \varepsilon_{t-1} + \mu_t \qquad (7)$$

Where Δ stands for a change in the CO_2, E, GDP, GDP^2, FD, FD×GDP, FD×GDP^2, and FD×E variables and ε_{t-1} is the one period lagged error correction term (ECT), which is estimated from equation (6). The ECT in equation (7) shows how quickly the disequilibrium between the short-term and the long-term values of the dependent variable (CO_2) is eliminated each period. The expected sign of ECT is theoretically negative (Katircioglu, 2010).

3.3 Data and Methodology

The data used in this thesis are annual figures covering the period from 1960 to 2010. Carbon dioxide emissions (CO_2) (kt) per capita, the energy use (E) (kt of oil equivalent) per capita, the constant GDP (2005 = 100) (y) per capita, the squared constant GDP (2005 = 100) (y2) per capita, and the composite financial index as a proxy for financial development (FD) are the variables in the conducted model. Data were gathered from the World Bank Development Indicators (2014).

3.3.1 Constructing a Composite Financial Index

Numerous studies have used various proxies for financial development. Ang (2009) argues that the selection of the key variables to proxy financial services, and therefore financial development and measuring the extent and efficiency of financial intermediation, are major problems in the empirical economics literature. Levine et al. (2000) maintain that constructing measures to reflect the abilities of different financial systems should be essential for researchers. A database constructed by Beck et al. (1999) sheds light on various measures of financial development for researchers. Alongside the selection of the variables in works by Ang (2009), Levine et al. (2000), and Beck et al. (1999), this thesis uses five different measures of financial development to construct a composite financial development index: (1) domestic credits by the banking sector (as percent of GDP) (DC); (2) domestic credits provided to the private sector (as percent of GDP) (DCP); (3) broad money supply (as percent of GDP) (M2); (4) the ratio of commercial bank assets to central bank assets plus commercial bank assets (A); and (5) liquid liabilities (as percent of GDP) (M3). The construction of composite financial development in this thesis can be presented in the following functional relationship:

$$FD = f(A, DC, DCP, M2, M3) \quad (8)$$

The variables of A and M3 were obtained from The Banks Association of Turkey (2014), while DC, DCP, and M2 were obtained from the World Development Indicators (2014). Commercial bank assets, such as ratio to central bank assets, plus commercial bank assets, were used to denote the relative importance of commercial banks. This importance is because commercial banks are more likely to identify profitable investment opportunities (Ang, 2009) and make better use of funds than central banks (King and Levine, 1993). Levine et al. (2000) argue that private credit (DCP) is an important proxy of financial intermediation and is more than a simple measure of financial sector size. Ang (2009) also states that credit provided to the private sector is an important indicator of financial development, since the private sector is able to utilize funds more efficiently and effectively compared to the public sector. As in Jenkins and Katircioglu (2008), overall credits provided by the banking sector (DC) were used in this thesis to include the overall credit expansion as an indicator of financial development. In addition, overall credits by the banking sector, broad money (M2), and liquid liabilities (M3) as a percent of the GDP have also been included, as in the work of Beck et al. (1999). Finally, Beck et al. (1999) suggests using stock market capitalization, which is defined as total shares traded on the stock market, as an efficiency indicator of stock markets. However, stock market capitalization was not used in this thesis. This was because the stock markets in Turkey started to operate in 1986 (insufficient number of observations on annual basis) and, as suggested by Ang (2009), the stock market in Turkey has been subject to considerable fluctuations since 1986 and is therefore not indicative of the depth of the Turkish financial system.

The above-mentioned financial indicators in equation (8) use a principal component factor analysis to construct a composite financial development index. Principal component analysis is a statistical method used to transform a number of correlated variables into a smaller number of uncorrelated variables, principal components, while retaining most of the original variability in the data (see Feridun and Sezgin, 2008; and Jalil et al., 2010). Ang's (2009) study on financial development indices and Chen's (2010) study on financial performance indices both used the principal component factor analysis. In this study, a varimax rotation was performed along with a principal component factor analysis, to extract a composite financial development index from the five financial development indicators, presented in equation (8). Factor loadings, eigenvalues, and the percentage of variance explained have also been computed to decide whether any of these five financial indicators will be included in the index (Ang, 2009; Hair et al.,1998). As proposed by Hair et al. (1998), financial indicators (or factors) are assumed to be significant and are retained in the analysis if their eigenvalues are at least 1 and the factor loadings are greater than 0.50.

The extracted factors from the principal component factor analysis were used to construct a comprehensive score or composite index of financial development based on the computation in equation (9):

$$FD\ \text{Index} = \sum_{\text{i}=1}^{\text{n}} \text{w}_{\text{i}} \times FS_i \tag{9}$$

Where the FD index is the composite financial development index, w_i is the weight or ratio of variation explained by each financial indicator divided by the variation explained by all financial indicators, and FS_i is the corresponding factor score of each financial indicator. The computation of w_i, in this thesis, is also formulated in equation (10):

$$w_i = \left(\frac{v_i}{\sum_{i=1}^{n} v_i} \right) \times 100 \qquad (10)$$

Where w_i is the weight of each i^{th} factor for the financial indictor, v_i is the variance explained by each i^{th} factor, and n is the number of factors (see also Chen, 2010).

Table 1: Principal Component Analysis for Constructing a Composite Financial Development Index

Principal Component	Eigenvalues	Percentage of Variance Extracted	Cumulative Percentage of Variance Extracted
1	3.681	73.622	73.622
2	.907	18.149	91.771
3	.338	6.752	98.522
4	.056	1.120	99.642
5	.018	.358	100.000
Financial Indicator	**Factor Loadings**	**Communalities**	**Factor Scores**
A	.550	.302	.149
DC	.905	.819	.246
DCP	.841	.707	.228
M2	.985	.970	.268
M3	.940	.884	.255

Note: Number of principal components (or factor) extracted is 1.

Table 1 presents the results of the principal component analysis. The eigen value of the first principal component is 3.681 (> 1.000), whereas the eigen values of the other components are less than 1.000. The first principal component explains about 73.622 percent of the standardized variance in the dependent variable and is better than the other linear combination of explanatory variables. Therefore, only one principal component is extracted in this analysis. The factor scores, which are provided in the second part of Table 1, are then used as the weights to construct the financial development index (Ang, 2009).

3.3.2 Methodology

This thesis uses Turkey as a case in testing the financial development-induced EKC hypothesis. The superior econometric methods, which takes unknown number of structural breaks, are employed by using GAUSS codes. Initially, new unit root tests, developed by Carrion-i-Silvestre et al. (2009), which consider unknown number of structural breaks till five, are carried out. This is because series indicates structural breaks over time, especially FD as revealed in Figure 2. In the second step, cointegration test by Maki (2012), which considers several number of structural breaks until five, is employed to approve the presence of the cointegrating vector in equation (2). In the presence of cointegration relationship, coefficients of long and short run values and also ECTs are measured by the dynamic ordinary least squares (DOLS) methodology. In the last step, Granger causality tests under the block exogeneity approach, impulse responses and variance decompositions are calculated to indicate further evidences to earlier findings of the thesis.

3.3.4 Unit Root Tests

Some approaches in the contemporary econometrics literature consider structural breaks in order to test for unit roots. Among them, it is mainly Perron (1989), Zivot-Andrews (1992), Lumsdaine-Papell (1997), Perron (1997), and Ng-Perron (2001) who consider one structural break in the tests, while Lee-Strazicich (2003) takes two structural breaks in the variables. Unlike these approaches, Carrion-i-Silvestre et al.

(2009) introduce the unit root test method which allows up to five structural breaks in the variables.

Carrion-i-Silvestre et al. (2009) offer the quasi-GLS (generalized least squares) procedures which allow an capricious number of changes in both the level and slope of the trend function. In addition, it extends the detrending approach offered by Elliott et al. (1996), which allows tests that have local asymptotic power functions, close to the local asymptotic Gaussian power envelope. Also, it considers several tests, in particular the class of *M*-tests, which are proposed by Stock (1999) and examined by Ng and Perron (2001). Carrion-i-Silvestre et al. (2009) also introduce that their quasi-GLS based method proposes improvements over standard approaches in small samples. Thus, this thesis adopts the quasi-GLS unit root tests by Carrion-i-Silvestre et al. (2009) for the variables in the conducted model.

Structural breaks are obtained by adopting the algorithm of Bai and Perron (2003) trough the quasi-GLS approach where the residual sum of squares are minimized by the dynamic process of programming (Carrion-i-Silvestre et al., 2009). The process of stochastic data generating in the GLS unit root tests can be shown follows:

$$y_t = d_t + \mu_t \qquad (11)$$

$$\mu_t = \alpha\mu_{t-1} + \upsilon_t \qquad t = 0, 1, ..., T \qquad (12)$$

Carrion-i-Silvestre et al. (2009) subsequently estimated five statistics tests to examine for the null hypothesis of a unit root under multiple structural breaks; these include:

$$P_T\left(\lambda^0\right)=\frac{\left[S\left(\bar{\alpha},\lambda^0\right)-\bar{\alpha}S\left(1,\lambda^0\right)\right]}{S^2\left(\lambda^0\right)} \tag{13}$$

Where P_T stands for the Gaussian point optimal statistic and S stands for the spectral density function.

$$MP_T\left(\lambda^0\right)=\frac{\left[c^{-2}T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2+\left(1-\bar{c}\right)T^{-1}\tilde{y}_T^2\right]}{s\left(\lambda^0\right)^2} \tag{14}$$

Where MP_T stands for the modified feasible point optimal statistic, based on Ng and Perron (2001).

$$MZ_\alpha\left(\lambda^0\right)=\left(T^{-1}\tilde{y}_T^2-s\left(\lambda^0\right)^2\right)\left(2T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2\right)^{-1} \tag{15}$$

$$MSB\left(\lambda^0\right)=\left(s\left(\lambda^0\right)^{-2}T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2\right)^{1/2} \tag{16}$$

$$MZ_t\left(\lambda^0\right)=\left(T^{-1}\tilde{y}_T^2-s\left(\lambda^0\right)^2\right)\left(4s\left(\lambda^0\right)^2T^{-2}\sum_{t=1}^{T}\tilde{y}_{t-1}^2\right)^{1/2} \tag{17}$$

Where MZ_α, MSB, and MZ_t are *M*-type test statistics which they are computed using GLS detrending approach.[1]

The asymptotical critical values are estimated via bootstrap method. Thus, the null hypothesis in the GLS unit root tests indicates the presence of a unit root in the variables.

[1] See Carrion-i-Silvestre et al. (2009) for further details.

3.3.5 Cointegration Test

Cointegration tests for the variables which are all integrated of order one, I(1) and do not take presence of structural breaks into account are likely to produce biased findings for long run equilibrium relationships (Westerlund and Edgerton, 2006). However, superior methods that consider the presence of structural breaks in the series exist in the relevant literature. Among them, the approaches by Gregory and Hansen (1996), Carrion-i-Silvestre and Sanso (2006), Westerlund and Edgerton (2006), and Hatemi-J (2008) consider just one structural break while testing cointegration. Therefore, Maki (2012) suggests a superior test for cointegration that considers structural breaks into account up to five breaks and the gap in the econometrics literature is filled.

Algorithm of Maki (2012) cointegration test assumes every period as a potential structural break and the *t*-statistic for each period is calculated. Periods which have minimum t ratios are attained as structural breaks. In order to test long run equilibrium relationship by employing Maki (2012) test, all variables should be stationary at their first differences which means I (1). Maki (2012) cointegration test proposed several models for cointegration features of variables. They are as follows:

Model 1: With Break in Intercept, and without Trend

$$y_t = \mu + \sum_{i=1}^{k} \mu_i K_{i,t} + \beta x_t + \upsilon_t \qquad (18)$$

Model 2: With Break in Intercept and Coefficients, and without Trend

$$y_t = \mu + \sum_{i=1}^{k} \mu_i K_{i,t} + \beta x_t + \sum_{i=1}^{k} \beta_i x_i K_{i,t} + \upsilon_t \qquad (19)$$

Model 3: With Break in Intercept and Coefficients, and with Trend

$$y_t = \mu + \sum_{i=1}^{k} \mu_i K_{i,t} + \gamma x + \beta x_t + \sum_{i=1}^{k} \beta_i x_i K_{i,t} + \upsilon_t \qquad (20)$$

Model 4: With Break in Intercept, Coefficients, and Trend

$$y_t = \mu + \sum_{i=1}^{k} \mu_i K_{i,t} + \gamma t + \sum_{i=1}^{k} \gamma_i t K_{i,t} + \beta x_t + \sum_{i=1}^{k} \beta_i x_i K_{i,t} + \upsilon_t \qquad (21)$$

Where K_i stands for dummy variables that are constructed by Maki (2012) as:

$$K_i = \begin{cases} 1 & when\, \mathrm{t} > \mathrm{T_B} \\ 0 & otherwise \end{cases}$$

Where T_B stands for the break point.

The critical values of Maki (2012) that are used to test for cointegration under multiple structural breaks obtained by Monte-Carlo simulations.

3.3.6 Estimating the Long Run and Short Run Coefficients

After revealing the cointegration relationship, long run and short run coefficients of equation (6) are estimated by the DOLS estimation method. Beside level forms of variables, Stock and Watson (1993) recommend to include differenced and lagged forms of regressors; it is suggested that any problems of internality and deviation in OLS estimators are removed.

DOLS approach can be employed regardless of whether independent variables are purely I (0), purely I (1), or mutually co-integrated; however, the regressand should be I (1). The DOLS method suggests powerful and stable estimations in the presence of internality and autocorrelation problems (Esteve and Requena, 2006). The DOLS approach is adopted to estimate equation (2) of the thesis, which can be shown as follows:

$$\ln\frac{CO_{2_t}}{P_t} = \alpha_0 + \alpha_1\left(\ln\frac{GDP_t}{P_t}\right) + \alpha_2\left(\ln\frac{GDP_t^2}{P_t}\right) + \alpha_3\left(\ln\frac{E_t}{P_t}\right) + \alpha_4\left(\ln FD_t\right)$$

$$+ \alpha_5\left[\left(\ln\frac{GDP_t}{P_t}\right)\times\left(\ln FD_t\right)\right] + \alpha_6\left[\left(\ln\frac{GDP_t^2}{P_t}\right)\times\left(\ln FD_t\right)\right] + \alpha_7\left[\left(\ln\frac{E_t}{P_t}\right)\times\left(\ln FD_t\right)\right]$$

$$+ \sum_{i=-q}^{q}\beta_i\Delta\left(\ln\frac{GDP_{t-i}}{P_{t-i}}\right) + \sum_{i=-q}^{q}\gamma_i\Delta\left(\ln\frac{GDP_{t-i}^2}{P_{t-i}}\right) + \sum_{i=-q}^{q}\delta_i\Delta\left(\ln\frac{E_{t-i}}{P_{t-i}}\right) + \sum_{i=-q}^{q}\mu_i\Delta\ln FD_{t-i}$$

$$+ \sum_{i=-q}^{q}\nu_i\Delta\left[\left(\ln\frac{GDP_{t-i}}{P_{t-i}}\right)\times\left(\ln FD_{t-i}\right)\right] + \sum_{i=-q}^{q}\phi_i\Delta\left[\left(\ln\frac{GDP_{t-i}^2}{P_{t-i}}\right)\times\left(\ln FD_{t-i}\right)\right]$$

$$+ \sum_{i=-q}^{q}\pi_i\Delta\left[\left(\ln\frac{E_{t-i}}{P_{t-i}}\right)\times\left(\ln FD_{t-i}\right)\right] + \varpi D_i + \varepsilon_t \qquad (22)$$

Where q stands for the lag structure (level) to be determined by the Akaike information criterion (AIC) and t is time trend. D_i stands for the dummy variables of the structural breaks up to five from Maki (2012). As a result, it is now possible to check whether the break periods imply a statistically significant effect in the long run.

After revealing the long run co-efficients by adopting DOLS approach, the short run coefficients and the error correction term will be calculated as well. Moreover, those break periods estimated in the cointegration test of Maki (2012) is added in equation

(6) to check whether the coefficients are statistically significant. Finally, the ECM can be estimated as follows:

$$\Delta \ln \frac{CO_{2_t}}{P_t} = \beta_0 + \sum_{i=1}^{n} \beta_1 \left(\Delta \ln \frac{CO_{2t-j}}{P_{t-j}} \right)_t + \sum_{i=0}^{n} \beta_2 \left(\Delta \ln \frac{GDP_{t-j}}{P_{t-j}} \right) + \sum_{i=0}^{n} \beta_3 \left(\Delta \ln \frac{GDP_{t-j}^2}{P_{t-j}} \right)$$

$$+ \sum_{i=0}^{n} \beta_4 \left(\Delta \ln \frac{E_{t-j}}{P_{t-j}} \right) + \sum_{i=0}^{n} \beta_5 \left(\Delta \ln FD_{t-j} \right) + \sum_{i=0}^{n} \beta_6 \left[\left(\Delta \ln \frac{GDP_{t-j}}{P_{t-j}} \right) \times \left(\Delta \ln FD_{t-j} \right) \right]$$

$$+ \sum_{i=0}^{n} \beta_7 \left[\left(\Delta \ln \frac{GDP_{t-j}^2}{P_{t-j}} \right) \times \left(\Delta \ln FD_{t-j} \right) \right] + \sum_{i=0}^{n} \beta_8 \left[\left(\Delta \ln \frac{E_{t-j}}{P_{t-j}} \right) \times \left(\Delta \ln FD_{t-j} \right) \right]_t$$

$$+ \beta_9 D_i + \beta_{10} \varepsilon_{t-1} + \mu \tag{23}$$

Where D_i is added to the model and indicates dummy variables of break periods from Maki (2012).

3.3.7 Granger Causality Test, Variance Decompositions and Impulse Responses

In the presence of the long run relationship introduced in equation (6) of the present thesis, Granger causality tests are adopted under the block exogeneity Wald tests under the ECM mechanism. However, the framework for the Granger causality tests can be estimated as follows:

$$\begin{bmatrix} \Delta \ln \frac{CO_{2_t}}{P_t} \\ \Delta \ln \frac{GDP_t}{P_t} \\ \Delta \ln \frac{GDP_t^2}{P_t} \\ \Delta \ln \frac{E_t}{P_t} \\ \Delta \ln FD_t \\ \Delta \ln \frac{GDP_t}{P_t} \times \Delta \ln FD_t \\ \Delta \ln \frac{GDP_t^2}{P_t} \times \Delta \ln FD_t \\ \Delta \ln \frac{E_t}{P_t} \times \Delta \ln FD_t \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \\ \mu_4 \\ \mu_5 \\ \mu_6 \\ \mu_7 \\ \mu_8 \end{bmatrix} + \begin{bmatrix} \partial_{11,1} & \partial_{12,1} & \partial_{13,1} & \partial_{14,1} & \partial_{15,1} & \partial_{16,1} & \partial_{17,1} & \partial_{18,1} \\ \partial_{21,1} & \partial_{22,1} & \partial_{23,1} & \partial_{24,1} & \partial_{25,1} & \partial_{26,1} & \partial_{27,1} & \partial_{28,1} \\ \partial_{31,1} & \partial_{32,1} & \partial_{33,1} & \partial_{34,1} & \partial_{35,1} & \partial_{36,1} & \partial_{37,1} & \partial_{38,1} \\ \partial_{41,1} & \partial_{42,1} & \partial_{43,1} & \partial_{44,1} & \partial_{45,1} & \partial_{46,1} & \partial_{47,1} & \partial_{48,1} \\ \partial_{51,1} & \partial_{52,1} & \partial_{53,1} & \partial_{54,1} & \partial_{55,1} & \partial_{56,1} & \partial_{57,1} & \partial_{58,1} \\ \partial_{61,1} & \partial_{62,1} & \partial_{63,1} & \partial_{64,1} & \partial_{65,1} & \partial_{66,1} & \partial_{67,1} & \partial_{68,1} \\ \partial_{71,1} & \partial_{72,1} & \partial_{73,1} & \partial_{74,1} & \partial_{75,1} & \partial_{76,1} & \partial_{77,1} & \partial_{78,1} \\ \partial_{81,1} & \partial_{82,1} & \partial_{83,1} & \partial_{84,1} & \partial_{85,1} & \partial_{86,1} & \partial_{87,1} & \partial_{88,1} \end{bmatrix} \begin{bmatrix} \Delta \ln \frac{CO_{2_t}}{P_t} \\ \Delta \ln \frac{GDP_t}{P_t} \\ \Delta \ln \frac{GDP_t^2}{P_t} \\ \Delta \ln \frac{E_t}{P_t} \\ \Delta \ln FD_t \\ \Delta \ln \frac{GDP_t}{P_t} \times \Delta \ln FD_t \\ \Delta \ln \frac{GDP_t^2}{P_t} \times \Delta \ln FD_t \\ \Delta \ln \frac{E_t}{P_t} \times \Delta \ln FD_t \end{bmatrix}$$

$$
+\ldots\ldots+\begin{bmatrix}
\partial_{11,i} & \partial_{12,i} & \partial_{13,i} & \partial_{14,i} & \partial_{15,i} & \partial_{16,i} & \partial_{17,i} & \partial_{18,i} \\
\partial_{21,i} & \partial_{22,i} & \partial_{23,i} & \partial_{24,i} & \partial_{25,i} & \partial_{26,i} & \partial_{27,i} & \partial_{28,i} \\
\partial_{31,i} & \partial_{32,i} & \partial_{33,i} & \partial_{34,i} & \partial_{35,i} & \partial_{36,i} & \partial_{37,i} & \partial_{38,i} \\
\partial_{41,i} & \partial_{42,i} & \partial_{43,i} & \partial_{44,i} & \partial_{45,i} & \partial_{46,i} & \partial_{47,i} & \partial_{48,i} \\
\partial_{51,i} & \partial_{52,i} & \partial_{53,i} & \partial_{54,i} & \partial_{55,i} & \partial_{56,i} & \partial_{57,i} & \partial_{58,i} \\
\partial_{61,i} & \partial_{62,i} & \partial_{63,i} & \partial_{64,i} & \partial_{65,i} & \partial_{66,i} & \partial_{67,i} & \partial_{68,i} \\
\partial_{71,i} & \partial_{72,i} & \partial_{73,i} & \partial_{74,i} & \partial_{75,i} & \partial_{76,i} & \partial_{77,i} & \partial_{78,i} \\
\partial_{81,i} & \partial_{82,i} & \partial_{83,i} & \partial_{84,i} & \partial_{85,i} & \partial_{86,i} & \partial_{87,i} & \partial_{88,i}
\end{bmatrix}
\begin{bmatrix}
\Delta\ln\frac{CO_{2_t}}{P_t} \\
\Delta\ln\frac{GDP_t}{P_t} \\
\Delta\ln\frac{GDP_t^2}{P_t} \\
\Delta\ln\frac{E_t}{P_t} \\
\Delta\ln FD_t \\
\Delta\ln\frac{GDP_t}{P_t}\times\Delta\ln FD_t \\
\Delta\ln\frac{GDP_t^2}{P_t}\times\Delta\ln FD_t \\
\Delta\ln\frac{E_t}{P_t}\times\Delta\ln FD_t
\end{bmatrix}
$$

$$
+\begin{bmatrix}\varphi_1\\ \varphi_2\\ \varphi_3\\ \varphi_4\\ \varphi_5\\ \varphi_6\\ \varphi_7\\ \varphi_8\end{bmatrix} ECT_{t-1}+\begin{bmatrix}\varepsilon_{1,t}\\ \varepsilon_{2,t}\\ \varepsilon_{3,t}\\ \varepsilon_{4,t}\\ \varepsilon_{5,t}\\ \varepsilon_{6,t}\\ \varepsilon_{7,t}\\ \varepsilon_{8,t}\end{bmatrix} \qquad (24)
$$

In equation (24), Δ denotes the difference operator. The ECT_{t-1} is the lagged error correction term obtained from the long run equilibrium model. Lastly, $\varepsilon_{1,t}$, $\varepsilon_{2,t}$, $\varepsilon_{3,t}$, $\varepsilon_{4,t}$, $\varepsilon_{5,t}$, $\varepsilon_{6,t}$, $\varepsilon_{7,t}$, and $\varepsilon_{8,t}$ are serially independent random errors with a mean of zero and a finite covariance matrix. According to the ECMs for causality tests, having statistically significant χ^2*- (chi-square) statistic(s)* for ECT_{t-1} in equation (24) meets the circumstances of having long run and short run causal relations.

Finally, the variance decompositions for CO_2 emissions and financial development are estimated, which indicates how many percent of the forecast error variance of the regressand can be revealed by exogenous shocks to the regressor. After variance decompositions, impulse responses are estimated to examine how the selected variable under consideration reacts to the exogenous shocks in the others.

3.4 Empirical Results

Table 2 provides descriptive statistics and the correlation coefficients in the series under consideration. The correlation matrix suggests a high linear relationship among the series, including the composite financial development index.

Table 2: Correlation Matrix and Descriptive Statistics

	Descriptive Statistics				Correlation Coefficients			
	Mean	Std.Dev.	Minimum	Maximum	1	2	3	4
CO_2	2.270	1.021	0.610	4.131	1.000			
GDP	4,623.623	1,580.271	2,315.941	7,833.529	0.988	1.000		
E	858.592	311.031	384.346	1,457.398	0.998	0.992	1.000	
FD	31.883	9.004	19.734	59.078	0.886	0.911	0.898	1.000

Before the empirical analysis, it would be prudent to look at the nature of the series in the line plots. Figure 2 plots the series over time, where it appears that a specific composite financial development index, created for this study (lnFD), exhibits multiple breaks over time; this reveals that it would be good to adapt the quasi-GLS-based unit root tests to investigate the order of the integration of the series.

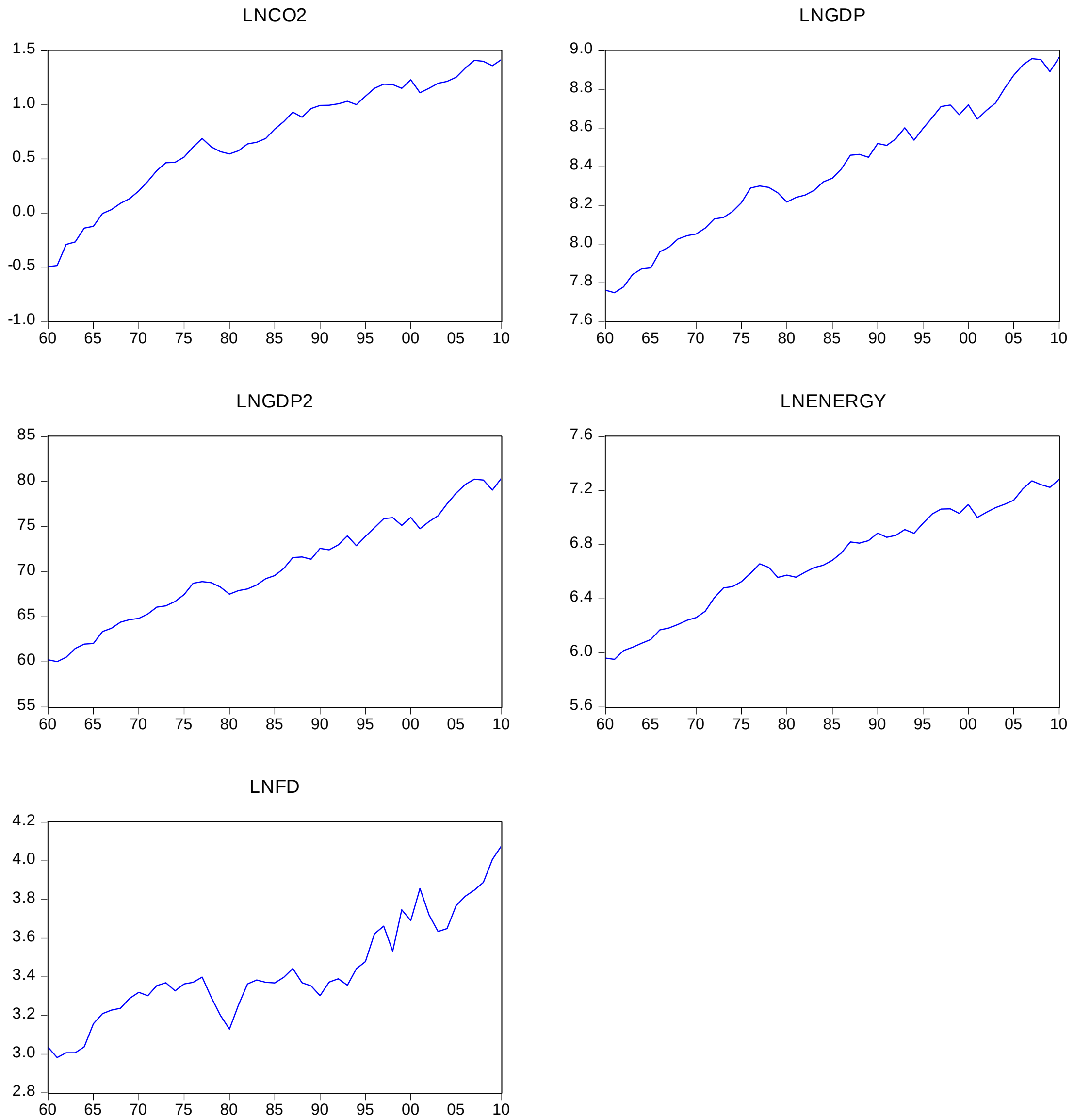


Figure 2: Line Plot of Logarithmic Series

Table 3 presents the GLS-based unit root test results for the series in the conducted model. The unit root test results indicate five statistically significant structural break points in the variables. Under the consideration of these break periods, unit root tests suggest that series are non-stationary at their level forms which means the null hypothesis of a unit root cannot be rejected for all of the variables. Therefore, since the null hypothesis of a unit root can be rejected again for all of the variables, series become stationary when the first differences are taken. GLS-based unit root tests results suggest that $lnCO_2$, lnGDP, $lnGDP^2$, lnE, lnFD, and the interaction variables are integrated in order one, I (1).

All of the variables in the conducted model are integrated in the same order; thus, the cointegration test employing Maki's (2012) approach for equation (6) is suitable. Cointegration tests were carried out under alternative model options for comparison purposes, as presented in section 3 of this study: (1) the EKC model with the main effects as presented in equation (5), and (2) the EKC model with interaction effects as presented in equation (6). The results of the cointegration tests under multiple structural breaks are given in Tables 4 and 5.

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

	Levels					Break Years
	P_T	MP_T	MZ_α	MSB	MZ_t	
lnGDP	16.84 [8.66]	16.10 [8.66]	-23.92 [-44.05]	0.14 [0.10]	-3.45 [-4.68]	1974; 1979; 1993; 1998; 2003
$lnGDP^2$	16.87 [8.66]	16.06 [8.66]	-23.98 [-44.05]	0.14 [0.10]	-3.45 [-4.68]	1974; 1979; 1993; 1998; 2003
lnE	19.60 [9.32]	19.10 [9.32]	-23.33 [-46.99]	0.14 [0.10]	-3.40 [-4.82]	1971; 1977; 1985; 1990; 2000
lnFD	18.70 [8.94]	17.93 [8.94]	-23.69 [-46.24]	0.14 [0.10]	-3.40 [-4.79]	1972; 1980; 1987; 1992; 2001
$lnCO_2$	20.06 [8.13]	17.06 [8.13]	-20.75 [-42.88]	0.15 [0.10]	-3.21 [-4.62]	1977; 1987; 1994; 1999; 2004
lnGDPFD	19.15 [8.91]	18.18 [8.91]	-23.00 [-45.95]	0.14 [0.10]	-3.37 [-4.78]	1973; 1980; 1987; 1995; 2001
$lnGDP^2FD$	19.09 [8.68]	18.09 [8.68]	-21.52 [-44.35]	0.15 [0.10]	-3.27 [-4.70]	1975; 1980; 1992; 1997; 2004
lnE_FD	16.94 [8.50]	15.97 [8.50]	-23.72 [-44.00]	0.14 [0.10]	-3.41 [-4.67]	1977; 1982; 1987; 1993; 2001

Table 4: The Quasi-GLS Based Unit Root Tests under Multiple Structural Breaks (Continued)

	First differences					
	P_T	MP_T	MZ_α	MSB	MZ_t	
ΔlnGDP	3.94*	3.91*	-24.37*	0.14*	-3.46*	-
	[5.54]	[5.54]	[-17.32]	[0.16]	[-2.89]	
$\Delta lnGDP^2$	3.93*	3.93*	-24.40*	0.14*	-3.45*	-
	[5.54]	[5.54]	[-17.32]	[0.16]	[-2.89]	
ΔlnE	3.91*	3.84*	-24.27*	0.14*	-3.46*	-
	[5.54]	[5.54]	[-17.32]	[0.16]	[-2.89]	
ΔlnFD	3.74*	3.76*	-24.30*	0.14*	-3.48*	-
	[5.54]	[5.54]	[-17.32]	[0.16]	[-2.89]	
$\Delta lnCO_2$	3.90*	3.80*	-24.29*	0.14*	-3.47*	-
	[5.54]	[5.54]	[-17.32]	[0.16]	[-2.89]	
ΔlnGDPF	3.82*	3.81*	-24.28*	0.14*	-3.47*	-
	[5.54]	[5.54]	[-17.32]	[0.16]	[-2.89]	
$\Delta lnGDP^2F$	4.03*	4.02*	-23.54*	0.14*	-3.40*	-
	[5.54]	[5.54]	[-17.32]	[0.16]	[-2.89]	
ΔlnEFD	3.84*	3.83*	-24.11*	0.14*	-3.46*	-
	[5.54]	[5.54]	[-17.32]	[0.16]	[-2.89]	

Note: [i]Break years are obtained 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 0.05 significance level. [iii]Numbers in brackets are critical values from the bootstrap approach by Carrion-i-Silvestre et al. (2009).

It is clear that the null hypothesis of there is no cointegrating vector can be rejected under multiple structural breaks, as it is indicated in Tables 4 and 5, for both the main and the interaction effects. All of the model options from Maki (2012) strongly reject the null hypothesis of no cointegration in equations (5) and (6). Therefore, the results from Maki (2012) reveal that the cointegration models and the estimations for the parameters in equations (5) and (6) would be robust in the long run.

Table 5: Maki (2012) Cointegration Test for the Main Effects under Multiple Structural Breaks

Main Effects Model: $lnCO_2$ = f (lnGDP, $lnGDP^2$, lnE, lnFD)

Number of Break Points		Test Statistics [Critical Values]	Break Points
$T_B \leq 1$			
	Model 0	-6.48 [-5.65]*	1963
	Model 1	-6.48 [-5.91]*	1963
	Model 2	-7.85 [-6.52]*	1964
	Model 3	-7.96 [-6.91]*	1984
$T_B \leq 2$			
	Model 0	-6.48 [-5.83]*	1963; 1994
	Model 1	-6.48 [-6.05]*	1963; 1994
	Model 2	-7.85 [-7.24]*	1964; 1984
	Model 3	-11.20 [-7.63]*	1970; 1984
$T_B \leq 3$			
	Model 0	-6.87 [-5.99]*	1963; 1973; 1994
	Model 1	-6.87 [-6.21]*	1963; 1973; 1994
	Model 2	-7.86 [-7.80]*	1964; 1971; 1984
	Model 3	-11.20 [-8.25]*	1970; 1984; 1992
$T_B \leq 4$			
	Model 0	-7.15 [-6.13]*	1963; 1973; 1980; 1994
	Model 1	-7.19 [-6.37]*	1963; 1969; 1973; 1994
	Model 2	-9.19 [-8.29]*	1964; 1971; 1978; 1984
	Model 3	-11.54 [-8.87]*	1970; 1984; 1992; 2000
$T_B \leq 5$			
	Model 0	-7.73 [-6.30]*	1963; 1969; 1973; 1980; 1994
	Model 1	-7.80 [-6.49]*	1963; 1969; 1973; 1980; 1994
	Model 2	-10.78 [-8.86]*	1964; 1971; 1978; 1984; 1991
	Model 3	-12.85 [-9.48]*	1970; 1977; 1984; 1992; 2000

Notes: [i]Numbers in corner brackets are critical values at 0.05 level from Table 1 of Maki (2012). [ii] denotes statistical significance at 0.01 level.*

Table 6: Maki (2012) Cointegration Test for the Main plus Interaction Effects under Multiple Structural Breaks

Main plus Interaction Effects Model:

$lnCO_2$ = f (lnGDP, $lnGDP^2$, lnE, lnFD, lnGDP × lnFD, $lnGDP^2$ × lnFD, lnE × lnFD)

Number of Break Points		Test Statistics [Critical Values]	Break Points
$T_B \leq 1$			
	Model 0	-7.24 [-6.75]*	1984
	Model 1	-7.30 [-7.07]*	1984
	Model 2	-8.87 [-8.41]*	1978
	Model 3	-9.07 [-8.84]*	1978
$T_B \leq 2$			
	Model 0	-8.05 [-7.49]*	1964; 1984
	Model 1	-8.46 [-7.84]*	1964; 1984
	Model 2	-8.87 [-10.34]	1978; 1993
	Model 3	-9.07 [-10.37]	1978; 1993
$T_B \leq 3$			
	Model 0	-8.36 [-5.99]*	1969; 1979; 1984
	Model 1	-8.28 [-6.21]*	1969; 1984; 2000
	Model 2	-8.87 [-7.80]*	1969; 1984; 2000
	Model 3	-9.07 [-8.25]*	1970; 1978; 1993
$T_B \leq 4$			
	Model 0	-8.93 [-6.13]*	1964; 1972; 1978; 1984
	Model 1	-9.35 [-6.37]*	1964; 1972; 1984; 1990
	Model 2	-14.22 [-8.29]*	1968; 1978; 1982; 1993
	Model 3	-13.78 [-8.87]*	1970; 1978; 1988; 1993
$T_B \leq 5$			
	Model 0	-8.41 [-6.30]*	1969; 1979; 1984; 1990; 2004
	Model 1	-8.28 [-6.49]*	1969; 1977; 1984; 1992; 2000
	Model 2	-10.78 [-8.86]*	1968; 1978; 1986; 1993; 2004
	Model 3	-24.48 [-9.48]*	1970; 1978; 1988; 1993; 2004

Notes: [i]Numbers in corner brackets are critical values at 0.05 level from Table 1 of Maki (2012). [ii] denotes statistical significance at 0.01 level.*

In the next step, the long-term coefficients of equations (5) and (6) will be estimated. It should be noted that structural breaks, which were estimated and shown in Tables 4 and 5, are included to the estimation of the long run coefficients in equations (5) and (6), by including dummy variables (Maki, 2012).

Table 7: Estimation of Long-term Coefficients

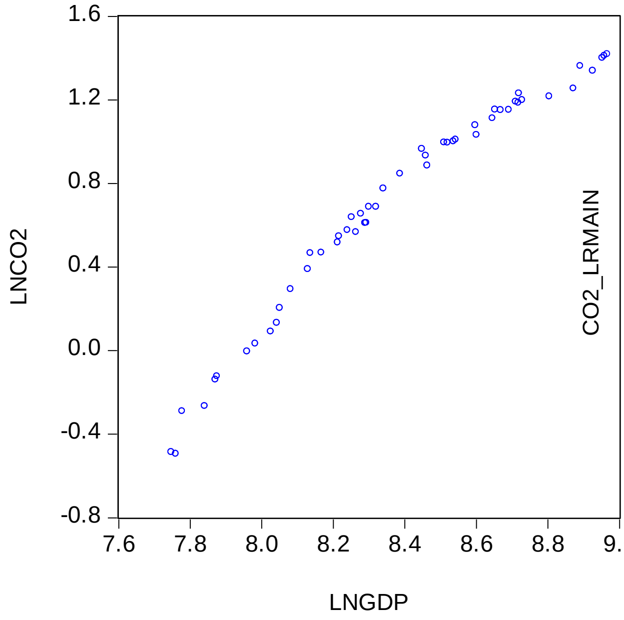
Regressor	Coefficient	Standard Error	*p*-value	Coefficient	Standard Error	*p*-value
	Panel (a). Model of EKC with Main Effects			Panel (b). Model of EKC with Main + Interaction Effects		
Main Effects						
lnGDP	12.178	1.574	0.000	41.024	14.449	0.007
lnGDP^2	-0.673	0.084	0.000	-2.290	0.745	0.004
lnE	0.398	0.218	0.082	0.103	2.197	0.962
lnFD	-0.136	0.065	0.052	48.091	18.949	0.015
Interaction Effects						
lnFD × ΔlnGDP	-	-	-	-11.201	4.689	0.022
$\text{lnFD} \times \Delta\text{lnGDP}^2$	-	-	-	0.622	0.242	0.014
lnFD × ΔlnE	-	-	-	0.307	0.658	0.643
D1970	0.022	0.024	0.350	0.034	0.029	0.245
D1977	0.009	0.026	0.727	0.050	0.030	0.103
D1984	-0.012	0.023	0.603	-0.005	0.027	0.853
D1992	-0.050	0.028	0.083	0.004	0.028	0.884
D2000	0.037	0.033	0.273	0.007	0.029	0.797
Intercept	-56.359	6.080	0.000	-182.904	57.716	0.003
Trend	0.006	0.003	0.052	0.003	0.002	0.187
Adj. R^2	0.999			0.997		
Δ Adj. R^2	-			0.002		
S.E. of Regr.	0.020			0.027		
D-W stat.	2.030			1.645		
Long-run variance	0.000			0.001		
S.S.R.	0.008			0.026		

Note: [i]Break years were selected based on Model 3 of Maki's (2012) cointegration test. [ii] Long-run covariance estimate was obtained by Barlett Kernel, Newery-West fixed bandwidth, which equals to 4.

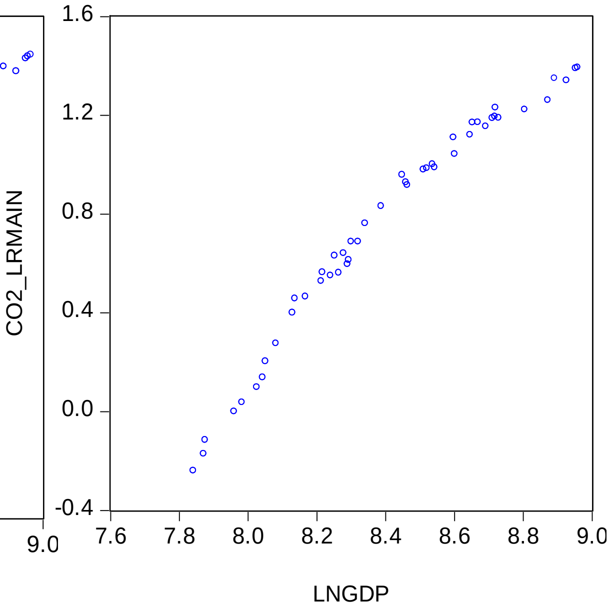
The estimated long run coefficients, as indicated in equations (5) and (6), are calculated by DOLS estimation method and indicated as two separate panels, in Table 6: (1) the model of EKC with the main effects, and (2) the model of EKC with the main plus the interaction effects. It is important to note that the D-W statistics indicate that the absence of autocorrelation and long-run variances are extremely low; therefore, it signals for the existence of moderating effects, especially in panel (b) of Table 6. In panel (a), the coefficient of GDP (without squaring) is highly elastic, and statistically significant ($\beta = 12.178$, $p < 0.01$), while that of the squared GDP (GDP^2) is negative and again significant ($\beta = -0.673$, $p < 0.01$). This finding signals for the inverted U-shaped EKC for Turkey. Nonetheless, as expected, energy consumption exerts both a positive and an inelastic effect on carbon emissions ($\beta = 0.398$, $p < 0.10$). Moreover, the estimated coefficient of the composite financial development index is inelastic, negative, and statistically significant ($\beta = -0.136$, $p < 0.05$), which suggests that a one percent change in financial volume would lead to a 0.136 percent change in CO_2 emissions in the reversed direction. These findings suggest that, in the case of Turkey, growth in the financial sector exerts a negatively significant effect on climate change and that indicates an effective energy management and policies in promoting the financial sector. Finally, the results from Table 6 show that a break in 1992 (as estimated in Maki's (2012) cointegration test) and time trend both exert a statistically significant effect on the carbon emission level. The coefficient of the intercept in Table 6 is negative and statistically significant ($\beta = -56.359$, $p < 0.01$), demonstrating that if there is no change in its determinants in equation (5), CO_2 emissions are likely to decrease substantially.

Secondly, in panel (b) of Table 6, it is observed that the coefficient of the GDP (without squaring) is highly elastic, statistically significant ($\beta = 41.024$, $p < 0.01$), and stronger, while that of squared GDP (GDP^2) is negative, elastic, and significant ($\beta = -2.290$, $p < 0.01$). It appears that the effects of the GDP on carbon emissions are stronger in the model with interaction variables. This finding signals for a stronger inverted U-shaped EKC for Turkey. On the other hand, the long-term coefficient of energy consumption is positive but insignificant in the second model in panel (b) of Table 6. However, this time, the coefficient of the composite financial development index is highly elastic, negative, and statistically significant (β = 48.091, $p < 0.05$).When interaction variables (effects) are considered in Table 6, it is seen that the financial development proxy has a significant moderating role on the effects of the GDP and GDP^2 on carbon dioxide emissions, since the coefficients of lnFD × lnGDP and lnFD × $lnGDP^2$ are statistically significant (Cohen and Cohen, 1983).Moreover, since the coefficient of lnFD × lnE is not statistically significant, it is concluded that financial development does not have a moderating role on the effect of energy consumption on carbon dioxide emissions in Turkey. To summarize, the results from Table 6 conclude that financial development in Turkey has a significant moderating role only on the effects of GDP and GDP^2 on carbon dioxide emissions in the long-term period.

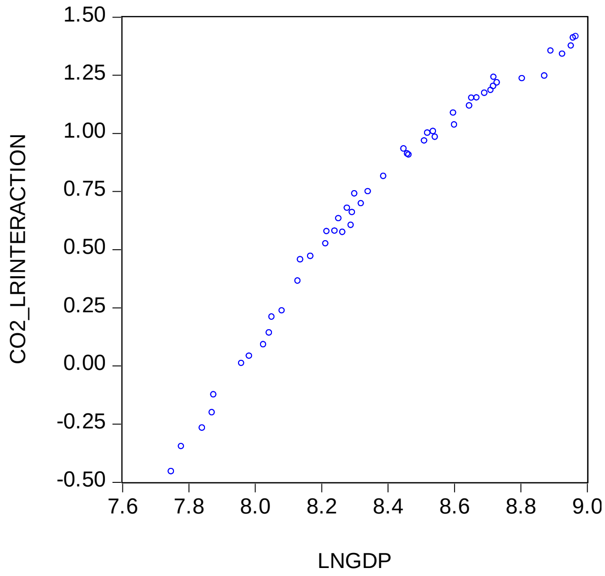
Before proceeding with the ECM estimations, Figure 3 should be noted; it plots scatter diagrams of (1) conventional EKC (with actual GDP and actual CO_2), (2) revised EKC (with actual GDP and estimated CO_2 from equation (5) by main effects), and (3) revised EKC (with actual GDP and estimated CO_2 from equation (6) by main plus interaction effects). Figure 3 shows that there is no significant change in the estimated CO_2 emissions among panels (a), (b), and (c) of that figure; however, the slope of CO_2 in conventional EKC with respect to actual GDP (in panel (a)) appears to be higher than those in panels (b) and (c). This indicates the existence of faster increases in the CO_2emission levels in the financial sector development.



Panel (a).
Conventional EKC



Panel (b).
Revised EKC with Main Effects



Panel (c).
Revised EKC with Interaction Effects

Figure 3: Conventional and Revised EKCs

Table 7 presents the results of the ECM estimations of both models with (1) the main effects, and (2) the main effects plus the moderating effects. Table 7 presents very similar results for the short-term coefficients, as compared to those in Table 6. Therefore, to summarize, in the long-term as well as the short-term period, financial development in Turkey moderates the effects of only the GDP and GDP^2 on carbon dioxide emissions. The ECT in the model with the main effects, in Table 6, is considerably low but negative and statistically significant ($\beta = -0.015$, $p < 0.05$); however, it is higher in the model, with moderating effects, negative, and statistically significant ($\beta = -0.199$, $p < 0.10$). The ECT in panel (b) of Table 7 reveals that the carbon emissions in Turkey react significantly to the long-term equilibrium path by a 19.9 percent speed of adjustment, through the moderating role of the financial sector on the EKC model.

Table 8: Estimation of ECMs

Regressor	Coefficient	Standard Error	*p*-value	Coefficient	Standard Error	*p*-value
	Panel (a). Model of EKC with Main Effects			Panel (b). Model of EKC with Main + Interaction Effects		
Main Effects						
ΔlnGDP	1.515	1.850	0.417	-164.904	78.679	0.058
ΔlnGDP^2	-0.078	0.108	0.473	9.943	4.443	0.045
ΔlnE	0.940	0.087	0.000	-7.705	9.333	0.425
ΔlnFD	0.064	0.031	0.046	-190.102	101.293	0.085
Interaction Effects						
ΔlnFD × ΔlnGDP	-	-	-	43.073	23.906	0.096
ΔlnFD × ΔlnGDP^2	-	-	-	-2.607	1.335	0.074
ΔlnFD × ΔlnE	-	-	-	1.807	2.791	0.529
$\hat{u}_{t-1}$	-0.015	0.006	0.032	-0.199	0.110	0.096
Intercept	0.016	0.006	0.017	-0.007	0.018	0.681
Trend	-	-	-	0.005	0.003	0.094
Adj. R^2	0.783			0.845		
Δ Adj. R^2	-			0.062		
S.E. of Regr.	0.023			0.020		
D-W stat.	2.676			2.550		
Long-run variance	0.000			0.000		
S.S.R.	0.022			0.005		

Note: [i]Break years were selected based on Model 3 of Maki's (2012) cointegration test. [ii]Long-run covariance estimate was obtained by Barlett Kernel, Newery-West fixed bandwidth, which equals to 4.

After estimating long run and short run coefficients, the direction of causal relationships can be investigated by the Granger causality tests under the block exogeneity approach, which employs Wald tests over the error correction mechanism for the short run and long run periods. The χ^2-statistics for both the long run and the short run causalities are indicated in Table 8, as calculated from equation (24).

The results in Table 8 reveal various causalities, both in the long-term and short-term periods. Long-term causality appears in equation (6); that causality runs from the regressors, including the composite financial development index (lnFD) to CO_2 emissions, since the overall χ^2-statistic is statistically significant (χ^2 = 21.287, p < 0.10) when $\ln CO_2$ is the dependent variable; in the cases of the other three models, where lnGDP, $\ln GDP^2$, and lnE are dependent variables, the other overall χ^2 statistics are statistically significant, indicating causalities from regressors to the related dependent variables.

Short run causal relationships are indicated in Table 8. They are mainly: (1) from the interaction variable of lnFD_E to lnE;(2) from lnGDP, $\ln GDP^2$, lnFD×lnGDP, and $\ln FD\times\ln GDP^2$, to lnFD; (3) from lnGDP, $\ln GDP^2$, lnFD, and $\ln FD\times\ln GDP^2$ to lnFD×lnGDP; (4) from lnGDP, $\ln GDP^2$, lnFD, lnFD×lnGDP to $\ln FD\times\ln GDP^2$, and finally from lnGDP, $\ln GDP^2$, lnFD, lnFD×lnGDP, $\ln FD\times\ln GDP^2$ to lnFD×lnE. It is worth noting that the results do not suggest short-term causalities from any regressor to $\ln CO_2$, however, the causality from lnFD×lnE from lnEhas been validated.

Table 9: Granger Causality/Block Exogeneity Wald Tests

Dependent Variable	χ^2-statistics [probability values]								χ^2-stat (prob) for ECT_{t-1}
	$\Delta lnCO_2$	$\Delta lnGDP$	$\Delta lnGDP^2$	ΔlnE	$\Delta lnFD$	$\Delta lnFD \times lnGDP$	$\Delta lnFD \times lnGDP^2$	$\Delta lnFD \times lnE$	
$\Delta lnCO_2$	-	1.249 [0.535]	1.503 [0.471]	3.691 [0.157]	1.253 [0.534]	1.180 [0.554]	1.396 [0.497]	4.100 [0.128]	21.287*** [0.094]
$\Delta lnGDP$	1.580 [0.453]	-	1.287 [0.525]	3.394 [0.183]	1.306 [0.520]	1.584 [0.452]	1.266 [0.530]	3.906 [0.530]	23.789** [0.048]
$\Delta lnGDP^2$	1.371 [0.503]	1.630 [0.442]	-	3.501 [0.173]	1.286 [0.525]	1.563 [0.457]	1.247 [0.535]	4.032 [0.133]	23.701** [0.049]
ΔlnE	0.776 [0.678]	0.078 [0.961]	0.113 [0.944]	-	0.076 [0.962]	0.077 [0.961]	0.124 [0.939]	5.037*** [0.080]	26.436** [0.022]
$\Delta lnFD$	0.785 [0.675]	8.869** [0.011]	8.930** [0.011]	0.320 [0.852]	-	8.800** [0.012]	8.900** [0.011]	0.399 [0.818]	16.100 [0.307]
$\Delta lnFD \times lnGDP$	1.301 [0.521]	8.554** [0.013]	8.721** [0.012]	0.341 [0.843]	8.444** [0.014]	-	8.653** [0.013]	0.553 [0.758]	16.153 [0.304]
$\Delta lnFD \times lnGDP^2$	1.729 [0.421]	7.772** [0.020]	7.989** [0.018]	0.782 [0.676]	7.705** [0.021]	7.646** [0.021]	-	1.162 [0.559]	14.852 [0.388]
$\Delta lnFD \times lnE$	1.094 [0.578]	7.899** [0.019]	8.086** [0.017]	0.575 [0.750]	7.842** [0.019]	7.867** [0.019]	8.081** [0.017]	-	14.553 [0.409]

Note: [i]*** and *** denote statistical significance respectively at 0.05 and 0.10 levels.*

Table 10: Variance Decomposition Results

Model: $lnCO_2$ = f (lnGDP, $lnGDP^2$, lnE, lnFD, lnGDP × lnFD, $lnGDP^2$ × lnFD, lnE × lnFD)

Period	S.E.	$lnCO_2$	lnGDP	$lnGDP^2$	lnE	lnFD	lnGDP × lnFD	$lnGDP^2$ × lnFD	lnE × lnFD
1	0.047	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.063	85.210	0.004	0.630	2.711	6.745	0.307	2.862	1.528
3	0.086	75.846	2.543	0.652	5.633	4.077	1.624	3.354	6.268
4	0.104	70.058	5.672	1.039	8.107	3.674	2.342	3.847	5.257
5	0.118	68.498	6.541	0.817	8.702	3.864	2.806	4.012	4.755
6	0.130	66.656	6.908	0.702	9.484	3.619	3.874	4.300	4.453
7	0.142	65.544	6.928	0.627	10.217	3.286	4.926	4.495	3.973
8	0.151	64.805	6.434	0.753	10.773	3.024	5.913	4.778	3.515
9	0.160	63.941	5.793	1.071	11.233	2.725	6.994	5.089	3.149
10	0.169	62.789	5.245	1.413	11.652	2.469	8.170	5.411	2.847

Table 9 gives the results of variance decomposition, which indicate that in the initial periods, low levels of the forecast error variance of CO_2 emissions are explained by exogenous shocks to output (lnGDP) and energy consumption (lnE). These ratios decline in the later periods. On the other hand, although it is seen that high levels of the forecast error variance of CO_2 emissions are explained by exogenous shocks to the composite financial development index (lnFD), these ratios start to decline over time. For example, the forecast error variance of CO_2 emissions by a shock to the lnFDvariable is 2.469 percent in period 10. When the interaction variables are considered, it is clear that the forecast error variance of CO_2 emissions, which are explained by exogenous shocks, to lnGDP × lnFD and $lnGDP^2$ × lnFD but not to lnE × lnFD increases over time. These results reveal that the moderating role of financial development in the forecast error variance of CO_2 emissions is explained by a shock to output increases over time. This finding is consistent with those in Tables 6 and 7.

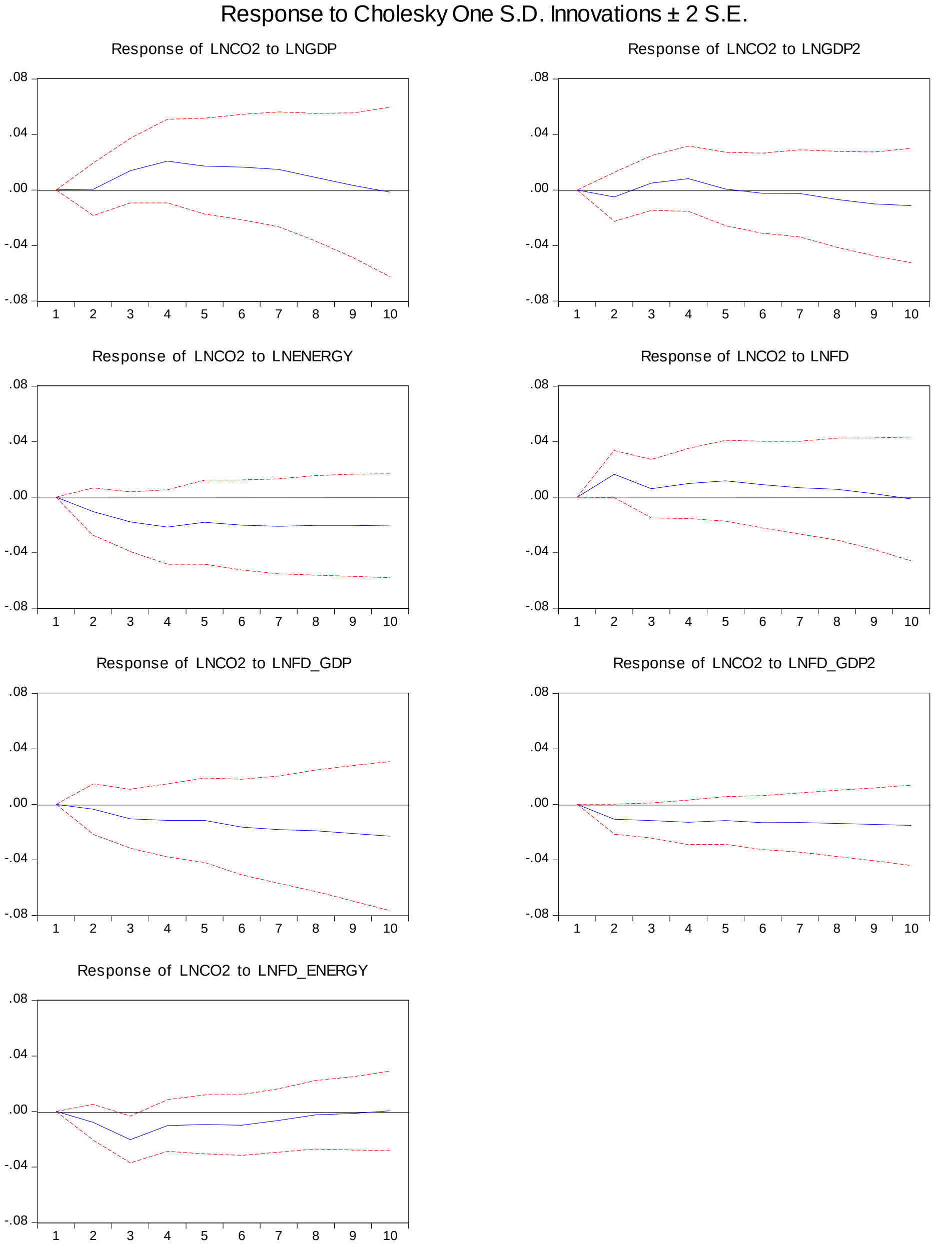


Figure 4: Impulse Responses

Finally, Figure 4 provides line plots of the impulse responses between CO_2 emissions and its determinants, including the interaction variables. As it is shown in the figure 4, the response of CO_2 emissions to a shock in the financial sector is positive, yet the degree of response starts to decrease in the longer periods. Moreover, it is clear that the response of the CO_2 emissions to the shocks in the interaction variables are negative over the periods, signaling the fact that financial development successfully moderates the effects of output and energy consumption on carbon dioxide emissions (leading to decreases in carbon dioxide emissions).

3.5 Conclusion

The present thesis empirically tested for the financial development-induced EKC hypothesis through the main effects and interaction (moderating) effects of the financial sector in Turkey. The results confirm the direct and moderating effects of financial sector development on the EKC, both in the long run and short run periods of the Turkish economy, which has shown considerable development in the financial sector in the last decade. Therefore, the conceptual model proposed in Figure 1 is confirmed in Turkey. To the best of our knowledge, the present model is applied for the first time in the related field of literature to examine the relationship among financial development and CO_2 emissions, by adopting theoretical EKC framework. The results of the present thesis confirm the existence of the financial development-induced EKC hypothesis and suggest that over the pathways of energy usage and real income growth, a long run equilibrium relationship exists among financial development and climate change in Turkey.

Financial development in Turkey has negative and direct effects on carbon dioxide emissions; the financial sector also moderates the effect of real output on carbon emissions both significantly and negatively, while it moderates that of the squared output positively. On the other hand, the moderating effect of financial development on the relationship between energy consumption and climate change are positive, albeit statistically insignificant; this suggests that financial sector development does not significantly moderate the effect of overall energy consumption on carbon emissions in Turkey. All of these results are very similar to those in the short-run models of the present thesis.

Estimations of error correction terms have shown that the contribution of regressors in the model with interaction effects (ECT = -0.015) are higher than that of the model with main effects (ECT = -0.199) to the convergence of carbon dioxide emissions towards a long-term equilibrium path. Granger causality test results indicate that there is a long-term causality in the EKC model with interaction effects; therefore, changes in both the direct effects and the interaction effects of the regressors in equation (6) will precede changes in CO_2 emissions, in the case of Turkey. This major finding is also strongly supported by impulse responses and variance decomposition analyses.

As mentioned in the relevant literature, a higher level of financial development is likely to attract additional foreign direct investments (FDI), which might result in higher levels of research and development (R&D) (Jalil and Feridun, 2011; Frankel and Romer, 1999). Since this situation will bring higher economic activity, it will affect the dynamics of environmental performance (Jalil and Feridun, 2011). It has been documented that successful R&D management in the countries might result in a reduction in environmental pollution. Moreover, financial development will also cause increases in industrial production, which might lead to pollution, as mentioned by Jensen (1996). The major findings of this thesis signal important messages to policy makers. According to the results of the present thesis, at the initial levels of real output in Turkey, financial development negatively moderates the effect of income on carbon dioxide emissions. Therefore, it might be argued that at the initial levels of output energy, conservation policies are successfully adapted in Turkey, when financial development drives economic growth through financial sector development, FDI, and industrial production, as mentioned above. This finding is parallel to those of Jalil and Feridun (2011), which were found in a Chinese context, in China. However, when the output is doubled, it is seen that the moderating role becomes positive; indicating that at the later stages of development, there appears to be an increase in carbon emission levels. The reality can be observed more clearly following the evaluation of Figure 2, since to the end of the line plots, carbon emissions show slight declines when it starts to increase at the end of the period. These results suggest that energy management policies in Turkey should be targeted for shorter-periods and they should contain long-term strategic planning as well. Such policies should encourage more investment in R&D to achieve environment sustainability over a longer span of time.

In summation, the present thesis proposed a new approach to investigate the direct and moderating effects of financial development on the EKC in Turkey; therefore, to test the stability of this approach, further and similar research could be conducted for additional comparison in other countries or regions with advanced financial systems.

Chapter 4

TESTING FDI-INDUCED EKC: THE CASE OF TURKEY

4.1 Introduction

Air pollution and global warming have been two of the most important global issues over the past several decades, and carbon dioxide (CO_2) emissions have been cited as one of the major causes of these problems. The Intergovernmental Panel on Climate Change (IPCC) (2013) emphasizes the importance of CO_2 emissions in contributing to green-house gas (GHG) emissions. It reports that 76.7% of GHG emissions consist of CO_2 emissions produced mainly by developing countries whose aim is to accelerate their growth rate and increase their national production in order to achieve better economic conditions. Therefore, understanding the reasons behind the CO_2 emissions of developing countries is of great importance for policymakers.

The environmental Kuznets curve (EKC) hypothesis suggests that there is an N-shaped relationship between economic growth and environmental pollution. This implies that environmental pollution increases at the first stage of economic growth and then starts to decline during the later stages of growth (Ozturk and Acaravci, 2010). Over the last decade, the relationship between environmental pollutants and economic growth has been extensively tested in the energy economics literature using the EKC hypothesis (e.g., Ozturk and Acaravcı, 2010; Alam et al., 2011). However, the literature on testing the EKC for the countries with the sub-segments of the economy such as; international trade, financial development, industrialization and foreign direct investments is rather limited and deserves attention.

To our knowledge, there is only one study (Mutafoglu, 2012) that investigates the interactions between air pollution, economic growth, and FDI in Turkey by applying the standard Granger causality test, which may cause nonstandard distributions and errors based on the co-integration features of variables (Lutkepohl and Kratzig, 2004). Clarke and Mirza (2006) state that because of the size distortions of unit roots and co-integration tests, inappropriate models can be applied to determine causal relationships of the variables. In order to avoid these problems, Toda and Yamamoto (1995) proposed a Wald test statistic that follows a chi-square distribution and can be applied irrespective of the integration or co-integration features of variables. In this study, we conduct the Granger causality test introduced by Toda and Yamamoto (1995) that avoids errors in unit roots or co-integration features of variables (Abu-Bader and Abu-Qarn, 2008).

4.2 Theoretical Setting

The inverted u-shaped relationship between CO2 emissions, energy consumption and economic growth has been investigated by Narayan and Narayan's (2010) EKC approach in the current literature (Jaunky, 2011; Shahbaz et al., 2013a and Al-Mulali et al.,2015a) as follows;

$$CO_{2t} = f(GDP_t^{\beta_1}, E_t^{\beta_2}) \quad (1)$$

Where CO_2 is carbon dioxide emissions (kt), GDP is gross domestic product and E is energy consumption.

The FDI-induced EKC hypothesis can be formulated by adding FDI as a regressor to the Narayan and Narayan's (2010) EKC model as follows:

$$CO_{2t} = f(GDP_t^{\beta_1},\ E_t^{\beta_2}, FDI_t^{\beta_3}) \quad (2)$$

Where FDI represents the foreign direct investment inflows.

The functional relationship between CO_2 emissions, economic growth, energy consumption and FDI can be represented as follows;

$$lnCO_{2,t} = \beta_0 + \ \beta_1 lnGDP_t + \beta_2 lnENG_t + \beta_3 lnFDI_t + \varepsilon_t \quad (3)$$

Where $lnCO_{2,t}$, $lnGDP_t$, $lnENG_t$ and $lnFDI_t$ are the logarithmic forms of CO_2 emissions, gross domestic product, energy consumption and foreign direct investment respectively.

4.3 Data and Methodology

The data used in this thesis are annual figures that cover the period of 1974-2010. Carbon dioxide emissions metric tons per capita, gross domestic product constant 2005 US$, energy use (kt of oil equivalent) and foreign direct investments inflows (% of GDP) data is collected from World Bank development indicators (2015).

4.3.1 Unit Root Test

Zivot and Andrews (1992) unit root test is employed under one endogenous structural break in the series. Three specifications of Zivot-Andrews unit root test are used in the current study. Model I indicates a break only in the intercept, model T represents a break in trend and model B indicates a break both in intercept and trend. Three models can be shown as follows;

Model I: $$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \theta DU_t + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \in_t \quad (4)$$

Model T: $$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \gamma DT_t + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \in_t \quad (5)$$

Model B: $$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \theta DU_t + \gamma DT_t + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \in_t \quad (6)$$

Where $DU_t = 1$ and $DT_t = t - T_b$ if $t > T_b$ and 0 otherwise. T_b stands for a possible break point.

4.3.2 The Bounds Test for Level Relationship

The bounds test within the ARDL approach is conducted in order to investigate the long-run level relationship between the variables. ARDL approach is proposed by Pesaran et al. (2001) and can be applied regardless of the integration order of the regressors whether independent variables are purely I (0), purely I (1) or mutually co-integrated. The ARDL mechanism suggests estimation of the following error correction model;

$$\Delta \ln CO_{2t} = a_{0_Y} + \sum_{i=1}^{n} b_{i_Y} \Delta \ln CO_{2t-i} + \sum_{i=0}^{n} c_{i_Y} \Delta \ln GDP_{t-i} + \sum_{i=0}^{n} d_{i_Y} \Delta \ln ENG_{t-i} + \sum_{i=0}^{n} e_{i_Y} \Delta \ln FDI_{t-i}$$

$$+ \lambda_{1_Y} \ln CO_{2t-1} + \lambda_{2_Y} \ln GDP_{t-i} + \lambda_{3_Y} \ln ENG_{t-1} + \lambda_{4_Y} \ln FDI_{t-1} + \varepsilon_t \quad (7)$$

where a_{0_Y} is the intercept and ε_{1t} is the error term. First and the second parts of the equation represent error correction dynamics and the long run relationship respectively. The null hypothesis of the bounds test is $\lambda_{1_Y} = \lambda_{2_Y} = \lambda_{3_Y} = \lambda_{4_Y} = 0$ which suggests the long run relationship of the variables where the alternative hypothesis is $\lambda_{1_Y} \neq \lambda_{2_Y} \neq \lambda_{3_Y} \neq \lambda_{4_Y} \neq 0$. The computed F statistics is compared with the critical values of Narayan (2005).

After revealing the long-run relationship between variables, error correction model (ECM) is employed in order to estimate short-run coefficients and error correction term. The ECM can be represented as follows;

$$\Delta \ln CO_{2t} = a_{0_Y} + \sum_{i=1}^{n} b_{i_Y} \Delta \ln CO_{2t-i} + \sum_{i=0}^{n} c_{i_Y} \Delta \ln GDP_{t-i} + \sum_{i=0}^{n} d_{i_Y} \Delta \ln ENG_{t-i} + \sum_{i=0}^{n} e_{i_Y} \Delta \ln FDI_{t-i} + \alpha ECT_{t-1} + \varepsilon_t \quad (8)$$

where ECT_{t-1} indicates the error correction term which denotes the speed of adjustment to the long run equilibrium level.

Goodness of fit of the model is tested by the diagnostic and stability tests. Diagnostic tests help to examine the model for the existence of serial correlation, functional form, normality and heteroscedasticity. Pesaran and Pesaran (1997) suggest conducting Brown et al. (1975) cumulative (CUSUM) and cumulative sum of squares (CUSUMSQ) tests for stability of the model.

4.3.3 Causality Test

Toda-Yamamoto (1995) causality test is applied in order to estimate the existence and direction of causality between variables. Toda-Yamamoto (1995) test has several superior properties. One of the biggest advantages of the Toda-Yamamoto test is that it is applied irrespective of the integration of the variables and cointegration properties of models. Toda and Yamamoto (1995) suggest Modified Wald stat (MWALD) to test the causal relationship among variables. In this method, VAR (k + d_{max}) is estimated where k is the optimal order of VAR model and $d_{max}$is the maximum order of integration. In this study, bootstrap test is performed with endogenous lag order developed by Hacker and Hatemi-J (2010) and bootstrapped critical values are calculated with 5000 simulations. Hacker and Hatemi-J (2001) information criteria is applied for the optimal lag selection in the model.

VAR (k + d_{max}) model can be estimated as follows;

$$lnCO_2 = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i}\, lnCO_{2,t-i} + \sum_{j=k+1}^{d_{max}} \alpha_{2j} lnCO_{2,t-j} + \sum_{i=1}^{k} \beta_{1i}\, lnGDP_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{2j}\, lnGDP_{t-j} + \sum_{i=1}^{k} \delta_{1i}\, lnENG_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{2j}\, lnENG_{t-j} + \sum_{i=1}^{k} \gamma_{1i}\, lnFDI_{t-i} + \sum_{j=k+1}^{d_{max}} \gamma_{2j}\, lnFDI_{t-j} + \varepsilon_{1t} \quad (9)$$

$$lnGDP = \beta_0 + \sum_{i=1}^{k} \beta_{1i}\, lnGDP_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{2j}\, lnGDP_{t-j} \sum_{i=1}^{k} \propto_{1i}\; lnCO_{2,t-i} + \sum_{j=k+1}^{d_{max}} \propto_{2j}\; lnCO_{2,t-j} + \sum_{i=1}^{k} \delta_{1i}\, lnENG_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{2j}\, lnENG_{t-j} + \sum_{i=1}^{k} \gamma_{1i}\, lnFDI_{t-i} + \sum_{j=k+1}^{d_{max}} \gamma_{2j}\, lnFDI_{t-j} + \varepsilon_{2t} \quad (10)$$

$$lnENG = \delta_0 + \sum_{i=1}^{k} \delta_{1i}\, lnENG_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{2j}\, lnENG_{t-j} + \sum_{i=1}^{k} \beta_{1i}\, lnGDP_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{2j}\, lnGDP_{t-j} + \sum_{i=1}^{k} \propto_{1i}\; lnCO_{2,t-i} + \sum_{j=k+1}^{d_{max}} \propto_{2j}\; lnCO_{2,t-j} + \sum_{i=1}^{k} \gamma_{1i}\, lnFDI_{t-i} + \sum_{j=k+1}^{d_{max}} \gamma_{2j}\, lnFDI_{t-j} + \varepsilon_{3t} \quad (11)$$

$$lnFDI = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i}\, lnFDI_{t-i} + \sum_{j=k+1}^{d_{max}} \gamma_{2j}\, lnFDI_{t-j} + \sum_{i=1}^{k} \delta_{1i}\, lnENG_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{2j}\, lnENG_{t-j} + \sum_{i=1}^{k} \beta_{1i}\, lnGDP_{t-i} + \sum_{j=k+1}^{d_{max}} \beta_{2j}\, lnGDP_{t-j} + \sum_{i=1}^{k} \propto_{1i}\; lnCO_{2,t-i} + \sum_{j=k+1}^{d_{max}} \propto_{2j}\; lnCO_{2,t-j} + \varepsilon_{4t} \quad (12)$$

4.4 Empirical Results

Table 10 shows the results of Zivot and Andrews' (1992) unit root test under one structural break in the series. According to unit root test results, $lnCO_2$ and lnENG have unit roots under one structural break at level form, which means they are not stationary at their levels. They become stationary when the first differences are taken. On the other hand, the null hypothesis of a unit root under one structural break in lnFDI and lnGDP can be rejected, which means lnFDI and lnENG are stationary under one structural break at their level forms.

Table 11: Zivot and Andrews (1992) Unit Root Test

	Statistics (Level)			Statistics (First Difference)			
	ZA_B	ZA_T	ZA_I	ZA_B	ZA_T	ZA_I	Conclusion
$lnCO_2$	-4.010	-2.791	-3.640	−6.790*	-4.61**	−5.923*	I (1)
Break Year	1985	1991	1985	1981	1987	1982	
Lag Length	0	0	0	0	1	0	
lnFDI	−4.875***	−4.581**	−4.977**	-4.367	-6.08*	−7.517*	I (0)
Break Year	1996	1991	1996	1993	2004	1993	
Lag Length	0	0	0	5	1	5	
lnGDP	−4.054	-4.680**	-4.831**	-4.384	-4.661**	−7.566*	I (0)
Break Year	2001	2002	2004	1998	1987	1998	
Lag Length	3	3	3	5	3	3	
lnENG	-3.856	-3.077	-3.802	-6.790*	-3.64	−8.523*	I (1)
Break Year	1986	1997	1986	1981	1987	1982	
Lag Length	0	0	0	0	4	0	

Notes: CO_2 is carbon dioxide emissions; FDI is foreign direct investment inflow; GDP is gross domestic product; and ENG is energy consumption. All the variables are in their logarithmic forms. ZA_B indicates the model with a break in both the trend and intercept; ZA_T is the model with a break in the trend; ZA_I is the model with a break in the intercept. *, **, and ***denote the rejection of the null hypothesis at the 1%, 5%, and 10% levels, respectively.

Zivot and Andrews' (1992) unit root test results reveal that the independent variables $lnCO_2$ and lnENG are integrated of order one, or I(1), while lnFDI and lnGDP are integrated of order zero, or I(0).

Table 12: Bounds Test for Level Relationship

Variables	With Deterministic Trend F_V	t_V	Without Deterministic Trend F_{III}	t_{III}	Conclusion
Fco2 (lnFDI, lnGDP, lnENG)					H_0 Rejected
p = 1*	6.706c	-4.737c	2.350a	-2.618a	
2	6.047c	-3.955b	2.350a	-1.937a	
3	5.332c	-3.905b	2.233a	-2.193a	
4	4.737b	-3.663b	1.594a	-2.047a	

Notes: Akaike Information criteria (AIC) are used to select the number of lags in the co-integration test. p shows lag levels and * denotes optimum lag selection in the model, as suggested by AIC. F_{III} represents the F-statistic of the model with unrestricted intercept and no trend, and F_V represents the F-statistic of the model with unrestricted intercept and trend. t_V and t_{III} are the t-ratios with and without a deterministic linear trend. [a] indicates that the statistic lies below the lower bound, [b]indicates that it falls within the lower and upper bounds, and [c]indicates that it lies above the upper bound.

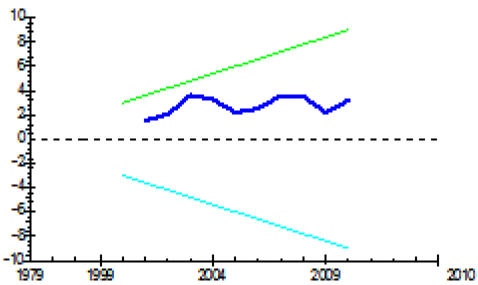
Unit root test results suggest a mix order of integration for the variables. Therefore, in order to investigate the long run equilibrium relationship between CO_2 emissions, economic growth, energy consumption, and FDI, a bounds test under ARDL approach can be employed (Pesaran et al., 2001). Table 11 shows bounds test results under two scenarios, namely the third model with an unrestricted intercept and the fifth model with an unrestricted intercept and trend (Pesaran et al., 2001). Lag 1 is chosen as the optimum lag based on the Akaike criteria, and the F statistics lie above the upper bound of Narayan (2005) critical values for small samples. The results of the bounds test reveal that the null hypothesis stating there is no level relationship is rejected, which means that there is a level relationship between the variables under investigation.

Table 13: Diagnostic Tests

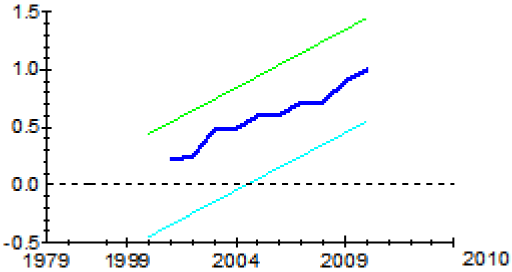
Test Statistics	LM Version	F Version
Functional Form	0.6693 [0.413]	0.2136 [0.654]
Normality	0.0846 [0.959]	-
Heteroscedasticity	0.3909 [0.532]	0.3710 [0.547]

Note: Numbers in parentheses are prob. values.

Bounds test results affirm the presence of a long-run equilibrium relationship between variables. Therefore, the ARDL model should be used in order to estimate long-run and short run coefficients. Table 12 shows the diagnostic test results for the ARDL model. The results confirm the validity of the ARDL model in the study. Following the diagnostic test results, the stability of the ARDL model should be tested. Figure 5 and Figure 6 show the results of CUSUM and CUSUMSQ, respectively. The plots of CUSUM and CUSUMSQ indicate that the ARDL model is stable both in the long-run as well as in the short-run.



Note: The straight lines represent critical bounds at 5% significance level.
Figure 5: Results of CUSUM in the model



Note: The straight lines represent critical bounds at the 5% significance level.
Figure 6: Results of CUSUMSQ in the model.

Table 13 presents the long-term coefficients of the ARDL model. The results indicate that lnFDI has an inelastic, positive, and statistically significant impact on CO_2

emissions, which are used as a proxy for air pollution. On the other hand, economic growth has a statistically significant, inelastic, and negative effect on CO_2 emissions in the long run, while lnENG has an elastic, positive, and statistically significant effect on CO_2 emissions in the long-run. In other words, FDI and increased energy consumption result in an increase in air pollution levels in Turkey, while economic growth cause a decline in the CO_2 emissions in the long run.

Table 14. Level coefficients in the long-term model trough the ARDL approach

Dependent Variable	Regressors			
	lnFDI	lnGDP	lnENG	Intercept
lnCO2	0.031* (0.000)	-0.173** (0.030)	1.181* (0.000)	-10.010* (0.000)

Notes: Numbers in parentheses are prob. values of t-statistics in each model.
*, **, and *** denote statistical significance at the 1%, 5%, and10% levels, respectively.

Table 14 presents the results of the conditional error correction model trough the ARDL approach. The error correction term (-0.492) of the model suggests CO_2 emissions in Turkey converge to their long-run equilibrium level by a 49.2% speed of adjustment every year due to the contribution of FDI, economic growth, and energy consumption. All independent variables have a statistically significant short-term impact on CO_2 emissions at various lag lengths. The short-term coefficients of FDI are not generally significant, except at lag 4. FDI has a positive effect on CO_2 emissions at lag 4. Moreover, when GDP increases by 1%, CO_2 emission levels in the country increase by 0.354% at lag 2. The short-term coefficients of energy consumption suggest a positive relationship with air pollution at different lag levels.

Table 15: Conditional error correction model trough the ARDL approach

Dependent Variable: lnCo2 (5, 4, 5, 5)*

Regressor	Coefficient	Standard Error	p-value
$\hat{u}_{t-1}$	-0.492	0.206	0.034
$\Delta lnCo2_{t-1}$	-0.390	0.222	0.105
$\Delta lnCo2_{t-2}$	-0.446	0.144	0.046
$\Delta lnCo2_{t-3}$	-0.452	0.209	0.052
$\Delta lnCo2_{t-4}$	-0.240	0.202	0.257
$\Delta lnFDI$	0.012	0.008	0.167
$\Delta lnFDI_{t-1}$	-0.017	0.011	0.155
$\Delta lnFDI_{t-2}$	0.002	0.011	0.799
$\Delta lnFDI_{t-3}$	-0.000	0.008	0.973
$\Delta lnFDI_{t-4}$	0.012	0.006	0.065
$\Delta lnGDP$	-0.269	0.151	0.101
$\Delta lnGDP_{t-1}$	0.354	0.164	0.051
$\Delta lnGDP_{t-2}$	-0.007	0.169	0.683
$\Delta lnGDP_{t-3}$	0.232	0.143	0.131
$\Delta lnENG$	1.356	0.187	0.000
$\Delta lnENG_{t-1}$	0.201	0.333	0.556
$\Delta lnENG_{t-2}$	0.884	0.283	0.008
$\Delta lnENG_{t-3}$	0.415	0.324	0.225
$\Delta lnENG_{t-4}$	0.499	0.247	0.066
Intercept	1.220	0.031	1.000

Adj. R^2= 0.958, S.E. of Regr. = 0.016,
AIC = -5.123, SBC = -4.207,
F-stat. = 14.504, F-prob. = 0.000,
D-W stat. = 2.553

Notes: * denotes p-lag structures in the model.

The Toda–Yamamoto (1995) causality test is employed in order to estimate the existence and direction of relationships between variables. Table 15 suggests that carbon emissions and FDI have a bidirectional relationship, which means that FDI causes air pollution and air pollution causes FDI in Turkey where Mutafoglu (2012) found a uni-directional causality running from air pollution to FDI by applying Granger causality test.

Table 16: Toda Yamamoto (1995) Causality Test

Hypothesis	**Chi-square P-value**	**Decision**
lnFDIdoes not cause $lnCO_2$	0.047	Reject
$lnCO_2$ does not cause lnFDI	0.032	Reject
lnENGdoes not cause $lnCO_2$	0.035	Reject
$lnCO_2$ does not cause lnENG	0.000	Reject
lnGDPdoes not cause $lnCO_2$	0.894	Fail to Reject
$lnCO_2$ does not cause lnGDP	0.139	Fail to Reject
lnFDI does not cause lnGDP	0.151	Fail to Reject
lnGDP does not cause lnFDI	0.018	Reject
lnFDI does not cause lnENG	0.155	Fail to Reject
lnENG does not cause lnFDI	0.003	Reject
lnGDP does not cause lnENG	0.027	Reject
lnENG does not cause lnGDP	0.195	Fail to Reject

Notes:5000 simulations are used in order to calculate bootstrapped critical values. HJC criteria is used for the optimum lag length selection.

Furthermore, energy consumption and air pollution have a bidirectional relationship, which indicates that a change in energy consumption leads to a change in air pollution and vice versa. On the other hand, FDI and GDP have unidirectional causality, which runs from GDP to FDI and which means that the FDI-led growth hypothesis is not relevant in the case of Turkey. Uni-directional causality from GDP to FDI is also confirmed by the Mutafoglu (2012) and it is concluded that there is no evidence of FDI-led growth hypothesis for the Turkish economy. In addition, there are unidirectional causal relationships running from energy consumption to FDI and from GDP to energy consumption. No causal relationship was found between GDP and air pollution in Turkey. This finding contradicts with the results of Mutafoglu

(2012) where the uni-directional causality from air pollution to GDP is confirmed for the case of Turkey.

4.5 Conclusion

In this thesis, the relationship between carbon emissions, economic growth, energy consumption, and FDI in the case of Turkey is investigated for the period 1974–2010. The long-run equilibrium relationship between the variables investigated is confirmed by the bounds test approach under ARDL mechanism. The error correction term indicates that the short-values of CO_2 emissions converge to their long run equilibrium level by a 49.2% speed of adjustment each year by due to the contribution of independent variables in the model. This result indicates that economic growth, energy consumption, and FDI are long-run determinants of air pollution in Turkey.

The existence of the EKC hypothesis can be examined by comparing the long-run and short-run coefficients in the regression that investigates the effect of economic growth on air pollution. If the estimated long-run coefficient of GDP is smaller than the estimated short-run coefficient, it confirms the existence of the EKC hypothesis (Narayan and Narayan, 2010). The results of the present study indicate that a 1% increase in GDP decreases the level of air pollution by 0.173% in the long run, while in the short-run a 1% increase in GDP increases the level of air pollution by 0.354% in Turkey. This finding implies that the EKC hypothesis is valid in Turkey and reveals contradictory results compared with the study by Ozturk and Acaravci (2010). The reason for this contradiction might be the sample of Ozturk and Acaravci (2010) which covers the period from 1968–2005. In the last decade, Turkish policymakers have searched for alternative energy sources in order to reduce environmental degradation and have invested more in alternative energy projects, such as solar and wind energy. Increased public awareness and technology improvements have also resulted in reduced environmental degradation.

The Toda–Yamamoto (1995) causality test is applied to examine the direction of the long-run relationships between variables. The test results reveal that FDI and air pollution have a feedback relationship in the case of Turkey. The causal relationship between FDI and air pollution can be explained by the scale effect, which suggests FDI inflows contribute to the air pollution level of countries via increased industrial output (Zarsky, 1999). Furthermore, the causal relationship that runs from air pollution to FDI supports the existence of the pollution haven hypothesis; countries with lower environmental standards attract more FDI because polluting firms choose to invest in these countries in order to decrease production costs (Chung, 2014) in Turkey. Our findings also indicate unidirectional causality from economic growth to energy consumption, which emphasizes the importance of energy for the economic growth of Turkey, an energy-dependent economy. There is a bidirectional relationship between energy consumption and air pollution as well. While economic growth causes energy consumption and energy consumption causes air pollution, it can be argued that economic growth has an indirect effect on air pollution. The causal relationship running from economic growth to FDI reveals that the FDI-led growth hypothesis is not valid in the case of Turkey. This finding implies that FDI in Turkey is economic growth-driven, which means stable economic growth creates a safe investment environment for foreign investors.

Policy makers should be aware of the existence of the pollution haven hypothesis and the scale effect in Turkey while promoting FDI for greater economic growth. Environmentally friendly regulations should be implemented in order to avoid the negative effects of foreign investments. As there is no causality from air pollution to economic growth, policymakers are free to improve the environmental standards and regulations to a reasonable level. In addition, stricter regulations and standards can help foreign investors to spread their environmentally friendly technologies and motivate domestic polluting firms to adopt such environmentally friendly technologies in Turkey.

Chapter 5

CONCLUSION

Considering the importance of financial development and FDI for economic growth and possible effects of these segments on environmental degradation, this thesis investigates the roles of financial development and FDI on EKC hypothesis for the case of Turkey in two different chapters.

Chapter 3 investigates the moderating role of financial development on EKC hypothesis in the case of Turkey for the period of 1960-2010. Two models are conducted as it is suggested by Cohen & Cohen (1983) and Chen & Myagmarsuren (2013). The first model is the main effects and the second one is moderating effects model which includes interaction variables. Maki (2012) cointegration test under multiple structural breaks is adapted to examine the long-run equilibrium relationship between the variables in the conducted models. Results of Maki (2012) cointegration test suggest the long-run equilibrium relationship between EKC and financial development for both models. These findings also confirm the financial development-induced EKC hypothesis for the case of Turkey. Long-run coefficients are estimated by DOLS approach for both main effects and moderating effects models. Results of DOLS estimation for main effects model suggest that GDP has positive, elastic and statistically significant effect on CO_2 emissions while GDP square has negative and inelastic impact on CO_2 emissions. On the other hand, energy consumption has inelastic and positive impact on CO_2 emissions which means energy consumption accelerates air pollution in Turkey. The long-run coefficient of financial development index is negative, inelastic and statistically significant which indicates a successful energy policies and management for promoting financial sector. On the other hand, moderating effect of financial development is examined by the moderating effects model by including interaction variables into the conventional EKC model. DOLS estimation results indicate a positive effect of GDP and GDP^2 has a negative and elastic effect on CO_2 emissions. This finding exerts a stronger inverted U-shaped relationship between air pollution and real income compared with main effects model. Long run coefficient of financial development also has an elastic and negative impact on air pollution. In addition, DOLS estimation results prove the significant moderating role of financial development on the impacts of GDP and squared GDP while it has no moderating role on the impact of energy consumption on air pollution.

Policy makers should be aware of the importance of financial development for the Turkish economy. Findings of this thesis indicate a negative effect of financial development on CO_2 emissions in long run which is a sign of successful energy management policy. As it is mentioned in the current literature (Jalil and Feridun, 2011; Frankel and Romer, 1999), financial development may cause higher economic activity and more investments on R&D which lead significant decreases in environmental degradation. Moderating impact of financial development on real income growth supports the idea of Jalil and Feridun (2011) in a sense that financial development in Turkey leads increases in real income and R&D investments to reduce air pollution in the host country. However, when the income doubles, financial development causes increases in air pollution. This finding indicates that policy makers should need long run strategic planning on energy management and encourage more R&D investments for longer periods of time.

Chapter 4 examines the relationship between CO_2 emissions, economic growth, energy consumption and FDI in Turkey for the period of 1974-2010. Long run equilibrium relationship between variables in the conducted model is confirmed by the bounds test under ARDL mechanism. Bounds test results suggest that economic growth, energy consumption and FDI in Turkey are the determinants of Carbon emissions in long run. Existence of FDI-induced EKC hypothesis is investigated by examining the long run and short run coefficients of the variables in the conducted model. Narayan and Narayan (2010) developed a new approach to test the validity of EKC hypothesis which states that EKC hypothesis is valid if the estimated long run coefficient of GDP is smaller than the estimated short run coefficient of GDP. According to the findings of this thesis, long run coefficient of GDP is negative and statistically significant while short run coefficient of GDP is positive and significant which supports the validity of EKC hypothesis for the case of Turkey.

Directions of causalities between variables are examined by the Toda-Yamamoto (1995) causality test. Causality test results indicate a bi-directional relationship between FDI and CO_2 emissions which can be explained by scale effect where FDI causes increases in industrial production and it contributes to the air pollution levels of the country (Zarsky, 1999). The causality that runs from air pollution to FDI indicates the validity of pollution haven hypothesis for the case of Turkey which suggests lower levels of environmental policies in countries attract more FDI inflows. According to the pollution haven hypothesis, polluting firms prefer to invest in countries where environmental regulations are low to decrease their production costs (Chung, 2014). Results of Toda-Yamamoto (1995) causality test results also indicates a unidirectional causality that runs from economic growth to energy consumption and a bidirectional relationship between energy consumption and air pollution. These findings indicate the energy dependency of Turkey and the importance of energy consumption for air pollution. FDI-led growth hypothesis is also tested by the causality test and results reveal a unidirectional causality from economic growth to FDI. Causal relationship between economic growth and FDI indicates that FDI-led growth hypothesis is not valid for Turkey but FDI is economic growth driven, which means stable economic growth is important for attracting foreign investors.

The existence of pollution haven hypothesis and scale effect in Turkey should guide policy makers while promoting FDI inflows in order to achieve higher economic growth. Stricter environmental regulations should be implemented to decrease the environmental degradation caused by FDI. Increases in environmental regulations will help foreign investors to motivate polluting domestic firms in Turkey to decrease environmental degradation.

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APPENDIX

Appendix A: Abstract for the publication of chapter 4 in the Journal of International Trade and Economic Development

The relationship between Co2 emissions, energy consumption, economic growth and FDI: the case of Turkey

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ABSTRACT

This study investigates the relevance of the environmental Kuznets curve (EKC) hypothesis in Turkey for the period 1974–2010 using carbon dioxide (CO2) emissions, energy consumption, economic growth, and foreign direct investment (FDI) variables. The long-run equilibrium relationship among CO2 emissions, energy consumption, economic growth, and FDI is revealed using the bounds test. The error correction model under autoregressive-distributed lag mechanism suggests that CO2 emissions converge to their long-run equilibrium level by a 49.2% speed of adjustment every year by the contribution of energy consumption, economic growth, and FDI. The Toda–Yamamoto (1995) causality test results imply that carbon emissions and FDI, energy consumption, and CO2 emissions have bidirectional causal relationships. On the other hand, there are unidirectional causal relationships running from economic growth and energy consumption to FDI and from economic growth to energy consumption. Our findings provide evidence of the validity of the pollution haven hypothesis, in addition to the scale effect, and the EKC in the case of Turkey.

Keywords: Air pollution; foreign direct investment; energy consumption; causality

JEL Codes: Q4, Q5, C01