The Financial Development, Energy Use, Trade Receptivity, and Carbon Emission of Sub-Saharan Africa and MENA Countries

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ABSTRACT

The abstract is assembled as a synopsis of discrete abstracts from diverse studies drafted by the author as they relate to the outlined variables in the dissertation topic.

The First study scrutinized the influence of energy utilization, trade receptivity, and financial development on CO_2 emissions of 10 countries in the Middle East and North Africa within the period of 1970 to 2017 employing DOLS {dynamic ordinary least squares} and the FMOLS {fully modified ordinary least squares}.

The main findings reveal energy utilization and receptivity of trade have a significant positive influence on CO_2 emissions. Contrarily, the influence of financial development on the emissions of CO_2 is negative and statistically significant.

The second study utilized the STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology model) to investigate the impact of natural resources extraction, population, affluence, and openness in trade on CO_2 emissions and energy utilization of 17 SSA (Sub-Saharan Africa) countries from 1971-2019. The Westerlund (2007) Error-Correction Model, The Pooled Mean Group (PMG-ARDL), the panel FMOLS {Fully Modified Ordinary Least Square} and dimension group mean Panel DOLS (Dynamic Ordinary Least Square techniques) were used to assess carbon emission and energy utilization long-run multiplier.

The empirical results reveal that natural resource extraction, urbanization, and income have a significant positive impact on energy utilization and CO_2 emissions in SSA countries in the remote future. On the contrary, openness in trade, in the long run, has

a negatively significant influence on energy utilization and the emission of CO_2 of SSA countries.

The third study examines the interaction of Foreign Direct Investment, fiscal development, renewable energy usage, economic growth, and CO_2 emissions of South Africa (1970 to 2014). The findings are: the existence of a statistically significant correlation among the series was detected by the Johansen multivariate cointegration and the ARDL bound cointegration result.

Furthermore, a significant positive correlation existed between GDP (economic growth), financial development, and CO_2 emissions in both the long run and short run. Contrarily, renewable energy consumption exerts a negative relationship on CO_2 in the short run. The granger causality results show proof of bidirectional stimulus running from renewable energy to economic growth.

Keywords: Carbon emissions; financial development; trade receptivity (openness); energy utilization; Environmental sustainability; Natural resources extraction; STIRPAT Model; foreign direct investment; renewable energy; MENA countries; SSA countries; South Africa.

ÖZ

Özet içeriği, tez konusundaki ana hatlarıyla belirtilen değişkenlerle ilgili olduğu için yazar tarafından hazırlanan çeşitli çalışmaların ayrı özetlerinden derlenerek bir özet olarak bir araya getirilmiştir.

İlk çalışma, enerji kullanımı, ticari kabul edilebilirlik ve finansal gelişmenin etkilerinin DOLS {dinamik sıradan en küçük kareler} ve FMOLS {tamamen değiştirilmiş sıradan en küçük kareler} kullanarak 1970-2017 döneminde CO_2 efüzyonunun Orta Doğu ve Kuzey Afrika'daki 10 ülkenin üzerindeki etkilerini incelemiştir.

Ana bulgular, enerji kullanımının ve ticaretin kabul edilebilirliğinin CO_2 emisyonları üzerinde önemli bir pozitif etkiye sahip olduğunu ortaya koymaktadır. Aksine, finansal gelişmenin CO_2 efüzyonu üzerindeki etkisi negatif ve istatistiksel olarak anlamlıdır.

İkinci çalışma, doğal kaynakların çıkarılması, nüfus, refah ve ticarette açıklığın CO_2 efüzyonları ve 17 SSA (Sahra Altı Afrika bölgesi) 'nın ülkelerindeki 1971 ve 2019 yılları arası enerji kullanımı üzerindeki etkisini araştırmak için STIRPAT (Nüfus, Zenginlik ve Teknoloji Üzerindeki Regresyona Göre Stokastik Etkiler modeli) ’ı kullanmıştır. Karbon emisyonunu değerlendirmek için ve enerji kullanımını uzun dönemli alarak Westerlund (2007) Hata Düzeltme Modeli, Havuzlanmış Ortalama Grubu (PMG-ARDL), FMOLS paneli {Tam Modifiye Olağan En Küçük Kare} ve boyut grubu ortalaması Panel DOLS (Dinamik Sıradan En Küçük Kare teknikleri) kullanıldı.

Ampirik sonuçlar, uzak gelecekte SSA (Sahra Altı Afrika) ülkelerindeki CO_2 efüzyonları ve doğal kaynak çıkarma, kentleşme, gelirin enerji kullanımı üzerinde önemli bir pozitif etkiye sahip olduğunu ortaya koymaktadır. Aksine, açık ticaret, uzun vadede, SSA (Sahra Altı Afrika) ülkelerinin enerji kullanımı ve CO_2 emisyonu üzerinde olumsuz ve anlamlı bir etkiye sahiptir.

Üçüncü çalışma, Güney Afrika'nın CO_2 çıkışının (1970-2014) etkileşiminin doğrudan yabancı yatırım, mali kalkınma, yenilenebilir enerji kullanımı, ekonomik büyümeye olan etkilerini incelemektedir.

Bulgular şunlardır: Johansen çok değişkenli eş bütünleşme ve ARDL bağlı eş bütünleşme testlerin sonucu ile seriler arasında istatistiksel olarak anlamlı bir korelasyonun varlığı tespit edilmiştir.

Ayrıca, hem uzun vadede hem de kısa vadede GSYİH (ekonomik büyüme), finansal gelişme ve CO_2 çıkışı arasında önemli bir pozitif korelasyon var oldu. Aksine, yenilenebilir enerji tüketimi kısa vadede CO_2 üzerinde negatif bir ilişki uygulamaktadır. Granger nedensellik sonuçları, yenilenebilir enerjiden ekonomik büyümeye doğru giden çift yönlü teşvikin kanıtını göstermektedir.

Anahtar Kelimeler: Karbon emisyonları; finansal gelişme; ticari alıcılık potansiyeli (açıklık); enerji kullanımı; çevresel sürdürülebilirlik; doğal kaynakların çıkarılması; STIRPAT modeli; doğrudan yabancı yatırım; yenilenebilir enerji; MENA(Orta Doğu ve Kuzey Afrika) ülkeleri; SSA(Sahra Altı Afrika) ülkeleri; Güney Afrika.

DEDICATION

I dedicate this dissertation to God Almighty

&

My Lovely Husband Mr. Chikezie Ugochukwu Ekwueme

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Chapter 1

INTRODUCTION

For the past decades, global warming is one of the contemporary challenges that have gained attention globally due to its devastating consequences on mankind. The escalating global warming has been ascribed to the activities of mankind. According to Djalante (2019), GHG (Green House Gases) and which the chief is CO_2 is a substantial cause of the global warming menace and CO_2 are emitted via the activities of human beings. The emission intensity of CO_2 differs amidst nations due to each nations' discrete social and natural attributes.

According to Fernandez-Amador, Francois, and Tomberger, 2016, the resultant effect of global heating revamping differs for all the world's regions and is copious, it can lead to deterioration of the health of the human populace and as well as the environment. A greater portion of the factors instigating global warming and climatic change has been attributed to the emission of GHG particularly CO_2 and it has been debated that to ward off imminent economic growth and national security in the long-run, swift attentiveness focused on mitigating the emissions of carbon is requisite (White House,2016). Additionally, developing and advanced nations have prioritized the moderation of carbon dioxide emissions which comprises 81% of the GHG (Khan et al. 2021 and Ahmad et al. 2020).

Examination by climate experts over the last centenary reveals that the agglomeration of CO_2 in the airspace has escalated exceedingly (Kwakwa et al. 2018). Virtually all nations are contributors to the escalation in emissions of CO_2, for instance, in 2019, China contributed 27%, the United States 11%, India 6.6%, European Union (27 countries in EU) 6.4%, Indonesia 3.4%, Brazil 2.8%, and Russia 2.2% to the global emission of GHG (greenhouse gases) (OCED, 2020). According to World Development Indicators (2020), over the years the world's CO_2 emission accelerated constantly from 3,112,685.279 per capita metric tons in 1960 to 36,440,000,000 per capita metric tons in 2019.

The situation of global climate change has not resonant alike in developed nations and developing nations like nations in Sub-Saharan Africa (SSA) and MENA regions. For instance, Sub-Saharan Africa (SSA) and MENA nations suffer most from the change in climate and natural disasters owing to the fact that they have an economy that is greatly dependent on natural and environmental resources. Also, Sub-Saharan Africa and MENA countries' economies have been distinguished by speedy urbanization, natural resources, trade, economic growth, and vigorous population growth which in turn could result in a rise in the level of pollution. Contrarily, to the 2005 emission rate, it is predicted that by 2030, the natural pollution of African nations will constitute about 50% of the global pollution rate (Liousse et al. (2014).

To tackle the challenge of global warming, world leaders have committed to ensuring mitigate the emission of carbon so that this will assist in keeping the rise in the world temperature below 2°C (Ekwueme 2020). Researchers, ecologists, and policymakers are working simultaneously to analyze the likely predictors of carbon emissions for a long time. Since a change in climate or global warming is a universal phenomenon that entails an encompassing approach on everyone's part to mitigate the emission of carbon, research has been conducted for undeveloped nations (Al- Mulali and Ozturk 2016), developing countries (Charfeddine et al., 2018; Aboagye 2017a), advanced nations (Bekun et al. 2019), nations emitting low CO_2 (Ekwueme, 2020), and nations emitting high CO_2 (Alper and Onur 2016).

Several factors such as the high magnitude of financial development, trade, economic growth, population growth, foreign direct investment (FDI), urbanization, natural resources extraction, and utilization of energy has been identified to perform substantial functions in ascertaining the CO_2 emission level for countries (Khan et al. 2020, Charfeddine et al., 2018; Aboagye 2017a, Bekun et al. 2019, Ekwueme, 2020, Alper and Onur 2016). The current superfluous trend of carbon emissions internationally can be attributed to the excessive degree of development of the financial sector, openness in trade, usage of energy, and economic growth (Pata 2018, Siddique, 2017, and Khan and Ozurk, 2020).

Financial development can accelerate the emission of CO_2 in various ways. For instance, firstly, the development of the financial sector by enhancing the stock market standards can result in the expansion of the monetary channel, lowering of financing costs, and the edge of operational risk of itemized companies which in turn will increase the tendency of these firms to investing in new projects. This implies the creation of additional facilities and commodities which require more energy consumption, and in turn, escalates the emission of carbon dioxide. Secondly, an enormous level of financial efficiency and intermediations such as giving of loans to consumers can accelerate their consumption of exorbitant goods such as air conditioners, automobiles, and bigger homes, which in turn will result in pollution, and a rise in waste generation that may deteriorate the environment (Kirikkaleli, and Adebayo, 2020). Thirdly, financial development via foreign investment expansion can lead to rapid economic growth which in turn will accelerate the emission rate of carbon dioxide. Contrarily, others argued that the development of the financial sector can assist in the mitigation of emissions of carbon and thereby promote environmental quality. For instance, credit interventions can perform a vital function in multiplying and increasing companies' resources. Proficient usage of these resources by the firm by investing in eco-friendly projects will result in the mitigation of emissions of carbon (Tamazian, Chousa, & Vodlamannati, 2009; Claessens & Feijen, 2007).

The argument in the literature regarding the influence of trade on the environment is complicated. PHH (Pollution Heaven Hypothesis) supporters believe that trade receptivity (openness in trade) influences the quality of the environment of poor nations negatively because they are forced to reduce the environmental regulations in their bid to attract foreign companies and thus leading to a rise in the emission of pollutants. Consequently, negative externality emerges to the disadvantage of the poor host nation (Kwakwa et al., 2020). Further, others believe that receptivity of trade degenerates the environment by stirring nations to extricate extra resources that do not possess an explicit property right (Amuakwa-Mensah and Adom (2017). Additionally, trade receptivity through “the scale effect, technique effect, and composition effect” influences the environmental standards. The environmental quality of the environment is enhanced by the technique effect by empowering nations to import low pollution manufacturing techniques. Trade through its composition effect assist the transformation of the economy from agricultural-based to industrial based and finally to service which has relatively small pollution. The trade scale effect degrades the environment as it facilitates the expansion of manufacturing and consumption activities (Kwakwa and Aboagye, 2014).

Energy use is among the fundamental sources of carbon dioxide emissions. The development of the financial sector, trade sector, economy, and the increase in the activities of mankind has resulted in an enormous demand for the use of energy. The globalization of the social, political, and economic activities in the world has led to the doubling of energy usage thus making way for vigorous competition as regards development. According to Global Energy & CO_2 Status Report (2019), in 2018, consumption of energy globally escalated to 2.3% which is almost double the average growth from 2010, which is caused by an enormous demand for cooling and heating in some regions of the world and a vigorous global economy. More than half of the increase in energy demands is attributed to the higher demand for electricity, followed by an enormous increase in fuel and natural gas usage. Thus, the emissions of carbon dioxide globally increased by 1.7% to 33.1 gigatonnes in 2018 as a result of the higher utilization of energy. Generation of energy from coal remains the single greatest emitter, representing 30 percent of the entire energy-associated emissions of carbon dioxide. The world has been put in a consolidated (unified) form by the phenomena of globalization and this has permitted interactions among the countries in both negative and positive means. The exchange of economics activities brings about diverse positive things and negativities like the transfer of pollution and CO_2 emissions. The theory of globalization by Rosenberg, 2001 postulated that modification is urgently needed intellectually because in a globalizing world it is disastrous to offer automatic territorialism additional leasehold on life. The advancing countries are escalating their development speed by using any mechanisms as surmised in their policies concerning economic activities like the attraction of foreign investors, manufacturing, and industrialization and these accelerate the propensity to depend on enormous utilization of energy, this, in turn, increases the emission of carbon dioxide. Research has revealed that developing nations in their pursuit of converging with advanced nations tend to contribute more to change in climate, on the other hand, the advanced nations are putting in measures to mitigate their emissions of pollutants by switching to clean energy origins. Also, some of these countries in the quest to develop speedily with the advanced nations have attracted foreign companies into their countries with reduced environmental regulations, thus leading to a rise in the emission of pollutants.

Foreign Direct Investment (FDI) is vital for an economy as it provides capital and investment opportunities and performs a substantial function in the manufacturing of commodities and services. FDI enhances growth in the economy through the transmission of technology and productivity gains (Khan et al. 2020). FDI by increasing the manufacturing level and economic growth escalates the emission of carbon and thereby degrades the environment.

Numerous explanations reveal that natural resource extraction could increase pollutant emissions. Natural resources stand as one of the important sources in financial development, international trade, and emission of carbon dioxide. They may be used in financing various activities of the government which comprises both political, socioeconomic as well as diaspora remittance and foreign trade, with revenue gained from trade in natural commodities (Adedoyin et al., 2020). Gaining access to natural resources rents creates room for self-reliance, hence promoting financial freedom. This financial freedom may lead to economic growth which in turn will accelerate the emission of carbon. Additionally, in the quest of growth economically, natural resources especially in third-world (developing) nations are excessively used, all this requires more energy utilization that leads to an upsurge in the emissions of carbon dioxide (CO_2) (Asongu & Odhiambo, 2019). One argument, on the contrary, argues that natural resource rent has the likelihood of shielding the environment and helps in the mitigation of carbon emissions. According to Pata (2018) natural resources rent when employed in state capacity building can mitigate the possibility of carbon dioxide emission.

The association between economic growth and emission of carbon cannot be detached from both international and local activities in the economy. Inclusive in the economic activities that can be regarded from the international and domestic perspective are manufacturing as it connects to trade (that is export and imports), investments (both domestic and foreign investments), development of the financial sector, and extraction of natural resources. The escalation in the use of energy is linked with a sparkle in industrial production as a result of the high level of trade, financial development, investment, natural resources extraction among others and this accelerates the emissions of CO_2. Every region or nation that is waxing strong economically must experience escalating energy usage which will negatively affect the environmental standards as a result increase in emission levels. However, it is shown that advanced nations are putting extra effort to ensure a balance between environmental quality and economic growth, while the developing nations in the pursuit of their economic objectives are not balancing their economic growth with environmental quality. Based on the report of WDI (World Bank Development Indicator, 2020), the emissions of carbon dioxide of the Sub-Saharan Africa (SSA) region rose enormously from 87,278,293.1 metric million tons per capita in 1971 to 834,309,683,621,817 metric million tons per capita in 2019, while that of the Middle East and North Africa (MENA) region rose from 2.3 MMT (Metric Million Tons) in 1970 to 6.2 MMT in 2014. The CO_2 emissions rate from SSA and MENA nations suggests a potentially devastating problem in the future of its resultant effect on global warming to which these regions are vulnerable by its natural and social characteristics as the majority of the population depends on exportation, oil manufacturing, agriculture, and mining activities.

Given the foregoing, the aim of this study is to examine the impact of trade receptivity, financial development, foreign direct investment (FDI), natural resources extraction, energy consumption (unrenewable and renewable energy usage), industrialization, economic growth (GDP), urbanization, on CO_2 emissions of MENA and Sub-Sahara Africa. These variables are appropriately discussed in the following chapters. These variables are chosen to provide further insights on how these variables influences CO_2 emissions. Also, the probable influence of these variables particularly financial development, trade receptivity, natural resources extraction, and FDI on the sustainability of the environment and ecological soundness has not gained attentiveness a great deal especially in the African region. The MENA and SSA countries are used as a case for this research.

This research is novel in the sense that to the best of the researchers' knowledge, only a few research (Arouri et al, 2012, Omri et al.2015, Al-Mulali, 2011, Kwakwa and Adu, 2016) have combined some of these variables to investigate the quality of the environment as it relates to emissions of carbon dioxide in MENA and SSA countries. Nevertheless, none of them have investigated the impact of the selected variables on the CO_2 emissions of SSA and MENA countries in an exclusive regression. Thus, this study by using the sampled variables wants to address the void (gap) and also initiate a margin for future scholars who might be interested in investigating this field.

This work's second chapter is the influence of energy use, trade receptivity, and financial development on carbon dioxide emission in MENA countries. It was done with four different specifications of the model based on the EKC hypothesis. Two of the model acts as our criterion model which assessed the impact of financial development, trade receptivity, utilization of energy, and influence of trade, the square of trade, and economic growth on emissions of carbon, the remaining two models include the control variables for the analysis . The major motivation for the conduction of this research is to establish the influence of the sampled variables on the drivers of environmental deterioration particularly emissions of carbon in MENA countries. The first model tested the influence of trade, square of trade, GDP, and utilization of energy use on CO_2 emissions (which is the dependent variable) and the output reveals that energy use, economic growth, and trade receptivity enhances emissions of carbon in MENA countries while the coefficient of the square of trade was negative and insignificant. The second model tested the impact of trade, financial development, and energy use on CO_2 emission and the output reveals that trade and utilization of energy has a remarkable positive influence on emissions of carbon while the financial development has a significant negative impact on CO_2 emission. The third model tested the impact of trade, financial development, GDP, energy use, together with the control variables which are urbanization and industrialization on CO_2 emission and the output reveals that GDP, energy use, urbanization, and industrialization have a significant positive influence on emissions of carbon. The fourth model tested the impact of trade, square of trade, financial development, energy use, together with the control variables (urbanization and industrialization) on CO_2 emission and the output reveals that trade, GDP, energy use, urbanization, and industrialization have a remarkable positive influence on emissions of carbon. While the square of trade was negative and statistically significant. This implies that for MENA countries, emission of carbon is enhanced by trade, GDP (economic growth), energy use, urbanization, and industrialization, while financial development mitigates CO_2 emission. Furthermore, the positive sign for trade and the negative sign for the square of trade-in model 4 results support the postulation of EKC.

Chapter three models the impact of natural resources extraction on the emissions of carbon and energy utilization in Sub-Saharan Africa using the STIRPAT approach. The empirical results reveal that natural resource extraction, urbanization, and income have a significant positively inference on energy utilization and the emission of CO_2 in SSA nations in the long run. This suggests that environmental deterioration increases with an increase in natural resource extraction, urbanization, and affluence (income). On the contrary, in the long run, the influence of trade openness on energy utilization and the emission of CO_2 in SSA countries is negative and significant.

Chapter four is on the carbon emission effect of renewable energy utilization, fiscal (financial) development, and foreign direct investment in South Africa. South Africa is one of the nations in SSA Africa. The outcome reveals that Economic growth has a significant positive influence on emissions of carbon, while emissions are significantly reduced by renewable energy use in both the short-run and long run.

The remaining chapters are structured as follows: from chapter two (2) to chapter (4) comprises studies conducted on this topic. Chapter 5 comprises conclusions and the policy inferences deduced from the research.

Chapter 2

EMISSIONS OF CARBON DIOXIDE IN MENA COUNTRIES: INFERENCE OF FINANCIAL DEVELOPMENT, TRADE RECEPTIVITY, AND ENERGY UTILIZATION.

2.1 Introduction

The inquisitiveness of innumerable researchers and policymakers has erupted on the identification of the connection between trade receptivity, financial development, and emission of carbon (CO_2) attributable to the rising ultimatum of metamorphosis in climate and paramount global biodegradable. The outcome of global biodegradable and climate metamorphosis is plenty and varies for all regions in the world, its effect spans from environmental deterioration to its implication on the health of the human populace (Fernandez-Amador, Francois, and Tomberger, 2016). In countries that are still developing such as the Middle East and North Africa (MENA) countries and in advanced countries, the case of global warming has not been identical reverberant. MENA countries have an economy depending greatly on environmental and natural resources, fall within the regions which suffer greatly from climate change and natural catastrophes. Also, the economies of MENA countries have been distinguished by aggressive population growth, economic growth, trade, and speedy urbanization which consequently could lead to an increase in pollution levels.

World Bank expects the Middle East and North African nations to grow their economy during 2019-2021continually at a tolerable velocity of about 1.5 to 3.5 percent, with some dawdlers and a few emerging growth stars. According to them, this growth is a result of natural resources and rapid growth in population. An alarming prediction is that organic pollution of countries in Africa will by 2030 comprise about 50% of the world level as opposed to the rate in 2005 (Liousse et al. (2014).

Emission of carbon dioxide (CO_2) is a primary contributor to change in climate and global warming and this carbon dioxide is emitted through human activities. The increasing change in climate has been attributed to human activities. The CO_2 emission level varies among countries, as a result of the specific natural and social features of each country. Over the previous century, Observation by climate scientists shows that CO_2 concentration in the air has been increased enormously (Kwakwa and Adu, 2016). Almost all countries are contributing to the rise in emissions, with China up 4.7%, the US by 2.5% and India by 6.3% in 2018 (OCED, 2018).

Outrageous levels of energy utilization, financial development, growth in the economy, and receptivity of foreign trade can be said to lead to the present excessive trend of emission of carbon globally (Kwakwa and Adu, 2016). A lot of reasons which show why the financial development possibly will cause the increase in air pollution. The first is by improving the standard of the stock market and itemized firms can lower their financing costs, expand the channel of their monetary, and verge for operational risks. In this regard, companies decide to raise the level of investments in the new projects, to create more goods and new facilities. All of these demand more consumption of energy that will create more CO_2 emissions. The second point shows that developing financial sectors might flag the direction for the expansion of foreign investment as to a swift economic growth that will consequently, make the CO_2 emissions to rise. The third point, successful financial mediations, and efficiency could permit consumers to buy expensive items by giving them loans, but buying bigger homes and automobiles as along with air conditioners and other items can result in a very significant rise in CO_2 emissions (Gokmenoglu et al., 2015b; Sadorsky, 2010; Zhang, 2011). On the contrary, one argument suggests that financial development would be able to provide a shield for the environment and assist in the cut of CO_2 emissions. Credit intermediation would play an important role in assisting to increase resources and multiply firms. A firm that would be able to develop financial development can execute well due to the more proficient usage of its energy and resources. In this situation, the level of air pollution is expected to decrease (Claessens & Feijen, 2007; Tamazian, Chousa, & Vodlamannati, 2009).

In comparison to other countries such as OECD members as well as emerging economies like China, the contribution of the Middle East and North African countries are small, it has increased greatly from 2.3 to 6.2 million metric tons in 1970 to 2014 (The World Bank, 2018). According to the World Bank indicator, globally, carbon emission has increased from 4.0 {million metric tons in 1970} to 5.0 {million metric tons in 2014}. The rate of carbon emission from MENA countries implies possibly consequential future problems considering its effect on the change of climate to which the region is susceptible by its' social and natural features as most of the populace rely on mining activities, oil production, and exportation.

Data available data from Word Development Indicators of World Bank data suggest that the increase in emissions of carbon emissions in the MENA region is found to follow an identical pattern with the sub-region growth in financial development, energy consumption, receptivity of trade level, and income from 1970 to 2014 (see figures 1 below).

For example, the MENA region's GDP per capita increased from the U.S. $4,303 in 1970 to the U.S. $7,845 in 2018. The impressive growth performance the region has witnessed could be the cause of this development (The World Bank, 2018). Also according to the World Bank Indicator 2018, MENA region consumption of energy has been accelerating with carbon emission with CO_2 emission increased from about 324,041kilotons (kt) of oil equivalent in 1971 to 36,138,285kt of oil equivalent in 2014, while the consumption of energy increased from 466 to 2353(kg) of equivalent oil per capita in 2018. Concerning trade receptivity and financial development according to World Bank Indicator2018, the trade receptivity rose from about 55% in 1970 to 78% in 2017, while financial development represented by domestic credit to the private sector (% of GDP) rose from about 17% in 1970 to 54% in 2018. The adoption of the trade liberalization policies linked with the structural adjustment programs (SAP) and economic recovery programs (ERP) of the International Monetary Fund and World Bank that many MENA countries adopted in the 1980s and 1990s as a remedy for the abysmal economic performances, they were experiencing maybe a contributory factor to this increment in the trend of exports and import.

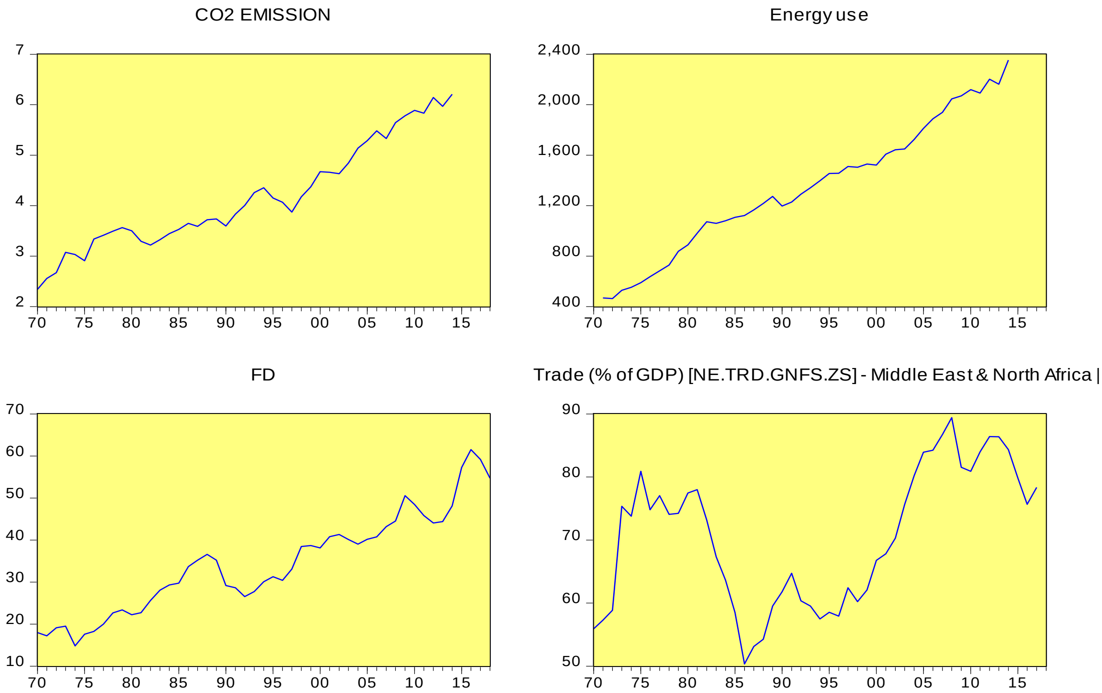

Figure1: financial development (FD), CO_2 emissions, trade, and energy utilization in the MENA region within 1970 -2017. Source: Authors computation using data from World Bank Indicator, 2018.

The data displayed in the figures above suggest that the path of emissions of carbon in the MENA countries is influenced by the paths of trade receptivity, financial development, and energy utilization as all graphs above show an upward trend which means an increase in financial development, trade energy consumption increases Emission of CO_2 in the MENA region.

In light of the above, this study aimed at investigating the impacts of financial development, receptivity, and utilization of energy on CO_2 emissions in MENA Countries using Fully modified ordinary least squares method.

This study will be instrumental in the literature in general and especially for the MENA region regarding carbon emissions determinants, as we discovered a dearth of research in the MENA region that accounts for the development of financial, consumption of energy, emissions of CO_2 emission and trade receptivity in a single regression. Meanwhile, the literature shows extensive documentation on the possibility of trade receptivity and financial development having a positive effect on carbon emissions and likewise the possible positive outcome of financial development on energy utilization (Kohler, 2013, Kwakwa and Adu, 2016, Sadeghieh, 2016, and Siddique, 2017). Therefore, the omission of one of these closely related variables from the emissions of carbon equation can result in an upwards bias of the estimated effect of energy utilization, financial development, and trade on emissions. Earlier studies, especially in the MENA region, focused mainly on the income and utilization of energy's influence on emissions or receptivity of trade and energy consumption on trade. Additionally, most of the previous studies are primarily case studies of a country using time series analysis and or cross-sectional data such as (Kohler, 2013 and Farhani and Rejeb, 2012) which have some limitations associated with their estimations (Baltagi, 2005). This implies the need for an undertaking of a panel data study that takes into account the shortcomings linked with time-series studies, permitting for heterogeneity across countries, and offering extra power by amalgamating the cross-sectional data and time-series data (Apergis and Payne, 2010).

Furthermore, there is a need for further research on this subject matter as previous studies' findings on the have not yielded conclusive results. By inclusion of quadratic trade term in our specification, we confronted the theoretical argument of the potential nonlinearities in the association between trade and emissions of CO_2 with MENA data in this research.

This chapter is structured as follows. Section two deals with the exhaustive list on review of related empirical works on the subject topic, Section three deals with the techniques employed in the study. Section four is on data analysis and elaboration of findings, finally, Section five is on the Conclusion and policy implication of the study.

2.2 Literature Review

Quite a number of extensive empirical research on the existing outcome of economic production within the environment in economic literature are available. The majority of the empirical literature that preceded the pioneer study of Kraft and Kraft (1978) concentrated on the association between energy and economic growth.

Other empirical works in this regard studies in this direction are Kaplan et al., 2011; Kaplan et al., 2011; Binh 2011; Lau, et al., 2011; Ghosh 2010; Yuan et al., 2008; Aqeel & Butt 2000; Stern 1993; Bekun et al. 2019, a,b; Emir & Bekun 2018; Ozturk 2010.

Further, other scholars concentrated on the environment and economic growth by utilizing the EKC (environmental Kuznets curve) hypothesis to estimate the U-shaped upturn nexus between environmental degradations and growth in the economy. The hypothesis is one of the best familiar hypotheses with respect to the effect of economic production's influence on the surroundings. According to the hypothesis of EKC, an upturned curve with a U shape would be employed to show a correlation connecting economic growth and the environment. This implies that at the first phase of economic growth, advancement in the measure of the pollution would have an ascending trend, however, it is limited to a particular level of development and then there would be a decline in the trend (“Panayotou 1997and Shafik & Bandyopadhyay 1992”). The empirical work carried out by a lot of authors depicted different conclusions. Empirical shreds of evidence on the validity of the EKC hypothesis were provided by (Galeotti, Manera & Lanza 2009; and Selden & Song 1994). However, Holtz-Eakin and Selden

(1995) discovered a curve that is unmodulated and rising; Friedl and Getzner (2003) discovered a curve with N-shape. In contrast, with these concluded the connection among economic growth and degradation in the environment has no significant relationship ("Agras & Chapman 1999; and Richmond & Kaufman 2006").

These studies (Soytas & Sari, 2009; Akbostanci et al., 2009; Acaravci & Ozturk, 2010; Apergis & James, 2010; Arouri et al., 2012; and Wang et al., 2011) have tried to scrutinize the connection linking these three variables by the combining energy utilization-growth literature with EKC literature. This research by consideration of the variables which include the utilization of energy, emissions of pollutants, and economic growth, simultaneously in the framework of modeling examined the relationships connecting utilization of energy, emissions of pollutants, and economic growth.

Mohammed, Guo, Haq, Pan, and Khan (2019) in their study applying bound tests discovered proof of long-run linkages among the variables, and the EKC hypothesis was confirmed by the result of this study. Additionally, it revealed that government expenditure tends to have an affirmative effect on environmental degradation and in contrast, financial development has a negative correlation that takes place with environmental degradation, which implies that financial development reduces environmental degradation.

Diverse causal relationship (such as two-way, one-way, and non-directional nexus) was discovered in the G7 countries while in India and China a bidirectional connection among emissions of carbon emissions, economic growth, and energy utilization are found by the study of Liu, Lei, Zhang, and Du (2019). However, their outcomes show the existence of enormous differences between developed and developing nations.

Sun, Clottey, Geng, Fang, and Amissah (2019) in their study assesses the connection between emissions of CO_2 and trade by incorporating energy usage and economic growth as crucial possible decisive elements for 49 nations that are categorized as the highest emitter of CO_2 in Road and Belt regions. The study found that trade receptivity had a negative and positive influence on the degradation of the environment, however, the impact is different in the various nations under study. The outcomes of the analysis of causality test using VECM support the causal connection in the long run between utilization of energy, degradation in the environment, trade receptivity, and economic growth in Europe, Road and Belt, low, middle, and high-income panels. The result confirmed the hypothesis of EKC.

The result of analysis of the research by Diallo and Masih (2017) suggests a decline in the emissions of CO_2 in the long run. Additionally, they discover that financial development has a substantial influence on the emissions of the CO_2. Therefore, the outcome is further braced by Shahbaz et al. (2013) who found out that the private sector credit had a dropping effect on CO_2 emission through their two different studies in South Africa and Malaysia respectively.

Farhani and Rejeb (2012) evaluate for 15 MENA countries from 1973-2008 the link between emissions of CO_2, energy utilization and growth in the economy applying the techniques of panel causality test, panel unit root tests, and panel cointegration. According to their result, there is no causal link between energy utilization and growth economically in the short run. However, there is a one-way causal association in the long-run flowing from emissions of CO_2 and economic growth to the consumption of energy.

Jalil & Feridun (2011) examined the linkage between financial development, utilization of energy, earnings, and ecological quality in China. A negative connection between financial development and ecosystem pollution in China was revealed by the study's outcome and thus EKC hypothesis is proven for China. Therefore, the researchers established that monetary development has facilitated a reduction in ecological pollution.

Zhang (2011) studied the possible association between emissions of CO_2 emission and financial development in China and discovered that monetary improvement played an essential part in the expansion of CO_2 emissions. He further buttressed that in comparison with other budgetary advancement pointers, the effect of the money connected intermediation scale on CO_2emissions are greater. However, though it may result in quantifiable changes in CO_2 emission. Its impact is far weaker.

Al-Mulali (2011) studied the association between utilization of oil, growth in the economy, and Carbon emission in MENA employing a panel representation. The cointegration result discloses correlation in the long run among the variables being studied. Furthermore, two-way causal association both in the short and long run among economic growth, CO_2 emissions and oil utilization was disclosed their results.

The outcome of study of Wang et al., (2011) confirmed that there are linkages of a relationship between utilization of energy, economic growth; and CO_2 emission. Additionally, they found bi-directional causality among energy consumption and economic growth and between CO_2 emissions and energy consumption. Also, they disclosed that emissions of carbon are caused by energy usage in the long run.

Apergis and Payne (2010) examined the correlation between utilization of energy, real output, and carbon dioxide emissions for 11 countries from 1992-2004. They found that energy utilization has a positive substantial influence on emissions of CO_2 in the long run. They discovered a two-way causal association among utilization of energy and emissions of CO_2 emissions in the long run. In contrast, a uni-directional causal link among utilization of energy, real output and CO_2 emissions were revealed the short-run dynamics in the study.

2.3 Data description and Methodology

2.3.1 Description of Data

Balanced cross-country panel data for 10 MENA nations which constitute Algeria, Iran, Egypt, Iraq, Morocco, Jordan, Kuwait, United Arab Emirates, Tunisia, and Saudi Arabia was employed by the study between 1970 and 2017. Due to missing data for the variables of interest for a number the countries, the original plan of using all the MENA countries was not possible. The nations that had the most available data for the period under study (1970-2017) were chosen. To control for heterogeneity differences and the fact that countries differ in various aspects, a panel model was used. There would be misspecification of results if heterogeneity of the difference is not being accounted for. Also, panel data have less collinearity, greater variability, more efficient estimates, are more informative, and possess more degree of freedom (Klevmarken, 1989). The data was collected from the 2018 version of the World Development Indicator of the World Bank.

Table 1: Abridged Table of Variables

Variables	Proxy	Symbols
Emissions of carbon dioxide	Metric per tons per capital	CE
Financial development	Domestic credit to private(% of GDP)	FD
energy utilization	Kg of oil equivalent per-capital	ENC
Trade receptivity	Addition of exports & imports { % of GDP}	T
Urbanization	Total urban population	URB
Economic growth	Gross domestic product (constant 2010 US $).	GDP
industrialization	Industrial value-added {as a share of GDP }	IND

Table 2: Summary of Descriptive Statistics

Stat.	CE	FD	T	T2	GDP	ENC	IND	UR
Mean	9.08	38.76	75.29	6662.74	13271.79	2688.03	40.75	1327204
Med.	3.20	33.72	71.70	5142.04	3637.78	950.49	36.05	894581
Max.	7.61	105.18	176.74	31.23	116232.8	12172.42	84.79	6001657
Min.	0.46	1.26	0.02	0.0004	730.10	180.70	16.25	18714
Std. dev	12.46	24.02	31.54	5487.80	21207.38	3338.38	15.67	1225601

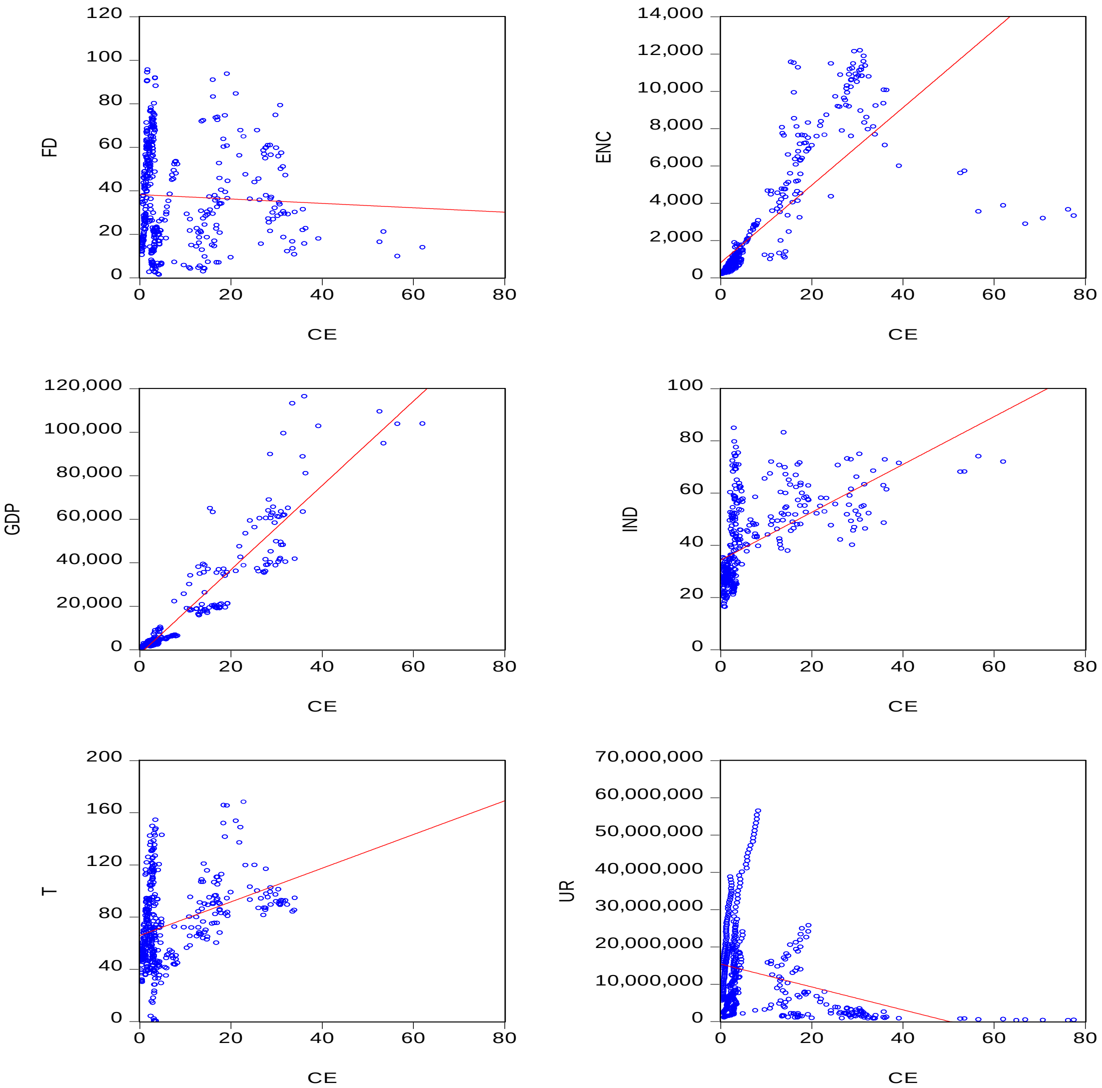

Figure 2: The scatter plot of the relationship between financial development (FD), trade, energy utilization and, CO_2 emissions in the MENA region within 1970 -2017. Source: Authors computation.

Table 3: Outcome of Correlation Coefficient Matrix

Corr.	CE	FD	T	ENC	GDP	IND	UR
CE	1.000						
T-Stat	....						
P-Value	…….						
FD	-0.0072	1.000					
T_stat.	*-0.1258*	……					
P.Value.	*0.8998*	……					
T	0.3232	0.5340	1.000				
T-Stat	*5.9556*	*11.0136*	……				
P.Value	*0.0000**	*0.0000**	……				
ENC	0.9603	0.0911	0.3167	1.000			
T.Stat	*60.0955*	*1.5958*	*5.8233*	…….			
P.Value	*0.0000**	*0.0111*	*0.0000**	……..			
GDP	0.9331	-0.0503	0.3563	0.8704	1.000		
T.Stat	*3.0573*	*6.3456*	*5.6418*	*30.8266*	……..		
P.Value	*0.0060**	*0.3797*	*0.0000**	*0.0000**	………		
IND	0.6878	-0.4260	0.1048	0.5763	0.6534	1.000	
T.Stat	*16.5231*	*-8.2109*	*1.8379*	*12.2977*	*15.0495*	……..	
P.Value	*0.0000**	*0.0000**	*0.0671*	*0.0000**	*0.0005**	………	
UR	-0.0879	-0.2353	-0.6012	-0.0470	-0.2136	0.1243	1.000
T.Stat	*-1.5394*	*-4.2218*	*-13.1199*	*-0.8216*	*-3.8122*	*2.1843*	……..
P.Value	*0.1247*	*0.0000**	*0.0000**	*0.4119*	*0.0002**	*0.0297***	………

Note: * and ** means.01% and 0.05% significance level respectively. The null hypothesis was rejected

The statistics summary of FD (financial development), CE (Carbon emission), IND (industrialization), ENC (energy utilization), GDP (growth economically), T (trade receptivity), UR (urbanization), and T^2 (square of trade) is disclosed in table 1 above. FD's mean of $38.76 is small unlike that of the other nations that have developed and those that are still developing. The maximum and the minimum value of 105.18 and 1.26 respectively shows that there is much variation in the level of FD across time and countries. The mean of Trade is 75.29%, which suggests that for the period under study, the trade as a share of GDP is in excess of 75 percent on average. This implies that over the period under study that the sub-region on average was civilly open to global trade. The maximum and the minimum values of trade are 176.74 and 0.02 respectively. ENC (Energy consumption) means is 2688.03 kilograms, the maximum and minimum figures are 12172.42 and 180.70. Thus, it is conspicuous that there is great variability across countries and time in the consumption of energy. Also, the mean, maximum, minimum, and standard deviation of CE (carbon emission) suggest a large variability across time and countries.

The scatter plot in figure 2 acts as a predecessor to sight the relationship between emissions of carbon dioxide and the variables under study and it buttressed a positive relationship between energy utilization, trade receptivity, industrialization, and emissions of carbon. While its relationship with financial development and urbanization is shown as negative by the plot. Therefore, from the scatter plots all the variables are detrimental to the environment except for urbanization and financial development. The variables' -correlations which are accordant with the fundamental theories of economics are displayed in the table of the correlation matrix result above.

2.3.2 Model Specification.

It is argued theoretically through the hypothesis of EKC the nexus between energy and emissions is linear, and non-linear interrelation exists between trade and emissions. Also, the EKC hypothesis states that the interconnectivity between income and carbon emissions is quadratic. Thus we model the inference of financial development, trade receptivity, utilization of energy, and economic growth on emissions of carbon based on the EKC hypothesis as follows:

$$CE_{it} = \alpha + \theta X_{it} + \lambda N_{it} + \mu_{it} \quad (1)$$

The explained or dependent variable is CE (carbon emissions), i mean countries under study, t means time, X means a vector of independent variables which are financial development, receptivity of trade, economic growth, and utilization of energy. μ comprises of the unobservable country-specific effect and the remainder disturbance. N comprises of control variables (urbanization and industrialization) which were included to avoid biasedness in the results. The inclusion of these two variables was based on the fact that they are known to affect carbon emissions according to Kwakwa & Adu 2016. These variables were also used in literature by (Kwakwa & Adu 2016; Siddique et al. 2016; Siddique 2017; and Sharma, Wang, Shi, Li, & Wang 2011).

The functional form of our model is further expanded and written as follows:

$$CE = \alpha_i + \theta_1 FDi_t + \theta_2 T_{it} + \theta_3 GDP_{it} + \theta_4 ENC_{it} + \lambda_1 UR_{it} + \lambda_2 IND_{it} + \mu_{it} \quad (2)$$

Square of trade openness is incorporated in Equation (2) to calculate equation (3) below to evaluate the EKC hypothesis;

$$CE = \alpha_i + \theta_1 FDi_t + \theta_2 T_{it} + \theta_3 T_{it} 2 + \theta_4 GDP_{it} + \theta_5 ENC_{it} + \lambda_1 UR_{it} + \lambda_2 IND_{it} + \mu_{it} \quad (3)$$

Four models were advanced from equation 3 above in our estimation. Two of the model acts as our criterion model which assessed the impact of financial development, trade receptivity, utilization of energy, and influence of trade, the square of trade, and economic growth on emissions of carbon. The remaining two models include the control variables for the analysis. For the analysis, the whole variables are not logs.

Based on theory and economic intuition, The EKC hypothesis is expected to hold in this region, thus FD, T, GDP, UR (urbanization), and IND (industrialization) is therefore anticipated to have a positive influence on carbon emissions since the region under study is a developing one and the pollution haven hypothesis is likely to hold in this case. Also, the square of trade is anticipated to have a negative outcome on carbon emission based on our expectation of the EKC hypothesis to hold in this region and also is a region comprising of developing countries.

$$\theta_1, \theta_2, \theta_4, \theta_5, \lambda_1, \lambda_2 ..... > 0, \qquad \theta_3 < 0 \tag{4}$$

2.3.3 Econometric techniques

This section focuses on the econometrical procedure applied in the course of this study. First, preliminary analysis that dwells on summary statistics as reported in table 1. Subsequently, Stationarity checks to ascertain and test the variables under review. Third, investigation of cointegration among the outlined variables. Finally, application of the dynamic ordinary least squares {DOLS} and fully modified ordinary least squares {FMOLS).

2.3.3.1 Test of Unit root test

The stationarity test was first carried out because most panel data are known to be non-stationary, thus estimating such variables will lead to a spurious result. According to

Levin and Chu (2002) is viewed as the augmented Dickey-Fuller (ADF) test panel extension and it is stipulated below:

$$\Delta X_{it} = \alpha_i + \lambda X_{it-1} + \Sigma j - 1\lambda_{it}\Delta X_{t-1} + \mu_{it} \quad (5)$$

Where i and t = 1

i mean the countries under study, T is the time under study. Pi represents the lags' number and µit is the stationary term. The variables for its country over time (t) are denoted by Xit. The null hypothesis of LLC is H_o: λ =p-1 =0 and H_i= λ <0.

IPS test by Im, Pesaran, and Shin (2003) is an extended version of the LLC test, for all the panel units it allows for heterogeneity on the coefficient (λ) of AR (autoregressive), this characteristics of IPS makes it superior to LCC. The null hypothesis of IPS is Ho: λ_i= 0ᵾ$_1$, H_i: λ_i <0ᵾ$_1$

2.3.3.2 Cointegration test.

This study made use of the Pedroni cointegration test. According to Pedroni (1999), the Pedroni cointegration test is an extension of Engle- granger cointegration test which states that 1(1) series are cointegrated when the residual from their spurious regression are integrated order of 1(0). The seven tests are categorized into two groups; test for heterogeneous cointegration based on the within dimension technique and on the between means technique (Pedroni, 1999; Martins, 2011).

The Pedroni cointegration test regression equation according to Pedroni (1999) is stated below:

$$Y_{it} = X_{it}\lambda_i + \delta_i + \hbar_i + \mu_{it} \quad (6)$$

To determine if cointegration exists the test is to be carried on the residual from the static long-run regression form expressed below;

$$\mu_{it} = P_i \mu_{it-1} + y_{it} \tag{7}$$

The null hypothesis expressed as $p_i = 1$, implying no cointegration among variables.

2.3.3.3 FMOLS {fully modified ordinary least square}.

The last step after testing for cointegration is the application of the extended version of Phillip and Hansen FMOLS estimator for time-series data proposed by Pedroni (2000) to scrutinize the effect of utilization of energy, trade receptivity, financial development, economic growth, urbanization, and industrialization on emissions of CO_2. The FMOLS estimation technique was chosen because it is appropriate for the estimation of endogenous variables and equations with a 1(1) series. Furthermore, FMOLS is seen to be robust for both variables that are not stationary and endogenous and variables.

Generally, the panel FMOLS is expressed in equation 8 below:

$$\hat{\beta}_{fmol} = \left\{ \sum_{i=1}^{K} \sum_{t=1}^{F} \left(y_{it} - \overline{y}_i \right)^1 \right\}^{-1} \left\{ \sum_{i=1}^{K} \sum_{t=1}^{F} \left(y_{it} - \overline{y}_i \right) \hat{X}_{it}^{+} + F\hat{\Delta}^{+} + \varepsilon\mu \right\} \tag{8}$$

Where $\Delta\varepsilon\mu$ represents serial correlation correction term and to achieve the endogeneity correction y_{it}^{+} is used to represent the transformed variable of yit.

The panel DOLS is estimated again to check for the vigorousness of the results. The DOLS Coefficient is estimated as follows:

$$\hat{\beta}_{dol} = \sum_{i=1}^{K} \left(\sum_{t=1}^{F} N_{it} N_{it}' \right)^{-1} \left(\sum_{t=1}^{F} N_{it} \hat{X}_{it}^{+} \right) \tag{9}$$

$$where\ Z_{it} = \left(x_{it} - x_i, \Delta x_i,\ t-q,\ ...., \Delta x_i,\ t+q \right)\ \ is\ 2\left(q+1\right)X1\ \ \ vector\ of\ regressors \tag{10}$$

Two models FMOLS and DOLS were utilized because FMOLS is appropriate for the estimation of endogenous variables and equations with 1(1) series and panel DOLS was estimated again in other to check for the vigorousness of the results.

2.4 Discussions of the Findings

The outcomes of econometric methods used in this research in order to check the variables in question are presented and discussed in this section.

2.4.1 Cross-Sectional Dependence Test

A cross-sectional dependency test was conducted to ascertain whether the data are cross-sectionally dependent. In a cross-country panel analysis, the extant cross-sectional dependency happens due to undetected model specification or common stocks that are part of the error terms. According to Pesaran, Ullah, and Yamagata (2008), though cross-sectional dependency within panels may be described as weak or strong, failure to determine the existence of dependence cross-sectionally among the variables under study results to estimations that are bias and inconsistent standard errors of the computed parameters.

Thus, the study examined the cross-sectional dependency within our chosen panels utilizing Pesaran (2004) Scaled LM and Pesaran et al. (2008) parametric test. The cross-sectional dependency Lagrange multiplier (CDLM) Pesaran (2004) test adds the squares of the correlation coefficient between cross-sectional residuals. The null and alternative hypotheses were consistent with the CDLM1 test used by Breusch et al (1980). This method is utilized when T > N or N > T, where T is (the time dimension of the panel) and is asymptotically standard and normally distributed and N is (the cross-sectional dimension). The following formula is used to calculate the test:

$$CD_{LM} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \widehat{p}_{ij}\right) \tag{10}$$

$$\widehat{\beta}_{fmol} = \left\{\sum_{i=1}^{N}\sum_{t=1}^{T}\left(x_{it} - \overline{x}_i\right)^1\right\}^{-1} \left\{\sum_{i=1}^{N}\left(x_{it} - \overline{x}_i\right)\hat{y}_{it} + T\Delta + \varepsilon_{\mu}\right\} \tag{11}$$

Where pij denotes the result of the sample residual pairwise correlation, which is stipulated as:

$$P_{ij} = P_{ji} = \frac{\sum_{t=1}^{T}\varepsilon_{it}\varepsilon_{jt}}{\left(\sum_{t=1}^{T}\varepsilon_{it}{}^2\right)^{\frac{1}{2}}\left(\sum_{t=1}^{T}\varepsilon_{jt}{}^2\right)^{\frac{1}{2}}} \tag{12}$$

The null hypothesis and alternative hypothesis are to be investigated were pij = pji =corr (εit, εtj) = 0 for i, j and (pij = pji, 0) for specific i , j, respectively. The augmented form of the CD_{LM1} computation proposed by Breusch et al. (1980) is the CD_{LM1adj} test of Pesaran et al. 2008 and is found below:

$$CD_{ML1adj} = \frac{1}{CD_{LM1}}\left[\frac{(T-K)P_{ij}{}^2\mu T}{\sqrt{\upsilon_{ij}{}^2}}\right] \tag{13}$$

Where N~ (0, 1) and CD_{LM1} is calculated as

$$CD_{LM1} = T\sum_{i=1}^{N-1} \sum_{j=i-1}^{N} \widehat{p}_{ij}{}^2 \tag{14}$$

This test null hypothesis is “the cross-sections are not related”. The correlation coefficients between residuals of the cross-section after the computation of the ordinary least square (OLS) is being added and squared by this test and is utilized when N is constant and T moves to infinity and has N $\frac{(N-1)}{2}$ degrees of freedom.

Table 4: Outcome of cross dependency test.

Test	Statistic	Prob. Value
Pesaran scaled LM	1.3896	0.1646
Pesaran CD	-0.9395	0.3475
Bias –corrected Scaled LM	1.2832	0.1994

The null hypothesis of no CD is not rejected by all the tests as shown in Table 4 above. Thus, we conclude that there is an absence of CD (cross-sectional dependence) across the sampled panel units.

2.4.2 Outcome of Panel-Unit root tests.

The study examined the stationarity of the series in their levels using the Breitung, IPS, and LLC tests. Selection of lag length was done using SIC

Table 5: Outcome of Panel unit root test

Methods	**CE**	**FD**	**T**	**T2**	**GDP**	**ENRC**	**UR**	**IND**
LLC-t*								
Level	-0.207	-0.859	-1.285	-1.589	0.788	1.385	-0.062	-1.589
First diff.	-8.216**	-10.387**	-5.002**	-1.589**	-5.002**	-5.501**	-3.612**	-6.816**
IPS-W-stat								
Level	-0.803	-0.8046	-1.999	-2.553	0.996	1.179	4.037	-0.092
First diff.	-10.211**	-9.556**	-10.687*	-11.226**	-6.718**	-9.120**	-2.941**	-0.464**
Breitung- t- stat								
Level	- 0.283	-0. 097	-3.713	-3.880	0 .215	0. 902	-3.073**	-1.178
First diff	-4.596**	-4.237**	-7.810**	-8.720**	-5.072**	-4.694**	-	-8.269**

Notes: *** denotes null hypothesis being rejected at the 5% significance level. Asymptotic normality is assumed by the probabilities of all the tests computed.*

At level, the non-stationarity of all variables was not rejected by all the tests except for the Breitung that rejects the existence of unit root for urbanization. All three tests rejected the null hypothesis of stationarity for all variables at a 5- percent significance level at the first difference of the variables. Therefore, all the variables are integrated at order one difference I(I) showing their stationarity at first difference. Thus we proceed to the cointegration test since all the variables are 1(1).

2.4.3 Panel-cointegration test

The existence of long-run relationship among the variables was done using the Pedroni cointegration test and the result is displayed in table 6 below.

Table 6: Pedroni - Panel Cointegration test

Test statistics	**CE, FD, T, GDP, INV, & UR Statistics**	**CE, FD, ENC, & T Statistics**	**CE, ENC, T, T^2 GDP Statistics**	**CE, FD, T, T^2, ENC INV, and UR Statistics**
Panel PP- Stat	-5.3699***	-0.9408***	-6.8084***	-6.6856***
Panel Rho-Stat	0 .3904	-1.0301***	-1.1748	1.2334
Panel V-Stat	-0 .3242	0 .8060	0.0926	-1 .0351
ADF Statistic	-0.7251	1.5392***	-1.8215**	-3.3009***
Group Rho-Statistic	0.5096	-3.4755***	-2.0150**	1.0653
Group PP Statistic	-11.4631***	-8.4654***	-8.1287***	-11.5181***
Group ADF Statistic	-.8251**	-2.6441***	-2.3806***	-1.9736**

, ** ,and * means the null hypothesis was rejected at 0.01%, 0.05% and 0.10% significance level*

The cointegration test for each group of the series provided mixed results, some tests accepted the null hypothesis while the others rejected it. Nevertheless, based on Gao and Zhang (2014) and Kwakwa and Adu (2016) who stated that PP statistics is more powerful than rho-statistics in the validation of whether cointegration is present among the series and the fact that majority outcomes of the various group of series rejected the null hypothesis of no correlation in the long- run, we, therefore, finalized that the variables, in the long run, have a stable relationship.

2.4.4 FMOLS and DOLS test results

The Fully Modified Ordinary Least Square by Pedroni and Dynamic Ordinary Least Square off stock and Watson argumentation estimation are estimated in table 7 below, having tested and ascertained that the variables are linked together in the long run.

Table 7: Results of Panel Estimation of FMOLS and DOLS of MENA 1970-2017

		FMOLS		
	Model (1)	**Model (2)**	**Model (3)**	**Model (4)**
FD		-0.0221***	0.0028	-0.0036
T	0.0768***		0.0150**	0.0037
0.0415***				
T^2	-0.0010***			-
0.0002***				
GDP	-2.26		0.0001***	
ENC	0.0003***	0.0020**	0.0013***	0.0012***
IND			0.0150*	0.0585***
UR			2.84E**	2.61E***
		DOLS		
	Model 1	**Model 2**	**Model 3**	**Model 4**
FD		-0.0141	0.0042	0.0094
T	0.0115	0.0069	0.0037	-0.0116
T^2	-8.10			-0.0002***
GDP	0.0001***		0.0001***	
ENC	0.0008***	0.0020***	0.0014***	0.0001***
IND			0.0087*	0.0680***
UR			5.655E**	8.06E***

****, **, and * means the null hypothesis was rejected at 0.01%, 0.05% and 0.10% significance level*

The estimation of the four models produces identical results in both FMOLS and DOLS. Generally, from the results, the influence of all the variables on emissions of carbon is positive and statistically significant except fiscal (financial development) and square of trade whose coefficients were significantly negative at a 1% significance level. Furthermore, the enormity of the estimated coefficient was not affected much by the addition of the control variables terms. Financial development results indicate a negative outcome with the emission of carbon in the MENA region with a coefficient of 0.022. This implies that a rise in financial development by a unit will lead to a reduction in emissions of CO_2 in the MENA region by 0.022 units. Consequently, high financial development over time in the region such as credit interventions can perform a vital function in increasing companies' resources. Proficient use of these resources by the firm by investing in eco-friendly projects will result in the mitigation of emissions. Additionally, financial development can provide resources that will be channeled into research and development that facilitate a transition to clean energy uaeSome studies carried out in accordant with these are the study by (Mohammed et al 2019; Diallo & Masih, 2017; and Sadeghieh, 2016) who discovered the presence of negative bond among FD and CO_2 emission. Sadeghieh, 2016, in his study discovered that for Turkey a 1% rise in the development financially will lead to scaling down in CO_2 emission in FD with 0.157%.

Trade openness results show that it contributes positively to the emission of CO_2 in the MENA region with a coefficient that ranges from 0.041 to 0.076. This suggests that openness of trade enhances the emission of CO_2 at less than one unit in the MENA region. However, the square of openness to trade has a negative coefficient that is statistically significant. Thus, an increase in the square of openness to trade by one unit will lead to a reduction in emission of carbon by 0.001 units. As revealed by the outcome of model 1. Hence, this outcome authenticates the existence of a non-linear association between trade and the emissions of carbon in MENA countries. Thus, this implies for the MENA region, the techniques and compositions influence of trade is greater than the scale effect. Therefore, since trade decreases the emission of carbon in the long run, the pollution haven hypothesis can be deduced to be a proportionately short-run occurrence for the MENA region. Furthermore, the positive sign for trade and the negative sign for the square of trade-in model 1 and model 4 results support the postulation of EKC. This finding is consistent with the following work; (Sadeghieh, 2016; Kwakwa & Adu, 2016; Anis, Saida, Christopher, & Anissa 2015).

Energy consumption result shows that it has a positive contribution to the emission of carbon in the MENA region with a coefficient that spans from 0.001 to 0.002. This implies that I unit increment in consumption of energy will lead to 0.001 unit to 0.002 unit increase in emission ofCO_2. Thus, in the MENA region consumption of energy will lead to an increase in the emission of carbon, though in a small proportion as the figure is quite very low. The reason is a constant change towards energy efficiency in the Middle East as well as alternative sources of energy (Ahmed, 2019). For instance, Dubai's 2030 energy plan is geared towards reduction of demand for emission of carbon dioxide and energy by thirty percent within the year 2030 through assured supply of energy and efficient utilization of energy whereas achieving sustainable objectives and environment (Ahmed, 2019). Also, there is the growth of huge renewable energy schemes in Jordan, UAE, Qatar and Saudi Arabia, etc. (Ahmad, 2019). This result is in line with (Kwakwa, 2016, Mohammed et al., 2019, Sadeghieh, 2016, and Diallo & Masih, 2017).

With regards to industrialization, its impact on the emissions of carbon in the MENA region is discovered to be positive and statistically significant. Thus a unit rise in the industrial GDP's portion of the MENA region will result in a rise in the emission of carbon with a 0.015units to 0.068 and vice versa. Therefore, as MENA's economy becomes more industrialized, the emission of carbon from the machines utilized is increased.

Urbanization is statistically significant and has a positive coefficient, it means that an increment in the population of urban areas in the MENA region will enhance carbon emission. The explanation for this could be the fact that the fast-moving rate of urbanization comes with numerous problems such as the removal of vegetation cover to construct infrastructure to satisfy the expanding urban population need and heavy traffic jams which result in a constant rise in the utilization of fossil fuel. Also, the sustenance of urban infrastructure like the system of transportation accelerates the use of energy which in turn accelerates pollutants in the region. The reliable findings with (Omri et al., 2015; and Kwakwa & Adu 2016).

2.4.5 Diagnostic Test

The estimated output of DOLS and FMOLS models are tested against correlation problems to confirm the reliability of the results, this is due to the nature of the measurement of some of the variables are employed in this work. To test for multicollinearity in this study the VIF (variance inflation factor) was utilized. According to the literature, the VIF value of 1 means the absence of correlation among a predictor and the other remaining predictor variables while if VIF is above 4 calls for further investigation. However, if the VIF is more than 10, then there is conspicuous evidence of serious multicollinearity that will need correction. The output of the test is shown in table 8 below for FMOLS models 2 and 3 which shows that the variables are likely to be correlated. From the result, it is obvious that no problem of collinearity exists among the variables since all are having VIF values that show less than 2.21. Identical results were acquired for model 1 and 4, however, is not stated here. Since the main estimator: FMOLS takes accounts for serial correlation, thus serial correlation testing was not done.

Table 8: Results of Multicollinearity test Using Variance Inflator Factor (VIF)

	Model 2(FMOLS)		Model 3(FMOLS)	
	Coefficient variance	Uncentered (VIF)	Coefficient variance	Uncentered (VIF)
FD	3.14	1.19	1.61	1.92
T	4.86	1.11	1.60	1.71
T2				
GDP			1.71	1.38
ENC	1.24	1.19	5.16	1.75
IND			7.85	1.75
UR			8.52	2.21

2.5 Conclusions and Policy Implications

Global warming issues have been on the front burner of most economies and MENA countries are no exception. The region has joined the world on the global strides to mitigate against global warming in terms of decoupling from economic growth, CO_2 emissions. This is the motivation for the current study to consider the interaction among growth in the economy, pollutant emissions, receptivity of trade, industrialization, energy utilization, and urbanization. To this end, the influence of energy utilization, receptivity in trade, and financial development on emissions of carbon using fully modified ordinary least squares and dynamic ordinary least square the study in 10 MENA countries starting from 1970 to 2017. The fact on the absence of study that assessed the influence of energy utilization, trade receptivity, and financial development on the economic growth of carbon in a single regression equation on the emission of CO_2 in the MENA region is the motivating factor that leads to the conducting of this research. Meanwhile, there is well documentation in the literature on the possibility of trade and financial development having a positive effect on growth and also the possibility of the positive effect of financial development on energy consumption. Therefore, the omission of one of these closely related variables from the emissions of carbon equation can result in upwards bias of the estimated inference of financial development and utilization of energy on emissions of CO_2.

The main outcomes of these studies reveal proof of a negative connection between emissions of CO_2 and financial developments. Consequently, outrageous development financially over time will result in mitigation of CO_2 emissions in the region. The influence of trade receptivity and utilization of energy on the emissions of CO_2 is positive and statistically significant. Similarly, our empirical results are being validated by the apparition of the EKC. Additionally, from the empirical results, the pollution haven hypothesis can be deduced to be a proportionately short-run occurrence for the MENA region.

The major policy implication emerging from our study is the empirical results indicate there is an inverse U shape between carbon emissions and trade in MENA countries. The U-shaped relationship turning points was estimated at a GDP approximation of US$5483, which is yet to be attained. Thus, we assert that the MENA region is at the lower stage of the reverse U-shaped relationship, and enlarging economic growth over the period under investigation is detrimental for the territory. The fundamental notion of the EKC (Environmental Kuznets Curve (EKC) is that in the first phase economic growth deteriorates the quality of the environment. However, later on, the situation revert to a turning point, and the quality of the environment is now enhanced by economic growth, and that environmental quality is a U or N shaped curve. Thus the summit of the U pattern curve linked with the EKC hypothesis for the MENA region as found by our empirical study implies that emissions of carbon rise with economic growth, equalize, and decline.

Consequently, this study suggests that sacrificing economic growth to lessen the emissions of CO_2 quantity in countries in the MENA region is pertinent as they will attain a decline of CO_2 emissions through conservation of energy and trade without having a negative effect on economic growth in the long run.

Thus policymakers in MENA countries should formulate policies that will stimulate a rise in trade receptivity as this will mitigate the emissions of carbon in the MENA nations in the long run. Additionally, outrageous development financially over time will result in mitigation of CO_2 emissions in the region as revealed by the empirical result, this suggests the importance of promoting activities that will accelerate development financially and trade openness in the region by government, policymakers, and stakeholders in the region. Thus as the MENA economy grows financially and opens more to trade, there will be a reduction in the emission of CO_2, this is because of the postulation that the soaring level of receptivity of trade and financial development increases innovations in technology by enhancing disbursement on research and development geared towards energy-saving which aftermath is energy efficiency and thus reduces CO_2 emissions. However, in addition to the attainment of goals of sustainable ecosystem and evolution of giant projects in renewable energy in MENA countries, consumption of energy is discovered to accelerate the emissions of carbon dioxide in MENA nations, hence enactment of policies geared to securing clean energy supply and usage is requisite.

The study, therefore, recommended that to enhance financial development and trade openness, it is essential to adopt the policies of financial liberalization, because the enlargement of the financial sector, will promote exports and openness to trade in countries in the MENA region. Furthermore, adequate resources should be provided by the financial sector to create new institutions, organizations, and instruments that will aid economic development thus leading to financial development.

Considering the positive effect of urbanization and industrialization on the emission of CO_2 in the MENA region, measures should be put in place to ensure decentralization of growth in the country, which will, in turn, lead to a reduction of pressures in the urban centers. The governments in the MENA countries should encourage rural development. Technologies that are low in the emission of carbon should be promoted and utilized in the industrial sector.

Finally from the empirical results, we can deduce that emission of CO_2 in MENA countries can be explained by both financial and non-financial variables.

Chapter 3

Modeling the Impact of natural resources extraction on the emissions of carbon and energy utilization in Sub-Saharan Africa using the STIRPAT approach.

3.1 Introduction

For the past decades, global warming is one of the contemporary challenges that have gained attention globally due to its devastating consequences on mankind. According to Djalante (2019), GHG (Green House Gases) of which the chief is CO_2 is a substantial cause of the global warming menace.

According to Fernandez-Amador, Francois, and Tomberger, 2016, the resultant effect of global heating revamping differs for all the world's regions and is copious, it can lead to deterioration of the health of the human populace and as well as the environment. A greater portion of the factors instigating global warming and climatic change has been attributed to the emission of GHG particularly CO_2 and it has been debated that to ward off imminent economic growth and national security in the long-run, swift attentiveness focused on mitigating the emissions of carbon is requisite (White House,2016). Additionally, developing and advanced nations have prioritized the moderation of carbon dioxide emissions which comprises 81% of the GHG (Carbon Footprint, 2018; Owusu & Amsumadu Sarkodie, 2016, Khan et al., 2021). According to World Development Indicators (2020), over the years the world's CO_2

emission accelerated constantly from 3,112,685.279 per capita metric tons in 1960 to 4,555,224,176 per capita metric tons in 2016.

To tackle the challenge of global warming, world leaders have committed to ensuring mitigate the emission of carbon so that this will assist in keeping the rise in the world temperature below 2°C (Ekwueme 2020). Researchers, ecologists, and policymakers are working simultaneously to analyze the likely predictors of carbon emissions for a long time. Since a change in climate or global warming is a universal phenomenon that entails an encompassing approach on everyone's part to mitigate the emission of carbon, research has been conducted for undeveloped nations (Asumadu-Sarkodie and Owusu 2016;), developing countries (Ekwueme et al. (2021); Ekwueme and Zoaka (2020), Charfeddine et al., 2018; Aboagye 2017a), advanced nations (Bekun et al. 2019), nations emitting low CO_2 (Ekwueme, 2020), and nations emitting high CO_2 (Alper and Onur 2016), and several factors such as growth in the economic, trade, population, and energy usage were revealed by these studies to perform substantial functions in ascertaining the CO_2 emission level for countries. Although numerous research has strived to analyze the drivers of CO_2 emission to provide a solution to environmental challenges not so much has been undertaken to analyze the inference of extraction of natural resources on pollutant radiations. The probable influence of natural resources extraction on the sustainability of the environment and ecological soundness has not gained attentiveness a great deal especially in the SSA region. Thus, there is a need to investigate the likely drivers of carbon emissions with the inclusion of natural resource extraction through further studies. Additionally, previous studies produced conflicting results depending on the country of study, period, and the techniques used in these studies, and the practical and policy implication might seriously be affected by these things.

Extraction of natural resources promotes deterioration of the environment via undiscriminating discarding of waste chemicals into the atmosphere, land, and water and enormous utilization of energy needed for extraction.

Therefore, this paper is aimed at scrutinizing the environmental deterioration effects of extraction of natural resources activities in Sub-Saharan Africa using a STIRPAT (Stochastic Impacts on Population, Affluence, and Technology) model. According to Asongu & Odhiambo, (2019), and (Kwakwa et al. 2020), Natural resources extraction, high level of international trade, population growth, consumption of energy, and economic growth can be linked to the recent high trend of emissions of carbon globally. Numerous explanations reveal that natural resource extraction could increase pollutant emissions. Natural resources stand as one of the important sources in financial development, international trade, and emission of carbon dioxide. They may be used in financing various activities of the government which comprises both political, socioeconomic as well as diaspora remittance and foreign trade, with revenue gained from trade in natural commodities (Adedoyin et al.,2020). Gaining access to natural resources rents creates room for self-reliance, hence promoting financial freedom. This financial freedom may lead to economic growth which in turn will accelerate the emission of carbon. Additionally, in the quest of growth economically, natural resources especially in third-world (developing) nations are excessively used, all this requires more energy utilization that leads to an upsurge in the emissions of carbon dioxide (CO_2) (Asongu & Odhiambo, 2019). One argument, on the contrary, argues that natural resource rent has the likelihood of shielding the environment and helps in the mitigation of carbon emissions. According to Pata (2018) natural resources rent when employed in state capacity building can mitigate the possibility of carbon dioxide emission.

Sub-Saharan Africa (SSA) is used as a case for this study because is among the region that suffers most from the change in climate and natural disasters owing to the fact that they have an economy that is greatly dependent on natural resources. Also, Sub-Saharan Africa countries' economies have been distinguished by speedy urbanization, natural resources, trade, economic growth, and vigorous population growth which in turn could result in a rise in the level of pollution.

Based on the report of WDI (World Bank Development Indicator, 2020), the emissions of carbon dioxide rose from 87,278,293.1 metric tons per capita in 1971 to 834,309,683,621,817 metric per tons per capita in 2019. The CO_2 emissions rate from SSA nations suggests a potentially devastating problem in the future of its resultant effect on global warming to which the region is vulnerable by its natural and social characteristics as the majority of the population depends on exportation, oil manufacturing, and mining activities.

According to Figure 3 below, the increment in energy usage and emissions of carbon in Sub-Saharan Africa exhibit a likely pattern with the regions' natural resources rent, Population (urbanization), Affluence (income), and the rate of trade openness (World Bank Development Indicator 2020). For instance, the SSA region's natural resource rent proxied by the total natural resources rent rose from 4.105793973 in 1971 to 7.386037132 in 2019, income measured by GDP per capita increased from 1445.39 in 1971 to 1656.70 in 2019. Energy utilization in SSA rose 677.3083839 in 1971 to

687.2276934 Kilogram (oil equivalent per capita) in 2019. The urban population of SSA increased from 18% in 1971 to 40% in 2019.

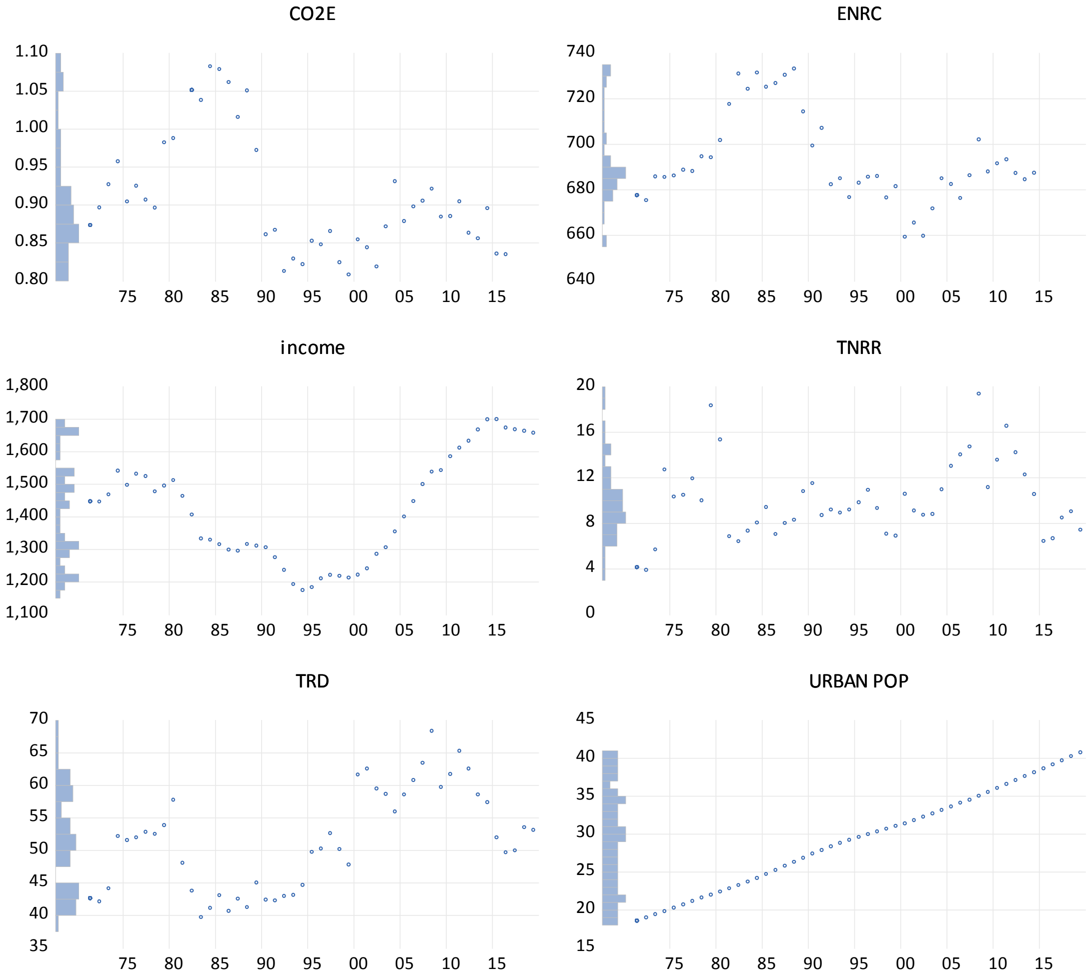

Figure 3: SSA regional data on Natural resources rent (TNRR), Urbanization (urban pop), Energy use (ENRC), Income, TRD (trade openness), and C02E (carbon emissions). Source: WD1 (World Bank Development indicators), 2020. Author's computation

Thus, the major target of this research is centered on using the STIRPAT model to investigate the impact of natural resources extraction (proxied by total natural resource rent), population (proxied by urbanization), affluence (income), openness in trade on CO_2 emissions and energy utilization of SSA (Sub-Saharan Africa) countries using the Westerlund (2007) Error-Correction Model, the Pooled Mean Group (PMG-

ARDL), FMOLS (Fully Modified Ordinary Least Square) and dimension group mean Panel DOLS (Dynamic Ordinary Least Square) techniques.

This research is novel in the sense that to the best of the researchers' knowledge, it is the first to investigate the footprint of natural resources extraction (proxied by total natural resource rent), population, Affluence, openness in trade on CO_2 emissions, and energy utilization of SSA (Sub-Saharan Africa) countries in an exclusive regression in Sub-Saharan Africa using the STIRPAT model and the above-mentioned econometric techniques. Thus, it will contribute to the literature broadly and particularly in the SSA (Sub-Saharan Africa) region as there is a dearth of review of related literature on linkages among natural resources extraction, energy utilization, and emissions of carbon in SSA. Empirical research such as Adedoyin et al., 2020, Ahmed et al., 2016, Ben-Salha et al., (2018), Ulucak and Khan, (2020), Shahbaz et al., 2018; Badeeb et al., 2017 considered natural resources rent alone with other variables in the regression using other economies as a case study and also they did not employ the STIRPAT model as they utilized other models. Therefore, the outcome of this study is likely to inform better and reliable policy directions.

The research outcomes will assist the policymakers to understand the interconnection between natural resource rent and carbon emissions and the exigency to initiate strong institutions, regulations, and policies that will accelerate the metamorphosis from antique automation that exploit many natural resources to contemporary automation that absorbs value-addition, recycling, and unnatural resources.

Finally, the peculiarity of this study is in the computation of the Westerlund (2007) Error-Correction Model, the Pooled Mean Group (PMG-ARDL), FMOLS (Fully

Modified Ordinary Least Square) and dimension group mean Panel DOLS (Dynamic Ordinary Least Square) techniques.

This chapter is designed as follows. Section two deals with the exhaustive list on review of related empirical works on the subject topic, Section three deals with the techniques employed in the study. Section four is on data analysis and elaboration of findings, finally, Section five is on the Conclusion and policy implication of the study.

3.2 Literature Review

The long-lived perspective among the models and theories used in the analysis of the effect of activities of humans on environmental quality is the equation of IPAT {Environmental Impact (I) Population (P) Affluence (A) and Technology (T)}with its refinement. This model (equation) credited to Commoner (1972) and Ehrlich and Holdren (1971) postulated that the environmental impact is dependent on the magnitude of technology, affluence, and population. This implies that the technological level which is the diverse ways through which productive resources are utilized by the society can have a substantial influence on the extent of environmental impact by increasing or decreasing it. Similarly, the environment may be negatively affected by an enormous affluence level given that it will lead to an increase in the electrical demand and machines that consume much energy, amount of pressure on natural resources, and a rise in the economy consumption rate. Also, enormous affluence can be linked to pollution and wastes generation. A growing rate of population in a bid to satisfy the needs of the society (like food, energy, transportation, water, and building of houses) would amount pressure on the environment, this, in turn, may lead to deterioration of the environmental quality.

The model of IPAT was revised to the Stochastic Impacts on Population, Affluence, and Technology (STIRPAT) model by Dietz and Rosa (1994) with the introduction of a stochastic term into the former model. This advancement of the model permits the estimation and testing of the hypothesis of undue effects from the environmental prime mover. The model of STIRPAT since its modification has been utilized by numerous studies such as Shahbaz et al., (2016), Kwakwa et al. (2020), Hassan (2016), Uddin, et al., (2016), and Li and Lin (2015) to examine the likely drivers of CO_2 emissions for countries. STIRPAT model was also utilized to analyze the drivers of energy utilization by other studies such as Ma et al., (2017), Salim & Shafiei (2014), Zongjie et al, (2016), Kwakwa et al. (2020), and Wang and Han (2016). Nevertheless, the outcome from these researches has not been consistent.

3.2.1 Empirical Review of Studies Using STIRPAT Model to Examine the Influence of Population, Affluence, Technology, and Natural Resources Extraction on CO_2 Emissions.

Kwakwa et al. (2020) used the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model to examine the effects of natural resources extraction on the quality of the environment of Ghana in the long run from 1971 to 2013 and discovered that natural resource extraction, urbanization, and income increased the energy utilization and emissions of carbon thereby accelerating the environmental deterioration of Ghana, while carbon emission was found to be reduced by international trade. Adams et al., (2016) employing the STIRPAT approach found that institutional quality, openness in trade, and income mitigates the emission of carbon in Ghana, but urbanization accelerates the emissions of carbon in Ghana. Amuakwa-Mensah and Adom (2017) employing the STIRPAT approach reported that forest size and globalization enhance the emissions of carbon, while energy efficiency mitigates emission of carbon in Sub-Saharan Africa. Similarly, the empirical work of Wang et al. (2011) discovered that for Minhang District, Shanghai China urbanization, affluence, and the size of the population have a positive influence on the emissions of CO_2, but the emissions of CO_2 is been mitigated by energy intensity. Shahbaz et al., (2016) reported that trade openness, energy, and income affect the emissions of CO_2 positively in the long run. Also, Hassan (2016) technology, urbanization, and income affect the emissions of CO_2 positively. Li and Lin (2015) reported that energy intensity, industrialization, urbanization, and income have a positive impact on the emissions of CO_2.

3.2.2 Empirical Review of Studies Using STIRPAT Model to Examine the Influence of Population, Affluence, and Technology on Energy Utilization.

Concerning empirical studies on energy utilization that utilized the model of STIRPAT, Ma et al., (2017) for instance, discovered that energy intensity, GDP index, urbanization, and population affect the energy consumption of commercial buildings in China positively. Cai et al, (2012) examined the factors that drive utilization of energy in China using the STIRPAT model, the output of their study revealed that the urbanization rate (measured by the distribution of rural and urban population factors have an enormous impact on utilization of energy than the total population factor which impact is small. Similarly, they discovered that energy utilization is increased by household consumption in China. Zongjie et al. (2016) investigated the energy utilization of Hotels using the STIRPAT model. They found that unit revenue of energy, unit area of revenue, and occupancy rate have a positive influence on the hotels' energy utilization, while the hotel energy consumption was reduced by temperature. Shahbaz et al., (2016) discovered that trade openness, capital stock, affluence, and urbanization have a substantial impact on the utilization of energy using the STIRPAT model. Similarly, Shahbaz et al., (2017) employing the STIRPAT model found that for Pakistan, transportation, technology, and income enhances consumption of energy. Inglesi-Lotz and Morales (2017) discover that income, industrial share, and population positively affect the utilization of energy, whereas the association of non-linearity between education and energy usage was observed by the study. Wang and Han (2016) reveal that population, ICT investment, and research and development reduce the intensity of energy in China.

3.2.3 Empirical Review of other related studies using the Non-STIRPAT model.

Other research that did not employ the STIRPAT such as Ekwueme et al (2021), Adedoyin et al., (2020), Kwakwa et al. (2018), Balsalobre-Lorente et al., (2018), Ekwueme & Zoaka (2020), Aboagye (2017a), Bekun et al (2019), Salahuddin et al., (2018), Sinha and Shabbaz (2018) and Dong et. al., (2018) discovered that natural resource extraction, trade openness, industrialization, urbanization, and income among others have a significant impact on emissions of carbon dioxide. For example, Adedoyin et al. (2020) in the study of the economic growth, coal rent, and emissions of carbon in countries in BRICS found that coal rent has a significant negative influence on CO_2 emissions for countries in BRICS. Dong et al (2018) disclosed that clean energy and natural gas mitigates CO_2 emissions in both the long run and short run, nonetheless, natural gas capacity to reduce the emissions of carbon dioxide, in the long run, will be weak while that of the clean energy will continually accelerate with regards to mitigation of CO_2 emissions. Ekwueme and Zoaka (2020) revealed that the development of the financial sector has a negative inference on the emissions of CO_2 and found a positive significant association between utilization of energy, receptivity in trade, and carbon emissions in their study of the interrelationship between economic advancement (growth), use of energy, receptivity in trade, financial development, and

CO_2 emissions in the MENA nations. The outcome of the study additionally favours the hypothesis of EKC in MENA countries. Bekun et al (2019) panel pooled Group Autoregressive distributive lag examined the association between non-renewable and renewable energy usage, natural resources rent, economic growth and found that in the remote future (long-run) positive links exist between natural resources rent and carbon emissions, which implies relying on excessively on earnings from natural resources could enhance carbon emissions in the long-term. within the framework of the hypothesis of EKC, Kwakwa et al. (2018) examining the interconnection between financial development and extraction of natural resources discovered that emissions from gaseous fuel utilization, construction, and the manufacturing sector is increased by natural resource extraction using data from Tunisia from1971 to 2016. Balsalobre-Lorente et al., (2018) exploring the linkages between the abundance of natural resources, openness in trade, economic growth, energy innovation, and emissions of CO_2 of five countries in the European Union from 1985 to 2016 found that the link between growth in economy and emissions of carbon dioxide exhibit an N-shape. Further, their outcome affirms that natural resources abundance and energy usage - have a negative inference on carbon emissions while openness in trade exerts a positive influence on the emissions of CO_2. Utilizing the postulation of EKC, Sinha, and Shabbaz (2018) used the ARDL technique to investigate India' carbon emissions from 1971 to 2016, they discovered in both short-run and long-run use of renewable energy and trade mitigates emissions ofCO_2, nevertheless, the result is better in the long period.

Additionally, the empirical studies of Kwakwa and Aboagye (2014); Aboagye (2017b); Mensah and Adu (2013); Kwakwa et al., 2015; Adom (2013) discovered that at the macro and micro level, energy utilization is influenced several factors, however, these studies did not utilize STIRPAT approach.

Nevertheless, out of the literature reviewed above, none of the literature examined the linkages between natural resources extraction, population, Affluence, and trade openness on CO_2 emissions and in energy utilization in an exclusive regression in Sub-Saharan Africa. Thus, to address the void (gap) observed in the literature, this study scrutinized these environmental measures incorporating natural resources extraction in an exclusive regression using data from Sub-Saharan Africa.

3.3 Data and Techniques

3.3.1 Data

The study employed balanced panel data sourced from the World Bank Development Indicator (2018) report for 17 SSA (Sub-Saharan Africa) countries: Zimbabwe, Zambia, Togo, South Africa, Sudan, Senegal, Nigeria, Mauritius, Kenya, Ghana, Gabon, Cote d'Ivoire, Congo Republic of Brazzaville, Congo Democratic Republic, Cameroon, Botswana, and Benin for a period of 1971-2019. The panel data was utilized to account for heterogeneity differences and because of the disparity of countries in various aspects. According to Klevmarken, (1989), there would be outcomes' misspecification if diversity difference is not being elucidated. Furthermore, panel data hold an extra degree of freedom, less collinearity, extra estimate that are efficient, greater variability, and is more informative. In this study, our dependent variable is the environmental impact which is proxied by carbon dioxide emissions and energy utilization. Our independent variable is natural resource extraction, trade openness, population (proxied by urban population), and affluence (income). The summary of the variables, their symbols, and their measurement are listed in Table 9 below.

Table 9: Variables Used and the Proxy

Symbols	Variables	Proxy
AFF	Affluence	(income)-Gross domestic product (GDP) per capita .
TNRR	Natural resources extraction	Natural resources rent (total)
TRD	Trade openness	{percentage of GDP}sum of imports and exports
ENRC	energy use	Kilogram (oil equivalent per-capita)
URBN	Population	urban population (% of the total population)
CO2E	Carbon emissions	Metric per tons per capita

3.3.2 Model Specification.

This study theoretically is based on the STIRPAT framework. As stipulated in segment two, with the introduction of a random term the IPAT equation was refined to the STIRPAT framework (model) by Dietz and Rosa (1994) to investigate the influence of affluence, technology, and population on the environment. Below is the mathematical expression of the model.

$$I_t = DP_t^{\alpha^1} A_t^{\alpha^2} T_t^{\alpha^3} R_t^{\alpha^4} e_t^{\in i} \quad (15)$$

Where T denotes technology, A denotes Affluence, P denotes population, D is the intercept or constant term, the stochastic term is the $e^{\in i}$, the period is denoted by t, while the parameters to be analyzed is denoted by α^s. The technological level (that is efficiently converting of inputs) has been measured by numerous variables of which openness in trade is fundamental. Population can be represented by urbanization and/or total population, but for this study, we used urbanization to measure population. Affluence has been represented by income, while Energy utilization and carbon dioxide emissions are used to measure environmental impact in much empirical research. Significant variables that are worthy of consideration are added to the above equation 15 given that its nature permits the modification of the model. Hence, the natural resource extraction (R) is included in the model which gave rise to equation 16 below:

$$I_t = DP_t^{\alpha^1} A_t^{\alpha^2} T_t^{\alpha^3} R_t^{\alpha^4} e_t^{\in i} \quad (16)$$

All the variables were logged and thus the model functional form is broadened and stated below:

$$LnI_t = D + \alpha_1 LnP_t + \alpha_2 LnA_t + \alpha_3 LnT_t + \alpha_4 LnR_t + \varepsilon_t \quad (17)$$

3.3.3 Econometric approach

The econometrics techniques utilized in this study are discussed in this section. To ascertain whether the data are cross-sectionally dependent, we follow the test proposed by Pesaran (2004), Pesaran (2004) Scaled LM, and Breusch and Pagan (1980). The study examined the stationarity of the series to make sure that there is an absence of unit root latest at the first difference and to avoid the estimation of equation (17) producing spurious results. The unit root tests of second-generation which permit cross-sectionally dependent data was utilized. The CADF (Cross-sectionally Augmented Dicker- Fuller) technique formulated by Pesaran 2007 was applied in this study were employed to ascertain the series stationarity. Consequently, the second generation error-correction-based panel cointegration test developed by Westerlund (2007) for unobserved factors was utilized to ascertain the presence of the long-term relationships among the series. The Westerlund (2007) Error-Correction Model allows for heterogeneity and cross dependence. The study made use of the Pooled Mean Group (PMG-ARDL), dimension group mean Panel Dynamic Ordinary Least Square (DOLS) techniques, and Fully Modified Ordinary Least Square method (FMOLS) to assess carbon emission and energy utilization from equation (17) long-run multiplier.

3.3.3.1 PMG-ARDL (Pooled Mean Group Autoregressive distributive lag model)

The Pooled Mean Group (PMG-ARDL) was also conducted to examine the short-run and the long-run association between the variables. The main feature of PMG-ARDL is that it allows the short-run coefficients (including the intercepts, the speed of adjustment to the long-run equilibrium values, and error variances) to be heterogeneous across, while the long-run slope coefficients are restricted to be homogeneous across countries. The PMG-ARDL is deemed effective being an alternative model to the GMM (Generalized Methods of Moments) because it utilizes the cointegrating form of the Pesaran, Shin, and Smith (1999) ARDL model. The PMG-ARDL equation is expressed below:

$$\Delta Y_{it} = \phi_i (y_{i,t-1} - \lozenge_i^{'} X_{it}) + \sum_{j=1}^{F-1} \varpi_{ij}^{*} \Delta Y_{i,t-1} + \sum_{j=0}^{q-1} \vartheta_{ij}^{*} \Delta X_{i,t-j} + \mu_i + \ell_{it} \quad (18)$$

Where

$$\phi_i = -(1 - \sum_{j=1}^{F} \varpi_{ij}), \lozenge_i = \sum_{j=0}^{q} \vartheta_{ij} / (1 - \sum_{k} \varpi_{ij}), \varpi_{ij}^{*} = -\sum_{n=j+1}^{p} \varpi_{in} \quad (19)$$

$$j = 1, 2, ..., f-1, and \quad \vartheta_{ij}^{*} = -\sum_{n=j+1}^{q} \vartheta_{in} \quad j = 1, 2, ..., q-1 \quad (20)$$

Y_{it} is the environmental impact proxied by carbon emission and energy utilization, X_{it} is the independent variable. The long-run association between the variables is shown by the vector $\lozenge_i$. The parameter ϕ_i is the error-correcting speed of the adjustment term. If ϕ_i = 0, then there would be no evidence for a long-run relationship. Under the prior assumption that a return to equilibrium is shown by the variables, it is expected that this parameter should be negative and statistically significant.

3.3.3.2 FMOLS {Fully Modified Ordinary Least Square}

The latest version of Hansen and Phillip Fully Modified Ordinary Least Squares which was projected by Pedroni (2000) for the estimation of heterogeneous panel data was applied to investigate the long-run multiplier of carbon emission and energy utilization from equation (17). FMOLS is considered to be strong for non-stationarity variables and endogenous variables.

In general, equation 21 below shows the panel fully modified ordinary least square:

$$\widehat{\beta}_{fmol} = \left[\sum_{i=1}^{K} \sum_{t-1}^{L} \left(X_{it} - \bar{X}_i \right)^1 \right]^{-1} \left[\sum_{i=1}^{K} \sum_{t=1}^{L} \left(X_{it} - \bar{X}_i \right) \widehat{Y}_{it}^{t} + T \hat{\Delta}^{t} + \ell \mu \right] \quad (21)$$

Where $\Delta \ell \mu$ constitutes correction term of serial correlation and to resolve for intransitivity (endogeneity) Y_{it}^{t} is used to show the converted variables of Yit.

The panel extension of Watsons and Stock Dynamic Ordinary Least Squares is computed in pursuance of scanning for the robustness of the outcome. Therefore, the coefficient of DOLS is estimated in equation 22 below:

$$\widehat{\beta}_{dol} = \sum_{i=1}^{K}\left[\sum_{i=t}^{L} W_{it}W_{it}'\right]^{-1}\left[\sum_{t=1}^{L} W_{it}Y_{it}^{t}\right] \quad (22)$$

$$where W_{it} = \left(X_{it} - X_{i}, \Delta X_{i}t - q, \ldots\ldots, \Delta X_{i}t + q\right) \; is \; 2\left(q+1\right) X1 vector \; of \; regressor \quad (23)$$

3.4 Empirical Results and Discussions

The outcomes of the study utilizing some econometrics methods are discussed in this section.

3.4.1 Descriptive statistics

Table 10: Summary of descriptive statistics

Statistics	**LNCO2E**	**LNENRC**	**LNAFF**	**LNTNRR**	**LNTRD**	**LNURBN**
Mean	-0.60	6.32	7.41	1.47	4.11	3.61
Median	-1.87	6.16	7.17	1.86	4.13	3.65
Maximum	2.39	8.04	9.88	4.07	5.05	4.49
Minimum	-4.77	5.33	5.62	11.59	1.84	2.19
Std. Dev.	1.26	0.62	0.86	2.08	0.50	0.38

Table 11: Results of Correlation Coefficient Matrix

Correlation	LNCO2	LNENRC	LNAFF	LNTNRR	LNTRD	LNURBN
LNCO2E	1.000					
T-Stat	-----					
P-Value	-----					
LNENRC	0.837	1.000				
T-Stat	*39.708*	-----				
P-Value	*0.000**	-----				
LNAFF	0.8836	0.763	1.000			
T-Stat	*48.967*	*30.597*	-----			
P-Value	*0.000**	*0.000**	-----			
LNTNRR	-0.076	-0.0316	-0.046	1.000		
T-Stat	*-1.987*	*-0.821*	*-1.205*	-----		
P-Value	*0.047**	*0.412*	*0.229*	-----		
LNTRD	0.248	0.073	0.364	0.107	1.000	
T-Stat	*6.652*	*1.907*	*10.133*	*2.804*	-----	
P-Value	*0.000**	*0.057**	*0.000**	*0.005**	-----	
LNURBN	0.467	0.360	0.629	0.199	0.374	1.000
T-Stat	*13.696*	*10.012*	*21.019*	*5.295*	*10.446*	-----
P-Value	*0.000**	*0.000**	*0.000*	*0.000*	*0.000**	-----

* *represents statistical rejection at 0.05 and 0.01% significance level*

Table 10 reveals the descriptive statistics of $LNCO_2E$ (emission of carbon), LNENRC (energy use), LNAFF (Affluence), LNTNRR (total natural resource rent), LNTRD (Trade), and LNURBN (urbanization). The mean of LNCO2E is 0.60. The minimum (-4.77) and the maximum (2.39) values revealed the inconstancy level of carbon emission. Thus, it can be deduced that in comparison to other regions in Africa and the world, the carbon emissions of Sub-Saharan African countries were relatively low. The mean of LNENRC is 6.32. The minimum (5.33) and the maximum (8.04) values revealed the inconstancy level of energy usage. The mean, maximum and minimum value of the LNAFF, LNTNRR, LNTRD, and LNURBN suggests large fluctuations with time.

The outcome of the correlation matrix in Table 11 revealed the interrelationship between the variables and is in conjunction with the postulated economics theories. For example, it is anticipated that Affluence (income), population (urbanization), and trade will be positively correlated with the emissions of CO_2.

3.4.2 Panel CD (cross-sectional dependence) test

We fol1ow the test proposed by Pesaran (2004), Pesaran (2004) Scaled LM, and Breusch and Pagan (1980) to diagnose whether the data are cross-sectionally dependent. The outcome of the test is displayed in Table 12 below.

Table 12: CD tests outcome.

	CD: CO2		**CD: Energy**	
Test	**Statistic**	**Prob. Value**	**Statistic**	**Prob. Value**
Breusch-Pagan LM	1097.068	0.0000*	5648.363	0.0000*
Pesaran scaled LM	58.273	0.0000*	334.236	0.0000*
Pesaran CD	6.001	0.0000*	74.112	0.0000*

*denotes significant at 0.01%

The null hypothesis of no CD is rejected by all the tests at a 0.01% significance level as shown in Table 12 above. Thus, we conclude that there exists CD (cross-sectional dependence) across the sampled panel units.

3.4.3 Pesaran CADF Panel Unit root test outcomes

Considering that our panel data are dependent cross-sectionally, the panel unit root (first-generation) techniques cannot be used because it tends to reject the null hypothesis of non-stationarity in the presence of cross-sectional dependence. Thus, the second generation unit root- CADF (Cross-sectionally Augmented Dicker- Fuller) panel unit root test proposed by Pesaran (2007) which allows for cross-sectional dependence in the data was utilized to ascertain the stationarity of the variables under study. The outcome of the second-generation panel unit root test is presented in Table 13 below.

Table 13: Second generation unit root test (Pesaran CADF Panel Unit Root Test)

	LEVELS				**FIRST DIFFERENCES**			
Variables	**Intercept**		**Intercept and Trend**		**Intercept**		**Intercept and trend**	
	t-bar	**P-value**	**t-bar**	**P-value**	**t-bar**	**P-value**	**t-bar**	**P-value**
LNCO2E	-1.237	(0.108)	-0.355	(0.361)	-8.471*	(0.000)	-7.645*	(0.000)
LNTNRR	-0.856	(0.145)	-1.057	(0.145)	-6.123*	(0.000)	-3.776*	(0.000)
LNAFF	0.467	(0.680)	0.426	(0.665)	-5.407*	(0.000)	-4.565*	(0.000)
LNTRD	0.878	(0.810)	0.172	(0.568)	-8.838*	(0.000)	-6.947*	(0.000)
LNURBN	-2.832*	(0.000)	-3.988*	(0.000)	-		-	

*denotes significant at 0.05%

The outcome of table 13 above reveals that at level the six series are non-stationary except LNURBN which is stationary at level. The additional test indicates that the series: LNCO2E, LNTNRR, LNENRC, LNAFF, and LNTRD are static at the first difference at a 0.05% level of significance. Therefore, based on the results we deduced that LNURBN are I (0), the other remaining variables are I (1) series.

3.4.4 Westerlund (2007) ECM Panel Cointegration Test

Westerlund (2007) Error-Correction Model was utilized to ascertain if there is an interconnection between the series in the long run. The model finds out whether cointegration is present or not using 4 test statistics of panel cointegration (Ga, Gt, Pa and Pt). The results presented in Table 14 below shows that model 1 (CO2E, TNRR, TRD, AFF & URBN) rejected the hypothesis (null) of an absence of cointegration, except for Ga, while in the second model (ENRC, TNRR, TRD, AFF & URBN), Gt rejected the hypothesis (null) of the absence of cointegration. The robustness of the existence of cointegration between the variables in both models was also confirmed by the Kao cointegration test outcome in Table fifteen (15) beneath. Thus, the study concluded that an association exists between LNTNRR, LNAFF, LNTRD, LNURBN, and LNCO2E, and between LNTNRR, LNAFF, LNTRD, LNURBN, and LNENRC in the long run.

Table 14: Outcome of Westerlund (2007) ECM Panel Cointegration Test

	LNCO2E, LNTNRR, LNTRD, LNAFF & LNURBN		**LNENRC, LNTNRR, LNAFF, LNTRD & LNURBN**	
Stat.	**Value**	**Z-value**	**Value**	**Z-Value**
Gt	-3.033*	-2.539* (0.006)	-3.195*	-1.506* (0.066)
Ga	-9.701	1.752 (0.960)	-8.705	4.130 (1.000)
Pt	-13.008*	-3.831* (0.000)	-10.150	0.684 (0.753)
Pa	-13.471	-2.265* (0.012)	-9.822	1.948 (0.974)

*denotes significant at 0.05%. Ga and Gt denote group mean, Pt and Pa denote panel tests.

Table 15: Outcome of Kao cointegration test

	LNCO2E, LNTNRR, LNTRD, LNAFF & LNURBN		**LNENRC, LNTNRR, LNAFF,LNTRD & LNURBN**	
Stat.	**t.statistic**	**Prob.Value**	**t.statistic**	**Prob.Value**
ADF	-5.8327*	0.0000	1.4791*	0.0696
Resid. V	0.0630		0.0027	
HAC. V	0.0358		0.0026	

* and ** denotes significant at 0.05 and 0.10 significance level.

3.4.5 Outcome of Fully Modified Least Squares and Dynamic Least Square Techniques

Having determined that the series are correlated in the long-run, the DOLS and FMOLS estimation was undertaken. The outcomes are presented in Table Sixteen (16).

Table 16: Long-run estimation of Panel FMOLS, and DOLS Techniques Results

Variable	FMOLS-CO2E	DOLS-CO2E	FMOLS-ENRC	DOLS-ENRC
LNAFF	0.3838*	0.3002*	0.3340*	0.2882*
	(0.0000)	(0.0000)	(0.0000)	(0.0009)
LNTNRR	0.1032*	0.0623*	0.0342*	0.0176*
	(0.0441)	(0.0396)	(0.0014)	(0.0013)
LNTRD	-0.3102*	-0.2726*	-0.0560*	-0.0901*
	(0.0000)	(0.0000)	(0.0120)	(0.0119)
LNURBN	0.8382*	0.9044*	0.3677*	0.3428
	(0.0136)	(0.0061)	(0.0374)	(0.1969)

*denotes significant at 0.05%

3.4.5.1 Environmental Effect of Affluence

The output of the FMOLS and DOLS in Table 16 above reveals that in the long run, LNAFF (income) influence the emission of CO_2 is significantly positive. A 1% rise in income will lead to a 0.30%-0.38% increment in the emissions of carbon. This implies that environmental deterioration increases with an increase in affluence (income). Excessive affluence can accelerate the manufacturing and consumption of goods, which in turn will result in pollution, a rise in waste generation, and overutilization of natural resources that may deteriorate the environment. This outcome is accordant with Kwakwa et al.'s (2020) findings.

With regards to ENRC (energy), the output of the FMOLS and DOLS in Table 16 above reveals that LNAFF (income) have a positive impact on the use of energy in SSA, this suggests that an increase in income by 1% will lead to 0.33% increase in energy utilization. This means that a rise in income will accelerate energy consumption in Sub-Sahara Africa (SSA). This is rational since an increase in utilization (consumption) accelerates the demand for high-energy consuming commodities as the economy grows.

Recently, the majority of the sampled SSA countries like Ghana, Nigeria, Benin, etc., the quest cars and other commodities that consume energy appear to have increased. People tend to get commodities that will make their life enjoyable for them, as their income increases. Thus, seeing individuals buying washing machines and private cars in addition to other things when their income appreciates is not unconventional. Similarly, the desire to acquire additional income can make others buy commercial vehicles. This leads to a rise in the quantities of imported vehicles in these countries, which consequently increases CO_2 emissions indirectly by increasing the rate of energy use.

3.4.5.2 Environmental Effect of Extracting Natural resources

From the output of the FMOLS and DOLS in Table 16, LNTNRR (Natural resources extraction) in the long run has a positive influence on carbon emission in SSA countries. This means that over time, a 1% rise from natural resources rent will amount to a 0.06-0.10% increase in the emission of carbon in SSA countries under study. The deterioration impact of extracting natural resources on the environment of SSA countries can be attributed to the increasing oil exploration in the oil-producing SSA countries and the illegal and legal mining activities in these countries. For example, the activities of illegal mining in countries such as Nigeria and Ghana do not satisfy the minimum environmental regulation and thus deteriorate the environment Kwakwa et al. (2020). Similarly, exploration of oil and gas degrades the environment through the tumultuous exploration linked with the coastal oil and gas industry, ship traffic, construction work, and drilling which produces noise pollution which affects the sea ecosystem stability and that of its habitat. Also, the progressive exploration of oil utilizes an enormous amount of energy which produces carbon and this deteriorates the environment. Additionally, disposing of gas through the burning of natural gas produces photochemical agents, carbon dioxide, and nitrogen dioxides which deteriorates the environment. This result is accordant with Bekun et al. (2019) and Kwakwa et al. (2020). Thus, there is a need to have renewable resources which will drastically reduce the emission of carbon in SSA countries and this can only be achieved by transiting from antique automation that exploits increased natural resources to contemporary automation that absorbs value-addition, recycling, and unnatural resources. Hence, decreased environmental pollutants will enhance environmental quality and promote economic development.

Regarding the energy model, in the long run, LNTNRR (Natural resources extraction) has a significant positive influence on energy utilization in SSA countries. This means that a 1% rise from natural resources rent will amount to a 0.01%-0.03% increase in the utilization of energy in the long run. This outcome is in line with apriori expectation because the incessant exploitation of natural resources is largely dependent on energy-consuming machinery which cannot operate energy. Hence, energy utilization rises with an increase in natural resource activities in SSA countries. This result is insightful on the need for policymakers in SSA countries to pay attention to the activities of natural resource extraction when setting strategies to handle the energy security issues of their countries.

3.4.5.3 Environmental Effect of Urbanization

The output of the FMOLS and DOLS in Table 16 above reveals that LNURBN (urbanization) in the long run has an impact that is positively significant on the emission of CO_2. A 1% increment in urbanization will lead to a 0.83-0.90% increment in the emissions of carbon. This implies that environmental deterioration increases with an increase in urbanization. This suggests that urbanization accelerates pollutant emissions which in turn deteriorates the environment of countries in the SSA region in the long run. The fast-moving rate of urbanization comes with numerous problems such as the removal of vegetation cover to construct infrastructure to satisfy the expanding urban population need and heavy traffic jams which result in a constant rise in the utilization of fossil fuel. Hence, this incident mitigates the environmental quality. Additionally, there is a rise in the generation of waste as a result of the recent uncontrollable increase in the urban population of the SSA countries especially in Nigeria, Ghana, Kenya, and Zimbabwe which has surpassed the local government capacity in these countries to sustainably handle it. This has made these countries to be ranked among the top 6 dirtiest countries in Africa in 2020 (State of Global Air Report 2020). This result is accordant with Ulucak et al., (2020) and Ekwueme and Zoaka (2020).

Concerning the use of energy, the output of the long-run FMOLS in Table 16 shows LNURBN (urbanization) impact on energy usage is positive and statistically significant. This suggests that in the long run, a 1% rise in the rate of urbanization enhances the utilization of energy by 0.36%-0.38%. This is rationally based on the fact the erection functioning and sustenance of urban infrastructure like the system of transportation accelerate the use of energy. Additionally, swift urbanization leads to a rise in the utilization of services and goods, this, in turn, results in a rise in the energy utilized for their manufacturing. This result is accordant with Inglesi-Lotz and Morales (2017) and Shahbaz et al., (2017).

3.4.5.4 Environmental Effect of Openness in Trade

The output of the FMOLS and DOLS in Table 16 above reveals that LNTRD (trade openness) in the long run has a significantly negative influence on emissions of carbon dioxide in SSA countries. An increment in trade openness by 1% will amount to a 0.27%-0.31% reduction in the emission of carbon. This implies that the environmental quality is enhanced by the trade technique effect by empowering nations to import low pollution manufacturing techniques. Also, Trade through its composition effect assists the transformation of the economy from agricultural-based to industrial based and finally to service which has relatively small pollution. (Kwakwa and Aboagye, 2014). This implies that the aftermaths of trade are outpaced by the environmental improving effects of trade openness in SSA countries. This result is accordant with Lopez et al. (2018) which revealed that international trade can result in CO_2 emissions abatement in China as having eco-friendly trade policies helps to conserve the environment and promote economic growth.

Concerning energy, the impact of LNTRD (trade openness) in the long run on the use of energy is negative and statistically significant. This suggests that a 1% rise the trade openness reduces energy usage by 0.05%-0.09% over time. This result is accordant with Adom and Kwakwa (2014) who discovered in the case of Ghana that trade has a negative impact on energy intensity in the long run. A similar result was reported by Wang and Han et al. 2016. The impact of trade on the demand for energy may be debated from the level of economic development. Openness in trade implies that a country eases up on tax and other procedures to enlarge the foreign trade and enhances the foreign trade to GDP (gross domestic product) ratio. Openness in trade in return is anticipated to contribute positively to economic growth. Subsequently, this initial growth in the economy might enhance energy usage owing to soaring economic activities such as outrageous government spending, production, and consumption which is known as the scale effect. The country may grow enough in the later phase of the economic growth to transit their manufacturing techniques from energy-intensive industries to the service sector and or install technologies that are energy efficient which are referred to as composition and technique effect respectively. Thus, at the later levels of economic growth, energy use may be reduced.

3.4.6 Results of Diagnostic Test

Table 17: Variance Inflator Factor test result (Multicollinearity)

	CO2E-MODEL		**ENRC-MODEL**	
Variables	**Coefficient variance**	**Uncentered VIF**	**coefficient variance**	**Uncentered VIF**
LNINCOME	0.0087	1.3065	0.0031	1.1370
LNTNRR	0.0003	1.0909	0.0001	1.2616
LNTRD	0.0053	1.1018	0.0004	1.2455
LNURBN	0.0090	1.3067	0.0310	1.1313

To certify the authenticity of the outputs of the FMOLS and DOLS Models' estimated output was tested against the problem of correlation, as a result of the nature of the proxy used for some of the variables used in this article. The Variance Inflation Factor (VIF) was employed to check for multicollinearity in this work. Literature opined that the absence of correlation among the regressors is denoted by a VIF value of 1, an additional examination is required for a VIF value that is greater than 4, and there is obvious evidence of multicollinearity when the VIF value is greater than 10. The result of the test in table 17 above reveals that there is no evidence of multicollinearity or correlation among the regressors as all the value is within the range of 1.13 and 1.30 in both models. A serial correlation test was not undertaken because Fully Modified Least Squares takes into consideration serial correlation.

3.4.7 Estimation output of the pooled mean group with dynamic ARDL

Table 18: Estimation output of the pooled mean group with dynamic ARDL (Dependent variable: LNCO2E)

	LNAFF	**LNTNRR**	**LNTRD**	**LNURBN**	**Adjustment Parameter**
Long-run	0.9850*	0.0464**	0.0812	-0.1761	-0.3241*
	(0.0000)	(0.0917)	(0.1101)	(0.1220)	(0.0000)
Short-run of cross-sections					
Benin	0.6188	-0.0394*	0.2833*	-2.9848	-0.0851*
	(0.4951)	(0.0475)	(0.0210)	(0.5337)	(0.0001)
Botswana	-0.3299	-1.0356*	0.3857	-0.1328	-0.3207*
	(0.6325)	(0.0080)	(0.1363)	(0.8924)	(0.0000)
Cote d’Voire	0.4480*	-0.1101*	0.0296	-5.9163	-0.5918*
	(0.0253)	(0.0080)	(0.7538)	(0.6317)	(0.0001)
Cameroun	3.2383	0.4586*	0.3960	-7.9326	-0.7061*
	(0.3137)	(0.0220)	(0.4864)	(0.8599)	(0.0000)
Congo Dem. Rep	4.1516*	-0.0595*	-0.0031	-0.0031	-0.6961*

	(0.0150)	(0.0057)	(0.8426)	(0.8426)	(0.0004)
Congo Rep.	1.6242	0.1242*	0.3213*	-7.5518	-0.2130*
	(0.1361)	(0.0022)	(0.0317)	(0.9388)	(0.0004)
Gabon	-0.2774*	0.0143*	-0.1576*	6.5496**	-0.3662*
	(0.0065)	(0.0028)	(0.0146)	(0.0742)	(0.0000)
Ghana	-0.1602	-0.1618*	-0.0435*	4.3060	-0.5771*
	(0.4364)	(0.0001)	(0.0037)	(0.8185)	(0.0001)
Kenya	0.7499	-0.1642*	0.1358*	2.8817	-0.3006*
	(0.1199)	(0.0003)	(0.0094)	(0.3537)	(0.0001)
Mauritius	0.6224*	-0.0137*	0.0240	7.4872	-0.0040
	(0.0720)	(0.0012)	(0.6581)	(0.6891)	(0.2019)
Nigeria	0.4774	0.0978*	-0.1296*	13.9980	-0.3865*
	(0.1515)	(0.0001)	(0.0012)	(0.9026)	(0.0007)
Sudan	-1.4317*	-0.0264*	0.0248	-0.5166	-0.2669*
	(0.0083)	(0.0000)	(0.1337)	(0.8821)	(0.0003)
Senegal	0.0373	0.0521*	-0.0034	-4.4362	-0.4010*
	(0.9202)	(0.0047)	(0.9237)	(0.8069)	(0.0001)
Togo	-0.6603	0.0564*	-0.5258*	-295.66	-0.7028*
	(0.1374)	(0.0091)	(0.0072)	(0.9506)	(0.0000)
South Africa	0.6144*	0.0229*	-0.1821*	-0.9166	-0.0771*
	(0.0216)	(0.0001)	(0.0011)	(0.9286)	(0.0014)
Zambia	-2.2703	-0.0396*	-0.4950*	-1.1769	-0.4474*
	(0.1176)	(0.0056)	(0.0012)	(0.8731)	(0.0002)
Zimbabwe	-0.0571	0.1123*	0.0981*	7.3176	-0.5479*
	(0.4960)	(0.0005)	(0.0213)	(0.2444)	(0.0000)

P-values are in parenthesis. * and **denotes significant at 0.05% and 0.10%. ARDL (1, 1, 1, 1, 1)

The outcome of the long-run estimation of the PMG-ARDL of the energy model in Table 18 is similar to the outcome of the FMOLS and DOLS estimation for LNAFF and LNTNRR in Table 16 above except for LNTRD and LNURBAN that are not significant. In the long run, LNAFF (income) and LNTNRR (natural resource extraction) have a significant positive influence on the emissions of carbon in SSA countries. A 1% increment in LNAFF and LNTNRR will lead to a 0.98% and 0.04% increase in the emissions of carbon. The convergence parameter or the error correction coefficient is negative and statistically significant for the panel, showing adjustment to the long-run equilibrium. Also, for the individual countries, the convergence parameter for the entire nation was significant.

Further, the estimations of the short-run coefficients of the individual countries are shown in Table 18 above, income has a positive significant impact on the emission of carbon in Cote d'Ivoire, Congo Democratic Republic, Mauritius, and South Africa in the short run, while its impact is negative in Gabon and Sudan. Natural resource extraction has a negative influence on carbon emission in Benin, Botswana, Congo Democratic Republic, Ghana, Kenya, Mauritius, Sudan, and Zambia in the short run, while its impact is positive in Zimbabwe, South Africa, Togo, Senegal, Nigeria, Gabon, Congo Republic, and Cameroun. In the short run, trade openness has a negative impact on carbon emission in Zimbabwe, Zambia, South Africa Togo, Nigeria, and Ghana, while its impact is positive in Kenya, Gabon, Congo Republic, and Benin. The impact of urbanization in the Short-run is not significant in all the countries except for Gabon where the impact is positive and statistically significant.

Table 19: Estimation output of the pooled mean group with dynamic ARDL (Dependent variable: LNENRC)

	LNAFF	LNURBN	LNTNRR	LNTRD	Adjustment Parameter
Long-run	0.0077	0.2562*	-0.0261*	-0.1371*	-0.1722*
	(0.7691)	(0.0000)	(0.0060)	(0.0000)	(0.0002)
Short-run of cross-sections					
Benin	-0.6616	0.8218	-0.0151*	0.0818*	-0.1699*
	(0.2191)	(0.2734)	(0.0006)	(0.0005)	(0.0005)
Botswana	0.6616*	-0.9545*	-0.0063*	-0.3455*	-0.6046*
	(0.0009)	(0.0029)	(0.0001)	(0.0001)	(0.0001)
Cote d'Voire	0.4671*	-0.0607	0.0183*		-0.1517*
	(0.0095)	(0.9720)	(0.0145)	0.0585**	(0.0003)
				(0.0669)	
Cameroun	0.1045*	0.1197	-0.0013*	-0.0254*	-0.0152*
	(0.0002)	(0.3142)	(0.0067)	(0.0001)	(0.0007)
Congo Dem. Rep	0.6019*	0.0075*	-0.0504*	65.626	-0.1292*
	(0.0021)	(0.0005)	(0.0000)	(0.9764)	(0.0047)
Congo Rep.	0.5635*	-3.4114	0.0161*	-0.0982*	-0.0176*
	(0.0009)	(0.5706)	(0.0003)	(0.0003)	(0.0093)
Gabon	-0.1195*	0.1988	-0.0149*	-0.1891*	-0.0623*
	(0.0408)	(0.8767)	(0.0033)	(0.0094)	(0.0005)
Ghana	0.2699*	1.1633	-0.0201*	-0.0806*	-0.0057**
	(0.0130)	(0.7587)	(0.0006)	(0.0000)	(0.0845)
Kenya	0.2520*	-0.0670	-0.0004	-3.6978*	-0.3006*

	(0.0001)	(0.3115)	(0.1510)	(0.0343)	(0.0001)
Mauritius	0.5235*	2.3604	-0.0139*	0.0823*	-0.0097*
	(0.0015)	(0.5155)	(0.0000)	(0.0039)	(0.0001)
Nigeria	-0.0855*	2.3970*	0.0058*	0.0003*	-0.2245*
	(0.0001)	(0.0120)	(0.0000)	(0.0415)	(0.0000)
Sudan	-0.5147*	-0.4425	-0.0026*	0.0617*	-0.1410*
	(0.0002)	(0.1329)	(0.0000)	(0.0000)	(0.0019)
Senegal	0.1665*	1.1510	0.0364*	-0.0946*	-0.1111*
	(0.0153)	(0.6900)	(0.0000)	(0.0001)	(0.0004)
Togo	0.1772*	-56.426	-0.0003	-0.0028	-0.3455*
	(0.0005)	(0.8514)	(0.3518)	(0.3484)	(0.0001)
South Africa	0.6241*	-1.4222	0.0134*	-	-0.0704*
	(0.0216)	(0.7616)	(0.0001)	0.1177*	(0.0016)
				(0.0005)	
Zambia	-0.2392	0.3739*	0.0107*	-	-0.6143*
	(0.0005)	(0.0190)	(0.0000)	0.0792*	(0.0000)
				(0.0000)	
Zimbabwe	0.1886*	1.7205*	0.0457*	-0.0841*	-0.2239*
	(0.0000)	(0.0483)	(0.0000)	(0.0000)	(0.0000)

P-values are in parentheses. * and **denotes significant at 0.05% and 0.10%. ARDL (1, 1, 1, 1, 1)

The outcome of the long-run estimation of the PMG-ARDL of the energy model in Table 19 is similar to the FMOLS and DOLS estimation outcomes in Table 16 except LNTNRR. LNAFF (income) has an insignificant positive influence on energy use in SSA countries. In the long run, the impact of LNTRD (Trade) and LNTNRR (natural resource extraction) on the utilization of energy are significantly negative. The convergence parameter or the error correction coefficient is negative and statistically significant for the panel, showing adjustment to the long-run equilibrium. Also, for the individual countries, the convergence parameter for the entire nation was significant.

Further, the estimations of the short-run coefficients of the individual countries are shown in Table 19 above. Income has a significantly positive impact on energy usage in Zimbabwe, South Africa, Togo, Senegal, Mauritius, Kenya, Ghana, Cote d'Ivoire, Congo Republic, Congo Democratic Republic, Cameroun, and Botswana in the short run, while its impact is negative in Nigeria, Gabon, and Sudan. In the short-run, natural resource extraction have a negative impact on energy use in Sudan, Mauritius, Ghana, Gabon, Benin, Botswana, Cameroun, and the Congo Democratic Republic, while its impact is positive in Zimbabwe, Zambia, South Africa, Senegal, Nigeria, Congo Republic, and Cote d'Ivoire. In the short-run, trade openness has a negative impact on carbon emission in Zimbabwe, Zambia, South Africa, Senegal, Kenya, Ghana, Gabon, Congo Republic, Cameroun, and Botswana, while its impact is positive Sudan, Nigeria, Mauritius, Cote d'Ivoire, and Benin. In the short run, the impact of urbanization on energy use in Botswana is negative, whereas its influence is positive in Zimbabwe, Zambia, Nigeria, Gabon, and the Congo Democratic Republic.

3.5 Conclusion and Policy Implications

This research utilized the STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology approach) to analyze the impact of natural resources extraction (proxied by total natural resource rent), population (proxied by urbanization), affluence (income), and openness in trade on CO_2 emissions and energy utilization of 17 SSA (Sub-Saharan Africa) countries from 1971-2019. This motivation for the conduction of this research is the fact not much has been done by former literature to analyze econometrically the influence of extraction of natural resources on environmental deterioration drivers, particularly CO_2 emissions. Sub-Saharan Africa (SSA) is used as a case for this study because is among the region that suffers most from the change in climate and natural disasters owing to the fact that they have an economy that is greatly dependent on natural resources. Also, Sub-Saharan African countries' economies have been distinguished by speedy urbanization, natural resources, trade, economic growth, and vigorous population growth which in turn could result in a rise in the level of pollution. The Westerlund (2007) Error-Correction Model and Kao cointegration technique were utilized to ascertain the presence of interconnection between the series in the long run. The Pooled Mean Group (PMG-ARDL), the panel FMOLS {Fully Modified Ordinary Least Square} and dimension group mean Panel DOLS (Dynamic Ordinary Least Square techniques) was employed to assess carbon emission and energy utilization long-run multiplier.

The empirical results reveal that natural resource extraction, urbanization, and income have a positive significant impact on energy utilization and the emission of CO_2 in SSA nations in the long run. This suggests that environmental deterioration increases with an increase in natural resource extraction, urbanization, and affluence (income). On the contrary, openness in trade has a negatively substantial influence on energy utilization and the emission of CO_2 of SSA nations in the long run. This implies that environmental deterioration mitigates with a rise in foreign trade. The quality of the environment is enhanced by the technique effect by empowering nations to import low pollution manufacturing techniques. Trade through its composition effect assist the transformation of the economy from agricultural-based to industrial based and finally to service which has relatively small pollution and installs energy-efficient technologies, the energy demand may be reduced.

The policy implications from the outcome of this research are that since natural resource extraction ventures enhance environmental deterioration, policymakers in the region should enforce extra rigorous eco-friendly environmental regulations that will promote the extraction of natural resources in a more thrifty mechanism. Laws that will regulate oil production and mining activities should be strictly enforced. Also, in dealing with the issues of energy security, there is need for policymakers to give attention to natural resource extractive ventures.

Additionally, since urbanization and income were discovered to enhance energy utilization and carbon emissions, there is a need for policymakers to facilitate the transition to a renewable energy source and to stimulate the expansion and use of technology that emits low-CO_2 to address urban development, energy security, and enhance sustainable and green development in the region.

Finally, since trade is found to mitigate carbon emissions, there is a need for the government of SSA countries to reduce tariffs on commodities that enhances environmental quality and to increase non-tariffs and tariffs blockades on commodities that are not eco-friendly.

Chapter 4

CARBON EMISSION EFFECT OF RENEWABLE ENERGY UTILIZATION, FISCAL DEVELOPMENT, AND FOREIGN DIRECT INVESTMENT IN SOUTH AFRICA

4.1 Introduction

Government across the globe entrenched goals such as to enhance the volume of development and growth of their country economically. The government constructs different policies which are geared towards increasing the level of investment to actualize some of these goals, as it is believed that adequate financial development enhances economic growth. Financial institutions through the provision of credit facilities to the public in general with pliant policies increase investment, thus they work as an accessory of government. The financial crisis is seen as a main economic issue. In this present age, pollution and energy usage are presumed to be among the vital disquiet environmentally, hence a further examination of the correlation between foreign direct investment, fiscal development, energy consumption, and emissions of CO_2 is paramount. Fiscal (financial) development and FDI (foreign direct investment) play an enormous role in goods and service manufacturing. FDI and fiscal development (FD) is imperative for an economy as it offers investment and capital opportunities. Furthermore, in addition to capital and labor, energy is an essential factor of production. According to Mohammed, Guo, Haq, Pan, and Khan (2019), financial development enhances the consumption of energy and hence accelerates growth in the economy. Also, FDI through productivity gains and transmission of technology promotes economic growth as it provides alluring investment opportunities which offer direct funding capital (Lee, 2013 and Sinha and Sen, 2016). Unavoidably the deliberation about emissions of CO_2 the reduction has continued to be a major concern, the bane of sustainable development, and a global hindrance towards achieving a greener environment (Alola & Alola, 2018; Alola, 2019a&b; Bekun, Alola & Sarkodie, 2019; Saint Akadiri, Alola, Akadiri & Alola, 2019). However, one of the first things that should be done in the construction of a more sustainable and greener environment is the reduction of the emissions of CO_2.

There is numerous literature on the impact of CO_2 emissions on the ecosystem's health and the factors played by macro and microeconomic factors in their determination. According to the study of Auffhammer and Carson (2008) on the emissions of CO_2 in China on a provincial level, emissions of CO_2 have increased drastically over the past five years. CO_2 emissions affect human health in addition to the damage to the ecosystem (Chen et al, 2017). Emissions of carbon are concurrently increased by enhanced production rate and growth in the economy. Thus, the use of energy, fiscal development, and FDI contribute to degradation in the environment through carbon emissions by increasing the level of production and growth of the economy. The degree of the correlation between emissions of CO_2 and economic growth in a nation is determined by numerous factors however, in theory, fiscal development, openness in trade, usage of energy, and FDI are the major ones that are discussed. Recent empirical works examining the linkages between financial development and emissions of CO_2 discovered that there is a changing (dynamic) correlation between CO_2

emissions and fiscal development (Khan et al. 2021, Pata, 2018). According to the study of Pata (2018), there seems to be an improvement in urbanization when there is financial development in a nation, and consequently more consumption of energy.

Additionally, CO_2 emissions increase directly or indirectly in a country with increased financial development and trade because countries improve in their export with higher financial development and R&D (research and development), which in turn increases emission level as a result of increased production (Huang and Zhao 2018). It is essential for nations to have a formal and congenital plan for energy, fiscal development, urbanization, and FDI, to assimilate the emissions effects. There is an introduction of new debates and technologies such as climate and energy finance that have emerged resulting from the notion of fiscal development and its impact on the climate. They provide explanations on the reasons why a nation's finance should be connected to its energy policies and strategies (La Rovere, Grottera, and Wills, 2018).

This research assessed the correlation between FDI, clean energy utilization, fiscal development, and the emissions of carbon in South Africa for a period of 44 years (1970 to 2014) and associated causality association between emissions of CO_2, fiscal development, FDI, and growth in the economy. Five major hypotheses of granger causality were tested; first, to determine the direction and how FDI and GDP contribute to each other. Secondly, investigation of causality direction between GDP and emissions of CO_2 using granger causality test. Thirdly, to examine the causality relations between FDI and emissions of CO_2. Fourthly, the causality association between financial development and GDP was investigated to ascertain in which direction do Financial development contributes to GDP. Finally, to examine the causality link between emissions of CO_2 and fiscal development, which in literature has been rarely considered.

The case of South Africa is considered in this study because globally and in Africa, South Africa is among the few vast and fast-moving developing nations. The peculiarity of the features of its economy is distinct from other African emerging economies. For instance, according to Enerdata (2019), they are ranked 7th greatest carbon emitter in the world. In the African region, South Africa is the largest carbon emitter making up about 45% of the total continent. In 2019, their GDP in absolute value is at $351.4 Billion with an estimated GDP growth rate of 0.20% (WDI, 2020). Similarly, according to the 2019 report of UNCTAD, After Nigeria, South Africa is the second-largest economy with FDI inflow in Africa, and they are the leader of the inflow of FDI to the southern region. For instance, in comparison with 2017, the southern African region in 2018 witnessed a 13% rise in FDI to the tune of $32 billion, and the greatest portion of approximately $5.3 billion out of this amount was received by South Africa. Thus, these unique features informed the motivation to investigate the correlation between FDI, clean energy utilization, fiscal development, and the emissions of carbon of South Africa.

In novelty, this study is the first study aimed at finding stimulus (causality) relationships between fiscal developments, FDI, and emissions of CO_2 i CO_2n South Africa. In South Africa, the impact of energy use (consumption) on economic growth and or energy consumption on CO_2 emissions have been examined (see Balawa and Andrew, 2017; Shahbaz et al., 2013; Kohler, 2013; Menyah and Wolde-Rufael, 2010) but no study have examined the linkages or correlation among FDI, renewable energy consumption FD (fiscal development), and emissions of CO_2 in South Africa, thus the need to include this idea into research. Furthermore, FDI and fiscal development are very vital to analyze because South Africa as an emerging economy is the number one emitter of carbon in African continents because of its heavy reliance on energy production based on coal. The Vector Autoregressive method (VAR) is selected because it deviates from the norm of estimation techniques such as ARDL and least squares regression methods employed by previous empirical work. Examination of the impacts of fiscal development and FDI on the CO_2 emissions in the present state of the art is an unconventional contribution to South Africa's energy and environment literature and sub-Saharan Africa as a whole. The deductions from this research will be insightful for policymakers in South Africa as they are presently involved in energy efficiency policies and strategies that are geared towards the reduction of CO_2 emissions. The findings will also be helpful to other Sub-Saharan African countries that are yet to put in place a proper and well-established energy plan to accommodate the pressure of financial development and FDI growth.

The arrangement of the study's other sections is as follows: an overview of the extant and related studies is featured in section two while section three highlights the econometrics method and data used. In section four, the outcomes of the estimations are discussed, while section five presents the conclusion and the policy implications.

4.2 Review of Related Literature

The association between FDI, energy usage, fiscal development, and emissions of CO_2 are reviewed in this section. Theoretically, the association between FDI and economic growth could be linked to the prior model of Neo-classical growth. FDI can promote economic growth according to the model by accelerating capital stock. Also, according to the new growth model, both long-run and short-run technology changes associated with FDI will result in economic growth. Numerous studies according to the orthodox theories are in agreement with the initial idea that assumed that there are positive impacts of FDI on growth in the economy. Also, evidence of the positive impact of exports and FDI on economic growth was provided by Makki and Somwaru (2004) article who examined the impact using a sample of 66 developing nations. The granger causality between FDI and GDP was undertaken by Hansen and Rand (2006) employing heterogeneous panel data, and they found that FDI's influence on the growth of the economy, in the long run, is positive. Evidence of the unidirectional effect of FDI on GDP was discovered by the study of Hsiao and Hsiao (2006), both directly and indirectly using the exports of chosen samples of East and Southeast Asian economies.

According to the study of FDI's impact on the economic growth of Nigeria by Ekwueme (2018) the study discovered there is a positive impact of foreign direct investment on GDP, and therefore recommended formulation of policies by the government which is geared towards the increase of FDI inflow in the nation. A positive correlation in the long run between foreign direct investment (FDI) and GDP was proven by Nosheen (2013) in his work on the FDI impact on the economic growth of Pakistan. Evidence of the positive effect of FDI on economic growth was found by Iamsiraroj and Ulubasoglu (2015) with a case of selected 140 countries. However, a significant positive impact of foreign direct investment on GDP was discovered by Carkovic and Levin (2002) in nations that are developing. Also, the absence of Granger causal linkages between economic growth and FDI in the short run was discovered for Tunisia by Belloumi (2014). According to Herzer et al (2008), there could be a negative correlation between FDI and economic growth.

Additionally, a reverse relationship is postulated by the growth-led FDI hypothesis that economic growth can lead to the creation of new activities in the economy and new markets which will, in turn, leads to the attraction of FDI concentration. Thus, the causality association between economic growth and FDI is not an essentially one-way direction. Each of them is not excluded by these two directions. A two-way direction (bidirectional) causality linkage between foreign direct investment and economic growth was discovered by Basu et al. (2003) in a sample of 23 developing nations.

4.2.1 Carbon Effect of Renewable Energy

Kirakkaleli and Adebayo (2020) found that global renewable energy usage has a significant positive impact on environmental sustainability in the long run, which implies that an increase in the usage of clean energy will accelerate environmental standards and vice versa. Contrarily GDP (economic growth) accelerates global emission of carbon according to their findings. Ji et al., (2020) found that renewable energy and eco-innovations mitigate emissions of carbon, while GDP enhances carbon emissions in their study of the importance of fiscal decentralization in promoting a sustainable environment of Switzerland, Spain, Germany, Canada, Belgium, Austria, and Australia using the non-linear and linear methods.

Zhang et al., (2021) utilizing wavelet coherence and gradual shift causality tests, dynamic ordinary least square (DOLS), fully modified OLS (FMOLS), and auto-regressive distribution lag (ARDL) using the STIRPAT model investigated how gross capital formation, urbanization, and financial development affects emissions of CO_2 in Malaysia. They discovered extant long-run linkages between the series and that urbanization, gross capital formation, and economic growth have a positive significant influence on emissions of CO_2. A substantial dependency between urbanization, gross capital formation, economic growth, and emissions of CO_2 have revealed their wavelet coherence test results.

Ahmad et al., (2020) examined the impact of renewable energy on the degradation of the environment of North-western provinces of China from 1995 to 2014 utilizing the Nonlinear (ARDL) Autoregressive Distributed Lag bounds testing approach. They found that positive shock from renewable energy influences the emissions of carbon in the North-western provinces of China adversely. Additionally, they discovered that in the long -run emissions of carbon increase with a reduction in the consumption of renewable energy. Also, they found that positive shocks from GDP and non-renewable energy increases the degradation of the environment in the short and long run.

4.2.2 Carbon Effect of Economic Growth (GDP)

Kirkkaleli et al., (2020) in their study of how Turkey's environmental footprint is affected by openness in trade, growth in the economy, energy use, and globalization discovered that GDP has a negative influence on the ecological footprint in the short and long run. while in the short run, trade openness mitigates ecological footprint. Furthermore, they found globalization has a negative impact on the ecological footprint of Turkey in the long run.

According to Cowan et al. (2014) in their study reexamination of causality linkages between CO_2 emissions in BRICS countries, consumption of electricity, and economic growth. The BRICS countries studied are South Africa, Russia, Brazil, China, and India. In India and China, no proof of Granger causality between CO_2 emissions and GDP. They discovered a one-way causal direction running from CO_2 emissions in South Africa and Russia; in Brazil, a converse correlation between CO_2 emissions and GDP was found. Liu (2006) found the existence of a causality association between economic growths and emissions of CO_2 for Norway. Also, the causality running from economic growth and emissions of CO_2 is bidirectional according to Kim et al. (2010). The non-existence of causal correlation in the short-run between growth economically and CO_2 emissions were detected by Saboori et al. (2012) work, on the other hand, he found one-way directional causality in the long-run running from economic growth to CO_2 emissions.

According to Leitao (2015), utilization of energy use and growth economically in the long-run cause CO_2 emissions; emissions of CO_2 emissions and economic growth causes consumption of energy. An identical outcome was discovered by Wang et al. (2011). The existence of bi-directional stimulus (causality) between GDP (economic growth) and emissions of CO_2 and uni-directional stimulus (causality) from financial development to carbon emission was discovered by Shahbaz et al. (2013). The same relationship was found by Omri (2013) for nations in the MENA region. Bloch et al. (2012) from the point of view of supply-side substantiate the proof of uni-directional causal linkages between coal usage and output in both the long-run and short-run in his study of the linkages between China's coal consumption and income. Under the demand point of view analysis, they also found in both the long-run and short-run existence of a uni-directional causal link from income to coal usage. An enormous positive correlation between CO_2 emissions and economic growth in Portugal were found by Leitao (2014). For China, Japan, and the USA, the same finding was proved by Azam et al. (2015), while for India's situation a significantly negative linkage was found.

4.2.3 Carbon Effect of Fiscal Development, FDI, and Trade Openness

Khan et al., (2021) investigated the impact of fiscal decentralization on the emission of carbon of 7 (seven) OCED countries starting from 1990 to 2018 They found that fiscal decentralization through various avenues such as human capital and institution indirectly affects the emissions of carbon in addition to its direct impact. Their findings reveal that environmental quality is improved by fiscal decentralization.

Khan et al., (2020) applied the panel FMOLS (fully modified ordinary least squares) on the data from 17 Asian countries from 1980-2014 in their study of causal linkages between environmental pollution by CO_2 emissions and net FDI (foreign direct investment) discovered that environmental pollution increases with an increase in inward foreign direct investment and vice versa. Their study supports the pollution Haven hypothesis. Also, bidirectional causality between FDI and carbon emission was revealed by their panel causality results.

Ji et al., (2020) in their study of the importance of fiscal decentralization in promoting a sustainable environment of Switzerland, Spain, Germany, Canada, Belgium, Austria, and Australia using the non-linear and linear methods discovered that fiscal denaturalization by reducing emissions of carbon enhances the environment of these nations. Additionally, they found that renewable energy and eco-innovations mitigate emissions of carbon, while GDP enhances carbon emissions

Kirakkaleli and Adebayo (2020) applying the Bayer and Hanck cointegration, dynamic OLS (DOLS), canonical cointegrating regression (CCR), and fully modified OLS (FMOLS) discovered that global green energy usage and global development financially have a positive substantial inference on environmental sustainability in the long-run, contrarily GDP (economic growth) accelerates global emission of carbon.

Baloch et al. (2020) in their study of the linkages between financial development, energy innovation, and environmental quality of OCED (Organization for Economic Cooperation and Development) nations from 1990 to 2017 employing the Autoregressive Distributed Lag (Pooled Mean Group) discovered that financial development enhances the quality of the environment. Energy innovations were also found to enhance environmental quality.

In their study, Jianhui, Xiaojie, Pinglin, Hao, and Huayu (2019) employing VECM techniques assessed the impact of economic growth, financial development, and energy use on China's emissions of CO_2. The empirical results found a cointegrating relationship between energy use, economic growth, and financial development. Also, the result shows that the effect of energy use and financial development on CO_2 emissions are positively significant. Furthermore, there is one-directional Granger causal nexus of financial development and energy use. Siddique et al. (2016) discovered that energy usage and development financially by increasing CO_2 emissions are polluting the environment. A bi-directional causal linkage in the short and long run flowing from CO_2 emissions to energy use were uncovered by their study. The causality link between financial development and CO_2 emissions were further discovered by this study; while there is non-existent causality in the short run. They further buttress that environment-related problem such as CO_2 emissions are created by extensive use of power resources.

Furthermore, Abidin, Haseeb, Azam, Islam (2015) investigated for selected ASEAN countries the linkages between selected ASEAN countries FDI, energy utilization, T (trade), and FD. The empirical result found that the entire explanatory variables are related significantly in the long run after employing appropriate tests of stationarity.

In the long run during the period under study bi-directional causal correlation was discovered between trade and energy use; trade and FDI; trade and financial development; energy use and financial development. While uni-directional causal links flow from energy use to development financially in the short run were revealed by the Granger causality test results. Moreover, according to Ozturk and Acaravci (2013), there is a long-run nexus of energy utilization per person, financial development, carbon emissions per capita, real per capita, income, and the square of per capita real income, openness in trade. Consumption of energy is explained by enormous literature as a major factor that increases pollution, and economic growth. Thus, creativity concerning technology and cogent energy is highly needed.

Tamazian and Rao (2010) discovered that to achieve a better environment, financial developments are vital. Furthermore, according to the study, emissions of CO_2 are increased by trade. Also, Tamazian et al. (2009) found that emission of carbon dioxide is reduced by openness to trade, financial development, and financial liberalization in his study of the association existing among enhanced environment and financial development of the country under study starting from 1992-2004 (Brazil, China, Russia, India). Financial development is suggested to be helpful in the reduction of China's emission rate by Jalil and Feridun (2011)'s research. Their study further suggested that the fundamental causes of emissions of CO_2 are trade and energy use and trade are the major causes of CO_2 emissions and the study empirical result exposed Environmental Kuznets Curve (EKC).

Also, Siddique (2017) employing ADF unit root test and ARDL bounds methods discovered the existence of interconnection between capital, CO_2 emissions, use of energy, trade, economic growth, and financial development in the long run. The factors increasing the emission of carbon dioxide according to the empirical findings are energy consumption, financial development, economic growth, and trade. The result of the analysis revealed that economic growth can be actualized directly and indirectly using financial development and trade; the role played by financial development, Economic growth, and trade are very essential and imperative. However, this result is inconclusive as there is a tendency or possibility of achieving a reduction in energy use using financial development, as cogent energy might be increased by improvement or increase in financial development.

Xiaong et al. (2017) using a panel dataset from China assessed the regional differences in FMD's effect on emissions considering differences in various regions. The study opined that emissions could be reduced by financial development in China's developed cities thus leading to the abatement of environmental hazards especially in the less developed regions of China. This is because it is stated that the bringing of improvements in the environments by financial development can be hindered by institutional constraints and market forces.

These five variables (Financial development, FDI, energy consumption, economic growth, and CO_2 emissions) have rarely been researched together despite the existence of numerous literature on "FDI-Growth", financial development- Growth" or " CO_2 emissions-Growth" nexuses. Additionally, as far as we know there is no empirical literature encompassing all the variables used in this study, also the case of South Africa is unique in this study. Thus, research on the correlation and the Granger causal linkages among financial development, FDI, economic growth, energy usage, and carbon dioxide emissions in South Africa is paramount and highly needed, and this is the study's major target.

4.3 Data Representation and Methodology

4.3.1 Data

A time series and yearly dataset from the database of the World Bank Development Indicator from 1970 to 2014 was collected and used for the analysis of this study. The variables comprise foreign direct investment (FDI), FD (Fiscal development). Trade (T), REC (Renewable energy utilization), GDP (economic growth), and carbon emissions (CO_2). The descriptive statistics and correlation matrix (see Table 1 and 2) and the series plot is depicted in Figure 4 are all presented.

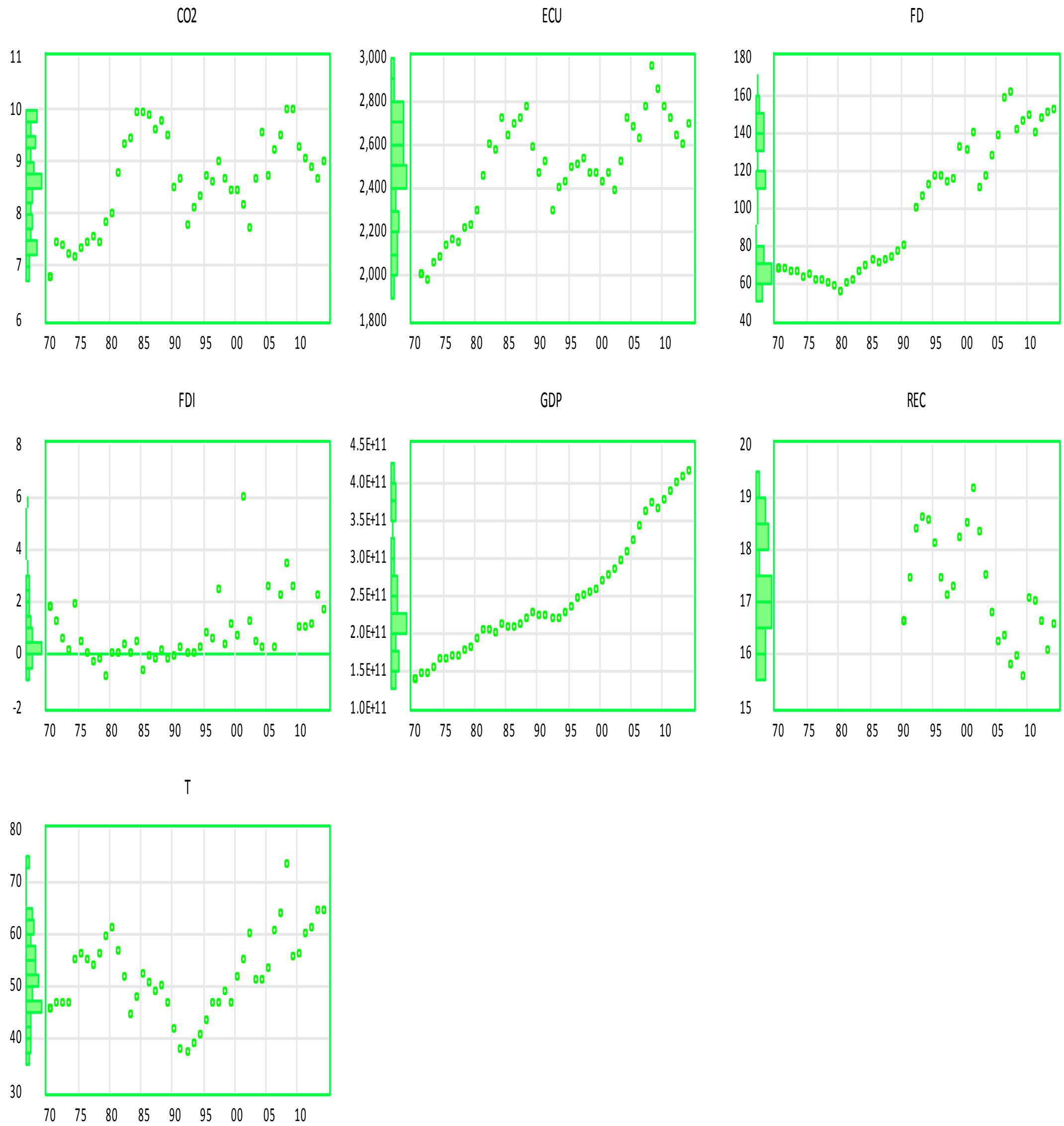

Figure 4: The graphical illustration of the relationship between fiscal development (FD), trade (T), renewable energy (REC), FDI, economic growth (GDP), and CO_2 Emissions of South Africa from 1970-2014.
Source: WD1 (World Bank Development indicators), 2020: Author's computation

From figure 4 above, FDI and GDP exhibit an upward trend, while CO2, REC, and T(trade exhibit) a fluctuating movement of an upward and downward trend.

Table 20: Variables summary table

Variables	Proxy	Symbols
Fiscal (financial) development	Domestic credit to private(% of GDP)	FD
C02 emission	Metric per tons per capital	CO2
Foreign Direct Investment	FDI net inflows (% of GDP)	FDI
Economic growth	GDP (constant 2010 US $)	GDP
Trade	Trade (percent of GDP)	T
Renewable energy utilization	Renewable energy utilization (share of primary energy consumption)	REC

Table 21: Summary of descriptive statistics

Stat.	LNCO2	LNFD	LNFDI	LNGDP	LNT	LNREC
Mean	2.147	4.53	20.25	26.18	3.94	2.84
Median	2.15	4.62	20.36	26.13	3.94	2.83
Maximum	2.30	5.07	23.01	26.74	4.28	2.95
Minimum	1.91	3.98	15.02	25.64	3.62	2.74
Standard dev.	0.10	0.36	2.05	0.30	0.14	0.05

Table 22: Correlation Matrix Outcomes

Correlation	LNCO2	LNFD	LNFDI	LNGDP	LNT	LNREC
LNCO2	1.000					
LNFD	0.6520*	1.000				
LNFDI	0.5677*	0.7358*	1.000			
LNGDP	0.6334*	0.8706*	0.7038*	1.000		
LNT	0.5549*	0.8107*	0.7762*	0.8964*	1.000	
LNREC	-0.8236*	-0.6823*	-0.5494*	-0.7714*	-0.6647*	1.000

Note: * means statistical significant at 0.01%

The descriptive statistics of carbon emissions, REC (renewable energy), FD (fiscal development), FDI, T (trade), and economic growth (GDP) are shown in Table 21 above. The mean of FD (4.53) is low in contrast to other developed and developing countries. Over time the variation in FD level is much as shown by the maximum and the minimum value which has a value of 5.07 and 3.98 respectively. The mean of FDI (20.25) is high, which implies that for the period under study the FDI of South Africa on the average is relatively large compared to other African countries. The maximum and the minimum value of FDI are 23.01 and 15.02. A small variability across time is suggested by the mean, maximum, and standard deviation of carbon emissions, trade, GDP, and REC. The correlations among the variables which is consistent with the established economic theory are exhibited in table 22 of the correlation matrix result above. Example positive correlation between GDP and CO_2 emissions. Also, it is expected that energy use (renewable) should be negatively correlated with CO_2 emissions.

4.3.2 Model specification

This study assessed the relationship among fiscal (financial) development, FDI, renewable energy use, economic growth, and emissions of CO_2 in South Africa, The dependent variable is CO_2 emissions while the independent variables are financial development, FDI, energy consumption, and economic growth. These variables in literature was used by Siddique, 2017, Siddique et al. 2016, and Mahmood, Furqan and Bagais, 2019.

$$CO_2 = f\ (FD, FDI, REC, GDP, T) \quad (24)$$

With natural logarithm the functional form of our model is stated below:

$$\text{LNCO}_2t = \O_0 + \O_1 LNFDt + \O_2 LNFDIt + \O_3 LNRECt + \O_4 LNGDP + \O_5 LNTt + \mu t \quad (25)$$

4.3.3 Estimation Techniques

Different test methods and tests were employed to scrutinize the correlation between FDI, fiscal development, trade, renewable energy use, economic growth, and CO_2 emissions. The test of the Unit root (see Dickey & Fuller, 1981) was first performed to ascertain the stationarity of the variables since it is a time series model. Zivot Andrew unit root test and ADF to test were adopted for the unit root test. The SIC (Schwartz selection criteria) was chosen as ascertaining the optimal number of lags in the ADF test. Also to counter autocorrelation, lagged difference was included in the ADF test. This study made use of the Johansen cointegration test together with a Vector Error correction model (VECM) analysis to determine the cointegration of time series variables. Afterward, the VECM Granger causality test (Engle and Granger 1987) was applied to determine the causal link between FD (fiscal development), REC (renewable energy consumption), and CO_2 emissions. According to Granger (1988), the pertinent technique to appraise the causal link among series if they are 1 (1) series is the VECM. Also, 1 The step-by-step method of the unit root structural breaks are presented by Zivot and Andrews (2002). There is statistical evidence of the long-run cointegration relationship among the series such that the employed VECM Granger causality method performed on equation 25.

4.4 Empirical Results and discussion

The stationarity of time series data is expected to steer clear of spurious regression and for soundness of result to hold. ADF unit root and Zivot Andrew was employed to check the data for stationarity to accommodate structural breaks as also mentioned by Bora, Kirikkaleli, Zoaka, Bekun, and Ekwueme (2019) resulting from the change in data utilization of the accustomed test of unit root methods (for example; ADF and PP unit root test) may be biased especially when the null hypothesis is rejected. Table 23 shows the ADF unit root result while Table 24 reveals the test outcomes of the Zivot Andrew unit root test which was done utilizing both trend and constant terms. Both table 23 and table 24 below show that at levels all the variables are not static but after the first difference, it was stationary. This implies that the entire variables being studied are integrated order of 1(1), thus the Johansen cointegration test is performed.

Table 23: ADF unit root results

	LNCO2	LNFD	LNFDI	LNGDP	LNT	LNREC
Level	-2.2358	-2.2766	-2.2766	-1.7241	-1.8334	-3.1072
First diff.	-6.526**	-4.515**	-3.773**	-4.651**	-5.960**	-3.699**

**** means rejection of null hypothesis at 5% level of significance. SIC was used to determine the optimal lag length of ADF.*

Table 24: Result of Unit root test (Zivot-Andrews)

	Level	First Difference	Integration order
LNCO2	-3.7414	-7.3184**	I (1)
Break Year	1984	2002	
LNFD	-2.8161	-7.5376**	I (1)
Break Year	1990	2002	
LNT	-4.4677	-64594**	I (1)
Break Year	1989	1992	
LNREC	-5.1061	-7.3043	
Break Year	2002	2009	

*** means rejection of null hypothesis at 5% level of significance.* The optimal lag length was determined using *SIC.*

Table 25: VAR lag selection order

Lag	LogL	LR	FPE	AIC	SC	HQ
0	112.80	NA	1.54	-10.17	-9.87	-10.10
1	210.58	130.36*	5.03	-16.05	-13.96	-15.60
2	271.68	46.54	1.38*	-18.44*	-14.56*	-17.60*

This study made use of the Johansen cointegration test together to discover the cointegration of time series variables understudy with a Vector Error correction model (VECM) analysis. The optimal length obtained as seen in table 25 above is 1 and table 26 below shows the outcome of the Johansen cointegration test.

Table 26: Results of Johansen Co-integration test

Number of cointegrating equation	Trace statistics	5% critical value	Probability value	Maximum Eigen statistics	5% critical value	Probability value
None*	161.1466	95.7536	0.0000	64.9481	40.0775	0.0000
At most 1*	96.1984	69.8188	0.0001	38.9501	33.8768	0.0114
At most 2*	57.2432	47.8561	0.0051	25.9051	27.5843	0.0807
At most 3*	31.3431	29.7970	0.0329	18.2345	21.1316	0.1213

Source: author’s computation

Table 26 above suggests the null hypothesis of cointegration being absent among the examined variables was rejected at a 0.05% level of significance The result of Trace statistics indicate that at 5% significance level that there is four co-integrating equation. While at 0.05% significance level two cointegrating equation is shown by the Max-Eigen statistics. Thus, a cointegration exists in the long run among the variables being studied. This is accordant with Leitao (2015) and Siddique et al, (2016). We made use of the vector error correction model (VECM) because the variables are related in the long run. Granger causality test was also employed to ascertain the causality between the variables under study. 1987 of Engle and Granger's VECM Granger causality test was applied to determine the causality between foreign direct investments, fiscal development, renewable energy usage, and CO_2 emissions. According to Granger (1988), the pertinent technique to appraise the causal link among series if they are 1 (1) series is the VECM (Vector Error Correction Method).

Table 27: Cointegrating equation of VEC Model

Cointegrating Equation	Coint EQL	STD errors	t-statistic)
LNCO2(-1)	1.000		
LNFD(-1)	0.4731	0.1069	0.4422
NFDI(-1)	-0.0546	0.0046	-11.6682
LNGDP(-1)	0.3079	0.0567	5.4261
LNT(-1)	-0.0554	0.0971	-0.5707
LNREC(-1)	1.5567	0.1090	14.27

From Table 27 above, it can be seen that GDP, and REC are positively related to CO_2 emissions in the long run, while the impact of FD ıs ınsignificant. which implies that a percentage increase in GDP will increase emissions of CO_2 by 0.30%. This is in line with the following work; Xou (2018), Ekwueme and Zoaka (2020), Abidin, et al., (2015), and Jianhui (2019). Ekwueme and Zoaka (2020) reveal that GDP has a positive influence on the carbon emissions of MENA countries. Abidin et al (2015) found that for the chosen ASEAN countries that their FD, foreign direct investment, usage of energy, and Carbon emissions are related in the long run.

Table 28: Estimation results of VECM

Variable	Coefficient	Std.Errors	t-statistics
C	0.1248	0.0051	2.4418
ECM(-1)	0.0950	0.0355	2.6784
DLNFD(-1)	0.1137	0.0308	3.6856
DLNFDI(-1)	-0.0014	0.0014	-0.0043
DLNGDP(-1)	0.5998	0.1840	3.2583
DLNT(-1)	-0.0820	0.0346	-2.0362
DREC(-1)	-1.1792	0.0802	-2.2330
R-Squared	0.785		
Adj R-squared	0.669		
Loglikehood	73.77		
AIC	-6.26		
SIC	-5.86		

Additionally, Table 28 below shows the estimated parameters of the VECM. The test result revealed that at a 0.05% significance level a positive and statistically significant error correction term (ECM). This implies that the digression from the equilibrium of South Africa's emission of carbon will adjust automatically and that exposure of the system to shock will converge in equilibrium in the long-run equilibrium for LNCO2 at a relatively low speed (which is 9%). The adjustment speed is very low considering

South Africa too much dependency on coal-based energy usage. Additionally, the results reveal that LNFD (Financial Development) and LNGDP (economic growth) correlation with CO_2 emissions in the short run is positive and statistically significant. The implication of this is that increasing FD and GDP by 1% will amount to a 0.11% and 0.59% increase in the emission of carbon. Contrarily, LNREC and LNT (trade) have a negative statistical relationship with the emission of carbon in the short- run, implying that increasing REC and T by 1% will lead to a 1.17% and 0.08 decrease in carbon emissions in the short run. This is accordant with Mahmood et al (2019), Diallo & Masih (2017), and Jianhui et al (2019). No significant linkages between FDI and carbon emissions in the short-run were revealed by our empirical analysis, this is consistent with Abidin et al (2015) who found a relationship that is insignificant between FDI and CO_2 emissions.

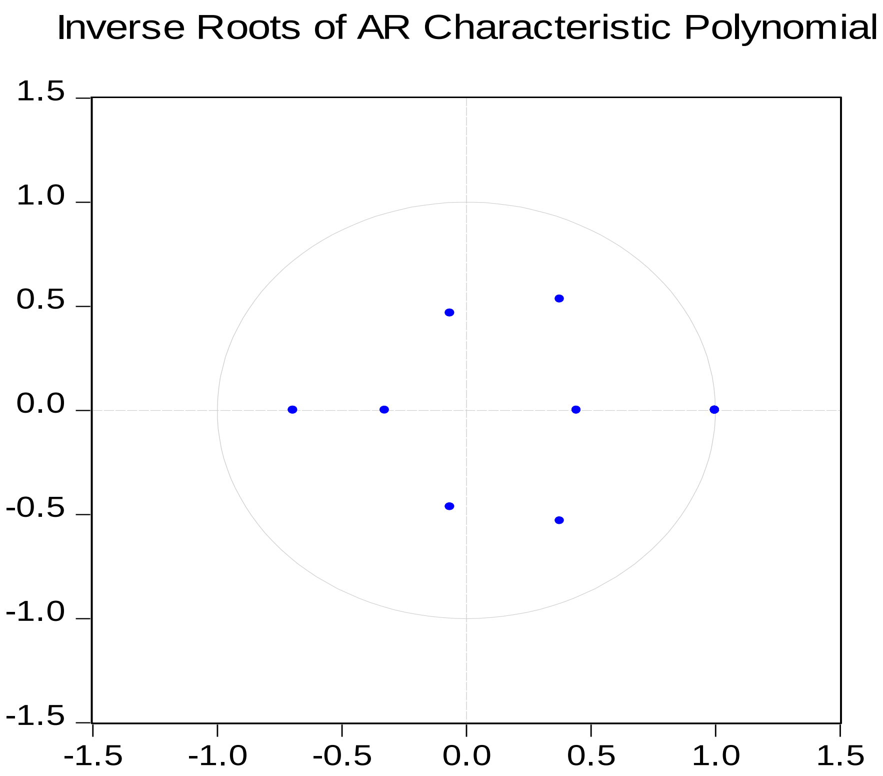

Figure 5: stability condition.
Source: Authors computation

Figure 5 above suggests that the stability condition of the VECM is satisfied. The VECM application for the test of Granger causality was conducted to ascertain the causal association among the variables (see Table 30).

Table 29: Results of block exogeneity Granger Causality

Dependent Variable	X^2 Statistics (P.value)						
	$\Delta LNCO2$	$\Delta LNFD$	$\Delta LNFDI$	$\Delta LNGDP$	ΔLNT	$\Delta LNREC$	Overall X^2
$\Delta LNCO2$	_	-0.93(0.3223)	0.04(0.8385)	1.74(0.1871)	0.15(0.6893)	1.05(0.6893)	5.09(0.4047)
$\Delta LNFD$	0.18(0.6621)	_	1.20(0.2732)	0.11(0.7352)	0.003(0.953)	2.43(0.1187)	4.27(0.5103)
$\Delta LNFDI$	0.08(0.7643)	2.30(0.1293)	_	0.26(0.6052)	3.46(0.0625)***	4.81(0.0283)**	9.27(0.0984)
$\Delta LNGDP$	9.15(0.0025)*	13.58(0.0002)*	0.98(0.3200)	_	5.60(0.0179)*	4.98(0.0255)**	36.64(0.0000)*
ΔLNT	6.22(0.0126)*	16.42(0.0001)*	4.07(0.0436)**	3.46(0.0627)	_	0.60(0.4371)	42.60(0.0000)*
$\Delta LNREC$	0.36(0.5449)	0.94(0.3303)	0.48(0.6635)	2.99(0.0833)***	0.08(0.7649)	_	9.78(0.0817)***

Note; ***, ** and * represents null hypothesis was rejected at 10%, 5%, and 1% respectively.

The Block Exogeneity Granger causality test results are presented in Table 29 above. The null hypothesis of no causal association between the variables was rejected, the implication of this is that there is a causal association between the variables running from the independent to the dependent variable. There is causality running from Trade, renewable energy to FDI (T, REC → FDI); from CO_2 emissions, fiscal development, trade, renewable energy to economic growth (CO_2, FD, T, REC →GDP); from CO_2 emissions, fiscal development, FDI(foreign direct investment) to trade (CO2, FD, FDI→ T), and (GDP →REC). Hence, we can conclude from the above results that there is bi-directional Granger causality from REC to GDP; from FDI to Trade, while the rest are uni-directional causality.

Additional estimation techniques were employed to check the robustness of VECM estimation output in Tables 27 and 28. The cointegration test of Pesaran et al., (2001) Autoregressive Distributed lag Model (ARDL) bound testing was utilized in ascertaining the robustness of the VECM test results. This technique was adopted because of its dynamic applicability despite the nature of the integration of the series. It also has the advantage of carrying dual computation by first estimating the long run and the short-run association between the variables and then examining the causal effect existing among the variables. The estimation output of the long-run and the short-run ARDL is presented in Table 30 below. While the ARDL bounds test results to cointegration are presented in Table 31 below.

Table 30: Estimation output of the long-run and short-run ARDL

Variable	Coefficient	Standard Error	*t-statistic*	P-Value
Long-run				
LNFD	0.0455	0.1636	0.2784	0.7840
LNFD1	0.0083	0.0091	0.9110	0.3750
LNGDP	0.1631*	0.0478	3.4103	0.0033
LNREC	-0.6113*	0.2158	-2.8314	0.0115
LNT	-0.2005	0.1361	-1.4737	0.1588
Short-run				
LNFD	0.0393	0.1427	0.2757	0.7861
LNFD1	0.0072	0.0081	0.8901	0.3858
LNGDP	0.1409*	0.0509	2.7670	0.0132
LNREC	-0.5282*	0.2124	-2.4864	0.0236
LNT	-0.1733	0.1270	-1.3641	0.1903
ECT	-0.8641*	0.2139	-4.0381	0.0009
Diagnostic tests				
Tests	f-statistics	Probability Value		
χ^2 White	1.3527	0.3567		
χ^2 Serial	0.3303	0.7235		

* and **denotes significant at 0.05% and 0.10% respectively. The number in parenthesis is the standard error.
Model: Lnco2=f (LNFD, LNFDI, LNGDP, NREC, LNT). ARDL **(1, 0, 0, 0, 0, 0)**

From Table 30 above, the output is similar to the output of the VECM output in Table 27 and Table 28 above. GDP has a significant positive relationship with carbon emission in the long run and the short run. This implies that 0.165 of carbon emissions in South Africa in the long and short run is caused by the process of growth in South Africa. REC (renewable energy) has a significant negative relationship with carbon emission in both the long run and the short run. This implies renewable energy will reduce the emission of carbon in South Africa substantially by 0.61% in the long run and 0.52% in the short run. FD and FDI have an insignificant positive relationship with carbon emission in both the long-run and the short-run. The study further conducted several diagnostic tests, and the findings revealed the absence of auto-correlation in the model and there is no heteroscedasticity. Similarly, in Table 31 below, the ARDL bound test from the t-statistics rejected the null hypothesis of no cointegration at 1% and 2.5%. The error correction term (ECT) shows that in the long run, the series will converge quickly with an enormous adjustment speed of 86%. This suggests that short-run disturbances could be rectified over time.

Table 31: ARDL bounds test results to cointegration

ƒ-Bounds Test	**HO: no level relationship**			
Test statistic	Value	Sig.	1(0)	1(1)
ƒ-statistics	2.8331	10%	1.81	2.93
K	5	5%	2.14	3.34
		2.5%	2.44	3.71
		1%	2.82	4.21
t-Bound Test	**HO: no level relationship**			
Test statistic	Value	Sig.	1(0)	1(1)
t-statistic	-4.0381	10%	-1.61	-3.49
		5%	-1.95	-3.83
		2.5%	-2.24	-4.12
		1%	-2.58	-4.44

The Fully Modified Ordinary Least Square (FMOLS) was also estimated. The result is presented in Table 32 below. The FMOLS output is similar to the ARDL long-run result in Table 30, the result shows that GDP has a significant positive impact on carbon emission in the long run. While REC (renewable energy) has a significant negative impact on carbon emission in the long run.

Table 32: FMOLS outcomes

Variable	Coefficient	t-statistics	Prob.
LNFD	0.0564	0.3793	0.7091
LNFD1	0.0087	0.8670	0.3980
LNGDP	0.1696	3.8190	0.0014*
LNREC	-0.6185	-3.1193	0.0062*
LNT	-0.2543	-2.0468	0.0565**

* and ** denotes significant at 0.05% and 0.10%

4.5 Concluding Remark and Policy

In the emissions of carbon emissions in South Africa and the world large, patently the gravity of foreign direct investment (FDI), fiscal development (FD), and usage of energy can be overlooked considering the hazardous consequences on global warming, economy, and human lives. Hence, this study scrutinized the correlation between foreign direct investment, renewable energy use, fiscal development (FD), and emissions of CO_2 in South Africa. The study intends to assess the contribution of increment in foreign direct investment (FDI) level, development financially, and increased renewable energy usage to emissions Carbon in South Africa. A suitable test of stationarity was followed by the study and from the result at level, all the series under study have unit root and became stationary after the first difference. The existence of a statistically significant correlation in the long run among the sampled variables was disclosed by ARDL bound test and Johansen multivariate cointegration technique. Furthermore, the result of the Johansen and the VECM cointegration analysis outcomes disclosed that fiscal development (FD), economic growth (GDP), renewable energy (REC), and emissions of CO_2 are related in the long run, and digression from the equilibrium of South Africa's emissions of carbon will adjust automatically, though at a small speed considering South Africa's too much reliance on coal-based energy consumption. Development in finance and growth economically have a statistically positive relationship with emissions of CO_2 in the short run, while green energy usage has a negative statistical interrelationship with the emission of carbon in the long run and short run. The implication is that renewable energy is good for South Africa as it will help to reduce emissions of CO_2. The granger causality results show overall causality among the series, however proof of bi-directional causal association running from renewable clean energy to economic growth; FDI to trade, and one causality direction running among the other variables{ (trade, renewable energy → FDI), (CO_2, fiscal development, trade, renewable energy→GDP(economic growth); (CO_2, fiscal development, FDI→trade), and (economic growth→renewable energy)}.

The policy implication of this study is that the implementation of energy efficiency programs currently pursued by the South African government to enhance renewable energy consumption should be facilitated with more determination since it is evident from our study that renewable energy usage promotes growth economically and reduces carbon emissions emissions in South Africa. Also, the government and policymakers should thrive to align these energy efficiency programs with other macroeconomic and financial variables such as foreign direct investment (FDI), fiscal development, trade openness, etc. to achieve a minimum CO_2 - emissions level in South Africa, thus yielding environmental sustainability.

Chapter 5

CONCLUSION AND POLICY RECOMMENDATIONS

This study investigated the influence of trade receptivity, financial development, foreign direct investment (FDI), economic growth (GDP), natural resources extraction, energy consumption (unrenewable and renewable energy usage), industrialization, urbanization on the CO_2 emissions. The design of presenting various studies carried out in line with the selected topic focusing on MENA (the Middle East and North African) and SSA (Sub-Saharan African) countries bit-by-bit is the design that was adopted in this dissertation. For each study, we deduced diverse conclusions incorporated with distinct policy implications. Hence, this dissertation conclusion is hinged on the summary of the conclusions of the various studies.

The first study which is in chapter two scrutinized the influence of energy utilization, trade receptivity, and financial development on CO_2 emissions of 10 countries in the Middle East and North Africa within the period of 1970 to 2017 employing DOLS {dynamic ordinary least squares} and the FMOLS {fully modified ordinary least squares. The main findings reveal energy utilization and receptivity of trade have a significant positive influence on CO_2 emissions. Contrarily, the influence of financial development on the emissions of CO_2 is negative and statistically significant. Thus, this implies that in the MENA region, the development of the financial sector will significantly mitigate the emissions of CO_2 over time. Similarly, our empirical results are being validated by the apparition of the EKC. Additionally, from the empirical results, the pollution haven hypothesis can be deduced to be a proportionately short-run occurrence for the MENA region.

In Chapter Three, we utilized the STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology model) to assess the impact of natural resources extraction (proxied by total natural resource rent), population (proxied by urbanization), affluence (income), and openness in trade on CO_2 emissions and energy utilization of 17 SSA (Sub-Saharan Africa) countries from 1971-2019. This motivation for the conduction of this research is the fact not much has been done by former literature to analyze econometrically the influence of extraction of natural resources on the environmental deterioration drivers particularly CO_2 emission in Sub-Saharan Africa (SSA). The Westerlund (2007) Error-Correction Model and Kao cointegration technique were utilized to ascertain if the series, in the long run, are interrelated. The auto-distributed regression method (Pooled Mean Group), FMOLS {Fully Modified Ordinary Least Square} and dimension group mean panel DOLS (Dynamic Ordinary Least Square techniques) to assess carbon emission and energy utilization long-run multiplier . The empirical results reveal that natural resource extraction, urbanization, and income have a significant positive impact on energy utilization and the emission of CO_2 in SSA nations in the long run. This means that environmental deterioration increases with an increase in natural resource extraction, urbanization, and affluence (income). On the contrary, in the long run, openness in trade has a negatively significant influence on energy utilization and the emission of CO_2 of SSA countries. This implies that deterioration of the environment mitigates a rise in foreign trade. The quality of the environment is enhanced by the technique effect by empowering nations to import low pollution manufacturing techniques. Trade through its composition effect assist the transformation of the economy from agricultural-based to industrial based and finally to service which has relatively small pollution and installs energy-efficient technologies, the energy demand may be reduced.

From chapter three, the correlation between foreign direct investment (FDI), renewable energy use, fiscal development (FD), economic growth, trade openness, and carbon emissions in South Africa (which is one of the nations in SSA) was researched. The unit root test of Zivot-Andrews and (ADF) Augmented Dickey-Fuller), Vector Autoregressive (VAR), and Pesaran ARDL (Autoregressive Distributed Lag bounds) approach were employed in the data analysis. The result of the Johansen, the vector auto-regressive error correction model (VECM), and the ARDL (Autoregressive Distributed Lag) bound cointegration analysis results to reveal that fiscal development (FD), economic growth (GDP), trade openness, renewable energy (REC), and emissions of CO_2 are related in the long run, and digression from the equilibrium of South Africa's emissions of carbon will adjust automatically, though at a small speed considering South Africa's too much reliance on coal-based energy consumption. Development in finance and growth economically have a statistically positive relationship with emissions of CO_2 in the short run, Renewable energy usage has a negative significant influence on the emission of carbon in both the long and short run. The implication is that renewable energy is good for South Africa as it will help to reduce emissions of CO_2. The granger causality results show overall causality among the series, however proof of bi-directional causal association running from renewable clean energy to economic growth; FDI to trade, and one causality direction running among the other variables{ (trade, renewable energy → FDI), (CO_2, fiscal development, trade, renewable energy→GDP(economic growth); (CO_2, fiscal development, FDI→trade), and (economic growth→renewable energy)}.

The main policy implications of this study are that enhancing openness in trade, in the long run, will mitigate CO_2 emissions in MENA nations. Additionally, outrageous development financially over time will result in mitigation of CO_2 emissions in the region as revealed by the empirical result. This suggests the importance of promoting activities and policies that will accelerate development financially and trade openness in the region by government, policymakers, and stakeholders in the region. Consumption of energy is discovered to accelerate the emissions of carbon dioxide in MENA nations, hence enactment of policies and projects geared to securing clean energy supply and usage is requisite.

Furthermore, Policymakers in the SSA region should enforce extra rigorous eco-friendly environmental regulations that will promote the extraction of natural resources in a more thrifty mechanism, stimulate the expansion and usage of green technology and energy-saving sources to deal with urban development, security of energy supply, and enhance sustainable and green development in the region. The SSA government should reduce tariffs on commodities that promote a quality environment and increase non-tariffs and tariffs blockades on commodities that are not eco-friendly.

Finally, the South African government should implement energy efficiency programs to facilitate the quick transition to renewable energy consumption. Also, the South African government and policymakers should thrive to align these energy efficiency programs with other macroeconomic and financial variables such as foreign direct investment (FDI), fiscal development, trade openness, etc. to achieve a minimum CO_2- emissions level in South Africa, thus yielding environmental sustainability.

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