Implication of Coal Expansion and Regional Energy Trading Center to Climate Goal: Dual Sustainability Analysis

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Implication of Coal expansion and regional energy trading center to climate goal: Dual sustainability analysis

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Abstract

This current study seeks to investigate the policy implication of Turkey's recent energy policies on its sustainable development. This study uses Turkey's country-specific data and series of 1974 to 2018 for effective investigation and justification of the findings of this study with emphasis on both short run and long run implications. Three models were fitted to achieve study objectives to accommodate both environmental sustainability and economic impacts. Ecological footprint was considered better measure and used as proxy for the environment related model. In summary, with environment models, the selected series (per capita GDP, Industrialization, agriculture, coal as a single energy use and mixed energy use) except per capita GDP² were found positively and significantly related to ecological footprint both in short run and long run which translates to poor performance of Turkey's environment. Also, using economic growth model, the selected series (Industrialization, energy use and agriculture) were all confirmed positively and significantly related to the economic growth (per capita GDP). Additionally, Environmental Kuznets Curve (EKC) was established for Turkey's environment and economic performance. Furthermore, using Granger causality as robust check to these findings, a nexus was found among the series confirming the validity of the cointegration (short and long run policies) estimations and results. In congruence with literature and hypotheses, the results from cointegration estimation shows that the twin

polices may be good to the economic performance but will spark off adverse effect on environment.

Keywords: ecological footprint; twin policies; coal /energy use; GDP; EKC; Turkey sustainable development.

JEL Classification: C1, C32, E6, L7, O4, Q3, Q4, Q5

1. Introduction

Turkey has remained a mirror of a fast developing, and emerging country through its industrial exploits and growth. Massive changes such as privatization of many state owned industries have been witnessed in Turkish economic development. Among the industries mostly affected are banking, communication and transport industries. With the speed of engulfing into entrepreneurialism, it could be said that Turkey is driving its economy entirely in a new direction. Turkey is considered a connecting link between European and Asian continents because of its strategic location in between the nations. Recently Turkey is named a hub of industrial and business activities within the Asian and European region. This new economic transformation agenda in industrial and manufacturing has placed Turkey as among the fast growing economies, and it is forecasted that Turkey is driving towards becoming one of the 10 largest economies globally in the year 2023 (Yavuz ,2013; Monje, 2008).

Turkey is on the path of both industrial expansion and sustenance of the trend in industry and economic development. Following the industrial expansion and businesses boom in Turkey, energy remains a very significant factor in fostering the prosperity, economic growth and development of the country. Turkey's demand for energy is overwhelming which is forecasted to be on increasing trend even in the future (Ediger, 2011). The country's demand for energy is far greater than its supply. In Turkey's 11th development plan, it is remarked that the country's primary energy demand is expected to increase to 18 percent by 2023 beyond 2018 levels. Turkey's energy demand has been on the increase for some decades because of its rapid industrial development with innovational plans (Kilic and Kaya, 2007). This has exposed Turkey into high importation of two major energy sources (Natural gas and Oil) for sustenance of energy generation in the country. In a way to minimize import of primary energy especially, hard coal and natural gas, Turkey's

authority has initiated the policy of coal expansion and subsidizing of new coal –fired power plants in attempt to increase mining capacity of the country’s widespread lignite coalfields (Cardoso and Turhan, 2018). According to the Ministry of Energy and Natural Resources, Coal position in the energy mix of Turkey is significant, and its power through burning coal meets a greater percentage of the country’s increasing electricity demand. Turkey’s energy mix could be seen from Figure 1 below with oil having a greater percentage followed by coal and gas. The massive industrial revolution in Turkey has put the country in a crossroad to future of its energy, and has equally awaken the need for energy security for the sustenance of the trend of the economic growth via industrial activities. As at 2017, Turkey’s industrial production growth rate was recorded at 9.1 percent (CIA World Factbook, 2019). In order to cushion the effect of high cost of energy sourcing, Turkey has embarked on a twin policies of coal expansion and maximization of Liquefied Natural Gas (LNG) via gas market liberalization. Turkey’s sectoral contribution to the 2017 economic performance could be seen in Table 1 below with agriculture contributing approximately 7 percent, industry contributing approximately 32.3 percent and service contributing 61 percent approximately.

Figure 1. Statistical presentation of Turkey’s energy mix

Source: Compiled by the author with Turkey’s energy data sourced from British Petroleum (BP) data review

Table 1. Turkey’s GDP Composition by Sector

Sector	Percentage contribution
Agriculture	6.8
Industry	32.3
Service	60.7
Labor force in sectors	
Agriculture	18.4
Industry	26.6
Service	54.9

Source: Compiled by author with information from CIA World Factbook, (2019)

Recently, Turkish government has commenced the process of limiting its over dependency on gas importation through alternative sources (expansion of coal and adoption of renewable energy sources). The policy of coal expansion was conceived by the Turkish authorities in support for energy boosting. The domestically harnessed coal was chosen as the preferred fossil fuel for electricity boosting. Much emphasis has been put on the domestic coal because of its presumed energy security which is considered essential and needful for industrial and economic expansion. This has necessitated doubling of the use of domestic coal for power generation as from 2019. Among the steps taken are the commissioning of two new coal power plants in Turkey in 2018 (Yumus Emre and Can-2), and the Soma Kolin Power Plant with additional capacity of 1.2 gigawatts (GW) which resumed operation in June 2019 (Kaya, 2011). Sequel to this, the Ministry of Energy and Natural Resources has encouraged coal-fired power plants by holding tenders for domestic coal lignite and this paved way for launching of 1.3 GW Hunutlu thermal power plant in September, 2019. According to CoalSwarm, Turkey is ranked the 13th largest fleet of operational coal plants globally with 18 gigawatts (GW) coal plants. The vision is to expand this to the tune of 30GW capacity by 2023. This policy does not negate the use of natural gas as natural gas has proven to be the highest source of energy to Turkey, rather, it is geared towards mitigating the dependency rate on import of natural gas. Because of Turkish strategic location and the perceived increase on Liquefied Natural Gas (LNG) globally, the country is seriously working towards making the most benefit of the situation. This is in line with Turkish eagerness to become a gas trading hub considering its strategic position among many countries both in Europe and Asia. This, they plan to achieve by developing both storage and regasification capacities in 2023.

However, with the trend of economic expansion via industrial performance and business boom leading to great stake in energy consumption and security, many energy economist and

environmentalists around the globe are worried as to environment and climate implication of both industrial revolution and the twin policies (coal expansion and natural gas maximization via gas market liberalization) of Turkish authorities. Following the path of industrialization has its environmental cost, just like any other industrialized economies, Turkey has had to pay an environmental price for its industrialization and economic growth expansion. The twin energy policies (coal expansion and gas maximization) of Turkey for energy security through fossil fuels sources which are known with high emitting of air pollution are not unconnected with hampering good environment performance and economic performance. Turkey's emissions have risen significantly over the past decades (CAT, 2019). The main sectors contributing to the rise of carbon emissions in Turkey includes industrial sector (industrial processes and product use), agricultural sector (agricultural activities as it includes cash crop farming, fishing and herders) and waste. These sectors accounted for 73 percent, 13 percent and 3.3 percent of emissions respectively. Air pollution is a major problem across Turkey, especially in the urban areas. Statistics from the Ministry of Environment and Urbanization, Turkey in 2017 shows the ranges of 151 and 200 amount of air pollution in almost every province of Turkey. So many provinces actually have the record of air pollution that exceed 300 which imply the greater environmental hazard via air pollution. Considering the kind of coal accessed in Turkey, the amount of CO₂ emissions in Turkey is on the increasing rate. The share of coal in Turkey's greenhouse gas emissions is accounting to a third of 500 million tons of Turkey's total emissions (Veyisoglu et al., 2016). Cost of coal expansion cut across both the economic and environmental sphere of the country ranging from polluted air, soil to water stressed. Coal production is associated with production of high amount of toxic ashes which are capable of polluting both the air and soil (Waldman and Caliskan, 2017). Powering of coal plant is water intensive project due to the application of wet cooling towers, and this increases the water intake for electricity generation (El-Khozondar, 2017). This has some economic implications when its impact is considered negative on the agriculture and food products via global warming and shortage of water through water stress (Dudu and Çakmak, 2018). In sum, Turkey's environment and climate is fast changing, and the effect will be felt across the country (Reckien et al., (2018): Cardoso and Turhan, 2018).

On the premises of Turkey's twin policies of coal expansion and gas trading via storage and regasification because of the country's economic and industrial expansion, the author undertakes the investigation of both the economic and environment implications of these policies. Also,

because of the industrial expansion following the economic performance of Turkey the current study seeks to research the impact of the current economic performance through industry on the environment performance of Turkey. This is done by testing EKC for the case of Turkey by applying a non-linear and historical pattern of economic growth (economic growth and squared economic growth) and industry in the model for more and valid findings on the policy implication of coal and gas trading in Turkey. Ecological footprint is utilized in this study in measuring environmental performance because of its content and for a comprehensive detail on the environment performance in Turkey. Other studies (Narayan and Narayan, 2010; Pao and Tsai, 2011; Akpan and Akpan, 2012; Sun et al., 1996 and Carlson et al., 2017) have in the past adopted carbon (CO₂) emission and greenhouse gas (GHGs) as the perceived correct proxies to expose the environment performance, however, divergent views from the CO₂ and GHG have considered the ecological footprint (EFP) as the more comprehensive measure of the environmental performance (Rees et al., 1996; Ulucak and Lin, 2017). Human activities in the areas of industrialization and agriculture and other businesses impact heavily on energy consumption and these largely contribute to emissions and increase of ecological footprint (Halicioglu, 2009; Grimes and Kentor, 2003). For this, industrialization and agriculture are considered among the variables in the model because of their importance Turkish economic performance. This study takes on a dual model approach of research to unveil both the environment and economic performance of Turkey under these policies. The study adopts different scientific approaches with different models involving the combination of different fossil fuels (coal, gas and oil) as the energy use on one model, and coal as a single energy source to measure energy use in other model. This is an attempt to expose the real impact of coal to both environment and economic performance of Turkey. Economic growth model was incorporated in this study for understanding of the nexus among the economic growth, industrial growth and energy uses towards Turkey's economic performance. Author utilizes different scientific approaches (such as structural break test, short and long run granger causal analysis for forecasting, Autoregressive Distribution Lag (ARDL) both in linear description (with short and long run) and bound testing of cointegration, and diagnostic analysis.) in making sure that maximum insight is ascertained from this study. This is not the first study on the environmental performance of Turkey, but this study differs from the existing works in the following ways: (a) applying two energy sources (groups [oil, gas and coal] and coal) as single energy use, (b) utilization of industrialization as among the variables to test environment, (c) building on

economic growth model with nexus among the economic growth, industrialization and energy use for insight on the Turkey's economic performance and , (d) the application of ecological footprint as the proxy to measure environment in Turkey for a comprehensive understanding of different dynamics of environmental performance.

Several studies such as (Al-Mulali et al., 2015; Alola et al., 2019; Bagliani et al., 2008; Chen et al., 2006 ; Solarin and Bello, 2018; Wang at al., 2008; Kiviyiro, and Arminen, 2014 ; Ozturk et al., 2016 ; Wang, 2012; Yu-ming, 2010; Neequaye and Oladi, 2015; Xu and Lin, 2015; Ahmed and Long, 2012 ; Tao et al., 2008; Sarkodie and Strezov, 2019 ; Al-Mulali et al., 2015; Dogan et al., 2016; Liu et al., 2017; Bell et al., 2018; Brown et al., 2011; Csereklyei et al., 2016) have applied similar variables in their energy and climate changes and come up with diverse findings.

Al-Mulali et al., (2015) applied ecological footprint as an indicator for environment to Investigate the environmental Kuznets curve (EKC) hypothesis for ninety three countries, the group find EKC for the selected areas; Alola et al., (2019) studied the impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe and they found non-renewable energy use contributing to the environment dilapidation and renewable energy sustaining the environment. Bagliani et al., (2008) applied ecological footprint as a measure to the environment in the analysis of sub-national area: the case of the Province of Siena (Italy) and they found a breakeven total ecological balance. Chen et al., (2006, October) researched on the effect of coal mining on China regional ecological footprint based on GIS, and they found coal mining detrimental to the ecological footprint of the coal mining area. Solarin and Bello, (2018) utilized ecological footprint to researched on the persistence of policy shocks to an environmental degradation index for 128 developed and developing countries. They found evidence of non-reverting mean in the series for 96 countries. Wang at al., (2008) studied the effect of coal exploitation on groundwater and vegetation in the Yushenfu Coal Mine. They found that coal exploitation has adverse effect on ground water and vegetation.

Kiviyiro, and Arminen, (2014) studied carbon dioxide emissions with energy consumption, economic growth, and foreign direct investment and found EKC for the six Sub-Saharan Africa. Ozturk et al., (2016) applied GMM approach to investigate the environmental Kuznets curve hypothesis for the upper middle and higher income. They found a negative relationship between ecological footprints and its determinants for the upper middle and higher income countries. They

also found EKC for the same categories of countries. Wang, (2012) applied EKC hypothesis in modelling the nonlinear relationship between CO₂ emissions from oil and economic growth. The result fails to support EKC. Yu-ming, (2010) researched Kuznets curve analysis of Guangxi ecological footprint and energy consumption. They found inverted U-shaped curve for ecological footprint and energy consumption. Neequaye and Oladi, (2015) investigate environment performance with growth, and FDI and found existence of EKC for carbon emission and greenhouse emissions from the energy and industrial sectors. Xu and Lin, (2015) investigate factors affecting carbon dioxide (CO₂) emissions in China's transport sector. They found EKC hypothesis existing for the case of economic growth and carbon emission. Ahmed and Long, (2012) tested environmental Kuznets curve for Pakistan, and found a supporting result for the EKC hypothesis between economic growth and carbon emission. Tao et al., (2008) tested the environmental Kuznets curve in China. They found long run cointegration relationship between per capita emission and economic growth. Sarkodie and Strezov, (2019) employed a panel data to test the effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. The result supports EKC for India and South Africa. Al-Mulali et al., (2015) tested for the environment Kuznets curve hypothesis, and found inverted U-shaped relationship between carbon emission and the selected series. Dogan et al., (2016) applied ARDL to research the impact of agriculture and Environmental Kuznets Curves in the case of Turkey. They found EKC for the Turkey and negative relationship between agriculture and carbon emission. Liu et al., (2017) investigate the impact of renewable energy and agriculture on carbon dioxide emissions with environmental Kuznets curve in four selected ASEAN countries. The result did not support the EKC in the selected countries.

Bell et al., (2018) research on sustainable bioeconomy in EU and found that it contributes to climate change mitigation and advocate that some land built-ups foster negative carbon emissions. Brown et al., (2011) investigate the energy use implication to the economic growth and found a positive relationship between energy and economic growth. Csereklyei et al., (2016) researched on the relationship between energy and economic growth in a stylized fact and they found a positive relationship between energy and economic growth. Ohlan, (2016) researched on the implication of renewable and nonrenewable energy consumption and economic growth in India and found a positive effect of energy use on Indian economic growth.

The rest of this current study is structured as follows: the second section gives a detailed theoretical background of the study. The third, fourth and fifth sections analyze the methodology, empirical analyses and conclusion of the paper, respectively.

2. Theoretical background

The theoretical background of this study is based on the Environmental Kuznets Curve (EKC) hypothesis. The supporters of Kuznets curve question the reliability of the linear and direct relationship between environment quality and economic growth (per capita income). Kuznets (1995) was the initiator of EKC hypothesis when he investigates the relationship between the per capita income and income inequality. He argued that the income inequality gap is reduced at a turning point where the rural farmers switched to white-collar jobs which give them access to higher per capita income. After the introduction of the Kuznets curve, many environmentalists and energy economists have started applying the hypothesis to test the environment quality with respect to historical pattern of economic growth. The first proponents of environmental Kuznets curve are Grossman and Krueger, (1991), Shafik and Bandyopadhyay, (1992) and Panayotou, (1993). The EKC hypothesis is adopted to monitor the performance of environment while the economy is growing. The proponents of EKC theory came up with the view of historical pattern of economic growth, and hence group the pattern into 3 effects. The scale effect, structural/technical effects and composite effect. This is demonstrated with the figure below

Figure 2. Environmental Kuznets Curve

3. Materials and Methods

3.1. Model specification, variables and data

The model specification is based on the theoretical background of this study, EKC, with different models that accommodate different selected variables for different purposes. The two basic models are the environment and economic growth models. The environment model presents the impact of the explanatory variables (GDP per capita, squared GDP per capita, industrialization, agriculture, fossil fuel energy mix and coal energy use) on the dependent variable (ecological footprint), while the economic growth model presents the impact of the selected explanatory variables (industrialization, agriculture and energy use) on the dependent variable (economic growth). Also, in attempt to have insight on the direct impact of coal as an energy source, the environment model is further split into two models, one with fossil fuel energy mix and the other with just coal as a single energy use. The model specification of ARDL bound testing for cointegration (for short run and long run) estimations and analysis is also based on Pesaran and Shin, (1998) and Pesaran et al., (2001) modelling of the cointegration. Hence, the specifications are presented in the equations below as follows:

$$EFP = (Y, Y^2, Ind, Eu, AG) \quad (1)$$

$$EFP = (Y, Y^2, Ind, COAL, AG) \quad (2)$$

$$Y = (Ind, Eu, AG) \quad (3)$$

From Eq.(1)→(3), *EFP* is ecological footprint as an environmental indicator or a measure of environmental dilapidation; *Y* and *Y*² are GDP per capita and GDP per capita squared for measure of economic growth respectively; *Ind* is a measure of industrialization; *EU* is a measure of mix energy use/consumption; *AG* is agriculture, and *COAL* represent the coal as a single energy use. The above equations are re-specified in an estimable econometrics and empirical forms as follows:

3.1.1 Econometric form

$$EFP = a_1 + a_2 Y_{it} + a_3 Y_{it}^2 + a_4 Ind_{it} + a_5 EU_{it} + a_6 AG_{it} + \mu_{it} \quad (4)$$

$$EFP = a_1 + a_2 Y_{it} + a_3 Y_{it}^2 + a_4 Ind_{it} + a_5 COAL_{it} + a_6 AG_{it} + \mu_{it} \quad (5)$$

$$Y = a_1 + a_2 Ind_{it} + a_3 EU_{it} + a_4 AG_{it} + \mu_{it} \quad (6)$$

3.1.2 Empirical model

$$\ln EFP = a_1 + a_2 \ln Y_{it} + a_3 \ln Y_{it}^2 + a_4 \ln Ind_{it} + a_5 \ln EU_{it} + a_6 \ln AG_{it} + \mu_{it} \quad (7)$$

$$\ln EFP = a_1 + a_2 \ln Y_{it} + a_3 \ln Y_{it}^2 + a_4 \ln Ind_{it} + a_5 \ln COAL_{it} + a_6 \ln AG_{it} + \mu_{it} \quad (8)$$

$$\ln Y = a_1 + a_2 \ln Ind_{it} + a_3 \ln EU_{it} + a_4 \ln AG_{it} + \mu_{it} \quad (9)$$

All the variables have been defined as they first appeared in Eq.(1)→(3), the sample period which is 1974-2018 is represented with t. μ_{it} is the error term, and a_i denotes the parameter or the coefficient to be estimates and analyzed, where $i = 1, 2, 3, 4, 5$ and 6. All variables are expressed in their natural logarithmic form. Ecological footprint (measured in gha per person) is used as a better option of indicator to measure or proxy to the environment. As noted earlier that ecological has gained a maximum support for a good proxy to environment by different scholars (Bagliani et al., 2008; Wang et al., 2013; Al-Mulali et al., 2015; Ozturk et al., 2016; Uddin et al., 2017; Alola et al., (2019); Ulucak and lin, 2017; Solarin and Bello, 2018; Katircioglu et al., 2018; Duman et al., 2019). Turkey's ecological footprint components can be grouped with percentage of each component as follows; cropland footprint with 53 percent, carbon footprint with 17 percent, grazing land footprint with 16 percent, forest land footprint with 9 percent, and fishing ground footprint and built-up land footprint with 4 and 1 percent respectively. This is presented in the figure below:

291

292 Figure 3. Turkey Ecological Footprint per person

293 Source: Prepared by author with Global Footprint Network 1961-2016 Data

As displayed in figure 2 above, cropland footprint has the largest share in Turkey's ecological footprint followed by the carbon footprint emission. This portray a change in the Turkey's ecological footprint, hence, carbon footprint was reported to have the largest share from 1961 to 2014 (Global Footprint Network, 2012).

Economic growth is measured as real GDP per capita (constant 2010 US\$) with squared real GDP per capita shown the turning point in EKC theory (Kiviyiro and Arminen, 2014). Industrialization is a measure of manufacturing or industry valued added (Opoku and Boachie, 2020). AG is a measure of agriculture value added (constant 2010 US\$) and it comprises cropland and farming, forestry and fishing (Liu et al., 2017 and Ullah et al., 2018). EU and COAL measure the energy use/consumption of Turkey. While, EU comprises of the basic energy sources (oil, natural gas and coal), COAL was used as a single energy source in a different model. The reason for this, is the author's interest on the significant impact rate of coal in Turkey's environment following the coal expansion policy of the country. They are expressed in million tonnes oil equivalent. The summary and definitions of the variables and their measurements are shown in Table 1 below

Table 2. Summary of Variables

Variables	Short forms	Measurements	sources	Literature
Ecological Footprint	EFP	Constant Per capita	Global Footprint Network (2018)	Al-Mulali et al., 2015; Ozturk et al., 2016; Uddin et al., 2017; Ulucak and lin, 2017
GDP per capita	Y	Constant 2010US\$	Updated WDI, 2019	Kiviyiro and Arminen, 2014
GDP per capita squared	Y ²	Constant 2010US\$	Updated WDI, 2019	Kiviyiro and Arminen, 2014
Industrialization	Ind	Constant 2010US\$	Updated WDI, 2019	Opoku and Boachie, (2020).
Energy Use	EU	million tonnes oil equivalent	British Petroleum (BP) Statistical Review of World Energy, (2019).	Shahbaz et al., (2017)

COAL	COAL	million tonnes oil equivalent	British Petroleum (BP) Statistical Review of World Energy, (2019).	Yu-ming, (2010); Chen et al., (2006, October);
Agriculture	AG	Constant 2010US\$	Updated WDI, 2019	Liu et al., 2017 and Ullah et al., 2018

309 Source: Authors Compilation

310 With the level of industrial progression in Turkey which is characterized by excessive energy
311 (fossil fuel) use, it is expected that the parameter (a_4) will be positively related to environment
312 degradation as proxy with ecological footprint. In the same manner, the parameters (a_5) of energy
313 use and coal which are majorly dependent on fossil fuels are expected to have positive relation
314 with environment degradation. The parameter (a_6) of agriculture is hypothesized to be positive
315 considering the major components of the ecological footprint are agriculture related and the
316 activities (such as land reclamation, chemical utilization, herders activities) that are obtainable in
317 the sector are capable of emitting greater percentage of pollution. Also, for the EKC to hold, the
318 parameters (a_2 & a_3) of GDP per capita and squared GDP per capita are expected to be positive
319 and negative respectively (Wang, 2012).

320 The data for this study spanned from 1974-2018 and were sourced from different sources ranging
321 from Global Footprint Network, 2019 for ecological footprint to British Petroleum (BP) Statistical
322 Review of World Energy, (2019) for energy use and coal, and World Development Indicator
323 (WDI, 2019) for GDP per capita, Industrialization and agriculture. The selected period of this
324 study was influenced by the availability of data for the selected variables. Turkey as a choice and
325 focused of this study is based on the current industrial and economic expansion of the country
326 coupled with the recent energy related policies of the authorities of Turkey.

327 **4. Empirical methodology, result and discussion**

328 The empirical methods employed in this research are descriptive statistics, unit root testing,
329 structural break test, optimal lag selection, cointegration test, and causality analysis.

330 Descriptive statistics was used in this study to confirm the characteristics and the suitability of the
331 data applied in this study. Among the features of the descriptive statistics are mean, median,
332 minimum and maximum, skewness, kurtosis and Jarque-bera. The size and the variability of the

data and the variables are highlighted with the features such as mean, median, standard deviation, minimum and maximum, while the stability, normality and the conformity of the data to symmetric or asymmetric is tested with skewness, kurtosis and Jarque-bera. On the size of the data and the variables, with consideration on the minimum and maximum, GDP per capita is the highest among the variables followed by energy use and coal. Also, based on mean variable with the highest variability is GDP per capita followed by energy use and coal. The normality of the data is accessed and determined with the probability (significance) of Jarque-bera in the variables. While ecological footprint, GDP per capita, Agriculture, coal and energy use are normally distributed the hypothesis of normally distributed is rejected in some variable (Industry). Considering the level of normality of the data and the variables which is relatively higher than the variable that is not normal, author considers linear scientific approach the best method for estimates and analyses of this study.

Table 3. Summary of statistics

Variable	LEFP	LGDPPC	LINDUS	LAGRIC	LCO2	LCOAL_	LENERGY
Mean	2.645040	7969.491	1.17E+11	5.44E+10	176.1279	18.82227	57.68679
Median	2.644677	7343.321	9.51E+10	5.09E+10	161.2510	17.13300	51.98004
Maximum	3.392690	14062.73	3.03E+11	8.29E+10	366.0368	38.45745	124.1634
Minimum	1.927702	4744.443	3.43E+10	3.90E+10	56.47165	5.694000	17.11888
Std. Dev.	0.446448	2660.151	7.59E+10	1.16E+10	89.41807	9.741478	31.49406
Skewness	0.219819	0.792812	0.964591	0.892942	0.476781	0.402741	0.516486
Kurtosis	1.734018	2.603130	2.920598	2.838702	2.103494	2.106593	2.088538
Jarque-Bera	3.217821	4.786808	6.679421	5.760919	3.069131	2.592502	3.400214
Probability	0.200106	0.091318	0.035447	0.056109	0.215549	0.273555	0.182664
Sum	113.7367	342688.1	5.05E+12	2.34E+12	7573.499	809.3574	2480.532
Sum Sq. Dev.	8.371266	2.97E+08	2.42E+23	5.66E+21	335814.9	3985.648	41658.78
Observations	43	43	43	43	43	43	43

Source: Computed by the author

4.1 Unit root/stationarity

Unit root/stationarity is adopted in this study to test the stationarity and the order (I(0), I(1) or mixed order) of integration. Time series data are known with instability that beclouds the scientific assessment of the data with respect to study. It is essential to test the stationarity of time series in any country specific analysis to make sure the approach, analysis and findings are obtained. The current study employed both the conventional (Philip-Perron (Perron, 1990), Augmented Dickey-Fuller (ADF, 1979), and Kwiatkowski-Philips-Schmidt-Shin (Kwiatkowski et al.,1992)

approaches of ascertaining the unit root and Dickey-Fuller structural break as a robust check to the findings of the conventional methods. Most times, conventional approach are weak in the face of structural break that might have impacted heavily on the movement of the variables selected to study an economy. Such structural break always leaves a permanent impact (shock) or break in the economy. Example of such structural break is the present COVID 19 pandemic that have left remarkable impact on the global economy. From the conventional approach, the author found the data non-stationary at level and most of the variables in the data are integrated at $I(1)$ except ecological footprint. In summary, unit root and mixed order of integration was uncovered. Going further to test reliability of the findings from the conventional method of unit root testing, Dickey-Fuller structural break method was employed for robust checking. Structural break established that the variables have unit root in the face of structural changes in the following year 1979 for ecological footprint, 2005 for energy consumption, 2007 for GDP per capita, 2000 for industrialization, 2000 for Agriculture, and 2000 for coal consumption. From the accounted dates, the structural changes that affected the selected variables spanned from 1979 to 2007, of which majority of the shocks or changes occurred during the period of 2000 as it appeared in majority of the variables (industrialization, agriculture and coal consumption). The periods of the shocks were all well accommodated in the period of this study, 1974-2018. Within these periods, two notable structural changes (energy shock and monetary policy) occurred that are capable of leaving a permanent shock to the economies of many nations including Turkey and impact the stability of their data and variables in research study. Specifically, oil crises that took place in 1979 through 2000's exemplified the structural shock from the angle of energy crisis. The shocks came as a result of fluctuations in the oil prices caused by the level of production and supply of oil due to some political instability and macroeconomic policies of the involved economies. Among the pioneers of the energy shocks was the 1979 oil crisis caused by Iranian Revolution of 1979. The global oil supply decreased because of the shutdown of production due to revolution and this pushed up the price of the product and this created a global shock. Even the 1980 Iraq-Iran war affected the oil production capacity of the region which caused another global energy crisis. Also, the 1990 Iraq's invasion of a fellow OPEC member, Kuwait caused another energy crisis that was short lived before the 2000's energy crisis (Hamilton, 2009; Roubini and Setser, 2004). Moreover, the worries of energy crisis that took place in 2000's are majorly caused by the middle East tension, excessive demand of oil by China and the fall of value on U.S dollar. There was an upward trend

of rise in oil price especially, from 2003-2008. Another, notable structural change was introduced by the monetary policy of U.S which affected its domestic economy with that of the foreign countries that pegged their exchange rate to U.S currency. U.S in a bid to enhance and boost its export and investment policies devalued its currency, and this affected the economy of other countries including Turkey who pegged their currencies to U.S currency. As the U.S export and investments are increasing, the export and investment of the foreign countries that pegged their currencies to U.S currency are decreasing because their currencies appreciate thereby making the prices of their products increases because of their currency appreciation. Turkey was among the victims of this monetary policy of U.S and the structural changes which are capable of impacting the stationarity of the variables involved. Turkey's experience of sever financial crises in 2001 and the 2008/9 global financial meltdown contributed to the Turkey's structural change capable of interfering with the stability of its economic indicators. The output of both conventional unit root test and the structural shock are presented in the tables 3&4 below.

Table 4. Stationarity Test

Variables	@ LEVEL		1 st Diff		Decision
	With intercept	intercept & trend	With intercept	intercept & trend	
<i>PP</i>					
LEFP	-1.0313	-5.0577**	-12.5647***	-12.5154***	MIXED
LGDP	3.3174	-0.4284	-5.6514***	-6.6709***	I(1)
LEU	4.7674	0.7248	-6.1549***	-8.6953***	I(1)
LIND	5.4141	0.6351	-4.7499***	-5.7347***	I(1)
LAGR	3.1771	-0.7465	-10.7282***	-14.4175***	I(1)
LCOAL	1.9470	-2.2467			
<i>ADF</i>					
LEFP	-0.5784	-4.9574**	-10.7182***	-10.5901***	MIXED
LGDP	2.2112	0.4869	-5.6288***	-6.4166***	I(1)
LEU	2.3161	-1.0320	-6.1529***	-7.2360***	I(1)
LIND	3.0763	-0.0292	-4.7499***	-5.6953***	I(1)
LAGR	2.6780	0.2735	-10.7282***	-11.8826***	I(1)
LCOAL	1.3186	-2.2467	-8.9515***	-9.2881***	I(1)

			<i>KPSS</i>	
LEFP	0.7955***	0.0918	0.0538	0.0540
LGDP	0.8110***	0.2044**	0.5111**	0.0888
LEU	0.8389***	0.2170**	0.6375**	0.1273*
LIND	0.7937**	0.2085**	0.6438**	0.1332*
LAGR	0.8041***	0.2040**	0.3625*	0.1778**
LCOAL	0.8364***	0.1780**	0.2773	0.0902

Notes: a: (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1% (b): P-value according to (1) Maclean et al., (1996) one-sided p-values (2) Kwiatkowski-Phillips-Schmidt-Shin (1992,)

Table 5. Structural break test

<i>Variable</i>	<i>ADF</i>	<i>P-value</i>	<i>Lag</i>	<i>Break date</i>	<i>CV(1%)</i>	<i>CV(5%)</i>
<i>Level</i>						
LEFP	-5.861787	<0.01***	9	1979	-5.3476	-4.8598
LGDP	-4.003455	0.5188	9	2007	-5.7191	-5.1757
LEU	-2.3766	0.99	9	2005	-5.3476	-4.8598
LIND	-4.477960	0.2469	9	2000	-5.719	-5.176
LAG	-6.623704	<0.0***	9	2000	-5.719	-5.176
LCOAL	-5.310380	<0.035	9	2000	-5.719	-5.176
<i>1st Diff</i>						
LEFP	-10.71129	< 0.01 ***	9	1993	-5.3476	-4.8598
LGDP	-7.590529	< 0.01 ***	9	2009	-5.7191	-5.1757
LEU	-7.81889	< 0.01***	9	2007	-5.3476	-4.8598
LIND	-7.56522	< 0.01***	9	2009	-5.719	-5.176
LAG	-13.12988	< 0.01***	9	2007	-5.719	-5.176
LCOAL	-10.47145	< 0.01***	9	2012	-5.719	-5.176

Notes: a: (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%

Source: Authors computation

4.2 Test for Cointegration (both the short and long run) and diagnostic tests

This study applied Bound (ARDL) testing approach to test for the cointegration of the model. That is if the variables are cointegrated, and whether there exist long run relationship among the variables. Both the long run and short run (error correction) relationships were determined with bound testing. To test for the cointegration, it is hypothesized that there is no cointegration or long run relationship between the variables with null hypothesis as $H_0 = \text{long run coefficients (e.g. } a_1 = a_6 = 0, F - \text{stat} < \text{bounds})$, and there is cointegration or long run relationship between the variables with alternative hypothesis as $H_1 = \text{long run coefficients (e.g. } a_1 = a_6 \neq 0, F - \text{stat} > \text{bounds})$. In sum, when the F-stats is greater than bound values (upper bounds $I(0)$) and lower bounds ($I(1)$), the null hypothesis is rejected and vice versa. The approach (Bound testing) applied in the current study has some striking advantages over the other methods (Engle and Granger, 1987; Johansen 1988 and Johansen and Juselius, 1990) in determining the cointegration and long run relationship between the variables. Among the disadvantages of both Engle and Granger, (1987) and Johansen, (1988) are the biasness of small sample from exclusion of short run dynamics (Alam and Quazi, 2003) and the rigidity method of the acceptable order of integration ($I(1)$) respectively. The Autoregressive Distribution Lag (ARDL) and Bound testing approach initiated by Pesaran et al., (2001) has the ability to test the cointegration and the long run relationship between the variables in a mixed order ($I(0)$, $I(1)$ or mixed order). Also, the bound approach has the ability to test the cointegration even when the explanatory variables are endogenous and equally suitable for smaller samples. Following the Pesaran and Shin (1998) and Pesaran et al., (2001), the model specifications for the long run and the short run (Error correction model) are as follows:

$$\begin{aligned} \ln EFP_t = & \emptyset + a_1 \ln EFP_{t-1} + a_2 \ln Y_{t-1} + a_3 \ln Y^2_{t-1} + a_4 \ln Ind_{t-1} + a_5 \ln EU_{t-1} + \\ & a_6 \ln AG_{t-1} + \sum_{i=0}^{\rho-1} \delta_1 \Delta \ln EFP_{t-i} + \sum_{i=0}^{q-1} \delta_2 \Delta \ln Y_{t-i} + \sum_{i=0}^{q-1} \delta_3 \Delta \ln Y^2_{t-i} + \\ & \sum_{i=0}^{q-1} \delta_4 \Delta \ln Ind_{t-i} + \sum_{i=0}^{q-1} \delta_5 \Delta \ln EU_{t-i} + \sum_{i=0}^{q-1} \delta_6 \Delta \ln AG_{t-i} + ECM_{t-i} + \mu_t \end{aligned} \quad (10)$$

$$\begin{aligned} \ln EFP_t = & \emptyset + a_1 \ln EFP_{t-1} + a_2 \ln Y_{t-1} + a_3 \ln Y^2_{t-1} + a_4 \ln Ind_{t-1} + a_5 \ln COAL_{t-1} + \\ & a_6 \ln AG_{t-1} + \sum_{i=0}^{\rho-1} \delta_1 \Delta \ln EFP_{t-i} + \sum_{i=0}^{q-1} \delta_2 \Delta \ln Y_{t-i} + \sum_{i=0}^{q-1} \delta_3 \Delta \ln Y^2_{t-i} + \\ & \sum_{i=0}^{q-1} \delta_4 \Delta \ln Ind_{t-i} + \sum_{i=0}^{q-1} \delta_5 \Delta \ln COAL_{t-i} + \sum_{i=0}^{q-1} \delta_6 \Delta \ln AG_{t-i} + ECM_{t-i} + \mu_t \end{aligned} \quad (11)$$

$$\begin{aligned}
432 \quad \ln Y_t &= \emptyset + a_1 \ln Ind_{t-1} + a_2 \ln EU_{t-1} + a_3 \ln AG_{t-1} + \sum_{i=0}^{p-1} \delta_1 \Delta \ln Y_{t-i} + \\
433 \quad \sum_{i=0}^{q-1} \delta_2 \Delta \ln Ind_{t-i} &+ \sum_{i=0}^{q-1} \delta_3 \Delta \ln EU_{t-i} + \sum_{i=0}^{q-1} \delta_4 \Delta \ln AG_{t-i} + ECM_{t-i} + \mu_t \quad (12)
\end{aligned}$$

434 The variables in equations (10) $\rightarrow$ (12) have been defined in the previous equations above. The
435 signs Δ , a_1 , δ_1 , ECM_{t-i} and μ_t are the notation of first difference (Δ) of the selected variables
436 which identifies the short run relationship between the variables, long run parameters or coefficient
437 ($a_1 \rightarrow a_6$) of the variables, short run parameters or coefficient ($\delta_1 \rightarrow \delta_6$) of the variables, the error
438 correction model (ECM_{t-i}) which shows the speed of convergence or adjustment to the
439 equilibrium level in times of structural changes in the economy, and white noise error term (μ_t).

440 Table 6, 7 and 8 display the outcome of the cointegration (both the short and long run) relationships
441 that exist between the selected variables in the above specified models. The output of the following
442 tests; goodness of fit, autocorrelation/serial correlation, bound testing of cointegration,
443 heteroscedasticity and CUSUM² from all the tables are explained together as follows: The
444 goodness of fit for the three (3) models are represented with R^2 (0.992650; 0.991; 0.9987) and
445 Adjusted R^2 (0.987537; 0.986; 0.9985) respectively. The outputs show the part of dependent
446 variables for the three (3) models that are explained by the explanatory variables, while the
447 remaining are explained by the residuals. Durbin Watson tests for the three (3) models confirmed
448 absence of autocorrelation and serial correlation, and they are shown as from the tables as
449 (1.786571; 1.9585; 1.94), LM serial correlation test rejects the null hypothesis of the presence of
450 serial correlation in all the models with insignificant results of both Chi-square and p-values. The
451 bound testing of cointegration for the three (3) models confirmed the variables cointegrated at 1
452 percent significant level as displayed in the various tables of 6, 7 and 8. Optimal lag for the three
453 (3) models were determined with Akaike Information Criterion (AIC) and 3 was considered the
454 appropriate lag. Error Correction Model (ECM) for the three (3) models were tested to confirm the
455 speed of adjustments and the outcomes show negative coefficients (-0.11273; -0.3045; -0.568) and
456 highly significant at 1 percent level each. This shows the ability of the dynamic model to return
457 back to equilibrium level after a certain level of disequilibrium at the speed level of 0.1%, 0.3 and
458 0.6 respectively. The existence of negative coefficient with high significant level also confirmed
459 the existence of long run relationship between the variables. The reliability and stability of the
460 models were confirmed with CUSUM & CUSUM2 outputs as pictured in figures 3,4,5,6,7 and 8

below the Table 8. From table (6), The short run and long run effects of the explanatory variables (per capita GDP, per capita GDP², Industrialization, Energy use and Agriculture) on environmental performance (ecological footprint) as represented in the first model are presented and interpreted as follows: a short run and long run (elasticity) positive relationship at 1 percent significant level is established between environment performance (ecological footprint) and economic growth (per capita GDP). The scale of the effect as shown by the values of the short run and long run coefficients (0.001001) is relatively small. This translate to numerical expression as a one percent increase in economic growth will lead to 0.001001 percent increase in ecological footprint in both short and long run respectively. This means that as the expansion of the economic performance/growth will translate to a relatively small level of dilapidated environment of Turkey. This is in line with the author's expectation. A short and long run negative (elasticity) relationship is established at quadratic point between environment (ecological footprint) and economic growth (per capita GDP²) at 1 percent significant level. This translates to positive effect of economic performance on environment performance at a turning point. It means that as the economy is growing at this level, there is less of environment dilapidation amounting to improvement in the quality of Turkey's environment. Quantitatively, a one percent increase in economic growth (per capita GDP²) will lead to -0.00579 percent decrease on ecological footprint (less environment dilapidation) in both short and long run respectively. This is a good trend for the Turkey's sustainable development and hence, a confirmation of inverted U-shape of Environmental Kuznets Curve (EKC) for Turkey. This supports the assertion of Wang, 2012 and findings of Narayan and Narayan, (2010); Neequaye and Oladi (2015); Xu and Lin, (2015); Ahmed and Long (2012); Song et al., (2008). A positive (elasticity) relationship is found between industrialization and environment (ecological footprint) in both short run and long run at 5 and 1 percent respectively. This is a pointer that the Turkey's experience of industrial expansion does not go without environmental implication. The environmental implication of Turkey's industrialization is negative which validates author's expectation. This shows that Turkey is still practicing and running a carbon filled economy and yet to adopt green economy. It is a sign that most manufacturing and industrial activities in Turkey are energy intensive which is anchored on fossil fuels (oil, natural gas and coal) energy sources. Numerically, this translates to a one percent increase in industrialization amounts to 0.00133 percent increase in environmental dilapidation in both short and long run. This supports the findings of Liu and Bae, (2018). Shahbaz et al., (2014b);

Hossain, (2011); Cherniwchan, (2012). Also, a positive relationship established between energy use and environment (ecological footprint) both in short run and long run at 1 percent respectively. This is not surprising when consider the energy mix of the energy source of Turkey which are mostly fossil fuels. Excessive utilization of nonrenewable energy sources impacts the environment via air pollution. Energy utilization cuts across all the facets of Turkey's sector ranging from transportation to industry and agriculture. This equally validates the authors expectation of the existence of positive relationship between energy use and Turkey's environment. Hence, a one percent increase in energy use will lead to 0.018030 percent increase in ecological footprint (environment dilapidation) both in short and long run. This supports the findings of Sarkodie and Strezov, (2019) for developing nations; Ozturk et al., (2016) for the case of 144 countries; Al-Mulali et al., (2015). A positive (elasticity) relationship is initiated between agriculture and the environment (ecological footprint) both in short run and long run at 5 percent significant level. This means that as the agricultural activities are inducing environment quality negatively. This backs the revelation on the figure 2 where the component parts of agricultural activities dominate the greater portion of the Turkey's ecological footprint. This translates to a one percent increase in agriculture will lead to 0.00118 percent increase in ecological footprint (dilapidated environment) both in short run and long run. This validates the authors expectation and supports the findings of Dogan, (2016) for Turkish; Liu et al., (2017) for ASEAN and Ullah et al., (2018) for Pakistan.

From the table 7, the similar findings were established except in some cases especially on the part of COAL as the energy source. Hence, the models as expressed in table 6&7 are same except the switch of the two-energy source (i.e., the complete energy source and coal). The short run and long run effects of the explanatory variables (per capita GDP, per capita GDP², Industrialization, COAL and Agriculture) on Turkey's environment performance (ecological footprint) as represented in the second model are presented and interpreted as follows: With the exception of per capita GDP², positive relationships were found between ecological footprint and all the selected explanatory variables (per capita GDP, Industrialization, COAL and agriculture). Hence, a positive (elasticity) relationship is found between economic growth (per capita GDP) and the environment (ecological footprint) in both short and long run respectively at 1 percent significant level. The scale of the effect as shown by the values of the short run and long run coefficients (0.00103) is relatively small. This is numerical expressed as a one percent increase in economic growth will lead to

0.00103 percent increase in ecological footprint in both short and long run respectively. This means that as the expansion of the economic performance/growth will translate to a relatively small level of damaged environment of Turkey. This is in line with the author's expectation. A short and long run negative (elasticity) relationship is established at quadratic point between environment (ecological footprint) and economic growth (per capita GDP²) at 1 percent significant level. This translates to positive effect of economic performance on environment performance at a turning point. It means that as the economy is growing at this level, there is less of environment damage amounting to improvement in the quality of Turkey's environment. Quantitatively, a one percent increase in economic growth (per capita GDP²) will lead to -0.00523 percent decrease on ecological footprint (less environment dilapidation) in both short and long run respectively. This is a good trend for the Turkey's sustainable development and hence, a confirmation of inverted U-shape of Environmental Kuznets Curve (EKC) for Turkey. This supports the assertion of Wang, 2012 and findings of (Narayan and Narayan, (2010); Neequaye and Oladi (2015); Xu and Lin, (2015); Ahmed and Long (2012); Song et al., (2008). A positive (elasticity) relationship is found between industrialization and environment (ecological footprint) in both short run and long run at 1 and 10 percent significant level respectively. This is a pointer that the Turkey's experience of industrial expansion does not go without environment implication. The environment implication of Turkey's industrialization is negative which validates author's expectation of positive sign in relationship between ecological footprint and industrialization. This shows that Turkey is still practicing and running a high carbon economy. It is a sign that most manufacturing and industrial activities in Turkey are energy intensive which is embedded on fossil fuels (oil, natural gas and coal). Numerically, a one percent increase in industrialization amounts to 0.0010 and 0.00104 percent increase in environment dilapidation in both short and long run respectively. This supports the findings of Liu and Bae, (2018); Shahbaz et al., (2014b); Hossain, (2011); Cherniwchan, (2012). Also, a positive relationship established between COAL and environment (ecological footprint) both in short run and long run at 1 percent respectively. This is not surprising when consider the amount of emission from coal as the energy source in Turkey. This equally validates the authors expectation of the existence of positive relationship between COAL and Turkey's environment. Hence, a one percent increase in COAL will lead to 0.0177 percent increase in ecological footprint (environment dilapidation) both in short and long run. This supports the findings of Yu-ming, (2010); Chen et al., (2006, October); Wang et al., (2008). A positive

(elasticity) relationship is initiated between agriculture and the environment (ecological footprint) both in short run and long run. This means that the agricultural activities are inducing environment quality negatively. This backs the revelation on the figure 2 where the component parts of agricultural activities dominate the greater portion of the Turkey's ecological footprint. This translates to a one percent increase in agriculture will lead to 0.0075 percent increase in ecological footprint (dilapidated environment) both in short run and long run. This validates the authors expectation and supports the findings of Dogan, 2016 for Turkish, Liu et al., 2017 for ASEAN and Ullah et al., 2018 for Pakistan.

Table 8 presents the result of economic growth model. The short run and long run effects of the explanatory variables (Industrialization, Energy use and Agriculture) on Turkey's economic performance (per capita GDP) as represented in the third model are presented and interpreted as follows: A positive (elasticity) relationship is found between economic growth and industrialization both in short run and long run at 1 percent significant level. This shows that Industrialization has a positive impact on Turkey's economic growth. Hence, numerically, a one percent increase in Industrialization will lead to 0.0035 percent increase in economic growth (per capita GDP) in both short and long run respectively. This validate author's expectation and support the findings of Ossadzifo, (2018); Opoku and Yan, (2019); Park, (2011). This is expected from Turkey's economy because of the strategic position of the country and according to the sectorial structure of the economy, manufacturing sector which is factored in industrialization is among the highest contributor to the economic growth of Turkey, see Table 1. A positive (elasticity) relationship is established between economic growth (per capita GDP) and agriculture both in short run and long run respectively. Quantitatively, a one percentage increase in agriculture increase the economic growth (per capita GDP) 0.0035 percent at 5 percent significant level. This is equally expected because Turkey is known with its global impact via farming and agricultural products. This supports the findings of Awokuse, (2009); Raza et al., (2012); Tsakok and Gardner, (2007); Kaya et al., (2012). Also, a positive (elasticity) and significant relationship is initiated between energy use and economic growth in both short run and long run. Virtually, all the sectors of Turkish economy are energy intensive, which translate into energy impacting the economy both directly and indirectly. This is shown with the scale of its (energy use) effect on economic growth, hence, a one percent increase in energy use will lead to 16.5929 percent increase in economic growth (per capita GDP). This is not surprising considering the level of energy utilization in

585 Turkish economic performance. This finding supports the findings of Csereklyei et al., (2016);
 586 Ohlan, (2016); Brown et al., (2011); Siddiqui, (2004)

587 Table 6. Cointegration (ARDL) assessments of EFP model with energy use

Variables	Coefficients	SE	t-statistics	P-value
<i>Short-path</i>				
D(LGDP)	0.001001	0.000114	8.804143	0.0000***
D(LGDP ²)	-0.00579	0.000811	-7.139889	0.0000***
D(LIND)	0.00133	0.000339	3.932820	0.0007***
D(LEU)	0.018030	0.004229	4.263579	0.0003***
D(AGR)	0.00118	0.000550	2.152015	0.0421**
CointEq(-1)*	-0.11273	0.103030	-10.800	0.0000***
<i>Long-path</i>				
LGDP	0.001001	0.000162	6.160098	0.0000***
LGDP ²	-0.00579	0.00120	-4.817059	0.0001***
LIND	0.00133	0.000488	2.731128	0.0119**
LEU	0.018030	0.005464	3.074587	0.0054***
LAGR	0.00118	0.000550	2.152015	0.0421**
Constant	-1.982301	0.441023	-4.494782	0.0002***
R ²	0.992650			
Adj.R ²	0.987537			
D.Watson	1.786571			
<i>Bound test(Long-path)</i>				
F-statistics	13.2154***	K=5,@ 1%	I(0)bound=3.5	I(1)bound=4.63
<i>Wald test(short-path)</i>				
F-statistics	71.91814***			
P-value	0.00000***			
<i>Serial Correlation test</i>				
F-statistics	0.427756			
Chi-square	0.4571			
P-value	0.6575			

Heteroscedasticity Test

F-statistics	0.710015
Chi-square	0.6553
P-value	0.7572

588 **Note:** *, **, *** Denotes rejection of the null hypothesis at the 1%, 5% and 10%

589 **Sources:** Authors computation

590 Table 7. Cointegration (ARDL) assessments of EFP model with COAL as energy source

Variables	Coefficients	SE	t-statistics	P-value
<i>Short-path</i>				
D(LGDP)	0.00103	0.000102	10.06176	0.0000***
D(LGDP ²)	-0.00523	0.000758	-6.9000	0.0000***
D(LIND)	0.0010	0.000326	3.0476	0.0055***
D(LCOAL)	0.0177	0.00741	2.3829	0.0254***
D(AGR)	0.0075	0.0060	1.2386	0.2275
CointEq(-1)*	-0.3045	0.104689	-12.4608	0.0000***
<i>Long-path</i>				
LGDP	0.00103	0.000176	5.8313	0.0000***
LGDP ²	-0.00523	0.00144	-3.626	0.0013***
LIND	0.00104	0.000566	1.8405	0.0781*
LCOAL	0.01765	0.007407	2.3829	0.0254**
LAGR	0.0075	0.0060	1.2386	0.2275
Constant	-1.98099	0.426499	-4.644788	0.0002***
R ²	0.991			
Adj.R ²	0.986			
D.Watson	1.9585			
<i>Bound test(Long-path)</i>				
F-statistics	17.745***	K=5, @ 1%	I(0)bound=3.5	I(1)bound=4.63
<i>Wald test(short-path)</i>				
F-statistics	70.37***			
P-value	0.000000			

Serial Correlation test

F-statistics	0.0853
Chi-square	0.8574
P-value	0.9186

Heteroscedasticity Test

F-statistics	0.87688
Chi-square	0.9994
P-value	0.5952

591 **Note:** *, **, *** Denotes rejection of the null hypothesis at the 1%, 5% and 10%

592 **Sources:** Authors computation

593

594 Table 8. Cointegration (ARDL) assessments of GDP per capita model

Variables	Coefficients	SE	t-statistics	P-value
<i>Short-path</i>				
D(LIND)	0.0035	0.00025	12.48	0.0009***
D(LAG)	0.00026	0.00012	2.108	0.0422**
D(LEU)	16.5929	4.5759	3.626	0.0009***
CointEq(-1)*	-0.568	0.1096	-5.184	0.0000***
<i>Long-path</i>				
LIND	0.0035	0.00028	12.410	0.000***
LAG	0.0011	0.0001	1.049	0.3013
LEU	16.593	4.5759	3.6261	0.0009***
Constant	4030.6	929.54	4.336	0.0001***
R ²	0.9987			
Adj.R ²	0.9985			
D.Watson	1.94			
<i>Bound test(Long-path)</i>				
F-statistics	6.188***	K=3,@ 1%	I(0)bound=4.29	I(1)bound=5.61
<i>Wald test(short-path)</i>				
F-statistics	4130.301***			

P-value 0.000000

Serial Correlation test

F-statistics 0.024924

Chi-square 0.9681

P-value 0.9754

Heteroscedasticity Test

F-statistics 0.288583

Chi-square 0.9382

P-value 0.9541

Note: *, **, *** Denotes rejection of the null hypothesis at the 1%, 5% and 10%

Sources: Authors computation

Diagnostic tests (CUSUM and CUSUM²)

Fig.4 CUSUM residual graphical plot for model 1 in Table 6	Fig.6 CUSUM residual graphical plot for model 2 in Table 7	Fig.8 CUSUM residual graphical plot for model 3 in Table 8
Fig.5 CUSUM ² residual graphical plot for model 1 in Table 6	Fig.7 CUSUM ² residual graphical plot for model 1 in Table 7	Fig.9 CUSUM ² residual graphical plot for model 1 in Table 8

600

601 4.3 Granger causality analysis (VECM)

602 The current study employed granger causality approach as a robust check to the findings of the
 603 cointegration estimation. The conventional linear and non-linear approach such as ARDL relies
 604 on the signs and relationships that exist between the dependent and independent variable to make
 605 their judgments on the analyses. This is always the problem of linear analysis without much insight
 606 on the power of forecasting the movement of the series, and no insight on the causality effect or
 607 relationships that exist between the series. It is important to stretch the signs and relationships
 608 found among the series via linear approach by establishing a forecasting or predicting relationships
 609 among the series for proper policy advice, and the granger causality is the valuable tool for this. It
 610 helps to build a historical trend among the series by determining if one series is useful in predicting
 611 another series. Because of the mixed order of integration that existed among the series, Vector
 612 Error Correction Model (VECM) is considered the best granger causality approach to utilize for
 613 effective and insightful analysis void of erroneous conclusion. Therefore, the empirical estimates
 614 of both the short run and long run (Block exogenous/VECM) granger causality are presented in
 615 table 8 below.

616 Table 9. Short and long run VECM Granger causality analysis/Block Exogeneity Wald Tests

Variables		Short run											
		Δ LEFP		Δ LGDP		Δ LIND		Δ LEU		Δ LAGR		Δ LCOAL	
Δ LEFP	$\sqrt{\sqrt{}}$	$\sqrt{\sqrt{}}$	2.210	[0.15]	1.122	[0.57]	1.745	[0.41]	9.983	[0.00]	0.242	[0.89]	
Δ LGDP	3.814	[0.14]	$\sqrt{\sqrt{}}$	$\sqrt{\sqrt{}}$	1.293	[0.52]	0.325	[0.85]	8.172	[0.02]	1.176	[0.56]	
Δ LIND	4.837	[0.09]	4.663	[0.01]	$\sqrt{\sqrt{}}$	$\sqrt{\sqrt{}}$	0.422	[0.81]	10.69	[0.00]	2.608	[0.27]	
Δ LEU	0.123	[0.94]	1.674	[0.43]	4.718	[0.01]	$\sqrt{\sqrt{}}$	$\sqrt{\sqrt{}}$	10.35	[0.00]	4.817	[0.08]	
Δ LAGR	0.406	[0.82]	5.723	[0.06]	5.869	[0.05]	2.952	[0.23]	$\sqrt{\sqrt{}}$	$\sqrt{\sqrt{}}$	1.623	[0.44]	
Δ LCOAL	0.525	[0.77]	1.580	[0.45]	3.733	[0.15]	0.684	[0.71]	5.340	[0.07]	$\sqrt{\sqrt{}}$	$\sqrt{\sqrt{}}$	
Long run													
	LEFP		LGDP		LIND		LEU		LAGR		LCOAL		
LEFP	$\sqrt{\sqrt{}}$	$\sqrt{\sqrt{}}$	5.482	[0.07]	7.010	[0.03]	2.025	[0.36]	0.339	[0.84]	1.484	[0.48]	

LGDP	4.092	[0.129]	√√	√√	1.326	[0.52]	2.123	[0.35]	4.837	[0.08]	1.261	[0.53]
LIND	2.595	[0.273]	4.883	[0.09]	√√	√√	2.241	[0.33]	16.67	[0.00]	3.444	[0.18]
LEU	7.456	[0.024]	4.016	[0.13]	6.989	[0.03]	√√	√√	0.019	[0.99]	1.043	[0.59]
LAGR	1.253	[0.535]	4.118	[0.13]	2.033	[0.36]	6.181	[0.05]	√√	√√	6.282	[0.04]
LCOAL	3.173	[0.205]	2.413	[0.30]	4.406	[0.11]	2.403	[0.30]	0.322	[0.85]	√√	√√

Note: **Bolden figures** in brackets are the prob. that represent 10%, 5% and 1% significance resp. while the figures before the brackets are the Chi-squares (χ^2) = Chi-squares (χ^2) [p-values]

The results displayed in the table above shows a unidirectional causal relationship between the following series in the short run; ecological footprint and industrialization (industrialization granger causing ecological footprint), between economic growth and industrialization (transmitting from industrialization to economic growth), energy use and agriculture, between energy use and coal. Bidirectional causal relationship was initiated between agriculture and economic growth (two-way transmission between agriculture and economic growth), between industrialization and agriculture. In the long run, the causal relationship was established as follows: a unidirectional causal relationship between ecological footprint and energy use (transmitting from energy use to ecological footprint), ecological footprint, economic growth and industrialization (transmitting from ecological footprint and industrialization to economic growth), industrialization, ecological footprint and energy use (transmitting from ecological footprint and energy use to industrialization) economic use and agriculture (transmitting from agriculture to energy use), agriculture, economic growth and industrialization (transmitting from economic growth and industrialization to agriculture), coal and agriculture (transmitting from agriculture to coal).

5. Conclusion and Policy implication

Recently, Turkey's government embarks on two sensitive energy related policies of coal expansion and consolidation of natural gas through construction of storage and regasification capacity. Considering the suspected aftermath effects of these policies on environment and economic performance, this study seeks to investigate the policy Implication of the policies on Turkey's sustainability development. Author adopts Turkey's country-specific data and series of 1974 to 2018 for effective investigation and justification of the findings of this study with emphasis on both short run and long run implications. Three models (two environment related and one economic) were applied to accommodate both environment and economic impacts. Ecological

footprint was considered better and used as proxy for the environment related model. In congruence with literature and hypotheses, the results from cointegration estimation show that the twin policies may be good to the economic performance but will spark off dilapidated environment. Also, EKC was established for Turkey's environment and economic performance. In sum, with environment models, the selected series (per capita GDP, Industrialization, agriculture, coal as a single energy use and mixed energy use) except per capita GDP² were found positively and significantly related to ecological footprint both in short run and long run which translates to poor performance of Turkey's environment. Also, using economic growth model, the selected series (Industrialization, energy use and agriculture) were all confirmed positively and significantly related to the economic growth (per capita GDP). Moreover, using granger causality as robust check to these findings, a nexus was found among the series confirming the validity of the cointegration (short and long run policies) estimations and results.

The findings of this study have important policy implications as they demonstrate that Turkey's economic performance is thriving at the expense of its environment. But with the establishment of EKC, it shows that the Turkey's economic growth/performance will cause a turning point in the economic growth and environment relationship thereby ushering in a better environment performance. Based on this, it will be policy wise for Turkey as a country to continue to boost production of goods and services to raise GDP. With the attainment of certain level of economic growth, the country(Turkey) will achieve good environmental performance. In order to achieve this turning point without suspending the principle of EKC, a conscious and strict environmental regulations are needed to ensure the achievement of sustainable development. On the side of private establishments and firms, policies such as enactment of environmental laws by setting pollution limits with penalty of fine or increased tax on any violated firm, attracting clean and energy efficient technologies through industrialization and discouragement of over reliance on fossil fuels energy sources by adopting alternative (renewable) energy sources. However, on the side of the public authority, government should take ratification and implementation of Paris agreement serious by working towards reducing its emission to the acceptable level which is less than 2⁰ C. Also, authority should reconsider and pursue with determined effort the Turkey's 2016 Renewable Energy Resource Area regulations projects, which is aimed at generating about 30 percent of its total electricity from renewable energy sources by 2023. Authorities should set out and implement an integrated long-term energy and climate for a protracted period of time, say

2050 as basis for a sustainable development model. This will involve tracking and monitoring system, building upon the long term goal. Turkey's government as a beneficiary of Clean Technology Fund (CTF) should utilize the opportunity and maximize the fund in innovating and accelerating her shift to a more renewable energy sources in order to achieve and maintain a clean nation with sustainable development.

The findings and policies recommended in this study have implications to the neighboring countries who are pursuing industrial and economic expansion without equivalent policy towards environment performance, and this study will aid their policy formulation with regards to their sustainable development goals.

Declarations

Ethics approval and consent to participate

I, the author is giving my ethical approval and consent for this paper to be published in your Journal if found publishable

Consent to participate

I, the author is giving my consent for participation in this paper to be published in your Journal if found publishable

Consent for publication

I, the author is giving my consent for this paper to be published in your Journal if found publishable

Availability of data and materials

Data sources are outlined above in the table 1 and will be made available on demand

Competing interests

I, the author hereby declare that there are no competing or conflicting interests on the paper

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704 **References**

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