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The impact of economic growth on carbon emissions in Kenya: An Environmental Kuznets Curve analysis.

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Abstract

Attaining economic growth whilst maintaining environmental quality is one of the greatest challenges today.

This study investigated the impact of gross domestic product, energy consumption, trade openness, urbanization, foreign direct investment, and financial development on carbon emissions in Kenya. The study uses the autoregressive distributed lag technique to analyze the presence of the environmental Kuznets curve hypothesis using model with secondary data from the period 1971–2019. The results do not validate the environmental Kuznets curve hypothesis in Kenya. Furthermore, the study shows that an increase in energy usage increases carbon emissions. Trade openness and financial development also increase emissions of carbon dioxide in the long run. Additionally, urbanization and foreign direct investment have a negative relationship with carbon dioxide emissions.

From the results, EKC is not a good foundation for formulating environmental policy in Kenya. The relationship between economic growth and environmental pollution is quite weak. Economic development may be suitable with better environmental conditions, but this demands a very deliberate policy agenda and a willingness to generate energy and goods in the most environmentally friendly way possible.

Contents

Table of figures

List of Abbreviation

ARDL	Autoregressive Distributed Lag
C2es	Centre for climate and energy solutions
CO2	Carbon dioxide
EKC	Environment Kuznets curve
FDI	Foreign direct investments
GDP	Gross domestic product
HDR	Human development report
GHGs	Greenhouse gases
ISS	Institute for Security Studies
INDC	Intended Nationally Determined Contributions
UNDP	United nations development program

1. Introduction

As the nations of the world transform their economies through growth and development, intensified industrialization process is involved. To achieve this, the economies use energy, mostly from fossil fuels which are non-renewable sources and contribute to the emissions of greenhouse gases (GHGS). According to the World Resource Institute(2020)[1] GHG emissions have grown by 53% from 1990 to 2018. This increase in emissions is attributed to human activities which are linked to energy consumption which accounts for about 75.6% of the total global emissions. The energy sectors contributing to carbon emissions include transportation, electricity and heat, buildings, manufacturing and construction, fugitive emissions and other fuel combustion. Other emissions come from agriculture which includes livestock and crop production accounting for 11.6% (5.8 GtCO2e); industrial chemicals, cement, and other materials 6.1% (3.1 GtCO2e); including landfills and wastewater 3.3% (1.6 GtCO2e); and land use, land-use change, and forestry, including deforestation 3.3% (1.6 GtCO2e). World Resource Institute (2020) [2]also estimates that carbon dioxide makes up 74% of total GHGs (CO2), and approximately 93% of the CO2 emitted comes from fossil fuel combustion.

A look at regional distributions of GHG emissions reveals that only a few countries are responsible for most of the global emissions. According to the Center for climate and energy solutions (C2ES)[3], China, United States and European union member states are the world's leading GHG emitters, followed by India, Russian federation, and Japan. The share of African countries' emissions to global greenhouse gas emissions is estimated to be about 3.8% according to CDP African report (2020)[4]. Historically, Africa has low economic activities and low energy consumption thus has contributed minimally to the global stock of carbon emissions over the years. Currently, Africa's economic activities compared to other continents remain low thus the

[1] 5 Facts about Country & Sector GHG Emissions (wri.org)

[3] Global Emissions - Center for Climate and Energy SolutionsCenter for Climate and Energy Solutions (c2es.org)

[4] CDP_Africa_Report_2020.pdf

continent accounts for a small share of global flow emissions, and its contributions to future global emissions is expected to remain significantly low (Collier et al., 2008). Kenya's share to GHGs stands at 0.13% of total global emissions, Climate link (2017)[5]. Figure 1 below shows a graphical representation of CO2 emissions and GDP per capita for the World and Kenya.

Graphs of CO2 emissions and GDP per capita for the World and Kenya.

Figure 1. Graphs of Carbon dioxide (CO2) emissions and GDP per capita for the world and Kenya.

Greenhouse gas emissions are a leading contributor to climate change and global warming. Some of the likely impacts of climate change are rising temperatures, changing patterns of rainfall, increasing desertification and rising sea levels. The impacts of climate change in Africa are expected to be severe especially on farming and food security, increased desertification conditions, rise in pests and diseases, floods and deforestation as reported by Institute for

[5] https://www.climatelinks.org/resources/greenhouse-gas-emissions-factsheet-kenya

Security Studies (ISS), 2010[6]. The threat posed by rising global temperatures driven by continued GHG emissions has led to a consensus among nations to cut down on CO2 emissions as expressed by the signing of the Kyoto protocol (1990) and the Paris Agreement in December 2015.

There are several studies looking at the effects of economic growth on the environment. Some of the available literature discusses economic development and environmental quality within the context of Environmental Kuznets Curve (EKC) hypothesis. This hypothesis postulates that the initial stages of economic development are associated with environmental degradation but as the economy matures, the quality of the environment improves. The EKC postulates that the initial stage of economic growth involves the intensive use of raw materials and release of pollutants which leads to environmental degradation. In the preliminary stages of development, people are more concerned with their own welfare improvement at the expense of the environment, hence little is done to protect and preserve the environment. However, at later stages of development many people become rich and thus demand a clean and high-quality environment which motivates stricter environmental policies. This explains why emissions of pollutants are remarkably high at the initial stage of development and exceptionally low when the economy has developed. (Dinda, 2004).

The process of economic development involves shifting from agriculture-based economy that is clean and green, to industrialization which enhances emission of pollutants and then further development leads to use of greener technologies hence slowing down and reversing environment degradation. Additional expansion of the economy results in growth of service-oriented economies (Singh & Yadav, 2021). The EKC idea suggests that economic growth is both the cause and the cure for environmental pollution. That is, the more the economy grows the more likely it will reverse the environmental damage caused by earlier stages of development(Kaika & Zervas, 2013). According to the EKC hypothesis, a plot of emissions against income per capita will show emissions rising as income grows to a certain point beyond which the emissions decline with income growth giving an inverted U-shaped curve. This is illustrated in figure 2 below.

[6] The Impact of Climate Change in Africa (ethz.ch)

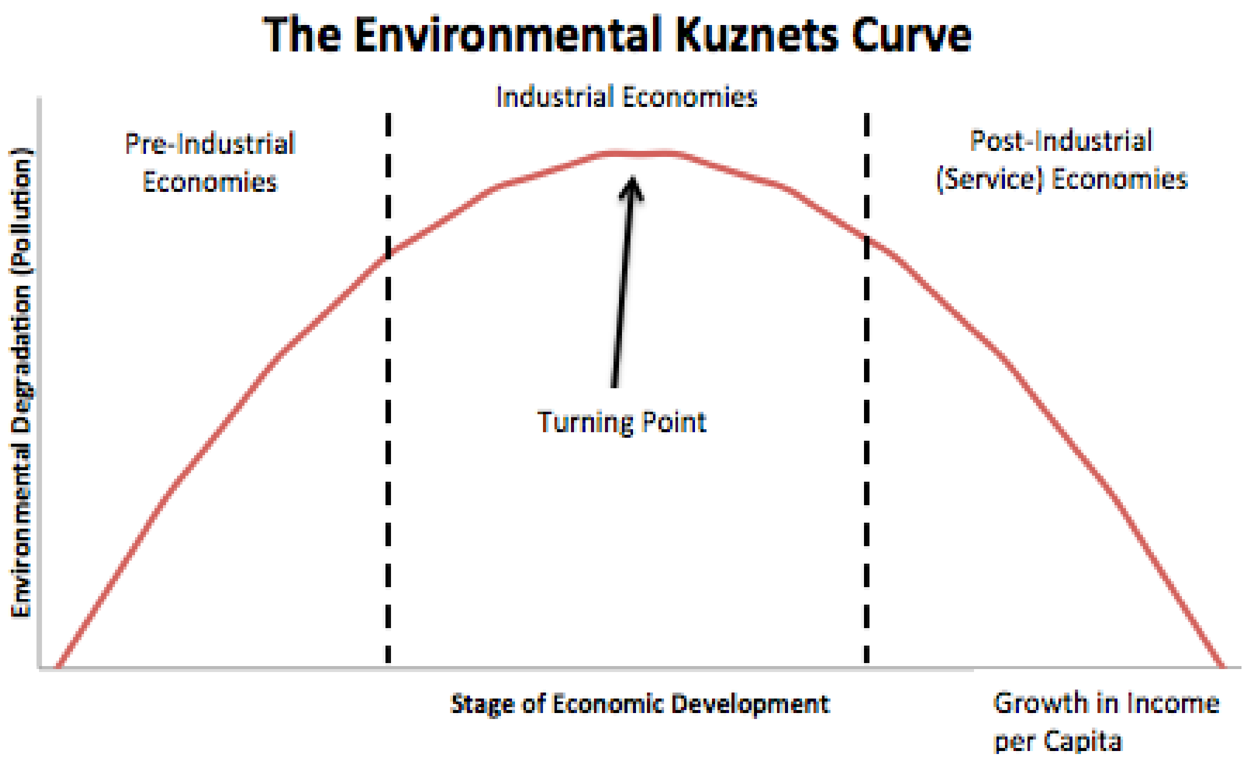

Figure 2. Environment Kuznets Curve.[7]

Several studies that test the EKC hypothesis in Africa (Al-Mulali & Sab, 2012; Demissew Beyene & Kotosz, 2020; Shahbaz et al., 2013). A study done by (Lin et al., 2016) probes the validity of EKC hypothesis and the driving forces of CO2 emissions in five African countries including (The democratic republic of Congo, Egypt, Kenya, Nigeria, and South Africa). The study finds no evidence of EKC hypothesis and thus caution against relying on this hypothesis as environmental policy. Similar findings were obtained from a study by (Al-Mulali, Saboori, et al., 2015) who investigated the validity of EKC hypothesis in Kenya using a time series data period from 1980 to 2012. In their analysis they used the ARDL method of cointegration analysis and found no evidence in support of the existence of EKC in Kenya. However, a study by(Sarkodie & Ozturk,

[7] Adopted from: https://www.brainyias.com/environmental-kuznets-curve/

2020) also investigated the EKC hypothesis with time series data spanning from 1971-2013 using ARDL method, partial least squares regression and Utest methods and found evidence in support of EKC hypothesis in Kenya.

In this study I will explore the effect of economic growth on carbon emissions in Kenya. Climate change is a global problem, and its effects are felt within and outside country borders. I complement previous studies looking at EKC hypothesis in Kenya (Al-Mulali, Saboori, et al., 2015; Sarkodie & Ozturk, 2020) by using broader period from 1971 to 2019 to provide deeper statistical evidence. Individual countries, including Kenya, have ratified the Paris agreement 2015[8] Thus, they are obliged to cut down on carbon emissions. The policy makers are thus faced with a twin challenge of growing and developing the economy whilst sustaining the environment. This is particularly true in cases where cutting down emissions requires reducing energy production. Since energy is a major driving force of economic growth a drop in energy production may mean a slump in the economy (Shahbaz et al., 2013). Countries may need to formulate energy and economic growth policies that are environmentally sustainable. The energy outlook for Kenya shows that it has the potential to provide energy to an economy 6.5 times larger with only slightly more than double its current energy usage, if it reduced reliance on bioenergy and enhanced energy efficiency IEA (International Energy Agency) 2019[9]. Bioenergy contributes two-thirds of Kenya's total energy demand. However, this demand share is expected to shrink by 15% when geothermal energy is adopted extensively.

1.1 Problem statement

Kenya's nominal GDP has grown from $12.705 billion in 2000 to $101.04 billion in 2020 (world bank figures[10]). The economy has expanded at an average rate of 4.7 % between 2015 and 2019. Despite this sustained growth, Kenya still faces poverty and inequality challenges. According to

[8] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[9] https://www.iea.org/articles/kenya-energy-outlook
[10] https://www.worldbank.org/en/country/kenya/overview#1

KIPPRA (2020)[11], The poverty head count rate is at 36% levels 2015/16, down from 52.3% in 1997/98 and 46.8 in 2005/06 respectively. However, today's poverty rate is not proportional to the GDP growth. Furthermore, Kenya has a medium human development index of 0.601/1 ranking 143 out of 189 countries. This is an increase from HDI index of 0.482 in 1990, 0.548/1 in 2015 representing a 24.7% increase in HDI value between 1990 and 2019, UNDP 2020[12] .

The growth of industry improved the welfare of the Kenyan population through employment creation and enhanced manufacturing activities (Ngui et al., 2016) and HDR-Kenya 2005[13]. With the growing industry, there are increased challenges of rapid urbanization, environmental degradation, and poor health quality due to emissions of industrial pollutants(Sarkodie & Ozturk, 2020). Industrial growth also contributes to a rise in energy consumption levels

The rising economic growth and development is also linked to an increase in demand for a clean and quality environment. Kenya is a member to the Paris Agreement and initially submitted her Intended Nationally Determined Contributions (INDC) which outlined its mitigation strategy. Kenya aims to reduce the GHG emissions by 30% relative to business-as-usual scenario by 2030. This target was based on conditional support. Kenya updated her nationally determined contributions where she committed to reducing GHG emissions by 32% by 2030. Some of the mitigation measures include expanding clean and renewable energy production; geothermal, solar and wind energy, and to improve energy and resource efficiency, such as low carbon and efficient transportation and reduce excessive use of fossil and non-sustainable biomass fuels by adopting clean, efficient and sustainable energy technology, Kenya-NDC[14].

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[11] https://kippra.or.ke/wp-content/uploads/2021/02/Kenya-Economic-Report-2020.pdf
[12] https://hdr.undp.org/sites/default/files/Country-Profiles/KEN.pdf
[13] https://www.undp.org/kenya/publications/2005-kenya-human-development-report
[14] https://unfccc.int/sites/default/files/NDC/2022-06/Kenya%27s%20First%20%20NDC%20%28updated%20version%29.pdf

1.2. Research questions

Against this background this study seeks to answer the following questions:

1. Is the Environment Kuznets Curve (EKC) hypothesis applicable in Kenya?
2. How does trade openness influence CO_2 emissions?
3. How does urbanization affect CO_2 emissions?
4. What policy recommendations can be drawn from the findings of the study?

1.3. Objectives of the study

The objectives of this study are:

1. To inquire about the applicability of the Environmental Kuznets Curve hypothesis
2. To examine the effect of trade openness on CO_2 emissions in Kenya
3. To analyze the effect of urbanization on CO_2 emissions Kenya
4. To draw policy implications from study findings

2. Literature review

2.1. Income growth, Energy and Environment quality

There is a lot of scholarly work about income growth, energy and environment quality. Existing literature conducts cross-country panel studies, examples include (Apergis & Ozturk, 2015; Cole et al., 2001; Farhani et al., 2013; Hossain, 2011; Kivyiro & Arminen, 2014; Martínez-Zarzoso & Maruotti, 2011; Mehrara, 2007; Sharma, 2011) while others look at single countries like (Abler et al., 1999; Al-Mulali, Saboori, et al., 2015; Shahbaz et al., 2012; Shahbaz et al., 2013; Zhang & Cheng, 2009; Zheng & Shi, 2017). A study by (Al-Mulali & Sab, 2012; Dinda, 2004) gives a detailed summary of the available literature.

There is a threefold approach when looking at the available literature on the relationship between economic growth and CO2 emissions(Kivyiro & Arminen, 2014). The first approach analyzes the relationship between economic growth and environmental pollution. Various research methods were used, and varied results obtained, for example(Ang, 2007; Halicioglu, 2009). The differing results can be explained by the different econometric methodologies, different data periods used and varying model specifications (Wagner, 2008). The relationship between economic growth and environment degradation is analyzed in the context of Environment Kuznets curve (EKC) hypothesis which is borrowed from Simon Kuznets thought on income growth and inequality. Kuznets hypothesized that economic growth will first increase the income inequality to a certain threshold before it declines (Kuznets, 1955). The EKC hypothesis postulates that increase in national income will increase pollution to a certain level beyond which further increases in income reduce pollution. This can be explained as; (i) the process of economic development involves moving from environmentally friendly agricultural economy to heavy emitting industrial economy and then to emission free service industry(economy); (ii) at low levels of income growth people show strong preference for economic performance over quality environment but at higher levels of income growth quality environment supersedes economic performance (Dinda, 2004; Singh & Yadav, 2021). When the economy is well developed people are more environmentally conscious, follow strict adherence to laws regarding the environment, use clean technologies and enhance expenditure on preserving and protecting the environment.

Because of such mitigation measures environmental pollution is abated (Dinda, 2004). Available literature within the context of EKC hypothesis includes (Agras & Chapman, 1999; Al-Mulali, Saboori, et al., 2015; Apergis & Ozturk, 2015; Dinda, 2004; Sarkodie & Ozturk, 2020). These studies, however, omit some variables like trade openness, foreign direct investment, urbanization, and financial development. I have included these variables in my study.

The second approach investigates the relationship between economic growth and energy consumption. There are a lot of conflicting ideas on this topic. The theory postulates that as the economy grows and intensifies its level of economic activities, the more energy it uses. Nevertheless, developed economies are expected to have higher levels of energy efficiency than developing economies. This makes the relationship between economic growth and energy use to be either negative or positive (Kivyiro & Arminen, 2014). This type of research was pioneered by Kraft & Kraft 1978 (Kraft & Kraft, 1978) who observed a unidirectional causality running from income growth (GDP) to energy consumption (from 1947-1979). There are several studies in this approach that have obtained differing results (Cheng, 1999; Glasure & Lee, 1998; Mozumder & Marathe, 2007) . Other studies in this area include (Belke et al., 2011; Eden & Hwang, 1984; Erol & Eden, 1987; Hondroyiannis et al., 2002; Mehrara, 2007; Ozturk, 2010; Yu & Choi, 1985) These studies also do not include trade openness and urban population variables in their analysis.

The third category of studies combines the two approaches. They investigate the relationship between CO2 emissions, energy consumption and economic growth. (Akadiri et al., 2019; Narayan & Narayan, 2010; Toda & Yamamoto, 1995; Zhang & Cheng, 2009).

2.2. Trade openness and Environment quality

The effects of trade openness on the quality of the environment is either positive or negative. A study by (Antweiler et al., 2001) argues that trade openness affects the quality of the environment depending on scale, technique, and composition. They observe that a more open trade is good for the environment. The scale effect refers to a situation where pollution increases with a rise in economic activities to meet excess demand created by accessing new international markets. The technique effect occurs when a country alters production methods to meet required environmental standards or when it has an access to environmentally friendly production techniques due to free trade. Lastly, the composition effect occurs when there is a change in industrial structure as a country specializes in production and trade in the goods of which it has a comparative advantage (Cole, 2004) .

As more countries open their boundaries for international trade they mostly emphasize growth of own exports. However, free trade may create a situation where multinationals move to developing countries which have less strict policies on environment (Zheng & Shi, 2017). Thus, the multinationals produces more carbon emissions in these countries than they would in their home countries n. Openness to trade may therefore reduce pollution in one nation while increasing it in another. This idea is captured in the pollution haven hypothesis and the displacement hypothesis.

The pollution haven hypothesis refers to a situation where heavily emitting multinational companies move to countries with relaxed environment regulations from countries with strict environmental rules. This happens as the real income of individuals grows. It necessitates the need for rigorous environmental protection as rich individuals desire a better-quality environment(Dinda, 2004).

The displacement hypothesis stipulates that trade liberalization creates a situation where heavily polluting industries move to 'poor' countries with less restrictive environmental policies as 'richer' nations implement rigorous environmental rules. The end effect is that environmental pollution is not reduced but displaced from one nation to another(Dinda, 2004). This means that heavy emitting or 'dirty' industries are concentrated in poor countries while environmentally friendly and service-oriented industries are concentrated in rich countries.

There are varying findings on the effect of trade on the quality of the environment, (Ferrantino, 1997; Lucas et al., 1992; Shahbaz et al., 2012) conclude that trade openness improves environment quality through technique effect, while the detrimental effects of trade openness on the environment have been observed in studies like (Abler et al., 1999; Cole et al., 2001). Therefore, as countries engage in trade, they should adopt policies that discourage pollution.

2.3. Urbanization and Environmental quality

The effects of urbanization on CO2 emissions has been examined by scholars. (Dhakal, 2009) observed that major cities of China which have at least 18% of total population in China contribute to approximately 40% of energy use and CO2 emissions in China. (Sharma, 2011) observes that GDP per capita and urbanization are important causal factors to CO2 emissions. A study by Martínez and Maroutti(2011) on the impact of urbanization on CO2 emissions in developing countries reveals evidence of an inverted U-shaped relationship between urbanization and CO2 emissions (Martínez-Zarzoso & Maruotti, 2011). However, the impact of urbanization on the environment is a contentious issue among scholars. A study by (Liu & Sweeney, 2012) concludes that CO2 emissions are much higher in scattered urban dwellings and less in compact urban areas. While (Fragkias et al., 2013) argues that smaller cities have lower emissions. According to IEA (2016)[15], the urban centers were responsible for 70% of the world's CO2 emissions in the year 2013. It is thus evident that urbanization has a certain impact on the emissions of carbon dioxide and the quality of the environment.

2.4. Foreign Direct investment and Environment quality

The effect of foreign direct investments (FDI) on the environment of the host country has been studied. Two contrasting hypotheses have been proposed: the pollution haven hypothesis and the halo effect hypothesis. The pollution haven hypothesis as discussed above refers to multi-national corporations moving to countries with less restrictive environmental regulations and contributing to pollution. On the contrary, the halo effect hypothesis postulates that the entry of

[15] https://www.iea.org/news/cities-are-at-the-frontline-of-the-energy-transition

multi-nationals positively impacts the host country’s environment using modern, clean, and eco-friendly technology(Kivyiro & Arminen, 2014).

2.5. Financial development and Environment quality

Recent studies looking at the effect of financial development on the environment opine that a developed financial sector can service environmentally conscious programs at lower costs, thus lowering harmful emissions from energy(Halicioglu, 2009). Financial institutions can offer access to cheaper financing costs, distribute the risk of operation, and finance new initiatives which enhance energy usage and CO2 emissions. A sound financial system may also attract foreign direct investment (FDI) that might increase CO2 emissions (Solarin et al., 2017).

3. Data and Model

3.1. Model specification

The study will estimate the following model.

Model:

$$lnCO_{2t} = \beta 0 + \beta 1 In\mathrm{GDPcapita\_ken}_t + \beta 2 In\mathrm{EnergycapitaWDI\_ken}_t + \beta 3 In\mathrm{tradeofgdp\_ken}_t + \beta 4 In\mathrm{urbanpop\_ken}_t + \beta 5 In\mathrm{fdi\_ken}_t + \beta 6 In\mathrm{fd\_ken}_t + \mu_t$$

Where CO_2 is Carbon dioxide emissions (in metric tons per capita), $I\mathrm{GDPcapita\_ken}$ is per capita GDP (constant 2015 US$), the variable $\mathrm{EnergycapitaWDI\_ken}$ is energy consumption measured as (kg of oil equivalent per capita) while $\mathrm{tradeofgdp\_ken}$ is Trade Openness (measured using exports and imports as a share of GDP), $\mathrm{urbanpop\_ken}$ is urbanization (measured using urban population as share of total population) and $\mathrm{fdi\_ken}$ is foreign direct investment, net inflows as a percentage of GDP, $\mathrm{fd\_ken}$ is financial development measured as domestic credit to the private sector by banks as a share of GDP while μ_t is the error term.

3.2. Data

The time series covers the period from 1971-2019 and it is derived from the World Development Indicators (WDI)[16] online database for Kenya. The variable energy is missing some values from 2015 to 2019, while CO2 emissions are missing values for the year 2019. I use means imputations method as suggested by (Pigott, 2001) and (Saunders et al., 2006) if only a few observations are missing from the sample. All the variables are transformed into logarithmic form. The variables used in the study are based on the literature as described in the literature review. Carbon dioxide

[16] https://databank.worldbank.org/reports.aspx?source=2&series=FD.AST.PRVT.GD.ZS&country=KEN

emission is used as a measure of pollution measured in metric tons per capita, GDP per capita is a measure of income growth, energy consumption is measured in Kg of oil equivalent per capita, trade openness is measured as a total of import and export as a share of GDP, the share urban population to the total population is a measure of urbanization, foreign direct investment is measured as net inflows as a percentage of GDP, domestic credit to private sector by banks as a share of GDP is a measure of financial development.

The trend of carbon dioxide, energy consumption, trade and foreign direct investment show a nonlinear pattern while GDP per capita, urbanization and financial development show an increasing trend. However, the variable trade decreased from 2014, The figure below shows the plots of the time series data used in the study spanning from 1971-2019.

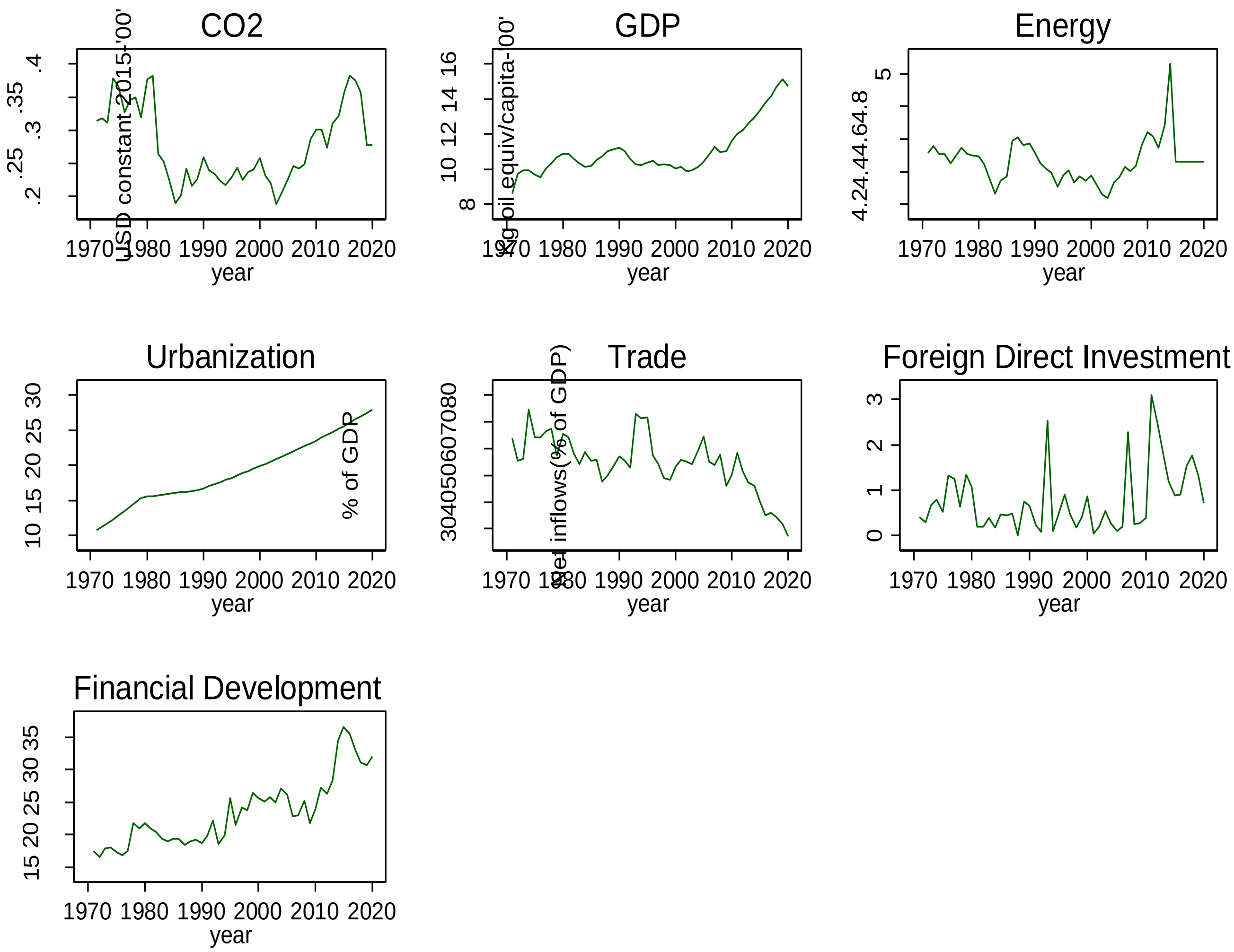

Figure 3 **Plots of the time series data**[17]

Source: Research data

[17] All the variables are log transformed

3.3. Estimation procedure

Testing for cointegration

This study employs the Autoregressive Distributed Lag (ARDL) bound testing approach as proposed by (Pesaran et al., 2001) to test for the cointegration within variables and to estimate short-run and the long-run coefficients of the variables. I selected the ARDL method because it uses a single equation to analyze long-run connections as opposed to the traditional Johansen system cointegration approach, which employs a set of equations. The ARDL approach can also be applied regardless of the order of integration provided stationarity on the first difference or below is achieved. For this reason, it is not mandatory to analyze the stationarity of the series. Additionally, the ARDL approach's features prove to be more effective at evaluating small samples than other methods. The ARDL-based estimators for long run coefficients are consistent with small sample sizes. Another merit is that it is possible to examine the short-term and long-term estimates at the same time. This overcomes the limitation of examining the long-run coefficients associated with the Engle-Granger method. This method also assumes all variables to be endogenous thus eradicating the endogeneity problem connected with the Engle-Granger method.

The Autoregressive distributed lag (ARDL) bounds test approach will estimate the following unrestricted error correction model

$$\begin{aligned}
\Delta \ln(CO2)_t = {} & \beta 0 + \sum_{k=1}^{n1} \beta 1k \Delta \ln(CO2)_{t-k} + \sum_{k=0}^{n1} \beta 2k \Delta ln\text{GDPcapita_ken}_{t-k} \\
& + \sum_{k=0}^{n1} \beta 3k \Delta ln\text{EnergycapitaWDI_ken}_{t-k} \\
& + \sum_{k=0}^{n1} \beta 4k \Delta lnIn\text{tradeofgdp_ken}_{t-k} + \sum_{k=0}^{n1} \beta 5k \Delta ln\text{urbanpop_ken}_{t-k_t} \\
& + \sum_{k=0}^{n1} \beta 6k \Delta ln\text{fdi_ken}_{t-k_t} + \sum_{k=0}^{n1} \beta 7k \Delta ln\text{fd_ken}_{t-k_t} + \lambda_0 \ln(CO)_{t-1} \\
& + \lambda 1\, In\text{GDPcapita_ken}_t + \lambda 2 In\text{EnergycapitaWDI_ken}_t \\
& + \lambda 3 In\text{tradeofgdp_ken}_t + \lambda 4 In\text{urbanpop_ken}_t + \lambda 5 In\text{fdi_ken}_t \\
& + \lambda 6 In\text{fd_ken}_t + \mu_t
\end{aligned}$$

The null hypothesis of no-cointegration, $\lambda 0 = \lambda 1 = \lambda 2 = \lambda 3 = \lambda 4 = \lambda 5 = \lambda 6 = 0$ is tested against the alternative hypothesis of $\lambda 0 \neq \lambda 1 \neq \lambda 2 \neq \lambda 3 \neq \lambda 4 \neq \lambda 5 \neq \lambda 6 \neq 0$

The appropriate lag length of the variables is determined by the Akaike Information Criterion (AIC). This criterion produces efficient and consistent results when capturing the dynamic relationship between variables, especially when the sample size is small (Lütkepohl, 2006) . The bounds testing involves comparing the estimated F-statistic with the critical bounds computed by (Pesaran et al., 2001) for large observations and (Narayan, 2005) for small observations

Criteria for EKC applicability

According to the EKC hypothesis, we can test for the applicability of EKC by including GDP and its square and examine the coefficients. If the coefficient of GDP is positive and that of GDP squared is negative, then EKC is applicable. That is, if these coefficients are statistically significant, we can conclude that an inverted U-shaped between the variables exists. However, because of possible collinearity or multicollinearity between GDP and square of GDP this approach has been challenged as it may lead to biased and inefficient estimates. Another way to establish the validity of EKC is by examining the income elasticity coefficient. We compare the short run and the long run elasticities and if the long run coefficient is less than the short run coefficients, this indicates that further growth in income will result in reduced CO_2 emissions. This method has been used by (Narayan & Narayan, 2010) to determine whether emerging economies have lowered their levels of CO_2 emissions with growth in their national income over time.

4. Results and discussions

4.1. introduction

This section presents empirical findings in order to examine the applicability of EKC in Kenya. I evaluate how trade openness, urbanization, and foreign direct investments (FDI) affect the quality of the environment.

4.2. Summary statistics

The descriptive statistics of all the variables used in this study are in table 1 below. This is the arithmetic average of the observations. It is the most used central tendency measure. It is commonly referred to as the average. The mean is sensitive to extreme high and low values. The per capita CO2 emissions mean value is 0.28. The minimum and maximum value ranges from 0.19 to 0.38 MT per capita. The mean value of energy consumed in the Kenyan economy is 446.47(kg of oil equivalent per capita). The minimum and maximum figures of energy usage is 423.71 to 506.00 in kg of oil equivalent per capita. The average value of GDP per capita is 1104.21. The minimum and maximum values of GDP per capita are 862.77 to 1513.44.

Table 1: Descriptive Statistics of variables used in Analysis

	(1)								
	mean	sd	min	max	p50	Var	skewness	kurtosis	count
CO2_ken	0.28	0.06	0.19	0.38	0.26	0.00	0.466	2.001	51
GDPcapita_ken	1104.21	143.86	862.77	1513.44	1057.62	20695.53	1.420	4.338	51
EnergycapitaWDI_ken	446.47	13.21	423.71	506.00	446.47	174.47	1.699	9.331	51
tradeofgdp_ken	54.73	10.29	27.35	74.57	55.31	105.80	-0.527	3.425	51
urbanpop_ken	19.13	4.56	10.78	28.00	18.58	20.80	0.211	2.144	51
fdi_ken	0.78	0.70	0.00	3.09	0.53	0.49	1.476	4.757	51
fd_ken	23.37	5.15	16.49	36.65	22.15	26.50	0.860	3.027	51
N	51								

I test for joint normality test using Jarque Bera, skewness and kurtosis joint-normality test and present the results in table 2. The Jarque-Bera test is a goodness-of-fit test that determines whether sample data has skewness and kurtosis like a normal distribution. Skewness measures the degree and direction of asymmetry. A symmetric distribution such as a normal distribution has a skewness of 0, and a distribution that is skewed to the left, e.g., when the mean is less than the median, has a negative skewness. While Kurtosis is a measure of the heaviness of the tails of a distribution. A normal distribution has a kurtosis of 3. Heavy tailed distributions will have kurtosis greater than 3 and light tailed distributions will have kurtosis less than 3. All three tests lead us to conclude that the data is not normally distributed. For this reason, all the variables are log transformed to attain normality.

Table 2: Jarque-Bera, Skewness and Kurtosis joint-normality tests

Jarque-Bera test

Equation	chi2	df	Prob > chi2
CO2_ken	4.945	2	0.08437
GDPcapita_ken	4.469	2	0.10705
EnergycapitaWDI_ken	6.359	2	0.04160
tradeofgdp_ken	3.441	2	0.17899
urbanpop_ken	110.816	2	0.00000
fdi_ken	3.824	2	0.14780
ALL	133.854	12	0.00000

Skewness test

Equation	Skewness	chi2	df	Prob > chi2
CO2_ken	.01571	0.002	1	0.96455
GDPcapita_ken	-.09315	0.069	1	0.79219
EnergycapitaWDI_ken	.50735	2.059	1	0.15128
tradeofgdp_ken	.60449	2.923	1	0.08731
urbanpop_ken	-1.7773	25.271	1	0.00000
fdi_ken	.18805	0.283	1	0.59481
ALL		30.608	6	0.00003

Kurtosis test

Equation	Kurtosis	chi2	df	Prob > chi2
CO2_ken	1.4279	4.943	1	0.02619
GDPcapita_ken	1.5168	4.400	1	0.03595
EnergycapitaWDI_ken	4.4663	4.300	1	0.03811
tradeofgdp_ken	2.4913	0.518	1	0.47189
urbanpop_ken	9.54	85.544	1	0.00000
fdi_ken	1.6694	3.541	1	0.05987
ALL		103.246	6	0.00000

I conduct correlations between variables and present the result in table 3 below. Carbon dioxide emissions show a positive linear relationship with all the variables except trade. In comparison to other variables, urbanization and trade are the least correlated with CO2 emissions. CO2 emissions are highly correlated with energy usage, GDP per capita and Foreign Direct Investments (FDI).

Table 3: correlation matrix

	CO2_ken	GDP~_ken	En~I_ken	urban~en	pop_gr~h	tradeo~n	fdi_ken	fd_ken
CO2_ken	1.0000							
GDPcapi~_ken	0.3317	1.0000						
Energy~I_ken	0.4048	0.3213	1.0000					
urbanpop_ken	0.0045	0.8126	0.1130	1.0000				
tradeofgdp~n	-0.0926	-0.7939	-0.1860	-0.7100	0.6207	1.0000		
fdi_ken	0.3025	0.4093	0.3133	0.3368	-0.2558	-0.1050	1.0000	
fd_ken	0.1982	0.7771	0.1252	0.8885	-0.8395	-0.6766	0.2583	1.0000

Bound test results

There is evidence of a long-run significant statistical relationship among the variables. The calculated F-statistics is greater than the upper critical bounds

Table 4. Bound test result

```
Pesaran/Shin/Smith (2001) ARDL Bounds Test
H0: no levels relationship                F =  10.659
                                          t = -6.975

Critical Values (0.1-0.01), F-statistic, Case 3

      | [I_0]   [I_1] | [I_0]   [I_1] | [I_0]   [I_1] | [I_0]   [I_1]
      |   L_1     L_1 |  L_05    L_05 | L_025   L_025 |  L_01    L_01
------+---------------+---------------+---------------+---------------
  k_5 |  2.26    3.35 |  2.62    3.79 |  2.96    4.18 |  3.41    4.68
accept if F < critical value for I(0) regressors
reject if F > critical value for I(1) regressors

Critical Values (0.1-0.01), t-statistic, Case 3

      | [I_0]   [I_1] | [I_0]   [I_1] | [I_0]   [I_1] | [I_0]   [I_1]
      |   L_1     L_1 |  L_05    L_05 | L_025   L_025 |  L_01    L_01
------+---------------+---------------+---------------+---------------
  k_5 | -2.57   -3.86 | -2.86   -4.19 | -3.13   -4.46 | -3.43   -4.79
accept if t > critical value for I(0) regressors
reject if t < critical value for I(1) regressors

k: # of non-deterministic regressors in long-run relationship
Critical values from Pesaran/Shin/Smith (2001)
```

4.3. Regression results

This section presents regression results from ARDL.

Table 5: Autoregressive Distributed Lag (ARDL) Model

	(2) GDP/Capita WDI
ADJ	
L.lnCO2_ken	-0.440***
	(-4.15)
LR	
L.lnEnergycap	0.824**
itaWDI_ken	(2.29)
L.lntradeofgdp	0.154**
_ken	(2.22)
L.lnfdi_ken	-0.0204
	(-0.78)
L.lnurbanpop_	-0.216**

ken	(-2.62)
L.lnfd_ken	0.278***
	(2.84)
L.lnGDPcapit	0.309**
a_ken	(2.10)
SR	
D.lnEnergyca	0.362***
pitaWDI_ken	(2.92)
D.lntradeofgd	0.0678**
p_ken	(2.27)
D.lnfdi_ken	-0.00897
	(-0.80)
D.lnurbanpop	0.698*
_ken	(1.82)
D.lnfd_ken	0.0142
	(0.34)
D.lnGDPcapit	0.136*
a_ken	(1.77)
_cons	-3.445***
	(-4.21)
N	49

T-statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Research data

4.4. Environmental Kuznets curve

In testing for the presence of the Environmental Kuznets curve (EKC) I follow the novel approach proposed by (Narayan & Narayan, 2010). This involves comparing both the short-run and long-run coefficients of GDP to evaluate whether a country has reduced carbon dioxide emissions over time. Carbon dioxide emissions are deemed to have reduced over time if the long-run income elasticities are smaller than the short-run income elasticity. From the regression results the long-run income elasticity (0.309) is larger than the short-run income elasticity (0.136). There is no evidence to support an inverted U-shaped relationship between economic growth and CO2 emissions since GDP growth has a positive effect on CO2 emissions in the short-run and in the long-run in Kenya. This implies that a 1% increase in Kenya's economic activities increases CO2 emissions by 0.309% in the long-run. This demonstrates that Kenya's economic growth increases CO2 emissions. That is, as the Kenyan economy grows, so will pollution. This validates the findings of (Al-Mulali, Saboori, et al., 2015). However, different results are obtained by (Shahbaz et al., 2012) for Pakistan, (Bekun et al., 2019) for the south African economy, and (Sarkodie & Ozturk, 2020) for Kenya.

The impact of per capita energy utilization on carbon emissions is positive and statistically significant at 5% significant level in the long-run. This implies that if all factors are held constant a 1% increase in per capita energy consumption would increase carbon emissions by 0.824%. This result compares with those of (Sarkodie & Ozturk, 2020).

The effect of trade openness on the emissions of CO2 is positive in the short-run and in the long-run at 5% significant level. This indicates that the country's foreign trade policy is yet to be environmentally sustainable. According to the coefficient value of trade openness, if all factors are held constant 1% increase in trade openness increases CO2 emissions by 0.154% in the long run. This agrees with the findings of (Al-Mulali et al., 2016) for Kenya. This supports the idea presented by (Nurgazina et al., 2021) that trade openness is likely to increase CO2 emissions in developing countries because of relaxed environmentally friendly laws in place governing the production process and less restrictive regulations that permit environmentally harmful commodities. This is commonly referred to as the pollution haven hypothesis and the displacement hypothesis. However, (Antweiler et al., 2001) and (Shahbaz et al., 2012) contend that trade liberalization improves environmental quality. They argue that foreign trade declines CO2 emissions in the country by having a technological effect.

The long-run results for urbanization suggest that 1% of urban growth will reduce pollution by 0.216%. This supports the findings of (Al-Mulali, Ozturk, et al., 2015). This implies that urban development results in less emissions. This supports the findings of (Martínez-Zarzoso & Maruotti, 2011).

The long-run results for FDI (capital) reveal that FDI reduces CO2 emissions. However, these results are not significant. This suggests that a considerable proportion of capital is invested in energy intensive and heavy-emitting industries. The results show that a 1% increase in financial direct investments would reduce CO2 emissions by 0.0204%. The result for financial development indicates that a 1% increase in financial development (increase of access to credit from banks) will increase CO_2 emissions by 0.278%. This indicates that Kenya's financial sector is yet to reach maturity, as it does not allocate projects to environmentally sustainable projects. This supports the findings of (Kivyiro & Arminen, 2014) for Kenya and (Cetin et al., 2018) for Turkey.

The model was tested for heteroscedasticity, and it was not found. The CUSUM and CUSUMsq tests were used to check the stability of the model. In both tests, the results indicate that the model is stable both in the short and long-run as shown in the figure below. The plots show the Cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMsq). The outer boundaries represent the critical bounds at 5% significance. The results show that the long-run parameters are stable because the plots of CUSUM and CUSUMsq are within the critical bounds of 5% significance. As a result, the estimation results can be used for policy implications in the case of Kenya.

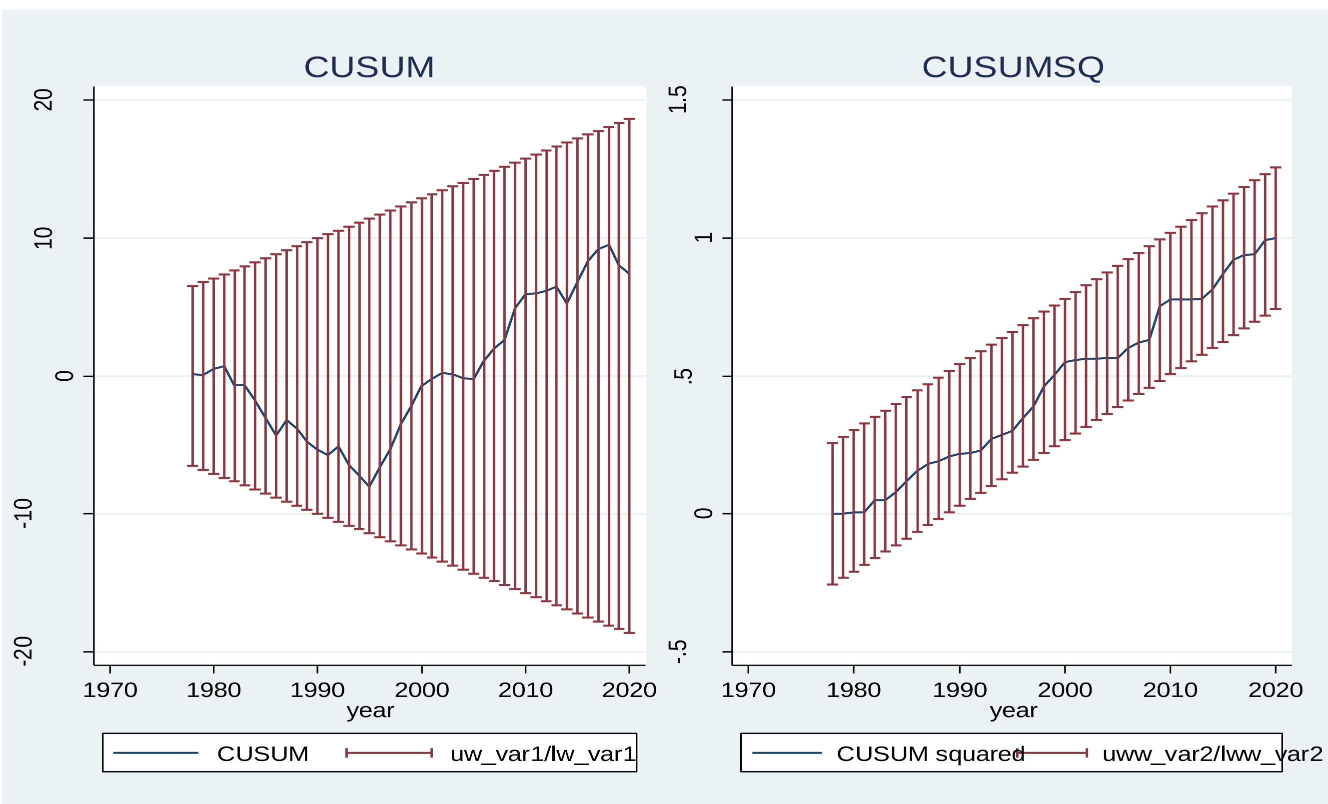

Figure 4. Plots of CUSUM and CUSUM square

5. Conclusion and Policy implications

This study has looked at the validity of the Environment Kuznets Curve hypothesis in Kenya. To test for the presence of EKC I employ a pollution model using the Autoregressive Distributed Lags (ARDL) bounds approach to evaluate the effect of GDP per capita, energy, trade openness, urbanization, foreign direct investment and financial development on carbon emissions using time series data from the year 1971 to 2019.

The results of the study show that Kenya should design environmentally sustainable policies since increased economic growth enhances CO2 emissions both in the short-run and in the long-run. It also shows that energy, trade openness and financial development have a positive impact on carbon dioxide emissions. The result for financial development is not significant implying that the financial sector has not matured to influence the environment positively. The effects of Urbanization and foreign direct investment are negative on carbon dioxide emissions.

From the study results, environment Kuznets curve hypothesis is not relevant for formulating environmental policies in Kenya. Policy designers cannot expect that increased economic growth would result in a better environment. At the same time reducing economic growth is not a viable approach because Economic growth is required to reduce poverty and unemployment levels. The country needs a development plan that incorporates growth and environmental sustainability. A plan that will decrease poverty with least environment degradation. These demands implementing sustainable models in agriculture, transportation, energy production and efficient use of resources.

Additionally, the country has to develop the financial sector because it will protect the environment. A strong financial sector can finance environmentally friendly projects that will help reduce CO2 emissions. The financial sector can offer conditional loans to businesses that limit the use of credit to eco-friendly projects.

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