CARBON DIOXIDE EMISSIONS, ECONOMIC GROWTH AND OPENNESS IN TURKEY: AN ARDL MODEL

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IN TURKEY: AN ARDL MODEL

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DECLARATION OF ORIGINALITY

I, İbrahim Murat Kara, certify that:

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ABSTRACT

Carbon Dioxide Emissions, Economic Growth and Openness in Turkey:

An ARDL Model

In this thesis, I examine the effects of economic growth and trade openness on carbon dioxide emissions in Turkey for the period 1960-2014. Before the empirical analysis, there is an overview about the recent literature in this nexus. I try to analyze the growth of the carbon dioxide emissions in Turkey by conducting an Autoregressive distributed lags (ARDL) model with a structural break. I apply Toda Yamamoto procedure of Granger causality to test the direction of causality among variables. Estimated models show that there is a long run relationship, thus a cointegration, between economic growth, trade openness and carbon dioxide emissions in Turkey. Although there are improvements in terms of energy efficiency, current policy measures are not enough to mitigate the increase in carbon dioxide emissions over the years.

ÖZET

Türkiye'de Karbondioksit Emisyonları, Ekonomik Büyüme ve Ticaret: ARDL Modeli Uygulaması

Bu tezde 1960-2014 yılları arasında Türkiye'nin yakalamış olduğu ekonomik büyüme ve uluslararası ticaretin karbondioksit emisyonları üzerindeki etkisi incelenmiştir. Ampirik analizden önce literatürde bu konuda yer alan çalışmalar gözden geçirilmiştir. Karbondioksit emisyonlarının artışını incelemek için yapısal kırılmalı ARDL modeli ve değişkenler arasındaki nedenselliği belirlemek için Toda Yamamoto testi kullanılmıştır. Modellerden alınan sonuçlar ekonomik büyüme, uluslararası ticaret ve karbondioksit emisyonları arasında uzun vadeli bir ilişki yani eşbütünleşme olduğunu göstermektedir. Dolayısıyla, Türkiye'de enerji verimliliği açısından gelişmeler olsa da mevcut politikaların karbondioksit emisyonlarındaki artışı önlemek adına yetersiz olduğu görülmüştür.

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CHAPTER 1

INTRODUCTION

Turkey has experienced high growth rates in the last decades as a developing country except during the period of Turkish banking crisis in 2001 and the global financial crisis in 2008. However, growth did not come without costs. Turkey experiences a rapid growth in carbon dioxide emissions as well (Ayvaz et al., 2017). Researches show that Turkey stands as one of the top 20 carbon dioxide emitters in the world (IEA, 2016; Olivier et al., 2016).

Indeed, there is a quite growing empirical body of literature which shows that economic growth boosts carbon dioxide emissions in most of the countries (Berahab, 2017; Narayan et al. 2016; Storm and Mir, 2016). Therefore, countries usually try to reduce the adverse effects of growth on environment in terms of increased emissions by implementing policies on energy consumption substances and improving their energy production techniques to reduce the adverse effects of growth on environment in terms of increased emissions. This concern is referred in the literature as low carbon strategy and green growth. The concept of “green growth” became popular in 2008 when the UN Environment Programme (UNEP) promoted “green stimulus packages” at the period of global financial crisis. The term of low carbon development strategy, on the other hand, was firstly used in United Nations Framework Convention on Climate Change (UNFCCC) and it refers to the low-emission or climate-resilient economic growth (Wahlen, 2012).

In the political arena, since 1994, several conventions and summits have been held by the United Nations to attract the attention of the world in climate change and to take necessary steps in preventing the increasing environmental degradation caused by carbon dioxide emissions. The first of these events was in Rio de Janeiro. This conference resulted in with the UNFCCC which has nearly a universal membership. Countries set forth the mitigation targets and agreed upon "common but differentiated responsibilities" (Nassef, 2002). Thus, although the common responsibilities are determined, the Convention embraced the equity principle among different nations. After five years, the Convention was extended with Kyoto Protocol which set forth legally binding emission targets to the parties of the Convention which have not been fulfilled (Ryding, 2012). The most recent and comprehensive meeting in this context was in December 2015 in Paris known also as Paris Agreement. According to the agreement, party countries have to take necessary steps to mitigate the effects of emissions on global average temperature. Countries also agreed to declare their targets every subsequent five years. Moreover, since economic growth is agreed to be a significant contributor to carbon dioxide emissions, countries also promised to transform their production and consumption patterns towards more sustainable prospects. At the time of writing this thesis, 197 countries signed the agreement and 173 of these countries have ratified it by the legislative power (UNFCCC, 2018). Turkey signed the agreement in 2016 but has not ratified it yet.

In the academic literature, the effects of economic growth and trade openness on carbon dioxide emissions are examined in numerous studies. Researches that focus on the relationship between economic growth and environment usually looks at the validity of Environmental Kuznets Curve (EKC) in the target research country (Grossman and Krueger, 1991; 1993; 1995; Holtz-Eakin, 1995; Perman and Stern, 2003; Dinda, 2004; McKitrick and Strazicich, 2005; Aldy, 2006 as cited in Stolyarova, 2013 and Alstine and Neumayer, 2008; Elgin and Oztunali, 2014; Moosa, 2017; Gill et al., 2017). The EKC hypothesis examines whether there is a U-inverted relationship between the economic growth and the amount of carbon dioxide emissions in a country. It is expected that, at the early stages of development of a particular economy, there will be increase in both energy use (which is mainly coal based) and carbon dioxide emissions. However, after a particular point, the society will put effort to implement more environmental friendly production techniques to protect their environment. This implementation will lead a reduction in per unit of production. The results about the existence of EKC maintain to be controversial in current literature. The EKC maintain as an important complementary concept to the long run causality estimation in econometrics.

Given the fact that the value of total imports and exports of countries has been increasing in the world, it is also important to understand whether the composition of imports and exports have a significant effect on emissions. On the one hand, transfers via import of environmental friendly technologies could reduce emissions, but on the other hand, the import intensity of fossil fuels over other energy sources could be correlated with carbon dioxide emissions. This is more probable if there is a high dependency in the energy sector for a country. The studies showed ambiguous results about the effects of trade openness on carbon dioxide emissions. Iyke and Ho (2017), for instance, discuss the controversial results in this nexus.

The most important aim of this study is to understand the impact of maintaining growth and trade policies on environment based on the case of Turkey. This is important as the empirical forecast studies suggest that the emission levels of Turkey will exceed the promised levels in the Paris Agreement (Pabuccu and Bayramoglu, 2016; Hamzacebi and Karakurt, 2015).

I examine the effects of economic growth and trade openness on carbon dioxide emissions in Turkey for the period 1960-2014. Before the empirical analysis, there is an overview about the recent literature in this nexus. Taking the standard IPAT model as base, I try to analyze the growth of the carbon dioxide emissions in Turkey by conducting an Autoregressive distributed lags (ARDL) model with a structural break. I also apply Toda Yamamoto procedure of Granger causality to test the direction of causality among variables. The previous studies which inspect the relationship between economic growth, trade openness and carbon dioxide emissions by building a co-integration model with ARDL bounds testing approach do not consider structural breaks for the case of Turkey. This thesis aims to close this gap.

The rest of the study is organized as follows: In chapter 2, I present the relevant literature. In chapter 3, there is an introductory information about Turkey's position in the context of carbon dioxide emissions. In chapter 4, I present the data and methodology of the study. In chapter 5, I present and evaluate the regression findings and then conclude in chapter 6.

CHAPTER 2

LITERATURE REVIEW

The factors that affect carbon dioxide emissions can be studied by concentrating on different aspects of the economy. In order to build relevant models, researchers use different combination of variables and estimation techniques. Here, I categorize the studies that are related to my subject area into three. Firstly, there are studies which try to understand the most important drivers of carbon dioxide emissions, by focusing on country-level analysis and looking at the determinants of the country's emissions from different perspectives. Secondly, there are studies based on panel estimation techniques. Because there are many studies in this form, I only mention the studies that include Turkey in their models. The third category includes a broader number of methodological approaches. Since this thesis specializes only on Turkey, I represent the relevant studies which focus on the carbon dioxide emissions in Turkey. For the motivation of this thesis, the studies I picked here are from the studies that put more emphasis on trade openness and economic growth as contributors to total carbon dioxide emissions.

One notable country-specific study in the first category by Jalil and Mahmud (2009) who point out that the main source of emissions is rather income as trade is insignificant in their model to explain emissions for China. Hossain (2012), on the other hand, indicates that energy consumption contributes to carbon dioxide emissions but economic growth, urbanization and trade openness have no impact on carbon dioxide emissions for the case of Japan. Yazdi and Shakouri (2014) find that EKC hypothesis is valid for Iran. Bento and Paulo (2014) find that openness is an insignificant variable to explain carbon dioxide emissions but economic growth increases carbon dioxide emissions for the case of Italy. Farhani and Ozturk (2015) find that economic growth is a contributor to carbon dioxide emissions and controlling for the other factors, a one percent increase in trade openness leads to an increase in emissions about 0.4 percent for Tunisia. Twerefou et al. (2016) find that there is a U-shaped relationship between economic growth and carbon dioxide emissions, thus there is no evidence of EKC hypothesis but trade openness increases emissions for Ghana. Dogan and Turkekul (2016) look at the impacts on carbon dioxide emissions in the USA over the period of 1960 and 2010. They conclude that trade openness helps to mitigate carbon dioxide emissions. Ali et al. (2016) also find that trade openness has a negative effect on emissions but economic growth increases carbon dioxide emissions for Nigeria. Ali et al. (2017) examine the impacts of economic growth, trade openness and urbanization on carbon dioxide emissions in Singapore between 1970-2015 and find that economic growth leads to an increase in emissions but urbanization helps reducing it. According to their study, trade openness is insignificant which means there is no evidence that promoting an open economy has an impact on carbon dioxide emissions. Shahzad et al. (2017) find that one percent increase in trade openness will increase carbon dioxide emissions by 0.25 percent for Pakistan. Hasson and Masih (2017)'s research suggests that trade reduces carbon dioxide emissions, thus, improves environmental quality for South Africa.

The second category of studies looking at the relationship between economic growth, trade openness and carbon dioxide emissions include panel estimations wherein the data of Turkey is also used in the estimation:

Akin (2014), for instance, investigates the effects of different indicators on carbon dioxide emissions for 85 countries and finds that trade openness reduces emissions in the long run but both economic growth and trade openness increase emissions in the short run. Ertugrul et al. (2016) analyse top ten emitters among developing countries. Their findings validate the EKC hypothesis for Turkey and trade openness has a statistically significant positive impact on carbon dioxide emissions as well. Ayeche et al. (2016) evaluate the effects of economic growth, trade openness and a few other indicators on carbon dioxide emissions for 40 European countries. Accordingly, economic growth and trade openness are found to be correlated with carbon dioxide emissions. In a similar vein, Lu (2017) looks at 24 Asian countries and finds that for Turkey, the elasticity of GDP is 0.94 and the renewable energy is mostly determined by GDP. Shahbaz et al. (2017) look at 105 different countries by grouping them as high, middle and low income countries. They use panel methods and analyse the relationship between three factors: economic growth, trade openness and carbon dioxide emissions. The results suggest that trade openness lowers carbon dioxide emissions and economic growth increases it for the case of Turkey.

In the third category literature, I look at the studies which specifically focus on the case of Turkey:

Say and Yucel (2005), for example, show that growth of GNP increases carbon dioxide emissions. According to Lise (2006), the major contributor to carbon dioxide emissions in Turkey is economic expansion. While the carbon intensity in general increases carbon dioxide emissions, energy intensity is responsible for a modest reduction in emissions. Thus, it is found that, there is no decoupling of carbon dioxide emissions and economic growth in Turkey over the period 1980-2003. Halicioglu (2009) conducts an ARDL analysis and finds that economic growth and trade openness increase carbon dioxide emissions, the first with a higher magnitude. Ozturk and Acaravci (2010) first find that there is no causal relationship from the economic growth to carbon dioxide emissions. However, their follow-up study in 2013 shows that both economic growth and trade openness Granger cause carbon dioxide emissions and they also validated EKC hypothesis for Turkey. Altintas (2013) builds an ARDL model to measure the effects of primary energy consumption, GDP and FDI on carbon dioxide emissions. He finds a long run relationship between variables. According to the causality tests, primary energy consumption and GDP Granger causes carbon dioxide emissions. Bozkurt and Okumus (2015) look at the effect of population on emissions by using Hatemi-J co-integration approach with a number of other indicators. The study shows the positive effect of population on emissions. Artal et al. (2015) employ an ARDL model and validate the EKC for the case of Turkey. Keskingoz and Karamelikli (2015) build an ARDL model by incorporating imports and exports separately to the model. Their finding suggests that energy use, exports and GDP affect carbon dioxide emissions positively but imports help reducing it. Hamzacebi and Karakurt (2015) employ Grey model to forecast carbon dioxide emissions of Turkey in the future. Their result shows that carbon dioxide emissions will reach up to o 496,404 million tons in 2025. In another forecast model, Pabuccu and Bayramoglu (2016) employ a neural network analysis to predict the amount of carbon dioxide emissions for Turkey in the future. They claim that the forecast amount is higher than Turkey's commitment in the Paris Agreement. Beser and Beser (2017) employ Johansen co-integration technique and confirm the EKC for Turkey. Kizilkaya (2017) finds that economic growth and energy consumption have positive impact on carbon dioxide emissions but there is no evidence of significant relationship between FDI and carbon dioxide emissions.

Table 1 gives a summary of the literature review at large of the studies on the carbon dioxide emissions in Turkey:

Table 1. Studies about the carbon dioxide emissions in Turkey

Author	Variables	Model	Time	Result
Altintaş (2013)	CO2 emissions, Primary energy consumption, GDP, FDI	ARDL	1970-2008	Evidence of cointegration from ARDL model.Primary energy consumption and GDP Granger causes CO2 emissions at 10 per cent significance level.
Artal et al. (2015)	CO2 emissions, GDP, Trade openness, Renewable energy	Johansen Cointegration	1981-2012	EKC is validated for GDP but not for trade openness.
Beser and Beser (2017)	CO2 emissions, Energy use, GDP, Employment, Population	ARDL	1960-2015	EKC is valid for Turkey.
Bozkurt and Akan (2014)	CO2 emissions, Energy consumption, GDP	Johansen Cointegration	1960-2010	Energy use has positive and emissions has negative effect on economic growth.
Bozkurt and Okumus (2015)	CO2 emissions, Population, Energy consumption, GDP, Trade openness	Hatemi-J Cointegration	1966-2011	Population, energy consumption, GDP and trade openness increase emissions.
Halicioglu (2009)	CO2 emissions, GDP, Energy Consumption, Trade Openness	ARDL	1960-2005	All three factors cause an in increase in CO2 emissions, GDP most effectively.
Hamzacebi and Karakurt (2015)	Energy-related indicators, not defined individually	Grey Model	1965-2012	CO2 emissions will reach up to 496,404 million tons in 2025

Table 1. Table 1 continued

Author	Variables	Model	Time	Result
Keskingoz and Karamelikli (2015)	CO2 emissions, Imports, Exports, GDP, Energy use	ARDL	1960-2011	Energy use, exports and GDP increase emissions.
Kizilkaya (2017)	CO2 emissions, GDP, Energy consumption, FDI	ARDL	1970-2014	GDP and energy consumption increase CO2 emissions but foreign direct investment does not.
Lise (2006)	Carbon intensity, Energy intensity, GDP	Decomposition Analysis	1980-2003	GDP affects most the CO2 emissions but there is no proof of EKC.
Ozturk and Acaravci (2010)	CO2 emissions, Energy consumption, GDP and Foreign trade	ARDL	1960-2005	Income is the most significant variable in explaining the carbon emissions in Turkey which is followed by energy consumption and foreign trade.
Ozturk and Acaravci (2013)	CO2 emissions, Energy consumption, GDP, Financial development and Foreign trade	ARDL	1960-2007	Foreign trade, GDP and energy consumption increases per capita emissions but financial development has no significant effect on per capita emissions in the long run.
Pabuccu and Bayramoglu (2016)	CO2 emissions, Population, GDP, Energy production, Energy consumption, Energy consumption for transportation	Neural Networks	1990-2013	The amount of CO2 emissions will be much higher than Turkey's commitment for Paris Agreement.
Say and Yucel (2005)	GNP, Population and CO2 emissions	Linear Regression	1970-2002	Energy consumption as a function of GNP and population increases CO2 emissions

CHAPTER 3

THE EMISSION PROFILE OF TURKEY

Turkey has become a party to the UNFCCC which was agreed in 1994. It was a major step to tackle global warming but Turkey has not been a party of the agreement until 2004. This late joining was due to Turkey's position in the agreement. Because Turkey is regarded as an OECD country, it was added to Annex-2 which proposes more strict measures and financial contribution to other countries. Because of that, Turkey has not been a party until it was provided a "special circumstance" in 2001 Marrakesh conference. Similarly, although Turkey signed the Paris agreement, as of February 2017 it has not yet ratified the agreement in National Assembly for similar reasons. Since Turkey is not in the category of "developing countries" according to the UNFCCC, it cannot benefit the financial aids from developed countries. Turkey declares that the emissions of the country is not as high as the most developed European countries or USA. This still constitutes a great obstacle between Turkey and the parties of Paris Agreement (Ozbek, 2017). Turkey's efforts on mitigating emissions have also been increasing with its integration process to the European Union which is an important global environmental actor, comprising many NGOs and active environmentalist politicians.

In fact, the two well-known economic measures to evaluate energy efficiency of a country are carbon intensity and energy intensity (Raupach et al., 2007).

Carbon intensity shows that how much emission is produced per unit of GDP. The behavior of carbon intensity helps us to understand the existence of the pollution reduction process in the economy. For example, an inverted U-curve for carbon intensity might signal an improvement in efficiency as a result of economic development (Roberts and Grimes 1997).

The Figure 1 demonstrates the carbon dioxide intensity in Turkey. Starting from 1960, the horizontal axis indicates years and the vertical axis shows the kilogram equivalent amount of carbon dioxide emissions generated from per kilogram solid fuel consumption. The current indicator shows that Turkey might be at the turning point of an inverted U-curve.

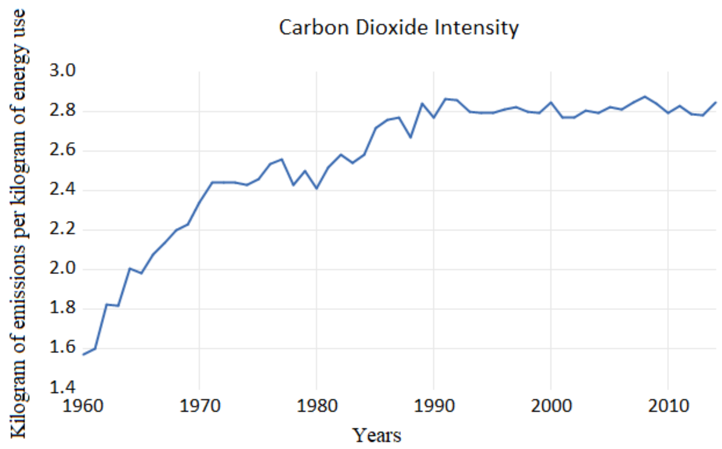

Figure 1. CO2 intensity (kg per kg of oil equivalent energy use): Own construction from the data obtained from World Bank

On the other hand, energy intensity is an indicator calculated by dividing total energy to the GDP which shows how much energy is exhausted per unit of GDP. According to European Environment Agency, the value of energy intensity decreased in all EEA (European Economic Area) countries between 2005 and 2014 except for Estonia, Iceland and Turkey (EEA, 2016).

Figure 2 then demonstrates the energy intensity in Turkey. Again, the horizontal axis indicates years starting from 1960 and the vertical axis shows how many kilograms of oil equivalent energy is used per capita in the case of Turkey.

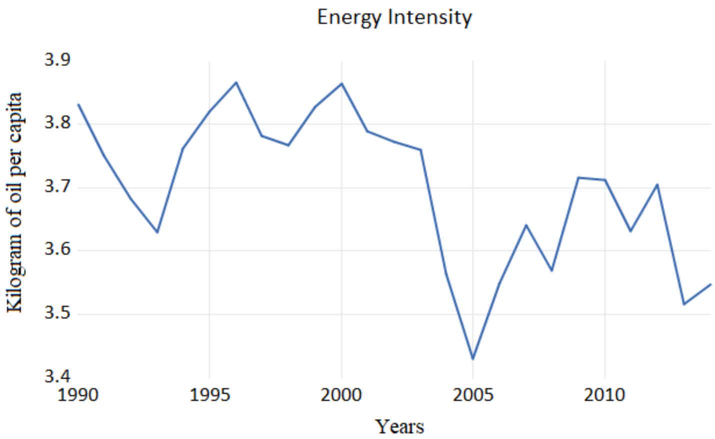

Figure 2. Energy use (kg of oil equivalent per capita). Own construction from the data obtained from World Bank

The evolution of carbon dioxide emissions in Turkey from 1990 onwards and the growth of emissions in different sectors was published by TUIK in April 2017. The second column in Table 2 shows the total emissions in million tonnes and the third column shows the percentage change of emissions where 1990 is the base year. Columns of Energy Industry, Agriculture and Waste indicate the total emissions in million tonnes in these sectors. We see that total emissions more than doubled between 1990 and 2015. Clearly, the energy sector is the major contributor to emissions and it nearly tripled since 1990.

Table 2. Greenhouse gas emissions by sectors (carbon dioxide equivalent), 1990 - 2015 (million tonnes)

Year	Total	Change(%)	Energy	Industrial	Agriculture	Waste
1990	213.9	-	134.4	23.69	44.8	11.1
1991	221.0	3.3	138.5	25.43	45.8	11.3
1992	227.4	6.3	144.7	25.12	46.1	11.5
1993	236.7	10.6	152.2	25.97	46.8	11.8
1994	230.2	7.6	148.9	25.33	44.0	12.0
1995	246.5	15.2	163.5	27.30	43.4	12.4
1996	264.2	23.5	179.2	28.11	44.2	12.7
1997	275.6	28.8	191.2	29.01	42.1	13.2
1998	277.6	29.7	191.0	29.35	43.7	13.5
1999	276.4	29.2	190.2	27.80	44.4	14.0
2000	296.4	38.6	211.7	27.80	42.5	14.5
2001	277.6	29.8	195.0	27.90	39.8	15.0
2002	284.5	33.0	201.9	29.25	38.0	15.4
2003	304.0	42.1	216.6	30.45	41.2	15.9
2004	315.1	47.3	223.3	33.11	42.2	16.5
2005	337.1	57.6	241.0	35.90	43.3	16.9
2006	361.7	69.0	260.5	38.96	44.8	17.5
2007	394.9	84.6	291.4	41.49	44.4	17.7
2008	391.8	83.1	288.5	43.40	42.1	17.8
2009	400.9	87.4	294.6	45.11	43.4	17.9
2010	406.8	90.1	291.8	50.99	45.8	18.2
2011	436.3	103.9	313.9	55.81	48.1	18.5
2012	448.9	109.8	319.3	57.72	53.8	18.1
2013	442.1	106.6	308.3	60.18	57.2	16.5
2014	455.6	112.9	321.2	60.78	57.2	16.4
2015	475.0	122.0	340.0	60.72	57.4	16.9

Source: TurkStat, Greenhouse Gas Emissions Statistics,1990 - 2015

Indeed, Turkey is among one of the founders of the International Renewable Energy Agency (IRENA) and has been showing significant efforts for its transition to renewable energy systems (MFA). However, although the amount of energy generated from renewable sources is increasing, the share of the renewable energy in proportion to total energy production is decreasing. This is due to high levels of energy demand of Turkey as a developing country. Turkey's target for 2023 is to increase the share of renewable energy in electricity production to 30 percent excluding hydro-power. According to the Ministry of Energy and Natural Resources, 34 per cent of the electricity production was obtained from natural gas, 31 per cent from coal, 24 per cent from hydro-power, 2 per cent from geothermal and 3 from other resources by July 2017 (MENR). There is also emphasis on increasing the ratio of renewable energy in the energy mix. Figure 3 shows that current policies are not compatible with future projections. The share of renewable energy halved since 1990.

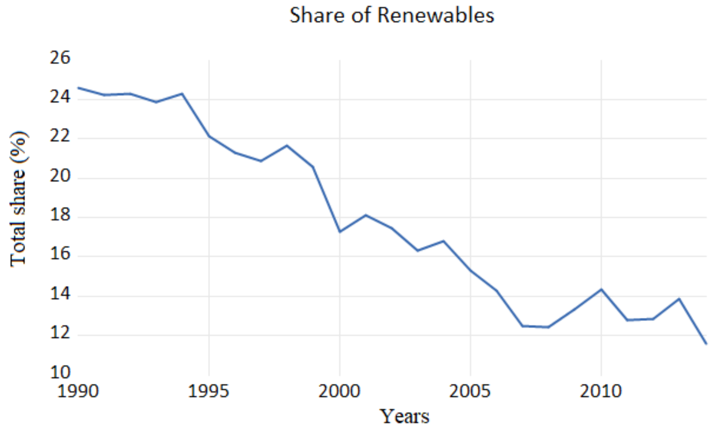

Figure 3. The share of renewable energy in total final energy consumption. Own construction from the data obtained from World Bank

Yet, there are also financial constraints to expand renewable energy technologies over the country. To overcome these constraints, the government in Turkey has been trying to encourage the investments on renewable energy technologies by guaranteeing fixed prices, financial guarantees for the projects of renewable energy, providing advisory support and exempting taxes from biofuel producers (Kavaz 2016). In spite of such efforts, coal consumption which is the most responsible contributor to carbon dioxide emissions is increasing at a very high level. Sahin et al. (2016) investigate Turkey's current policies about the coal consumption and use in a detailed manner. Accordingly, current policies could lead to maintain coal at the heart of energy sector. Given this background, in the next chapter, I will introduce the data and methodology used throughout this study to understand the evolution and trends in carbon dioxide emissions in Turkey, by putting an emphasis on economic growth and trade openness in Turkish economy.

CHAPTER 4

DATA AND METHODOLOGY

This chapter comprises five subsections. In the first section, I introduce the data and present the descriptive statistics. In the second section, I conduct four different unit root tests to determine whether the variables have unit root. Because it is crucial to check the stationarity properties of the variables prior to any time-series econometric analysis (Feridun, 2015). Then, in the third section, I introduce the base model, "IPAT equation", which is a traditional mathematical approach to measure the human impact on environment. Based on this equation, a stochastic approach to IPAT equation called STIRPAT (Dietz and Rosa, 1994; York et al., 2005) has become a common approach to investigate the human impact. I build the model using the data of Turkey. After that, in the fourth section, I introduce the co-integration technique I followed in this study. I justify why I use this model and build a relevant model to test long-run behavior of my target variables. Finally, once I reach the decision of co-integration I also check the direction of causality among carbon dioxide emissions, economic growth and trade openness by using Toda Yamamoto's approach in the fifth section.

4.1. Data collection and descriptive statistics

For the case of Turkey, I gather the data from the World Bank, World Development Indicators. The data covers the period over 1960-2014. Table 3 represents the definitions of the variables used in the analysis:

Table 3. Definitions of the variables

Abbreviation	Variable	Definition
LCO2	Carbon dioxide emissions	Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement.
LGDP	GDP per capita	Gross domestic product (in dollars) divided by midyear population (base year 2010).
LOP	Trade openness	Trade openness is the sum of exports and imports of goods and services measured as a share of gross domestic product.

I carry a standard log-linear analysis in this study. However, before conducting any further technique, it is important to see the general trend of these variables over time. We can observe the positive growth of these three indicators over the years when we look at the logarithms of the three series. As shown in Figure 4,5 and 6, we can observe a general increase in the three series:

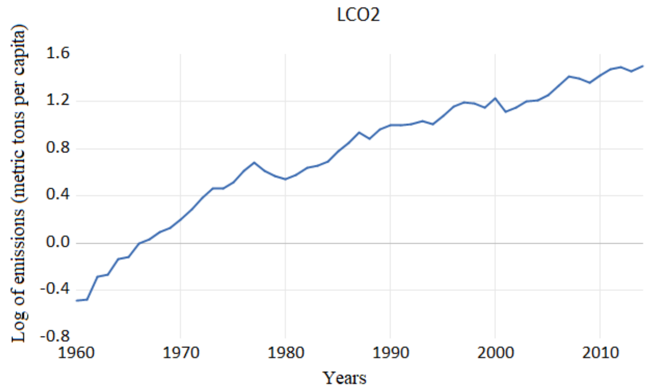

Figure 4. Growth of carbon dioxide emissions over time. Own construction from the data obtained from World Bank

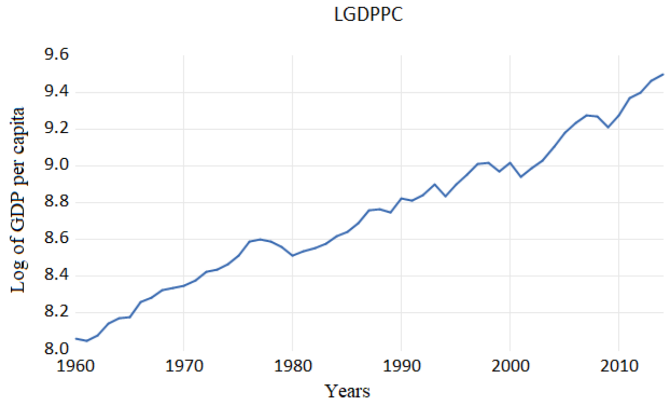

Figure 5. Growth of GDP per capita over time. Own construction from the data obtained from World Bank

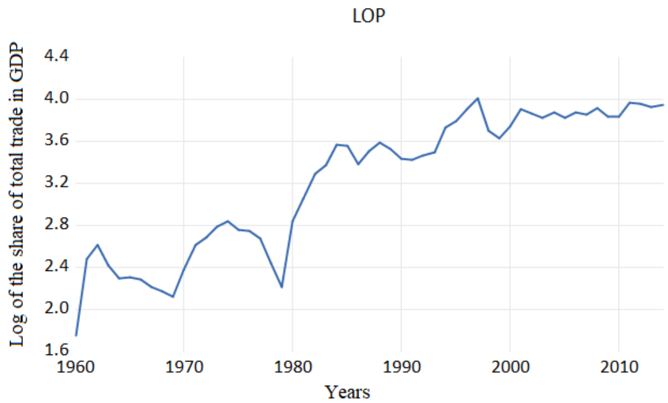

Figure 6. Growth of trade openness over time. Own construction from the data obtained from World Bank

In addition, the data covers a fifty-five years time span. The mean, medium, maximum and minimum logarithm values of the three variables can be seen on Table 4. Skewness is a measure to understand the data set's symmetry. The values indicate a fairly symmetric data set in our case. The kurtosis shows the tail-heaviness of the distribution and it takes the value of 3 for a normal distribution. When the value of kurtosis is between 1 and 3 which is our case, the data is less peaked and the tails are thinner than a normal distribution.

Table 4. Descriptive statistics of carbon dioxide emissions, economic growth and trade openness

	LCO2	LGDP	LOP
Mean	0.754984	8.736264	3.218179
Median	0.886462	8.749675	3.457495
Maximum	1.502182	9.496423	4.006793
Minimum	−0.490579	8.050282	1.745170
Std. Dev.	0.548429	0.388979	0.656195
Skewness	−0.620660	0.091684	−0.494034
Kurtosis	2.433253	2.116590	1.801122
Observations	55	55	55

Moreover, when we look at the correlations, the correlation matrix (Table 5) indicates there is a positive relationship between carbon dioxide emissions, economic growth and trade openness:

Table 5. Correlation matrix

CORRELATION	LCO2	LGDP	LOP
LCO2	1		
LGDP	0.97	1	
LOP	0.92	0.895	1

4.2. Unit root tests

A stationary series is defined as one which has a constant mean, constant variance and constant auto-covariances for each given lag. Non-stationary series are affected from shocks and these effects could last permanently or even become more influential as time passes. If one does not consider stationarity in the model, this may lead to a spurious regression which occurs when two time series are trending over time, a standard OLS regression gives significant coefficient estimates and a high R-squared although the two series are totally unrelated. To avoid a spurious regression, before we start a time series analysis, we should check the stationarity conditions of the variables (Brooks, 2008).

According to the Augmented Dickey Fuller (ADF), Philips Perrron (PP), Kwiatkowski–Phillips–Schmidt–Shin (KPSS) and Zivot-Andrews tests, none of our variables I(2), thus the variables are level or first difference stationary. The results of these tests are represented in Table 6:

Table 6. Unit root test results

Variable	ADF *t-statistic*	PP *Adj. t-statistic*	KPSS *LM-statistic*
LCO2	-2.89* (-2.59)	-4.0*** (-2.74)	0.87 (0.22)
LGDP	0.21 (-2.32)	0.22 (2.46)	0.89 (0.11)
LOP	-2.56 (-3.51**)	-2.65* (-3.44*)	0.89 (0.11*)
Δ LCO2	-7.24*** (-8.11***)	-7.24*** (-8.08***)	0.54** (0.09***)
Δ LGDP	-7.20*** (-7.14***)	-7.20*** (-7.14***)	0.08*** (0.05***)
Δ LOP	-7.27*** (-7.13***)	-7.37*** (-7.21***)	0.14*** (0.05***)

Note: I use Schwarz information criterion and *, ** and *** refer to 10,5 and 1 per cent significance levels.

After conducting ADF, PP and KPSS tests, I also make Zivot and Andrews (1992) unit root test to determine the structural breaks in the series. This test compensates for one structural break when we check the stationarity properties of the series. The conventional tests like ADF, PP and KPSS could give biased results because these tests do not consider the structural breaks in the series. Table 7 demonstrates the results of Zivot-Andrews test for our variables:

Table 7. Zivot-Andrews test results

Variable	t-statistic	Time Break
LCO2	-3.24	1970
LGDP	-3.57***	1979
LOP	-5.93***	1980
Δ LCO2	-8.88**	1978
Δ LGDP	-7.61***	2003
Δ LOP	-5.93***	1980

Note: *, ** and *** refer to 10,5 and 1 per cent significancy levels.

The estimated break dates for the levels of series are 1970, 1979 and 1980 for carbon dioxide emissions, GDP per capita and trade openness respectively. For the first difference of the series Zivot-Andrews test points the years 1978, 2003 and 1980 for carbon dioxide emissions, GDP per capita and trade openness respectively. One of the most important reason of these break years is probably Turkey's liberalization policy in 1970s.

4.3. Specification of the model

The roots of the model used in this study goes back to 1970s when Ehrlich and Holden systematized a neo-Malthusian formula to look at the anthropogenic effects on environmental degradation (White et al., 2015). The model is called as IPAT equation and it represents environmental impacts (I) as products of population (P), affluence (A) (or wealth) and technology (T).

$$I = P * A * T \tag{1}$$

This model was used frequently by mainstream environmental organizations and United Nations policy reports to refer the human impact on environment by exhausting resources and creating waste (White et al., 2015). The model allows future forecasts but it is an accounting equation and does not allow hypothesis testing (York et al., 2003). Stochastic approach to IPAT model (York et al. 2003) is a transformation of this equation and allows hypothesis testing:

$$I_i = \alpha P_i^{\beta_0} A_i^{\beta_1} T_i^{\beta_2} e_i \tag{2}$$

The indice ”i” indicates different countries or regions. β_0, β_1 and β_2 becomes the coefficients of the variables. α and e becomes the intercept and error term respectively.

Here, each side of the equation (1) is divided by population variable in line with Shahbaz et al. (2016) and Lean and Smyth (2010). Then we take the logs of each variable where LCO2 represents log of carbon dioxide emissions (metric tons per capita), LGDP represents log of GDP (per capita) and LTO represents log of trade openness (the total imports and exports as a share of GDP) and it is used in place of technology variable. York et al. (2003) provide a possibility to disaggregate T by representing it with a different indicator. This transformation and the stochastic approach to IPAT equation (2), leads us to a standard equation for hypothesis testing:

$$LCO_2 = \alpha_0 + \alpha_1 LGDP + \alpha_2 LTO + \varepsilon \tag{3}$$

Next, we formulate the ARDL model to capture the relation between the variables as follows:

$$\begin{aligned} \Delta LCO_{2t} = \alpha_0 + \alpha_1 LCO_{2t-1} + \alpha_2 L\mathrm{GDP}_{t-1} + \alpha_3 LTO_{t-1} + \textstyle\sum_i^p \gamma_i \, \Delta LCO_{2t-i} \\ + \textstyle\sum_j^q \delta_j \, \Delta L\mathrm{GDP}_{t-j} + \textstyle\sum_m^q \phi_m \Delta LTO_{t-m} + \omega BREAK_t + \beta TREND_t + \varepsilon_t \end{aligned} \tag{4}$$

I model the change in carbon dioxide emissions as a function of the lagged values of economic growth, trade openness and carbon dioxide emissions itself. An unrestricted error correction model where α coefficients represent long run relationship, γ, ϕ, ω coefficients represent short run relationship and if we incorporate a deterministic trend and a break year we get the (4).

The null hypothesis is there is no co-integration between these series which is H_0: $\alpha_0 = \alpha_1 = \alpha_2 = 0$ whereas the alternative hypothesis is H_1: $\alpha_0 \neq \alpha_1 \neq \alpha_2 \neq 0$

4.4. ARDL bounds approach

Autoregressive Distributed Lags models are common for the analysis of long run relationships between variables when the series are integrated of order one. Bounds testing is an extension of ARDL modelling which tests the significance of the lagged levels of the variables within a univariate error correction system. The test is based on standard F and t-statistics (Pesaran, 2001). The other prominent approaches to cointegration are Engle and Granger (1987), Johansen (1988) and Johansen and Juselius (1990). ARDL Bounds testing is more suitable for our analysis because the small sample properties of the bounds testing approach are far superior to that of multivariate cointegration (Narayan, 2005).

I apply ADF, DF-GLS and Philips Perron unit root tests to understand if the variables are stationary. The stationarity tests imply that none of our variables are I(2). At this point, ARDL (Autoregressive Distributed Lags) Bounds Approach of Pesaran and Shin (1999) and Pesaran et al. (2001) provide an appropriate structure to analyze both long and short run causality in our variables and hence mixture of I(0) and I(1) variables could be used in the model. Also, we can add different lag length to these variables. It provides us a single equation set-up which makes it easier to interpret (Giles, 2013).

Critical values for the upper and lower levels of the Bounds Test according to Narayan (2005) is given on Table 8. I use Narayan (2005) critical values rather than Pesaran (2001) because it is more suitable for small samples (Badeeb, 2017).

When F-statistic is greater than both lower and upper bounds (I0 and I1) we have significance, while a value between upper and lower bounds is an inconclusive result. The Bounds Test in our case implies that there is a long-run relationship between these variables at 1 percent significance level.

Table 8. ARDL bounds test co-integration results

Estimated Model	Optimal Lags	F-statistic	Cointegration
CO2 = f(CO2,GDP,OP)	(2,1,0)	11.62	Yes

Lower Bound	Upper Bound	
3.57	4.288	10%
4.2	5.03	5%
5.80	6.79	1%

Note: Optimal lag is determined according to SIC criterion. This lag formation is also optimal according to AIC criterion.

Once we get the results with ARDL model, we also need to check the direction of causality between our variables. I employ Toda and Yamamoto procedure to observe whether a significant Granger causality works between the variables.

4.5. Toda and Yamamoto causality test

Toda and Yamamoto approach to Granger causality does not require predetermined stationarity condition (whether I(0), I(1) and I(2)) in the series. The test is also applicable whether the series are co-integrated or not. Toda and Yamamota procedure is based on an augmented VAR modelling and evaluated according to a modified Wald test statistic (Chindo, 2014). Toda Yamamoto uses the maximum order of integration when it augments the VAR lag order. It estimates the (k+ dmax)th VAR. Since our unit root test indicates that our variables are not I(2), we take d=1.

I estimate a VAR with 4 lags (k=3 and d=1) with the following system of equations:

$$\begin{bmatrix} LCO2_t \\ LGDP_t \\ LOP_t \end{bmatrix} = A_0 + A_1 \begin{bmatrix} LCO2_{t-1} \\ LGDP_{t-1} \\ LOP_{t-1} \end{bmatrix} + A_2 \begin{bmatrix} LCO2_{t-2} \\ LGDP_{t-2} \\ LOP_{t-2} \end{bmatrix} + A_3 \begin{bmatrix} LCO2_{t-3} \\ LGDP_{t-3} \\ LOP_{t-3} \end{bmatrix} +$$

$$A_4 \begin{bmatrix} LCO2_{t-4} \\ LGDP_{t-4} \\ LOP_{t-4} \end{bmatrix} + \begin{bmatrix} \varepsilon_{LCO2_t} \\ \varepsilon_{LGDPt} \\ \varepsilon_{LOPt} \end{bmatrix}$$

Then, I check the Toda and Yamamoto causality test results (Table 9):

Table 9. VAR Granger Causality/Block Exogeneity Wald Tests as LCO2 emissions is the regressand

Excluded	Chi-sq	Prob.
LGDP	3.804	0.051
LOPPC	5.398	0.020

The Toda and Yamamoto Causality Test indicates that LCO2 does not Granger cause neither LGDP nor LOP and LOP does not Granger cause neither LGDP nor LCO2 which shows that there is no proof of any direction of causality in these two regressions. However, LGDP and LOP Granger causes LCO2 at 5 per cent significance level. Because of that, I do not further analyze other models of co-integration where LGDP or LOP is specified as regressands.

CHAPTER 5

EMPIRICAL FINDINGS

Table 10 gives us the ARDL estimations results where we have the log of carbon dioxide emissions as the dependent variable. The test results show that there is a significant relationship between carbon dioxide emissions, economic growth and trade openness for Turkey.

Table 10. ARDL Estimation Results, as LCO2 is the dependent variable

Variable	Coefficient	t-statistic
LCO2(-1)	0.486507	3.658516***
LCO2(-2)	0.377265	3.059939***
LGDP	0.834493	8.292605***
LGDP(-1)	-0.454874	-3.530731***
LOP	0.093328	4.438108***
BREAK	-0.041043	-3.15062***
C	-2.545569	-2.028372**
TREND	-0.008082	-2.467123**

In Table 10, we can also see the long run relationship between variables. All regression terms of the model constructed by optimal lag selection are significant. Controlling other factors, 10 per cent increase in economic growth leads to 8 percent increase in carbon dioxide emissions. This is in line with previous studies and hence not a surprise. Turkey is a developing country and has been experiencing average growth rate of 4.69 since 1990 according to the World Bank data. Moreover, it seems that industrialization and manufacturing are major contributors of carbon dioxide emissions (see also Table 4). Thus, the maintaining policies of industrialization are not compatible with sustainable growth.

On the other hand, if we look at the case of trade openness, the regression results indicate that, controlling other factors, a 10 percent increase in trade openness leads nearly a 1 per cent increase in emissions. This is in line with the great majority of studies. To my knowledge, the only different result about trade openness in the context of emissions for the case of Turkey is found in Shahbaz et al. (2017). The results of this study somehow differ from Shahbaz et al. (2017) who make a panel estimation by categorizing countries to the different income groups. Overall, Turkey is a country which has a fast growing energy demand and is able to provide only 26 percent of this demand from domestic resources (MFA). Thus, this could be the main reason for the significant effect of trade openness on carbon dioxide emissions.

Table 11 shows the result of error correction regression. The term CointEq(-1) is the speed of adjustment to long run equilibrium. It is significant at 1 percent significance level and negative which implies that about 13.6 per cent of any disequilibrium is corrected within a year. Thus, a disequilibrium led by a shock on GDP per capita or openness will take about 7 years for carbon dioxide emissions to adjust.

Table 11. ARDL Error Correction Regression, as Δ LCO2 is the dependent variable

Variable	Coefficient	t-statistic
C	-2.553651	-6.977184***
Δ LCO2(-1)	-0.377265	-4.219868***
Δ LGDP(-1)	0.834493	7.312363***
BREAK	-0.041043	-2.137825**
CointEq(-1)	-0.136228	-7.042227***

The model passes several diagnostic tests (Table 12). Histogram-normality test shows that we can reject the null hypothesis which assumes that the series is not normally distributed. Breusch-Godfrey LM test does not detect any serial correlation in the model and according to White test of heteroskedasticity, there is no heteroskedasticity problem in the model.

Table 12. Diagnostic test results

Test	F-statistic	p-value
$\chi^2 NORMAL$	0.934	0.626
$\chi^2 SERIAL$	0.911	0.409
$\chi^2 WHITE$	0.621	0.879

I check the stability diagnostic of the model by applying cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) tests built by by Brown et al. (1975). The results of CUSUM (Figure 7) and CUSUMSQ (Figure 8) tests show that the estimated parameters are stable over time at 5 per cent significance level:

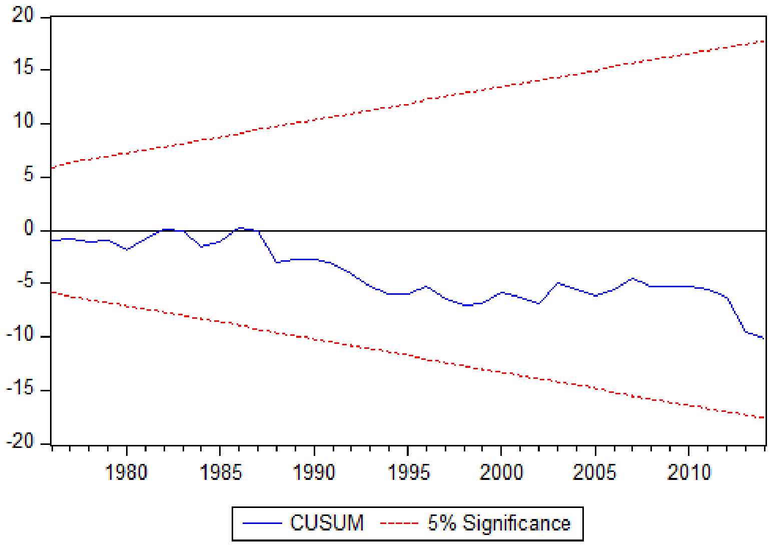

Figure 7. Cumulative sum of recursive residuals

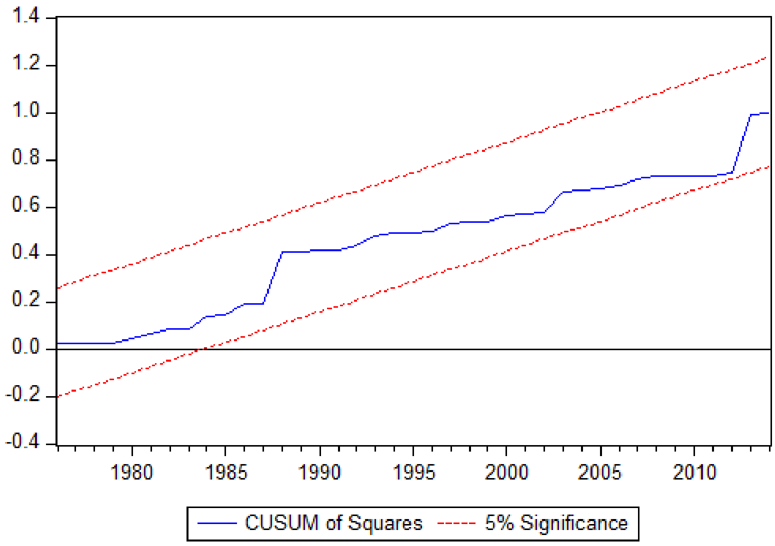

Figure 8. Cumulative sum of squares of recursive residuals

CHAPTER 6

CONCLUSION

In this study, I investigated the relationship between carbon dioxide emissions, economic growth and trade openness. I used the ARDL bounds approach and incorporated a dummy variable to capture the effects of structural breaks in the series. The previous studies which inspect the relationship between economic growth, trade openness and carbon dioxide emissions by building a co-integration model with ARDL bounds testing approach do not consider structural breaks for the case of Turkey. If an existing structural break is not included in a model, there is a risk of rejecting a false unit root null hypothesis. At the end, the model obtained by neglecting such a break may lead biased results (Feridun, 2015 as cited in Perron, 1989). Overall, this study provides a new model which overcomes the problem of structural break in time series analysis to the previous related works dealing with the macroeconomic series of economic growth, trade openness and carbon dioxide emissions.

The results of the ARDL bounds co-integration technique showed that there is a significant short and long run relationship between these variables. To check the causality between variables, I used Toda Yamamoto Granger causality approach. The result of this causality test showed that carbon dioxide emissions does not Granger cause economic growth which can be interpreted as the mitigation policies do not put any pressure on economic growth.

According to test results, economic growth and trade openness are significant contributors to emissions, the first with a higher magnitude. The positive effect of economic growth and trade openness shows that environmental impact may follow the EKC hypothesis for the case of Turkey. Moreover, the rate of carbon dioxide emission growth is not in line with green growth development strategy and Turkey needs to take precautions to reach a more sustainable growth.

All in all, the empirical results show that Turkey with the current composition of trade and economic growth targets should put much more effort on environmental and energy policies to be compatible with its environmental goals.

A further research could incorporate advanced structural break tests to eliminate the effects of crisis periods and reach more robust results. The effect of urbanization on emissions has not been referred in the literature for the case of Turkey. Appropriate time series models could be studied to evaluate the effect of high growth of urbanization on emissions in Turkey.

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