NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF ECONOMICS

CARBON EMISSION AND ECONOMIC GROWTH NEXUS: AN EMPIRICAL EVALUATION ON TESTING THE ENVIRONMENTAL KUZNETS CURVE (EKC) HYPOTHESIS IN OIL EXPORTING AND IMPORTING ECONOMIES.

MSc. THESIS

Joseph Tuakolon Tokpah

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January, 2023

Thesis defence was held online. The jury members declared their acceptance verbally which is recorded.

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We certify that we have read the thesis submitted by **Joseph TUAKOLON** TOKPAH titled "**CARBON EMISSION AND ECONOMIC GROWTH NEXUS: AN EMPIRICAL EVALUATION ON TESTING THE ENVIRONMENTAL KUZNETS CURVE (EKC) HYPOTHESIS IN OIL EXPORTING AND IMPORTING ECONOMIES.**" and that in our combined opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of International Relations.

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Declaration

I hereby declare that all information, documents, analysis and results in this thesis have been collected and presented according to the academic rules and ethical guidelines of Institute of Graduate Studies, Near East University. I also declare that as required by these rules and conduct, I have fully cited and referenced information and data that are not original to this study.

JOSEPH TUAKOLON TOKPAH

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Abstract

Carbon Emission and Economic Growth Nexus: An Empirical Evaluation on Testing The Environmental Kuznets Curve (Ekc) Hypothesis in Oil Exporting and Importing Economies.

JOSEPH TUAKOLON TOKPAH

Masters, Department of Economics

Supervised by Prof. Dr. Hüseyin Özdeşer

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This research aims to examine and compare the validity of the environmental Kuznets curve and the relationship between C02 emissions, Per capita GDP, per capita GDP square, fossil fuel consumption, oil price, and foreign direct investment in advanced oil-importing countries and oil-exporting economies from 1970 to 2020. The researchers considered these nations based on their contributions to oil supply and the economic characteristics of oil imports. Due to structural breaks, the study utilizes Karavias and Tzavalis's (2014) unit root test, valid under cross-sectional dependency, to help achieve the study's objectives. In addition, the Westerlund (2007) cointegration test was used to determine the long-run relationship between the variables. The result reveals the existence of cointegration in oil-exporting and oil-importing countries; thus, we conclude that there is a long-run association between the variables. The methodology employed for this research is the PMG-ARDL model established by Pesaran et al. (1999), which assesses the short- and long-run nexus between the regressand and the variables of interest.

It allows long-run coefficients to be homogeneous while short-run coefficients differ across cross-sections. A statistically significant association was observed from the estimation, thus, providing evidence to support the EKC hypothesis in both panels of countries. Henceforth, when we compare the EKC hypothesis in both groups of countries, it is evident that the significant similarity is that both panels of countries support the EKC framework. In addition, FDI and fossil fuel consumption have the same long-run positive effects on c02 emissions. The main difference between both groups of countries is that oil prices positively affect CO2 emissions in exporting countries while negatively affecting environmental degradation in oil-importing countries. Therefore, the study proposes that increasing green growth is an efficient means of reducing CO2 emissions and achieving sustainable development, which enhances contribution to environmental quality.

Key words: Environmental Kuznets curve, Per capita GDP, Carbon emission

Öz

Karbon Emisyonu ve Ekonomik Büyüme İlişkisi: Petrol İhraç Eden ve İthal Eden Ekonomilerde Çevresel Kuznets Eğrisi (Ekc) Hipotezinin Test Edilmesine Yönelik Ampirik Bir Değerlendirme.

Joseph Tuakolon Tokpah

Yüksek Lisans, Ekonomi Bölümü

Prof. Dr. Hüseyin Özdeşer (Danışman)

ve

Doç.Dr.Andisheh Saliminezhad (Ortak Danışman)

01.2023, 196 sayfa

Bu araştırma, çevresel Kuznets eğrisinin geçerliliğini ve C02 emisyonları, kişi başına düşen GSYİH, kişi başına düşen GSYİH karesi, fosil yakıt tüketimi, petrol fiyatı ve gelişmiş petrol ithal eden ülkelerdeki doğrudan yabancı yatırım ile petrol arasındaki ilişkiyi incelemeyi ve karşılaştırmayı amaçlamaktadır. 1970'den 2020'ye ihracat yapan ekonomiler. Yapısal kırılmalar nedeniyle çalışmada, çalışmanın amaçlarına ulaşılmasına yardımcı olmak için Karavias ve Tzavalis'in (2014) yatay kesit bağımlılığı altında geçerli olan birim kök testi kullanılmıştır. Ayrıca değişkenler arasındaki uzun dönemli ilişkiyi belirlemek için Westerlund (2007) eş bütünleşme testi kullanılmıştır. Sonuç, petrol ihraç eden ve petrol ithal eden ülkelerde eşbütünleşmenin varlığını ortaya koymaktadır; bu nedenle, değişkenler arasında uzun dönemli bir ilişki olduğu sonucuna varıyoruz. Bu araştırma için kullanılan metodoloji, Pesaran ve diğerleri tarafından kurulan PMG-

ARDL modelidir. (1999), gerileme ve ilgilenilen değişkenler arasındaki kısa ve uzun vadeli bağlantıyı değerlendiren. Uzun dönem katsayılarının homojen olmasına izin verirken, kısa dönem katsayıları kesitler arasında farklılık gösterir. Tahminden istatistiksel olarak anlamlı bir ilişki gözlemlendi, böylece her iki ülke panelinde de EKC hipotezini destekleyen kanıtlar sağlandı. Bundan böyle, her iki ülke grubundaki EKC hipotezini karşılaştırdığımızda, önemli benzerliğin her iki ülke panelinin de EKC çerçevesini desteklemesi olduğu açıktır. Ek olarak, DYY ve fosil yakıt tüketimi, c02 emisyonları üzerinde aynı uzun vadeli olumlu etkilere sahiptir. Her iki ülke grubu arasındaki temel fark, petrol fiyatlarının ihracatçı ülkelerde CO2 emisyonlarını olumlu yönde etkilerken, petrol ithal eden ülkelerde çevresel bozulmayı olumsuz etkilemesidir. Bu nedenle çalışma, artan yeşil büyümenin, CO2 emisyonlarını azaltmanın ve çevre kalitesine katkıyı artıran sürdürülebilir kalkınmayı sağlamanın etkili bir yolu olduğunu önermektedir.

Anahtar kelimeler: Çevresel Kuznets eğrisi, Kişi Başına GSYİH, Karbon emisyonu

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CHAPTER I

Introduction:

The term "emissions" refers to releasing greenhouse gases and their precursors into the atmosphere over a particular geographical region and for a certain amount of time. For example, CO_2 emissions are created whenever fossil fuels, such as coal and oil, are burnt and cement production. According to Ali Muhammad et. al (2020), C02 emissions have been associated to continuously detrimental changes in natural systems throughout the previous century. These changes have occurred due to man's inventiveness, proactive institutions, and public policies. The capacity of man to adjust to new circumstances makes establishing this link conceivable. The dangers associated with climate change might originate from either physical, chemical, or biological pressures. It might vary, depending on where it is, how many people there are, and how strong they are. The term for them is "exposure route." These threats can coincide, making the impact on one's health much more severe. The effects of climate change may also exacerbate some risks, which may have long-term implications for health and resilience Khalid et al. (2020). On the agenda for the United Nations' development work, lowering pollution levels is a primary objective. As part of the concept of global responsibility, nations all over the globe are cooperating to reduce emissions via the implementation of stringent legislation and coordinated efforts. However, it looks as if all of these efforts have been in vain since the pollution level is higher in locations with less money. Notwithstanding these obstacles and consequences, reaching carbon neutrality is one of the objectives of the sustainable green environment movement, which aims to safeguard our world. This is a global issue since every nation aspires to join the developed world at the expense of its home country Maneejuk et al. (2020).

On the other hand, according to Kuznets' curve, this paper examines how socioeconomic variables influence the quality of life across a range of development levels in oil-exporting and importing nations undergoing significant environmental deterioration. The wasteful use of products and the destruction of the natural environment contribute to the precarious position in which our planet now finds itself. This has directly led to the situation escalating into a worldwide crisis, which has significant repercussions not only for the political structure and economics of the globe but also for the planet itself. This crisis has severe ramifications for the environment. Lau et al. (2019)

Background of the study

Carbon-rich plants and creatures existed millions of years ago under the surface of the Earth, but they all died, decayed, were crushed, and finally burnt. As a result, the planet's climate has shifted significantly, primarily due to rising greenhouse gas levels in the atmosphere. Using more fossil fuels will make the problem much more severe. Gases that exacerbate global warming are one example, according to Cruz et al. (2017). Increasing evidence suggests that human activities, such as burning fossil fuels, significantly contribute to global warming. For example, coal and natural gas include easily ignited or detonated elements. The Environmental Kuznets Curve (EKC) theory postulates an inverted U-shaped connection between GDP per capita and environmental quality measures like CO_2 emission concentrations, Zoundi, Z. (2017). Environmental economist Simon Kuznets developed this concept.

The destruction of the environment, which was initially considered primarily a problem faced by wealthy countries and a side consequence of industrial riches, has evolved into a challenge for the existence of emerging nations. It is a component of the downward cycle of interrelated ecological and economic degradation in which many of the world's most impoverished countries are bound. The World Commission on Environment and Development Report of the United Nations, titled "Our Common Future, "depicted a precise scenario of the circumstances in 1987 by noting that progress and environmental protection often go hand in hand. The environment is where we all spend most of our time, and development is the process by which we all work to improve that environment. Right now, we need a new period of robust economic development that is both socially and ecologically sustainable. The ability of humankind to ensure that advancement is either sustainable or capable of satisfying the requirements of the present without putting the ability of future generations to do the same in jeopardy is under its hands. This ability is known as the "sustainability" or "capability" standard.

Dasgupta and Maler (1995) found a close connection between enjoying civil and political rights and preserving the natural environment. As a result of this connection, they concluded that greater weight should be given to local institutions to achieve this goal. According to (Carson, Jeon, and McCubbin 1997), the environmental Kuznets curve disproves the claim that an increase in pollution is a natural consequence of an increase in wealth since an increase in wealth results in an increase in consumption, which increases pollution. Also, Plassmann and Khanna (2010) pointed out that economists have identified two primary causes for this "inverted U-shaped" link between pollution and income. These arguments are as follows: The first theory is predicated on the hypothesis that various phases of economic growth are accompanied by varying degrees of pollution. The second explanation, based on how people like to spend their money, states that as household income increases, people are less willing to accept increased pollution as the price of increased money. This theory derives from the finding that individuals are more likely to spend their money on activities that they have pleasure in doing. In addition, Barbier (1997) and Carson et al. (1997) have hypothesized that consumers might indicate their preferences for environmental quality via various factors, including technological advances, civil and political rights, trade policy, and environmental policy.

Two general categories of reasons potentially explain the decreased pollution in tandem with rising prosperity. First, developed nations utilize cleaner production methods that reduce pollution per output unit. There are two main reasons why technology may be less damaging to the environment: it was designed to be so, or more developed nations have a greater propensity to adopt cutting-edge equipment that is more energy efficient. The second is that rising living standards and environmental protection go hand in hand (Carson, Jeon, and McCubbin, 1997). The groundbreaking study that Grossman and Krueger (1991) conducted on the potential environmental implications of NAFTA was the impetus for the establishment of EKC. On the other hand, Shafik and Bandyopadhyay (1992) were the first researchers to conduct a significant inquiry to validate the EKC theory following its conception.

In addition, a report published in 1987 by the World Commission on Environment and Development says that economic growth is essential to either preserve or enhance the quality of the environment. More economic activity is always harmful to the environment. It is based on set beliefs about technology, preferences, and environmental investments, according to the World Bank's World Development Report (IBRD, 1982), which popularised the EKC theory. People's desire to engage in environmental betterment and their ability to do so will increase with rising income. The statements of others have bolstered the validity of this argument. In particular, Beckerman (1992) argued that while there is evidence that early phases of economic expansion often contribute to environmental deterioration, being wealthy is still the best and possibly only method for most nations to have a decent environment.

Recent studies (Dasgupta et al., 2002; Perman and Stern, 2003) call into question the EKC in general, as it has never been shown that the EKC applies to all pollutants or environmental repercussions. However, much of the research on EKC is weak from an economics perspective, despite Stern's (2003) claim that EKC is mostly a matter of experience. To add insult to injury, Perman and Stern (2003) claimed that the growing body of studies supporting EKC's veracity was flawed because its writers had ignored the statistical characteristics of the data they had used. Not enough testing was done, for example, to verify whether the model was acceptable; it did not take into account serial dependencies or random patterns in time series. As a result, "When we take into account such data and utilize the applicable methodologies, we discover that EKC does not exist," as stated by Perman and Stern (2003), is correct. The EKC theory contends that until a country's GDP per capita reaches a particular level, it cannot invest in environmental advancement or enhance living standards. This is because these industries often get more significant amounts of financing in nations with greater GDP per capita.

The expansion of the global economy is a direct outcome of governments' efforts to liberalize, privatize, and globalize their financial systems. As a result, the demand for water, forest land, and air has increased, placing pressure on the ecosystem. Due to their status as public commodities, environmental materials face intense competition in the market and are often unprotected. Various environmental conditions, both now and in the future, may cause problems that may last for a while. Economists argue that a sustainable economy may provide for the demands of the present without compromising those of the future. Therefore, every country pays a premium on expanding its GDP to track its economic development (GDP). To calculate a nation's GDP, economists add up all of its produced goods and services sold domestically in a given year, Shahbaz et al. (2018)

Statement of the problem

The climate crisis is leading to an increase in the frequency and severity of tropical storms and other forms of extreme weather, such as heatwaves, floods, and hurricanes. However, even if all emissions of greenhouse gases were to stop tomorrow, the global average temperature would still increase over the next several years. That is why it is critical that we immediately start minimizing carbon dioxide emissions, ramp up our investments in renewable energy sources, and phase out fossil fuel usage Mazzanti, & Zoboli (2010)**.** People have not been able to find solutions to these issues since they do not comprehend what factors contribute to their occurrence or how to correct them. The idea that the people who reside in this region could care less about the surrounding ecosystem and are in critical need of aid from the rest of the world is pervasive.

By reevaluating our growth strategy in light of present circumstances, we have a once-in-a-generation chance to positively impact the lives of people in this area and their environment. Traditional theories of economic growth do not seem to pay much attention to energy as a source of growth, and most macroeconomic models do not consider the constraints that come with energy. However, natural resources, especially oil, have been critical to economic growth. Since oil is thought to be a resource that will run out, this could slow down economic growth. However, there is increasing evidence that energy is crucial to expanding economies worldwide (Hall and Klitgaard, 2012; Ayres and Warr, 2010; Johnson et al., 2012).

Previous research on the link between oil prices and growth has been recorded by authors including Golub (1983), Darby (1982), and Hooker (1999). They found that growth in several oil-importing and -exporting nations is affected by price swings. For example, if oil prices rise, a country's GDP will fall because more money will be spent on imports, reducing the country's overall economic output. Likewise, when oil prices rise, the currency's value falls, and vice versa when prices drop. However, this is not the case for nations that export oil. Countries, especially oil-importing countries, need to understand the link between the price of oil and the performance of their economies as a whole in order to make policies that will prevent the likely effects of oil price shocks and fluctuations.

Understanding the country's massive energy consumption and substantial contribution to the energy sector is essential for creating policy for the energy sector in oil-exporting countries. Thus, there is room for research and advancement in the subject, and the present study aims to add to the industry's literature. It is critical to comprehend how the oil industry influences economic growth in many OPEC nations, which have varied and expanding energy profiles. Literature on how rising or falling oil prices affects national revenue is currently limited and mostly neglected worldwide. Hence, it is crucial to close the literature gap in these nations. Numerous oil-exporting countries have reaped enormous financial rewards from significant investments in the sector over the years (Yates, 2006; Ologunde et al., 2020).

Many oil-exporting nations benefit economically when worldwide oil prices increase sharply due to shocks that cause a spike in the cost of the commodity. Oil and other resource production should bring massive profits to resource-rich countries' economies. Therefore it seems to reason that these countries would benefit from them. On the other hand, massive profits from resource rents may not always lead to anticipated economic growth and development levels. Despite their natural and human resources wealth, many oil producers still struggle with widespread social and economic problems. These issues affect every part of oil exporting society, from extreme poverty to extreme inequality and severe unemployment.

Research questions:

In this thesis, the researchers address the following concerns:

1. Is the environmental Kuznets curve supported for Oil -exporting countries (OPEC)?
2. Is the environmental Kuznets curve supported for advanced Oil-importing countries?
3. How can economic development be done without negatively impacting the environment?

Research Hypothesis:

This information informs the research questions. As a consequence of the aims of our inquiry, we have developed the following hypothesis**:**

H0: There is no significant relationship between economic growth and environmental deterioration in Oil exporting and importing economies.

H1: A strong association exists between environmental degradation and economic expansion in oil-exporting and importing nations.

H0: There is no significant relationship between oil prices and environmental degradation in Oil-exporting and importing economies.

H1: A strong positive correlation exists between oil prices and environmental degradation in oil-exporting and importing nations.

H0: No increasing association exists between foreign direct investment and C02 emissions in oil-exporting and importing economies.

H1: A strong positive correlation exists between foreign direct investments and environmental degradation in oil-exporting and importing economies.

Significance of the study

In order to achieve high levels of economic growth and development, oil exporting nations have recently transitioned from an agriculture-based to an industrialized economy. However, most OPEC member states have significant hurdles in dealing with fast population growth and a "youth bulge" of unemployed young men and women. Its entire pace of economic modernization has lagged behind its efficient petroleum industry. Despite past attempts at counter-cyclical budgeting, the "collapse" in oil prices has had a significant effect. They provide effective governance and financial issues, and their effectiveness is questionable. It has attempted to diversify its economy and achieved significant growth in tourism and as a financial hub. However, it is still a rentier economy that relies excessively on petroleum exports and foreign labor. The ambition of the government to diversify the economy away from oil is admirable. However, diversification necessitates accelerating structural changes to expand the private sector, shift to a knowledge-based economy, and increase export industries. These Improvements might include enhancing some aspects of the business climate, creating suitable structures for public-private partnerships, easing limits on foreign ownership, boosting competition, and supporting innovation. The more developed economies move their industrial hubs to the area and engage in environmentally damaging practices because of the region's lax environmental controls and policies. This is because locals lack access to the capital they need to launch successful businesses. Increased environmental deterioration in emerging countries results from the advanced economies' ability to outsource their industrial facilities to those countries. Therefore, it is of the utmost importance to ascertain whether or not improvements in environmental quality can be realized in the aftermath of substantial advances in economic growth, as predicted by the EKC hypothesis. Moreover, roughly half of the OPEC states have a critical structural economic dependence on petroleum revenues. Currently, only three OPEC members qualify as "failed states" (Iraq, Libya, and Venezuela), with Venezuela's failure almost entirely attributable to its reliance on petroleum revenues. Angola, Ecuador, and Nigeria are just a few of the other OPEC countries that have suffered greatly due to their governments' mismanagement and excessive reliance on oil money. Whether or not oil prices fluctuate often, the funds are typically used to purchase time while the underlying problem worsens. While external threats and actions have certainly hurt certain OPEC countries, there is no justification for the poor leadership in those countries. Most of these rescue operations were necessary due to their mistakes and carelessness. Better politics, governance, and economic development policies would have safeguarded them just as effectively, if not more so, in almost every instance. Hence, most members of OPEC are worried about greenhouse gas emissions (such as C02) because of the possibility that their production would rise due to economic growth. However, they are pollutants, something that every economy, not just those in oil-exporting nations, is working hard to reduce.

Objective of the study

The study aims to explore and compare the validation of the environmental Kuznets curve in oil-exporting and advanced oil-importing economies. Consequently, this research will evaluate and investigate the connection between growing economies and environmental deterioration, particularly concerning carbon emissions. Carbon emission was used as a proxy for environmental degradation. The inverted "U"-shaped relationship between per capita income and environmental quality is said to be supported by the evidence presented by the EKC hypothesis. Also, a significant rise in oil prices, FDI, and fossil fuel consumption are critical confounding variables in this study's effort to examine the connection between economic growth and environmental damage. However, when looking at changes in forest covering, the research revealed that the link between growing income and higher carbon emissions was less evident and resembled an inverted U. Therefore, examining the effects of ecological deterioration at different stages of development on the quality of the environment and economy in various oil importing and OPEC nations, as well as making pertinent comparisons across these nations, is also an essential aspect of the research process.

Research contribution:

Attempts have been made to overcome the limitations of previous contributions by applying new datasets, functional forms, and more complex econometric techniques, but the results have been uneven. For example, some scholars have suggested a graph as an inverted U, but others have rejected this conventional paradigm. To the authors' knowledge, this evaluation is the first to consider this nexus in a comparative sense for both developed oil-importing and net oil-exporting countries. For two reasons, we consider this choice. First, crude oil is the world's most traded commodity and the most prominent in the non-renewable energy market. Secondly, the choice of oil exporters and advanced oil importers can be related to the flow of crude oil and its refined products between these two sub-divisions. In addition, it employs the second-generation panel unit root and the PMG-ARDL estimation method in comparing twelve oil-exporting and oil-importing nations with high GDP per capita of these nations' wealth and environmental degradation. It is thus essential to determine and compare the degree of contribution of the energy consumption of the net givers (net oil-exporting countries) and the net receivers (net oil-importing countries) of crude oil. Therefore, this research adds to existing literature and recommendations, necessitating the need to maintain future energy security and achieve the environmental policy objectives of providing a secure environment.

CHAPTER II

Introduction to the Literature Review

Environmental deterioration has long been a concern for people worldwide; in recent decades, its importance has only increased. The natural environment has been shown to suffer from different types of industrialization in developed nations; nonetheless, despite the damage that economic growth has caused. The rate of economic progress and the desire for it have not slowed down Ozturk et al Anser M. K. (2019). Therefore, it is possible to study the relevant literature to get a more in-depth understanding of the previous research that has been carried out on the topic. Before choosing a subject for an academic inquiry, it is crucial to examine the relevant literature thoroughly. Regarding the study's topic, books, journals, newspapers, and other information sources may be found in several places, including but not limited to bookstores, libraries, and online, among other places. This section analyzes how a rising economy impacts the natural environment at various stages of development. Several research inquiries have been conducted to get a greater understanding of this subject and the related literature. The relationship between the worsening of the environment and the economy's expansion has been the subject of several studies. Environmental sustainability has made progress because of the work of many academics and business professionals who have voluntarily given their time, energy, and expertise to the cause. In this chapter, the research's conclusions are explained, backed up by several academic works and subjects related to the topic. The research being conducted for this chapter is explicitly looking for theoretical and empirical studies on the topic under consideration. Both theoretical and empirical reviews are included in this area of research endeavor. Further enhancing the paper's contribution to the body of literature and its understanding of the subject at hand is the suitable integration of pertinent ideas on EKC, Ozturk & Al-Mulali (2015).

Sectoral effects of environmental degradation:

Energy Sector

Energy is essential to the economic and social growth of nations. Those in charge of energy and the nation's administration must provide this fundamental need of the populace in an uninterrupted, dependable, timely, economical, and clean manner. This requirement applies equally to our manufacturers and artisans as it does to our domestic customers. In a globalizing world, the constant, dependable, and inexpensive supply of energy, the most fundamental and predominant factor in the pricing of final goods in the country's industry, is a requirement.

Worldwide, annual energy consumption increased in 2019, reaching an all-time high of 583.90 EJ. About 40% of worldwide energy output meets global electricity demand. Emerging nations produce most of the world's carbon dioxide (CO_2) emissions (Statistical review 2020). Since the discovery of petroleum, the world's carbon emissions from burning fossil fuels have skyrocketed, reaching dangerous levels. Consequently, higher atmospheric gas levels significantly affect the natural world and human health. Furthermore, several factors, including rising sea levels, melting glaciers and polar ice caps, and growing human mortality from insect-borne illnesses of humans and agriculture, all contribute to this (Nassar et al., 2016). CO_2 also regulates many ecosystems due to its role as the principal driver of global warming (Nassar et al., 2018).

CO_2 emissions sources in the Energy Sector

Gas flaring processes

Gas flaring eliminates grouse populations during oil production, hydrocarbon processing facilities, and refineries (Emam, 2015). In addition, flares are meant to ensure the effective combustion of gases through oxidation processes to create fewer hazardous emissions, as opposed to releasing the gases directly into the atmosphere (Soltanieha et al., 2016). Sadly, this process is responsible for more than 350 million tonnes of CO2 emissions annually and methane and black carbon emissions that have serious adverse effects (2018).

Heating processes and electrical energy generation

Heating occurs in most industrial processes, including crude oil extraction, refining, and power production (Ahwide & Aldali, 2013). Consequently, the infrastructure category data comprises chimney sample records for all heating-related facilities. Refineries use a heating process to decompose and separate the hydrocarbons in crude oil into fuel products such as LPG, Petroleum, Diesel, HFO, unprocessed Naphtha, and several other non-fuel fuel compounds.

However, numerous studies have demonstrated a positive and statistically significant correlation between carbon emissions and energy use (Soytas et al., 2007; Halicioglu, 2009; Dhakal, 2009; Cho et al., 2009). According to the IPCC's Fourth Assessment Report (2007), the principal cause of Greenhouse Gas intensity is carbon release from the usage of fossil fuels. In addition, the result shows that energy consumption in the industrial sector accounts for 51% of total energy consumption worldwide. Chang and Lin (1999) researched the variables influencing carbon emissions in Taiwan by examining 34 distinct sectors to provide a comprehensive view of industrial, environmental, and economic performance. Using Grey Relation Analysis, they observed that industrial output had the strongest association with carbon emissions, followed by power use. Zhao et al. (2010) utilized the Log-Mean Divisia Index approach to examine the variables that contributed to c02 emissions in Shanghai between 1996 and 2007. It was discovered that industrial activity was the principal driver driving up carbon emissions levels.

Transportation Sector:

The transportation industry is a growing driver of China's carbon emissions. The results indicate that energy efficiency's inhibitory effect on the transportation industry's carbon emissions increases as energy efficiency improves. In addition, the data indicate that urbanization reduces carbon emissions from the transportation sector, albeit to a lesser extent than energy efficiency. The effect of urbanization on carbon emissions ranges from -0.658 to -0.743. Nevertheless, this happens as urbanization levels increase. This is because the contribution of income growth, private automobile ownership, and cargo turnover to carbon emissions are nonlinear.

Carbon emissions from the transportation sector were 24% of total global carbon emissions in 2019, according to the International Energy Agency (IEA, 2021). This made the transportation sector the world's second-largest contributor to emissions. As a result, we must acknowledge the transportation sector's contribution to carbon emissions. For example, in 2018, China's transport industry accounted for 18% of total carbon emissions, making it one of the country's three main contributors to carbon emissions (IEA, 2021). The transportation industry has significantly contributed to China's carbon dioxide emissions. In addition, between 2005 and 2019, the income of the transportation industry, the number of private automobiles, and the amount of cargo turnover expanded dramatically. Consequently, the transportation industry's income rose from 1,099.94 billion RMB to 4,280.05 billion RMB. The number of privately owned automobiles rose from 18,439,800 to 22,465,900. The freight turnover grew from 8,025.8 to 1,993.94 billion ton-kilometers. Increases in income, private vehicle ownership, and cargo turnover have been shown to substantially impact carbon emissions in the transportation industry (Anwar et al., 2021; Mishalani, Goel, Westra, & Landgraf, 2014; Xu & Lin, 2015).

The world community is closely monitoring carbon dioxide and other greenhouse gases due to the danger of global climate change. According to research (Pengjun Zhao et al., 2022), the entire transportation sector and carbon dioxide emissions efficiency (TSCDEE) of the surveyed Chinese provinces was 0.618, suggesting that the majority of areas need further development. China's developed coastline areas include the provinces with the highest TSCDEE values.

This research demonstrates that transportation structure, traffic infrastructure level, and technology advancement substantially benefit TSCDEE. However, urbanization and urban population density have substantial adverse effects. The results are expected to influence the sustainable growth of global transportation significantly. China energy statistics yearbook (CESY) (2017) reports a 639 percent increase in the transportation sector's overall energy consumption from 1995 to 2017.This is the sector with the most rapid growth, and its energy consumption is connected to considerable increases in CO_2 emissions. In 2016, China's total traffic CO_2 emissions reached 851.2 million metric tonnes, accounting for 10.8% of global traffic CO_2 emissions and ranking second globally behind the United States. (International Energy Agency (IEA), 2018 Highlights of CO_2 Emissions from Fuel Combustion) (2019).

Transportation contributes to a large portion of Jakarta's CO concentration, according to research that analyzed the distribution of NO_2, SO_2, CO, and O_3 in the city using WRF-CHEM (Darmanto & Sofyan, 2012). The concentration of pollutants from this sector is affected by disparities in transportation, infrastructure, and motor vehicle ownership. Private automobiles have a disproportionate role in the expansion of urban transportation systems. As the number of cars on the road increases by 10% annually, the number of lanes can only increase by 1%. As a result, congestion, emissions, accidents, and substandard public transit are all outcomes (Mochtar & Hino, 2006).

Agriculture sector

Agriculture is the foundation of any nation's economic growth, food security, and technological advancement. Agriculture also provides millions of people worldwide with a steady income and a wide variety of food products. All nations rely on agriculture for economic growth, agro-based industries, and food production. Moreover, agriculture provides a daily source of income for millions of people in all nations. Finally, it nourishes us all with a variety of agricultural products. Thus, agricultural products largely contribute to environmental deterioration and CO_2 emissions (Ferreira et al., 2021; Khan, 2020: Patel et al., 2021). However, industrialization generated by economic progress displaces the traditional sector as agricultural and industrial resources are redistributed (Mahmood et al., 2019a, 2019b; Matsuyama, 1992). An investigation by (Alhassan et al., 2022) examines the impact of carbon dioxide emissions on agricultural growth in Ghana at both the national and regional levels. The findings indicate that aggregate carbon emissions negatively impact the country's agricultural growth, while financial development, labor, and capital boost agricultural development. In addition to their findings, they argue that industrial growth and emissions from the transport sector, industrial sector, and other sectors hurt the development of agriculture in Ghana. Despite the widespread adoption of these structural changes, many people worry about agriculture's potential excellent or negative impact on the environment and society (Khan, 2020; Mahmood et al., 2019a, 2019b; Sejian et al., 2019). (2011). For instance, (Khan, 2020) argues that we must recognize the adverse effects of agricultural inputs because of the potential for productive activities like fuel combustion and deforestation to worsen the environment. Over 70 billion cattle are grown yearly for human use, making livestock farming in the agricultural sector a potential contributor to environmental degradation. Over the last 20 years, fermentation has accounted for 40% of Pollutant emissions from ruminants (including cattle, sheep, goats, and pigs). The literature on this topic is extensive (Arcipowska et al., 2019; Bakare et al., 2020; Bonnin et al., 2021; Khan, 2020; Kong & Khan, 2019; Machado et al., 2017). Other significant contributors to agricultural emissions are crop leftovers (39%), manure left on pasture (15%), rice cultivation (10%), synthetic fertilizers (12%), manure management (17%), and other sources (cultivating organic soils (7%) and burning savanna (7%)). (Khan, 2020). The agriculture sector is responsible for 24 percent of the world's greenhouse gas emissions (GHGs), making it the single most significant contributor to global warming (Fuinhas et al., 2021). In addition, the 'carbon opportunity cost' of food production to meet food demand affects CO2 emissions, as stated by Hayek et al. (2021). According to Our World in Data (2022), "opportunity cost" refers to the potential profit lost when one option is selected over another. For example, farmers would instead increase yields to meet rising food demands brought on by population expansion and turn a profit than invest in restoring ecosystems (Hayek et al., 2021). Indeed, the same authors argue that restoring terrestrial ecosystems might lead to the emission-free removal of carbon dioxide.

The 'potential' or 'native' vegetation and food production in a particular area may significantly impact the associated costs. Several different reasons cause carbon emissions from farming. From 1995 to 2010, Tian et al. (2014) used data from 23 sources to estimate China's agricultural carbon emissions. They examined the CO2 emission coefficients from the five most important agricultural industries, including fertilizers, insecticides, diesel oil, plastic sheeting, and irrigation. Studies have shown that agricultural carbon emissions increased by a whopping 113.16% due to the economic component. Quantile regression has also been used in comparable studies, such as Lin and Xu's (2018) investigation of the variables contributing to China's agricultural sector's CO2 emissions. They concluded that while considering ways to reduce CO2 emissions in China's agricultural sector, it is essential to consider the different implications of the many elements at play. Finally, Chen et al. (2020) have estimated panel data models to investigate the elements contributing to China's agricultural carbon emissions. According to the findings, rising GDP per capita is the critical factor that hastening agricultural carbon emissions expansion. The studies by Gunnar Hansen (2019), Huang et al. (2019), Matysek et al. (2019), Rehman et al. (2019), and Nwaka et al. (2019) are also relevant (2020).

Construction Sector

The building industry is the second greatest carbon dioxide emitter, accounting for around 33% of worldwide co2 emissions (D. Urge-Vorsatz, A. Novikova, 2008). (D. Urge-Vorsatz, A. Novikova, 2008). The building sector utilizes about half of all energy used in European Union member countries. Over their cycles, nearly half of all CO2 emissions are emitted by buildings (D.E. Pataki et al., 2009). However, the construction industry has enormous energy-saving potential compared to other industries at a comparatively modest expense. According to the latest IPCC report, the building industry has tremendous potential for reducing CO2 emissions. The Intergovernmental Panel on Climate Change (2007) predicts a yearly decline of 6 billion tonnes CO2 equivalents by 2030. Research by (Lizhen Huang et al., 2018) analyses and compares the amount of CO2 emission produced by building activities internationally using the international environmental input-output table 2009. It evaluates the CO2 emission of the construction industry in 40 nations, including 26 forms of energy and non-energy consumption.

Based on the findings, the worldwide construction industry was responsible for 23% of all CO2 emissions in the world in 2009. This equates to 5.7 billion tonnes of CO2 emissions. The results also show that about 94% of the total CO2 emission from the worldwide construction industry results from indirect emissions. Direct CO2 emissions in the worldwide construction industry come primarily from four energy sources: gasoline, diesel, other petroleum products, and light fuel oil. Hard coal, natural gas, and non-energy consumption account for the bulk of indirect CO2 emissions. Thirdly, over sixty percent of all carbon dioxide emissions from the world's building industry are attributable to developing countries. Therefore, objectively analyzing urbanization's impact on CO2 emissions from the construction industry (Shengxi Zhang et al., 2021). They used panel data from 25 provinces in China (2008-2017). The consequences of urbanization on CO2 emissions from the building sector demonstrated geographical variance. In particular, a consistent downward trend was seen from highly urbanized to urban and under-urbanized areas. Also, their study finding implies that the effect of CO_2 emissions from the building sector grows with urbanization. This is because the construction sector supplies the material inputs for urbanization and is considered the largest source of CO_2 emissions during construction (Meng, 2009). Approximately 1% of China's population moves from the countryside to the city every year, increasing the need for housing in metropolitan areas (Wang et al., 2020). As a result, residential construction in China has surpassed 4 billion m^2 yearly since 2013, roughly eight times that in the United States (Chang et al., 2020). Additionally, the newly moved population stimulates the development of non-residential structures (such as offices, restaurants, educational institutions, and hospitals). Moreover, municipal infrastructure (such as roads and water systems) contributes to an increase in CO_2 emissions (Huang et al., 2018). Q Shi, J Chen, and L Shen (2017) used the structural decomposition analysis method and data from the World Input-Output Database to investigate the factors contributing to changes in carbon emissions in China's construction industry. The findings demonstrate that the energy intensity impact mitigated the most noticeable portion (108%) of the rise in building carbon emissions during the whole period. Increases in carbon emissions between 1995 and 2009 were caused by two main factors: changes in production structure (49%) and the influence of the final demand ratio (35%). From 2005 to 2012, Z Zhang and Bo Wang analyzed the building industry in China from the perspective of life-cycle CO_2 emissions. According to their research findings, CO_2 emissions in China's building industry climbed somewhat between 2005 and 2010 and surged substantially after that. Manufacturing construction materials accounts for 73% of total CO_2 emissions, while building operation accounts for 24%. Most of the CO_2 released during the production of construction materials comes from burning fossil fuels to create steel and cement (87%). At this point in the process, 83% of all CO_2 emissions come from the transportation of construction materials. At 49%, the CO_2 emissions from the building's central heating system are the most significant contributor to its overall CO_2 emissions throughout its operational phase. Most of the carbon dioxide (CO_2) released during the disposal phase of construction and demolition (C&D) debris comes from demolition work.

Place of OPEC in world economy.

Organization of Petroleum Exporting Countries (OPEC), is an association of 15 oil-producing nations. OPEC is a permanent international organization headquartered in Austria's capital, Vienna. The organization has influenced over 78% of the total amount of oil exported globally. Because these OPEC countries are responsible for producing a substantial proportion of oil supply around the world, they can influence the sale price of a barrel. They do this by maintaining tight control over the daily number of barrels placed on the market. When they wish to boost or reduce output, it is a decision that OPEC makes.

Why OPEC was formed?

In 1960, a group of nations with most of the world's oil reserves came together to create OPEC. Their goal was to keep the price of oil from falling. As soon as one nation lowers its oil price, other nations will follow suit to remain competitive on the worldwide market. This would result in an acceleration of the process through which oil reserves are depleted. A price range of $70 to $80 per barrel has been established as the objective for oil prices. There will be sufficient oil to satisfy the demand for the next 113 years at this price. If prices fall below such levels, OPEC members have agreed to limit their supply, which would cause prices to rise. The USA is the highest user of oil than any other nation in the world, averaging 18.84 million barrels per day, or about 20% of the global total. The Republic of China is the next, using around 11% of the global oil supply. Followed by Japan accounting for 5% of the global total oil supply. The Singapore benchmark price controls the price of gasoline at service stations. The price of crude oil influences this price, but solely for Asia-Pacific. Shipping charges and government taxes are added to the fuel price in Singapore, bringing it to 95% of the wholesale price. Even though the price of oil has decreased to 12-year lows in recent years, this reduction was not ultimately passed on to consumers. The refiners that transform crude oil into gasoline benefit from the decreased oil costs since they do not share the savings with customers.

How OPEC Affects the Economy

Oil-producing countries (OPEC) must maintain price stability in the international oil market. Because of this, it has an impact on petrol prices all over the world. Furthermore, oil is necessary for the manufacturing sector to convert inputs into outputs. Therefore, price increases are necessary to cover manufacturing and delivery costs. When the price of materials or labor goes up, the final product prices go up for consumers. Because oil is used as a source of energy for homes, the increase in the price of oil has a substantial impact on the cost of utilities for consumers. Energy expenditures account for approximately 5% of a typical family's weekly gross income, ranging from 3% for affluent families to over 10% for low-income ones. The rising cost of manufacturing (ultimately borne by consumers) and the rising cost of utilities for consumers might all contribute to a general rise in the cost of living. Thus, it causes inflation to rise and slows economic expansion. Companies decrease their profit margins due to the high oil price. Increases in oil prices will significantly impact businesses due to the widespread use of oil in production and transportation processes. Suppose businesses cannot pass on these higher costs to customers while maintaining their position as market competitors. In that case, they will see a decrease in their profits. For example, Consumers will spend less on luxury products like a new sofa or a new TV if the cost of utilities rises due to increased oil prices. Oil company share prices might increase during periods of high oil prices. This is because oil corporations can get supply contracts at higher rates since the cost of extracting oil is unaffected by price increases. In situations of increased oil prices, this might result in better profit margins for these businesses. Lesser cost manufacturers might join the market when prices increase. This is the balancing act between the OPEC nations and the US shale producers. US shale producers open the faucets when the price increases, boosting supply and bringing down the price of oil.

Drivers of OPEC Decisions

The Board of Governors executes the operations of OPEC, including carrying out the decisions made by the Conference and creating an annual budget. OPEC's mission is to "coordinate and unify the petroleum policies of Member Countries and determine the best means of safeguarding their Individual and Collective Interests. This means ensuring the stabilization of prices in international oil markets, eliminating harmful and unnecessary fluctuations; and providing a steady income to the producing Countries, an efficient, economic, and regular supply of Petroleum." Nakov and Pescatori's (2010) stylized equilibrium framework of the oil market shows a dominant producer and a competitive fringe. From this model, the factors that affect the dominant oil producer's production decision can be found. In this model, the price of oil is a markup over the marginal cost of oil production, which changes over time because of changes in technology in the oil extraction sector. The relationship between the ideal markup and the (absolute) price elasticity of the demand for OPEC oil is inverse. The dominant oil producer always selects a spot on its effective demand curve that is in the elastic region. If the number of people who need oil goes up, the price, markup, and production will all go up. Instead, a rise in production outside of OPEC would weaken OPEC's grip on the market, making it less able to raise prices (as well as oil prices). Moreover, to outline the possible elements that should explain, in part, OPEC's choices, we might go to Nakov and Pescatori (2010). The first group of potential variables aims to capture the state of the oil market now, the future of oil demand, and the predicted uncertainty around the future of oil demand. The risk of a production reduction increases as the outlook becomes gloomier and the level of uncertainty rises. The second group of potential candidates is associated with OPEC's position in the industry. The smaller OPEC's percentage of global production, the less likely they are to cut down on output to maintain its market position. Lastly, anecdotally speaking, OPEC output cutbacks are often a reaction to falling oil prices. Oil price may be able to convey essential information on the existing and predicted oil market tightness that is adequate to influence OPEC's members toward a decision. However, some of the factors may not be accessible in real-time.

Energy price.

The significance of prices in the economical production and consumption process is multifaceted. For the most part, prices act as signals for both buyers and sellers. When prices fluctuate in the market, they incentivize buyers and sellers to change the supply and demand of products and services. If its price rises sharply, customers may be prompted to buy less of a scarce commodity or service or even to search elsewhere. Increases in the cost of living might also make it more difficult for people to escape poverty. For manufacturers, a rise in pricing means more sales and more production. The overall price level controls the supply and demand for a product or service. When prices rise because demand exceeds supply, manufacturers, and suppliers get a clear signal of what customers are willing to pay for a product.

Energy costs tend to go down regardless of other variables. Therefore, when energy prices go up, customers tend to reduce their use of energy goods. Conversely, prices decline when people buy more energy products (Kongkuah et al., 2021a). As a result, we will have to cut down on our energy use, which will likely mean higher prices for related commodities and slower growth in energy demand. Since the market-oriented reform of pricing, Pizer and Sexton (2019) argue, energy costs have an ever-increasing effect on energy usage. Additionally, prices impact revenue and profit. Price multiplied by the amount sold yields total revenues for producers, which generate income when adjusted for production costs and taxes. For customers, prices define affordability, and quantity bought dictates the amount of discretionary cash available for other pursuits. Producers or sellers choose the price of delivering the fuel, with the variation between the cost of production and the selling price representing profit. The sellers evaluate the market and the prices buyers are willing to pay, then change the supply according to the demand.

World Economy and Oil Prices

Since oil impacts both socio-economic and political processes, it is becoming more critical to examine the global reliance of production and consumption, or supply and demand, on the volatility of oil prices. From 1989 to 2015, global oil consumption and supply both increased. However, this has not reflected significant changes in oil prices. So, the recent changes in oil prices can be broken down into three phases, each with its own set of stages. The first period is from 1989 to 1992, 1992 to 1996, and 1996 to 2000. The second period is from 2000 to 2003, 2003 to 2008, 2008 to 2014, and the third are from 2014 to 2016. The Gulf War, which happened from 1989 to 1992, greatly affected the price changes. The drop in oil prices from 1992 to 1996 was due to political unrest and the realignment of political power worldwide. From 1996–2000, the drop in oil prices was linked to the economic downturn in both Russia and East Asian countries. For example, Barings, England Bank, was sold for $1, the rouble fell twice in Russia, and the stock market stopped. Even though the world market got better in 2000, which made oil prices go up, they went down in the following years. However, the primary reason for fluctuating oil prices, with a high in 2008 and a subsequent decline, has been the recession in the mortgage and stock markets, which was a significant aspect of the 2008-2014 economic crisis. Also, significant events in world politics have happened in the past few years, like the crises in Ukraine and Syria. In 2016 and 2017, it changed between 60 and 65 dollars per barrel. By looking at how the price of oil changed in the first quarter, we can see that political factors are not the only cause of price changes. Economic growth is also a factor because it creates demand for oil in the real world, which could lead to a steady rise in GDP during this time. Changes in the oil market, especially in oil prices, show that it is no longer a tangible commodity but a financial portfolio. The rise in oil market futures trading since 2000 may contribute to this. Even though the world's GDP, industrial production, oil demand, and oil supply all move in sync, there is no logical or economic link between oil prices. Economic and mathematical models that consider the interdependencies between global GDP, oil demand and supply, and oil prices allow us to conclude. According to studies, the price of oil skyrocketed by 57% between 1989 and 2000 despite a 19-20% increase in both production and consumption. These measurements landed between 37% and 38% and 610%. Do not even bother weighing in on this. The highest oil prices, the Middle East conflict, and the likelihood of further reductions in oil prices are the primary reasons we zeroed in on 2011. Models showing the interconnectedness of global GDP, global industrial output, and global oil consumption and production between 1989 and 2015 support the above claims.

Theoretical Review:

Overview of the Environmental Kuznets curve (EKC)

The environmental Kuznets curve (EKC) hypothesis is well-established in energy and environmental economics literature. It was named after Simon Kuznets, who proposed that income disparity first increases and subsequently diminishes as economic development advances. Simon Kuznets was born in Pinsk, part of the Russian Empire at the time, on April 30, 1901. In 1971, he gains global recognition in economics for his empirically founded clarification of economic growth that has led to a new profound knowledge of the economic and social structure. Process of becoming. Carbon dioxide, sulfur, and nitrogen oxide emissions are directly proportional to energy use. The EKC exemplifies the relationships between energy use, economic development, and the environment. For example, Grossman and Krueger (1991) discovered that the link between economic development and environmental deterioration resembled the results of Simon Kuznets (1955), and they dubbed this correlation the EKC hypothesis. Since then, much research on different situations and contaminants has been published, either supporting or disproving this idea. The theory posits that while environmental degradation and pollution rise in tandem with economic development, once per capita income reaches a certain threshold (which will vary across indicators), the trend reverses. Henceforth, the Environmental Kuznets Curve (EKC) is a way to look at how economies handle environmental problems. It says there is an inverted U-shaped relationship between pollution and economic development. In the early stages of development, the environment gets worse as per capita income goes up, but as per capita income goes up, even more, the environment gets better. Economic growth ultimately results in better environmental conditions for the world's wealthiest people. This means the environmental effect index is inversely proportional to per capita income. On the other hand, Dasgupta and others (2002) say that many people have criticized the traditional EKC. Critics with an opposing view say that the curve will rise to a horizontal line showing the highest level of pollution that already exists because globalization encourages a "race to the bottom" in environmental standards (the scenario of Race to the Bottom). At the same time, the critics who have a favorable view say that the level of the curve will drop and move to the left as grocers (the scenario of Revised EKC). However, much research has not backed up these different schools of thought.

What is EKC?

The environmental patterns have been named the Environmental Kuznets Curve (EKC) as a result of the similarities between them and the link that Kuznets assumed to exist between the amount of inequality and per capita income (1955). during his presidential speech, which was given under the theme "Economic Growth and Income Inequality." He postulated a link between income and inequality in the form of an inverted U, suggesting that as per capita income rises, so does inequality until a certain threshold known as "the income turning point," beyond which inequality begins to decline while per capita income continues to rise. There was nothing like this hypothesis that Grossman and Kruger's (1991) empirical investigation uncovered. They looked into the EKC hypothesis and found that economic growth correlates with a U-shaped decline in environmental quality. The EKC hypothesis functions on the premise of an inverted U-shaped link between economic activity (usually determined by per capita income) and environmental quality (measured by environmental pointers like per capita CO_2 emissions). Also, the EKC hypothesis takes it for granted that this is a negative correlation. In other words, during the first period of economic development, environmental damage would worsen as per capita income rose but then improve when the point for per capita income was reached. Therefore, proponents of the EKC hypothesis argue that there is a transition from focusing on economic development to protecting the environment as nations develop and become more prosperous. These phenomena may be modeled using Kuznet's (EKC) environmental curve. Until a certain point, environmental deterioration rises with rising per capita income. However, beyond that threshold, environmental quality improves even as incomes increase. As a result, the EKC hypothesis demonstrates that as a nation's industry grows, environmental degradation rises proportionally and then begins to decline when a particular level of economic development is reached. It implies that ecological harm is inevitable during the first period of economic growth. Panyotou (2003) proposed several explanations for the downturn of pollution patterns. First, the pollution tipping point results from rich and progressive cultures putting a more excellent value on a cleaner environment and using institutional and non-institutional measures to attain this objective. In the beginning phases of a country's industrialization, primitive, inefficient, polluting businesses join the industrial arena, increasing pollution. However, when industrialization reaches more sophisticated levels, pollution will cease to increase until it reaches a suitable degree of development. Instead, it will initiate a U-turn. Moreover, the rise of the service sector will result in a further decline in pollution.

Origin of the environmental Kuznets curve.

The first explanation proposes that environment's demand is elastic to income. With rising incomes, people are increasingly concerned with their quality of life, want to protect the environment, and are ready to use healthier items. Consequently, the government will enforce tighter environmental protection laws, which will gradually improve the overall quality of the environment. Many studies, such as Carson R. et al.'s 1997 study on EKC, highlight the importance of income elasticity of environmental demand as a significant element in reducing the amount of environmental pollution. Scale, technology, and the organizational structure of economies are essential factors, which brings us to the second justification. Grossman and Krueger (1995) divide the environmental effects of economic expansion into three categories. First, we have the scaling impact. Rapid economic expansion harms ecological health by increasing resource and energy consumption and pollutant generation. The second consequence is structural, reflecting the impact of structural changes brought about by advancing economies on their surrounding natural environments. Finally, the technical effect is the third. As living standards rise and technological innovation spreads, polluting older production methods will give way to cleaner alternatives that ultimately benefit the environment. Therefore, EKC can be viewed as a curve where the early stages are dominated by the negative scale effect, then the early stages are dominated by the positive structural and technical influence, and ultimately the structural and technical influence will outweigh the scale effect. In this manner, environmental pollution worsens first, but then advances as income increases. The third element is derived from international commerce, or it is a significant component in generating EKC. Free trade has two effects on the environment. One is an environmental improvement due to technological advancements, and the other is an increase in environmental degradation due to the growth of the global economy. A model of the effects of free trade on the environment was developed by Antweiler et al. in 1998. It separates the effects of global commerce on the environment from economic size, method, and structure. Empirical support for this model was found in measurements of SO2 collected by the Global Environmental Supervising System. These measurements confirmed that, while international trade has a small structural effect on the environment, the combined effects of technological advancement and economic scale have a negative net effect. However, these empirical findings lead researchers to conclude that free trade benefits the planet. However, Chai J.'s 2002 empirical analysis, "Trade and environment," looked at the effects of free trade on the environment using data from the Chinese manufacturing industry. The research showed that China's massive increase in exports had a higher effect on the economy than the effect of technology, which means that free trade is unsuitable for improving the environment. So in this way, free trade hurts the environment in the short term, but in the long term, it helps the environment. Foreign direct investment (FDI) has double environmental effects; hence it is the fourth factor mentioned by Smarzynska B. and Wei S. (2001). While reducing environmental regulations to entice foreign direct investment (FDI) would make developing nations pollute havens, most developing countries get technology via FDI from industrialized countries, which helps enhance environmental quality.

A Theoretical Framework: Economic Development

The first section of the framework describes the two most well-known theories of economic growth: the neoclassical and endogenous growth models. It then discusses some critical consequences of growth theory when applied to the industrial use of an environmental resource. Finally, there is an emphasis on the impact of discounting and how the form of landscape pollution influences the optimal solution. From this, we may draw some inferences regarding the best forms of environmental taxation. There is talk about the theory of resource scarcity and what it could mean, as well as what the growth theory means for long-term economic growth. Also, in the first two sections below, we talk about the standard theory of economic growth, which does not include natural resources. This helps set the stage for talking about growth models that include natural resources in the following sections. In this study, we will use ideas that are thought to be at the heart of how people's actions affect the environment. Institutional and political economics are similar to neoclassical and ecological economics in some ways.

Mainstream or Neoclassical economics.

In neoclassical growth, proposed by Solow (1995) the economy must approach a stationary state devoid of net (new) investment. Growth is a transitory period in which a nation approaches its steady state. A developing economy with a modest capital stock per worker guaranteed rapid development as it builds its capital stock. However, if the rate of savings continues unchanged, all economies will ultimately achieve a state of zero growth equilibrium. No nation can develop forever just by collecting money. If the savings rate rises, there will be growth up to the point where a new equilibrium is established; however, the greater the savings level, the lower the population's living level. In accordance with this fundamental neoclassical growth hypothesis, technical advancement is the sole driver of continued economic expansion. Intuitively, advances in technical knowledge enhance the interest rate on capital, so countering the declining yields on capital acts as a restraint on economic expansion. The first models fail to expatiate how technology gets better over time. They are expected to occur independently, therefore, these models possess exogenous technological change. Modern models try to explain technological advancement to the growth model as the result of decisions made by companies and individuals. As knowledge in modern science grows, the practical link between productive inputs and outputs changes. Consequently, it is possible to create output in greater quantity or better quality with the same number of inputs. In the model under consideration, technical advancement raises the output function, increasing the equilibrium per capita stock and production levels. On the surface, increases in the degree of technical knowledge seem to increase the interest on capital, so offsetting the declining returns on capital that would then impede growth. The neoclassical growth model's main conclusion is that economic performance tends to improve over time. When all countries have the same access to new technology, their growth rates should be the same in equilibrium. Also, the actual growth rates of poorer countries should be faster than those of wealthier countries. The reason for this is that, during the "catching up" period, emerging countries may be able to grow faster than the global rate of technological progress. We would expect to see a link between growth rates and income levels in the wrong direction. Nevertheless, equilibrium growth rates will change if the rate of technological development in different countries changes for any reason. For example, suppose a country's "fundamentals" (its rate of saving and spending, technological progress, and population growth) are all the same. In that case, its production per person will reach a similar level. In these situations, there cannot be significant differences in objective living standards forever. Nevertheless, suppose any of these rules are different from country to country. In that case, the equilibrium output levels per person could be different for good. In this case, there is a "conditional convergence." Each country's growth rate will reach its equilibrium level, related to how fast its technology improves. For example, changes in savings and depreciation rates will cause equilibrium levels of income per capita to change. Evidence-based observation is used in the same way in neoclassical economics as in physics. Neoclassical economics relies on mathematical equations and necessitates empirical verification (Brahmachari, 2016). The neoclassical theory of economic growth aims to explain the elements that affect economic growth and the proportional contributions of other factors. Using the Cobb Douglas production function, economist Professor Robert Solow created the neoclassical economic development theory in 1956 (Gardoová, 2016). For proponents of neoclassical economic philosophy (Arrow, 1974), preferences are to blame for environmental issues. In contrast, proponents of Austrian economics (Von Mises, O'Neill, 2001) hold that a lack of a market for environmental products is to blame. There now exists zero eco-friendly options for purchase. However, environmental problems occur because of market imperfections. The market system has positive and negative externalities, as recognized by (Pigou, 1920). Conditions under which growth can be sustained (or at least consumption or utility may be maintained) are the primary focus of the neoclassical literature on growth and resources. Whether or not sustainability is achievable here, understood to mean constant consumption, depends on technical and institutional frameworks. Renewable and nonrenewable resource availability, starting capital and natural resource levels, and input substitution ease are all technical prerequisites. Market structure (clash against central planning), property rights (private versus common property), and ideals about the well-being of incoming generations all contribute to the institutional framework. Solow (1974) demonstrated that sustainability is possible in a limited and nonrenewable natural resource model without cost extraction and capital appreciation. Moreover, this is possible when the elasticity of substitution between the two inputs and other technical criteria are satisfied. Maximizing the aggregate utility throughout time is a crucial criterion for sustainability, achieved when people's utility is considered equally regardless of when they happen to live. Increasing consumption is possible forever. However, when the same model economy is subjected to competition, the resources are depleted, and consumption and social welfare finally drop to zero (Stiglitz, 1974). As with Stiglitz (1974), they want to see the development process in action. Both fossil fuel extraction prices and renewable energy resource production costs increase in the models when more expensive sources are used initially. The model is flexible enough to account for both the absence of technological change and the introduction of both external and endogenous (learned through experience) forms of technological advancement. Better than "neoclassical models," the optimum growth of such an economy seems to mirror past developments. As the economy increases and decreases its reliance on fossil fuels and accumulates capital, it moves through the pre-industrial, industrial, and post-industrial periods. The cost of nonrenewable resources decreases at first before eventually increasing. Together with the more general endogenous technological change models outlined above, this looks like a fascinating foundation for future research into growth and sustainability challenges.

Using a constant discount rate, Dasgupta and Heal (1979) demonstrate that even the most efficient development route eventually exhausts the resource and brings the economy to its knees. When people spend enough money over time to replenish our dwindling supply of natural resources, we may say we live in a sustainable society. According to this research, substitution and technological progress may decouple economic development from energy to other resources. Worn-out resources may be substituted by "equivalent" man-made capital (humans, machinery, factories, etc.). Neoclassical economists are concerned about what institutional engagements, not technological provisions, foster sustainability. They assume a cognizance that sustainability is exactly viable and then analyze what institutional measures may foster sustainability. Solow (1974) and others address scenarios when the elasticity of substitution between nonrenewable resources and capital is more prominent than unison. In the first example, substitute options are plentiful; therefore, non-sustainability is unlikely. If an economy employs nonrenewable resources, sustainability is impossible. With renewable resources, sustainability is theoretically possible, assuming no population increase. Mainstream economics presumes sustainability is theoretically viable until shown differently (Solow, 1993, 1997). Both neoclassical economics and ecological economics have a utilitarian stance since they are grounded on the idea of conservationism. In this guiding concept, people are the standard, normative beings that stand to gain from the services they consume. The ecological economy places a premium on the long-term well-being of both individuals and communities. In contrast, the neoclassical economic model emphasizes consumer autonomy at the expense of efficiency. In a 2005 study (Common and Stagl), Supporting the neoclassical view of economics, the Environmental Kuznets Curves are a crucial concept (EKC). They were scientifically evaluating the neoclassical economist's claim that sustainable economic growth is the answer to population and environmental issues led to the creation of the Environmental Kuznets Curve (EKC), which was designed in the neoclassical tradition (Hussen, 2004). Further, the Environmental Kuznets Curve (EKC), publicized by the World Bank's 1992 Report, supports the claim that a rise in economic activity will improve environmental quality, as Beckerman (1992) stated. The Kuznets Curve illustrates the link between economic inequality and per capita income, suggesting that inequality increases at a parabolic rate before peaking and beginning to decline (Kuznets, 1955). Grossman and Kruger's Environmental

Kuznets Curve from 1992 says that Kuznets Curves can also be used to show the correlation between per capita income and environmental issues. So far, it has been thought that the stages of economic development are linked to environmental degradation (Andrée, 2019). The Environmental Kuznets Curve (EKC) was then put forward as one of the theories to explain the link between per capita income and environmental problems. The Kuznets curve has been used extensively to determine how income affects the environment. Grossman and Kruger (1992), who were the first to make the U curve that shows the relationship between SO2 emissions and wealth, say that CO2 and SO2 are two types of pollution that could hurt the ecosystem. Income and environmental deterioration have a U-shaped statistical link (Yurttagüler, 2017). Increases in early-stage per capita income are associated with more severe environmental damage. After a certain point, often known as a threshold level or tipping point, per capita income rises. Conversely, environmental degradation is becoming less severe.

According to (Ginevicius & Romualdas, 2017), the EKC can be broken down into four distinct phases:

1. The pre-industrial stage of the U curve is characterized by rising per capita income and substantial environmental damage.
2. In the industrial economy stage, in which the trend of damage declines but per capita income continues to rise
3. In the post-industrial economy stage, in which the trend of damage declines but per capita income continues to rise.

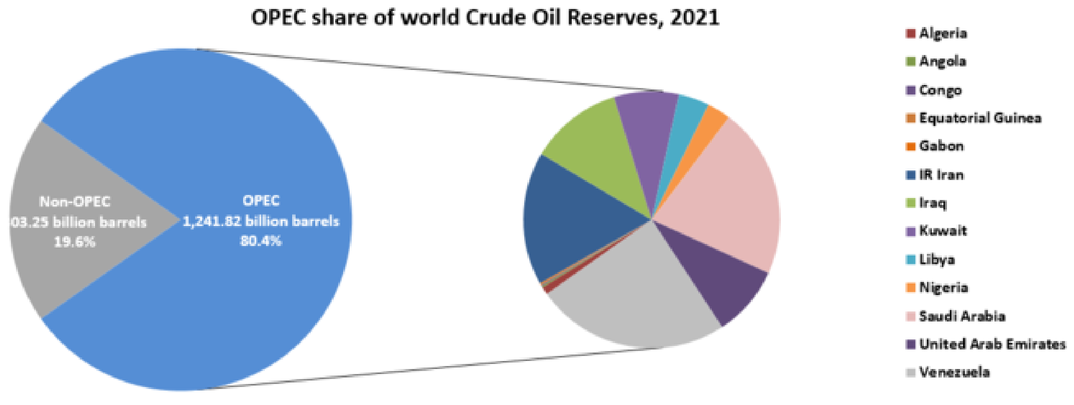
Endogenous growth theory:

The neoclassical growth model has two significant flaws that make it wrong. First, the facts do not match up with what was expected from convergence. Second, the models can only explain steady economic growth if a new technology comes from outside the economy. The theory does not explain how technology improves or changes at different rates in different countries. These findings led to efforts to "indigenize" technological development, which shows how technological progress results from choices made by organizations and people within the growth model. Endogenous growth theory is the name of the body of work that grew out of it (Paul Romer, 1980). Endogenous growth models have several different kinds (Aghion & Howitt, 1998). Early endogenous models of technological transformation allow the condition of technology responds to variations in one of the model's variables. However, they did not explicitly model a process that would lead to the best outcome. In learning-by-doing models, the state of technology depends on how much has been made so far. In the original Arrow model from 1962, capital goods become more productive over time as more of them are made. In some versions, the learning curve means that the production of a good gets more efficient as more of it is made. Hicks (1932) came up with the first induced technological change model, which says that innovation goes up in relation to the increase in the price of an input, like energy. The second endogenous growth model has a different link between capital and output. In these models, Y = AK, where A is a constant and K represents a combination of physical capital and abstract technical know-how. Increases in the savings rate have a multiplier impact on economic growth, increasing both the equilibrium level of income and the pace of economic expansion. Since there is no law of diminishing returns in economics, growth may go on forever as long as this broadly defined capital is acquired. Assembling manufactured capital or expanding one's knowledge base are two of the possible destinations for accumulated savings in AK models. On the other hand, R&D efforts are not accounted for in the models (R&D). As a result of these two characteristics, technological knowledge is unique. The first distinguishing feature is that it is not a consumable resource; its stock does not decrease as it is used. In addition, it causes productive positive externalities. For example, the societal advantages of invention far outweigh the private rewards to the original creator, even when the R&D business profits from the information gathered. As a result, the economy's growth rate is lower than what would be socially desirable since part of the value of knowledge development is external to those who produce it. When the external impact of knowledge generation perfectly balances the internal effect of declining returns on manufactured capital, the economy may maintain a steady growth rate. A greater savings rate improves the economy's growth pace, not only the income level at which it stabilizes (Perman & Stern, 2001). Investing in new ideas is encouraged by the hope of reaping the benefits of a brief monopolistic market. The third kind of endogenous technology model (Aghion & Howitt, 1998) explicitly models this incentive structure, called the Schumpeterian growth model. Companies invest in R&D for the potential of monopolistic profits. However, the capital goods market is plagued by imperfect competition and unpredictable innovations incorporated in successive generations of products. Owing to the presence of both positive and negative externalities, the optimal average growth rate may be either too high or too low. In addition to the direct beneficiaries of innovation, the public benefits from disseminating initial ideas and the insights they provide. Introducing new inventions that render older vintages of capital outdated has unintended consequences. In the long run, the pace of growth is a function of both capital accumulation and innovation. The benefits of innovating increase as capital is amassed. The economy may be expanding at a constant rate of growth unless there is a declining return on investment in innovation as technology grows (Aghion & Howitt, 1998). They argue that Pollution of the environment is a factor in two models (the environment being seen as a renewable resource). In contrast, the other two models deal with finite supplies of different kinds of resources. Two different sets of models, one using the AK framework and the other using the Schumpeterian framework, are included in each pair. Although environmental quality is a utilitarian argument, renewable resource models need to divert resources from the creation of end commodities in order to prevent pollution. Unlike the AK model without resources, where long-run growth might be positive, this version's findings are bleak. However, Aghion and Howitt worry that the Schumpeterian model's assumptions regarding its parameters are too liberal in allowing for infinite development (1998). Models based on nonrenewable resources usually treat that resource as indispensable. Once again, the AK model cannot have a consumption growth rate that is positive in the long term. Schumpeterian models based on nonrenewable resources allow for a limitless increase in consumption under less robust circumstances than their renewable resource counterparts. This seems contradictory, but it seems to derive from customers worrying about consumption in the latter situation. It would seem even less challenging to maintain expansion if renewable resources did not reduce the system's efficiency. Many versions of the endogenous growth model show a positive correlation between economic size and growth rate. As the economy expands, the amount of technological knowledge externality will increase, spurring faster expansion. Afterward, two fascinating possibilities arise. First, when businesses concentrate on one area, they can better share information and ideas, which boosts the local economy. Second, trade liberalization and a rise in trade volume may boost growth rates. Our environment is conducive to a never-ending cycle of success, and convergence is never necessary. Since technological innovation is now endogenous to the growth process, governments may manipulate the economic environment to accelerate the pace of knowledge creation. It could also be an excellent reason to invest in education or training. Intellectual property rights regimes, which offer incentives to develop while slowing down how quickly innovations spread, become very important.

Empirical Review:

Impacts of OPEC on world Energy prices:

OPEC's impact on the market has garnered much criticism. However, it significantly influences these markets because its member countries control most of the world's crude oil reserves. According to *OPEC Annual Statistical Bulletin 2022, the* Share of the World Crude Oil Reserve in 2021 constitutes about 80.4%. Moreover, since OPEC is organized as a cartel, its members are motivated to keep oil prices as high as possible while preserving their respective market shares worldwide. OPEC's positions in the worldwide petroleum market, as well as the price of oil, are both affected by a variety of various variables. The introduction of innovative technologies, most notably hydraulic fracturing in the United States, has significantly impacted the cost of oil throughout the globe while reducing OPEC's sway over financial markets. Consequently, global oil output went up while prices decreased dramatically, placing OPEC in a precarious situation. As of the middle of 2016, OPEC decided to keep production levels at a high level and, as a result, keep prices low to drive high-cost suppliers out of the market and recapture market dominance. Nonetheless, beginning in January 2019, OPEC cut down production by 1.2 million barrels per day for six months out of fear that a slowdown in economic activity would cause a supply superfluity. OPEC extended the agreement for an additional nine months in July 2019, bringing the total length of the agreement to 24 months. OPEC is up against formidable opposition from cutting-edge, environmentally friendly technologies. Some nations that rely on oil exports are considering switching to other energy sources due to the rising cost of traditional fuels. The organization is under constant threat from substitutes like shale drilling as an alternate energy source and hybrid and electric vehicles that minimize reliance on petroleum goods.



OPEC proven crude oil reserves , at end 2021 (billion barrels, OPEC share)

Venezuela	303.47	24.4%	United Arab Emirates	111.00	8.9%	Algeria	12.20	1.0%	Equatorial Guinea	1.10	0.1%
Saudi Arabia	267.19	21.5%	Kuwait	101.50	8.2%	Angola	2.52	0.2%			
IR Iran	208.60	16.8%	Libya	48.36	3.9%	Gabon	2.00	0.2%			
Iraq	145.02	11.7%	Nigeria	37.05	3.0%	Congo	1.81	0.1%			

Therefore, it regulates oil production, distribution, and pricing worldwide. 13 separate oil exporting nations make up this organization, which was formed in 1960. It has widespread clout and is often accused of manipulating oil prices for its members' advantage. However, it faces geopolitical conflicts, an excess of goods, a decline in demand, and the introduction of environmentally friendly technology.

Relationship between energy and economic growth:

Energy is essential for economic development, and increased energy consumption follows expansion. However, the connection between the two is tricky and sometimes misinterpreted. Energy access, renewable energy, and energy efficiency have all been thrust to the forefront of the development agenda thanks to the United Nations Sustainable Development Agenda for Sustainable Development. As more people have access to electricity, we must ask whether access alone can relieve energy poverty and support economic development, regardless of quantity or quality. However, a new line of thought suggests that governments that wish to expand their economies must first invest in energy infrastructure and other energy-intensive sectors. Some of the correlations in this argument are assumed, while others are factual. For example, even if there are wide discrepancies in energy use across nations with comparable incomes, we know that energy and earnings are related (more below). However, we know little about elasticity, the correlation between income and energy use, and the reasons for the wide variation in this correlation between countries and industries. To put it another way, discussions on this subject need depth and specificity. This involves avoiding making simplistic assumptions about the future and not applying the knowledge base of more developed nations to less developed ones. However, it is also a demand for more accurate statistics, more focused study into the unknowns, and a policy agenda that takes lessons from the successful to benefit the unsuccessful. It is safe to assume that nobody believes a single cellphone charger and light bulb are insufficient to end poverty. Nonetheless, they are essential as a starting point. Lighting reduces the need for inefficient fuels contributing to air pollution, allowing for longer work and school days. The availability of information and the convenience of connecting to other people is both enhanced by chargers. Economic progress begins when energy expands to convert hard physical work to other, more productive activities. The next phase in a community's development is the introduction of energy that allows for the pumping of water, the decrease of indoor cooking over biofuels, and the freezing of food. Finally, economic growth may begin when energy is available to support farming, commerce, and industrialization. The well-off romanticize subsistence life in the country, yet this is a luxury few can afford. No civilization has ever achieved modernization without a commercial and industrial sector. A modern energy system must be inexpensive, sustainable, dispatchable, dependable, and scalable to enable the development of an ever-more wealthy society. These trade-offs are prioritized depending on the community's demands and the country's resources. Consider, for instance, a rapidly expanding metropolis in a developing economy. Its system's dependability is crucial for establishing and expanding commercial firms, which stimulates economic growth. For new company owners to have the confidence to invest, compete, and eventually expand, dependability is essential.

Factors Affecting the Linkage between Energy and Growth:

Since the two oil price shocks of the 1970s, much talk has been about the energy intensity trend in developed economies. People often say there has been a decoupling of economic output and resources, which means there are not as many limits to growth as there used to be. This was one of the messages of the 1992 World Development Report, which talked about environmental issues before the 1992 Earth

Summit in Rio de Janeiro. Then, the link between energy and an aggregate output such as the gross domestic product may be influenced by the following:

a. switching from using energy to other inputs

b. A shift in technology

c. changes in the energy input's composition.

d. changes in the output's composition

Shifts in the mix of other inputs, such as from a labor-intensive to a capital-intensive economy, may influence the link between energy and production. However, this subject has not been thoroughly studied in the literature and will not be pursued further here.

A. Energy and Capital: Substitution and Complementarity

Whether or not capital and energy are complementary has been the subject of conflicting econometric analyses (Berndt & Wood, 1979; Apostolakis, 1990). Apostolakis (1990) found that capital and energy are complements in the long term but substitutes in the short run when comparing time series and cross-sectional data. As the cointegration literature has shown, it is now questionable whether or not time-series regressions in levels indicate short-run outcomes. Reconsidering Frondel and Schmidt's (2002) evidence suggests, based on the papers examined by Apostolakis and additional data from Germany. The energy cost share must be relatively low for complementarity to occur. Capital and energy cost shares are reduced, and the likelihood of discovering complementarity increases when materials are considered. There is more information on resource use from time series research than from cross-sectional investigations. Econometric findings that do not account for the cost of materials are more likely to be skewed than those that do. Instead, we fix the pricing of the other inputs so that their amounts may be optimized to reduce cost. Hicks's elasticity of substitution, which was first calculated, is the only known method for gauging deviation from an isoquant (Stern, 2004). When there are just two inputs, all substitution elasticities are equal. However, the flexibility of substitution is no longer uniform when dealing with many inputs (see Stern, 2004 for more details). Based on a VAR study of the U.S. macro economy, Stern (1993) concludes that energy and capital are neutral. However, first, it is crucial to consider the physical interdependence of manufactured and natural capital, as Kaufmann and Azary-Lee

(1991) show. Utilizing a typical production function, they account for the indirect energy needed elsewhere in the economy to create the capital that replaced fuel in the U.S. Forest products industry. Within the period from 1958 to 1984, they discovered that indirect energy expenses of capital more than compensated the direct fuel savings. In some years, the indirect energy costs of capital exceed the direct savings on fuel. Kaufmann and Azary-investigation Lee's findings are consistent with the claims that macro and micro replacement possibilities are distinct. In addition, it seems that money and power are only somewhat interchangeable, if at all. Complementarity is likely to vary depending on the sector and the level of aggregate analysis performed. However, suppose energy's cost share is low compared to capital. In that case, modest increases in the latter are required to achieve significant declines in energy consumption.

B. Innovation and Energy Efficiency

The autonomous energy efficiency index measures the energy consumption ratio to gross domestic product. It accounts for fluctuations in the ratio unrelated to shifts in the relative cost of energy (AEEI). These may result from technical development or other factors influencing the energy-output connection. An index of energy-enhancing technological progress is a more nuanced measure of this phenomenon (Stern, 1999). When there is endogenous technical change, changes in pricing may encourage more technological development. Therefore, rising energy costs tend to hasten the introduction of energy-saving technologies, whereas dropping energy prices may lead to technological shifts that increase energy consumption. It is also conceivable for this to impact total factor productivity increase (Berndt, 1990). According to Jorgenson (1984), technological advances are often unreliable and wasteful of resources. If this is the case, then cheaper energy causes a tremendous increase in total factor productivity. However, new data may disprove this finding (e.g., Judson et al., 1999). Information on the extent to which higher energy prices motivate manufacturers to make more energy-efficient items is provided by Newell et al. (1999). Utilizing the idea of a transformation frontier of reasonable cost and competence combinations, they break down the variations in cost and energy effectiveness of different electronics that use energy.

C. Energy Quality and Shifts in Composition of Energy Input

The quality of energy refers to how much money may be saved using one unit of heat from various fuels or electricity. The marginal product of the fuel is a metric used to assess energy efficiency. It represents the incremental gain in output that results from adding one more heat unit of fuel to the production process. Regarding fuel, specific options have a more comprehensive range of applications and higher economic value than others. Coal, for instance, cannot be utilized to power a computer in the same way electricity can. Physical scarcity, work capacity, energy density, sanitation, availability to storage, safety, flexibility of usage, conversion cost, etc. are the only factors contributing to a fuel's marginal product.

However, the marginal product is not just determined by these characteristics; it also changes with the activities in which it is used, the quantity and kind of capital, labor, and materials employed. In addition, the quantity and type of energy expended. Thus, the characteristics of energy are not static. For example, electricity, natural gas, oil, coal, wood, and biofuels are all considered low-quality alternatives to more reliable forms of energy, such as electricity. Typical pricing of various fuels per unit of energy provides credence to this idea since they reflect what the marginal product of that energy is.

D. Changes in the Composition of Output

In general, the output mix changes as an economy grows and develops. From the epicenter of development, people shift from agriculture and toward heavy industry. People move away from resource-intensive extractive and heavy industries in the later stages and toward services and light manufacturing. As a result, different industries have different energy intensities. There is a common belief that this will cause higher energy consumption rates at the beginning of the economic expansion and lower energy consumption rates in subsequent expansions (Panayotou, 1993). Nonetheless, service sectors need substantial energy and resource inputs. The service being offered may be ethereal, but the office skyscrapers, retail malls, warehouses, and residential complexes where the activity occurs are pretty physical, and energy is consumed in their operation and upkeep. Other service sectors, such as transportation, use a substantial amount of energy and resources. So, it seems unlikely that shifting to the service sector will completely separate energy and growth. The US service and household sectors are not significantly less energy intensive than other aspects of the economy provided indirect energy consumption in goods and services is taken into account. Little evidence also supports the claim that the energy/GDP ratio has significantly decreased as a result of the change in product mix over the last few decades. Also, on a global scale, it may be hard for developing countries to copy the structural change that has happened in developed economies (Stern et al., 1996). However, this change has come about because manufacturing has been sent overseas instead of just because service activities have grown. Eventually, there will not be any more countries where developing economies can send these jobs. Also, suppose the service sector does need a lot of material support. In that case, it is unclear if the developed world can keep moving toward a growing share of GDP from services for a long time. A further argument argues that because manufacturing prices have decreased relative to service pricing, the proportionate decline in manufacturing in industrialized nations is overstated when current prices are used to assess the relative sizes of the sectors (Kander, 2002).

Empirical Literature Review:

Using data from East African nations, Beyene et al. (2020) analyze the Kuznets curve related to environmental issues. Between 1990 and 2013, they examined 12 East African nations using the pooled Mean Group (PMG) Approach to evaluate the EKC hypothesis. The results demonstrate a bell-shaped relationship between per capita income and CO2 emissions, a proxy for environmental degradation. The result is a flatter "U"-shaped curve than the inverted U-shape postulated by the EKC hypothesis. Their finding disproves the hypothesis that economic activity in East African nations is responsible for CO2 emissions. The Environmental Kuznets curve (EKC) hypothesis is essential to comprehend the relationship between economic activity and environmental deterioration, as stated by Gyamfi et al. (2021). Their research focused on developing nations responsible for a significant portion of the world's activity. The PMGARDL estimator and heterogeneous causation tests were used to determine the direction of long- and short-term causality, respectively, within the scope of this investigation. Instead of an N-shaped curve, the investigated countries revealed an inverted U-shaped environmental Kuznets curve. There is a positive link between carbon emissions and renewable and nonrenewable energy sources. However, according to short-term statistics, there is no correlation between economic growth and either renewable or nonrenewable energy sources and CO2 emissions. The causality analysis revealed that the link between GDP and GDP2 is bidirectional. According to the conclusions of their research, an increase in renewable energy sources in the seven analyzed countries might lead to a decrease in pollutant emissions. Then, Gill et al. (2018) examine the occurrence of an environmental Kuznets curve (EKC) for greenhouse gases (GHG) assessed by CO2 emission in Malaysia from 1970 to 2011. The research also investigates the renewable energy source's ability to sequester greenhouse gases. The long-run significant positive GDP coefficient suggests that GHG is growing with economic expansion. However, the negligible GDP square coefficient denies the EKC transition. These data show a high GDP level for Malaysia at the EKC turning point. Therefore, only economic expansion can rectify Malaysia's environmental damage. The government should develop several policy measures to achieve the CO2 emission reduction goals Malaysia pledged to achieve in Paris. The production of renewable energy has a significant negative impact on CO2 emissions. Therefore, the government should prioritize energy production from renewable sources and develop a policy specifically for renewable energy production. (Carson et al., 1997) postulated that the possibility of an environmental Kuznets curve, in which pollution initially rises but subsequently declines with rising affluence has drawn much attention. Empirical research has inherent problems with data comparability and quality because it concentrates on various countries. By examining seven different forms of air pollution across the 50 US states, their study was able to sidestep these issues and discover that all seven pollutants correlate with rising per capita income. The research also finds substantial evidence of heteroscedasticity about the income-emissions link: lower-income states show much more variation in per capita emission levels than higher-income ones. Research on crude oil reliance and CO2 emissions affects military spending in net oil importers, as reported by (Wang & Umar et al., 2021). Due to their fast economic expansion, significant CO2 emissions, strong oil consumption, and increasing military power, empirical studies show that China and India have cointegration. However, Italy's closeness to the Middle East and its oil-dominated energy system makes it vulnerable to COD and CO2 emissions. However, cointegration between the US and France is weakened by military intentions and alliances, government financial constraints, and energy structure and laws. One policy repercussion is a need to build strategic reserves and diversify oil supply lines to reduce the burden on the military and guarantee adequate energy supplies. Spending on R&D should also be increased, and efforts should be made to speed up the transfer of military technology to civilian businesses to improve energy efficiency. In an economic development study, Akpan & Chuku (2011) avoided assuming environmental deterioration follows an inverted U-shaped trajectory. Using the ARDL and yearly time series data from 1960 to 2008, this research adds to the ongoing discussion on the existence of the EKC in Nigeria and the policy implications of this idea. As an indicator of environmental damage, the research utilized the number of carbon emissions generated by each participant. According to the results, the EKC hypothesis was proven false, and an N-shaped connection more accurately depicts the actual situation in 30 Nigeria based on the available data. Therefore, their results concluded that Nigeria's EKC hypothesis should not be utilized as a policy guide to address environmental problems. Tiwari (2011) researched the interplay between India's renewable energy usage, GDP growth, and carbon dioxide emissions. The researchers used a structural VAR approach. All variables are non-stationary in level form but are stationary in first difference form, as shown using unit root tests. The results of a cointegration study by Johansen-Juselius (1990) show no long-run association between the test variables. The study's novel analysis suggests that increasing the usage of renewable energy sources improves GDP and reduces CO2 emissions. Massive increases in GDP have a dramatic effect on carbon dioxide emissions. Barra and Zotti (2018) examine the relationship between national income (real GDP per capita) and environmental pollution (CO2 emissions per capita) using a relatively heterogeneous sample of 120 nations from 2000 to 2009. To assess the presence of a Kuznets curve for CO2 emissions, they used a two-step GMM estimator highlighting the nonlinear link between national income and environmental harm. Preliminary data indicate a U-shaped association between national income and environmental pollution; however, the problem of (non-)stationarity rendered the validation of Kuznets' theory fruitless. Results also indicate that as population and industrial productivity increase, the environmental strain will increase, increasing emissions and necessitating stricter environmental and energy conservation regulations. Using variance decomposition, we find that the share of renewable energy sources in total energy consumption explains a large chunk of the prediction error variance of GDP but a small chunk of CO2 emissions the forecast error variance. Additionally, (Nordin & Sek, 2021) tested the Energy-Environmental Kuznets Curve hypothesis in oil-importing and -exporting countries by employing heterogeneous estimators using panel data from 2000 to

2014. (MG, CCEMG, and AMG). They looked at the connection between energy use and GDP and GDP square. The results show that CCEMG has the lowest root mean square error (RMSE) for both sets of countries, making it the best suitable estimator. The calculated GDP and its square coefficients provide evidence for the EKC hypothesis in both groups of countries. The influence of explanatory factors is much more significant in nations that are net exporters of oil than those that are net importers of oil. According to the findings, cross-sectional dependence also plays a role in determining energy intensity. The findings of this research could give some helpful information on how the economy ought to be organized to achieve an optimal balance between its impact on the environment and other considerations. Ang (2007) examined the dynamic relationship between CO2 emissions, energy usage, and production in France between 1960 and 2000 using a multivariate vector error-correction model. The results show that CO2 emissions grow as energy usage increases and that there is a quadratic link between CO2 emissions and production over time. In order to clarify the causative linkages between output energy and output pollution, the research performed two causality tests in addition to the co-integration analysis. First, there is a one-way link between growing energy consumption and increasing production in the short term, suggesting that increasing output over time increases energy usage and CO2 emissions. Researchers found that an integrated framework was required to investigate it thoroughly due to the inextricable bond between these features. The results indicate that between 1960 and 2000, these factors had a comparatively substantial long-run correlation. The evidence for causation supports the hypothesis that, over time, economic growth has a causal effect on growing pollution levels and energy usage. The results also point to a one-way causal link between long-term energy demand increases and short-term production increases. The Environmental Kuznets Curve theory for carbon and ecological footprints was studied by (Murshed, Alam, et al., 2021) using yearly data from 1995 to 2015. Both the slope heterogeneity and cross-sectional dependence problems were taken into consideration. The results backed the EKC hypothesis for the sample of South Asian countries studied. In addition, the EKC hypothesis has been statistically supported by country-specific research for Bangladesh, India, Nepal, and Sri Lanka but not for Pakistan for the period reviewed. These findings contradict the findings of Pakistan's research. However, all five South Asian countries agreed that the environment would benefit from increased usage of renewable energy. Therefore, the findings imply that environmental challenges in South Asia are both the cause and the answer to economic development. Furthermore, increased renewable energy sources in South Asian countries might help protect the region's ecosystems. When looking at the sample of South Asian nations, the EKC hypothesis held. However, the rising use of renewable energy and renewable power sources has led to a dramatic reduction in such impacts. Kijima et al. (2010) theoretically investigate the environmental Kuznets curve. Dinda (2004) noted that all decision-makers in charge of environmental policies must theoretically understand how environmental quality would change. The EKC is explained in-depth and with the most recent information in this essay from a theoretical standpoint. As such, this study's overarching objective is to inspire further theoretical research into the link between environmental quality and social and economic development. According to the EKC hypothesis, there is an inverse U-shaped link between per capita income and environmental quality. In other words, when income rises, environmental quality initially rises to a certain point before declining. There have been passionate discussions about the EKC theory since the early 1990s, and a large number of empirical research back up the inverted-U relationship. However, the environment-income relationship may be more nuanced than the EKC predicts. Therefore, drawing an EKC relationship from empirical data is insufficient; instead, more advanced curve-fitting methods should be created based on theoretical research, according to Pearson (1994, p. 212). Using the SVAR model, plotted IRFs, and estimated Marjanovic et al. (2016) evaluate the impact of an uptick in RES on real GDP and CO_2 emissions. The research found that when the RES receives a positive shock, GDP increases, and carbon dioxide emissions decrease. A higher GDP affects carbon dioxide emissions in the paper's analysis significantly. The variance decomposition found that the proportion of RES contributed much more to the variation in the GDP prediction error than CO_2 emissions. According to the research results, increasing the proportion of renewable energy sources might increase CO_2 emissions first (in the first year). To meet environmental goals while minimizing costs, the Indian government may need to implement measures outside its support for RES, including demand-side management and energy conservation. Marjanovic et al. (2016) proposed that the environment that governs the links between carbon dioxide (CO_2) emissions and (GDP) varies through time as a result of variations in economic development, regulatory policy, and technology. However, a robust empirical connection exists between rising GDP and CO_2 emissions. They concluded that the trade-off between economic development and carbon dioxide (CO_2) emissions needs to be better understood and prevents practical actions from combating climate change. Their research aimed to create and use an Extreme Learning Machine (ELM) to predict GDP using CO_2 emissions. To better understand the connection between CO_2 emissions, economic development, and coal consumption in China and India, Govindaraju et al. (2013) used the recently developed cointegration approach for the years 1965-2009. Their research indicates a long-term connection between the factors in China's case but not India's. Furthermore, there is evidence in China of both a short-term and long-term bidirectional causation between economic growth and coal use, as well as between coal consumption and CO_2 emissions. Not only that, but research has also shown a direct link between economic growth and CO_2 emissions. Therefore, coal consumption, CO_2 emissions, and economic development in India are all interconnected in the near term. Granger argues that economic expansion is the primary driver of India's rapid increase in short-term coal consumption. Now that it has been demonstrated that the study's conclusions are usually consistent with those of other studies, the policy message for China and India is very apparent. China should exercise caution while enacting any conservation policies, whereas India should do so without jeopardizing long-term economic growth. Therefore, China may work harder than India to develop alternative policy options. While earlier works on EKC focused on various greenhouse gas emissions, more recent studies have taken ecological footprint data into account to assess the EKC hypothesis's robustness in the context of the global environment. Al-Mulali et al. (2015) utilized EFP as an indicator of environmental degradation across 93 low-, middle-, and high-income countries to test the EKC hypothesis. The results illustrated the inverted U-shaped relationship between economic growth and EFP only in the case of upper-middle and high-income economies. As a counterexample, it was shown that economic growth in low-income nations consistently raised the EFP. Research by Mikayilov et al. (2018) examined how rising CO_2 emissions in Azerbaijan have paralleled the country's booming economy. Cointegration analysis is performed for the period 1992-2013. In order to generate more trustworthy findings, we examine cointegration and estimate long-run coefficients using the Johansen, ARDLBT, DOLS, FMOLS, and CCR methods. Researchers compare the effects of cubic, quadratic, and linear specifications on CO_2 emissions in Azerbaijan and find that the latter is the most accurate. Furthermore, the findings from the various cointegration techniques agree with one another and demonstrate that economic expansion has a long-term, positive, and statistically significant impact on emissions, indicating that the EKC hypothesis is false for Azerbaijan. After using several approaches, the study discovered that the income elasticity of CO_2 emissions is between 0.7 and 0.8. Furthermore, it was discovered that any short-run imbalance might be corrected in less than a year to follow the long-run equilibrium route.

The research paper asserted that each dollar costs 1.8 times more than the global average in terms of CO_2 emissions when compared to global average data. By implementing energy-saving measures, the researchers confirm that Azerbaijan can achieve economic growth without increasing CO_2 emissions (Opitz et al., 2015, among other things). To put it another way, some applicable policies that can boost energy efficiency include deploying less energy-intensive technology, avoiding power loss during distribution and transmission procedures, and using alternative tariff methods to control energy use. Although the current study's findings do not specifically identify the root causes of the elements that increase CO_2 emissions in response to economic expansion, some steps must be taken to achieve sustainable development in the case of developing countries. In addition, Halicioglu F. (2009) investigated the numerous facets of the Turkish economy, including CO_2 emissions, energy consumption, exports, and imports. He used time-series data from 1960-2005 to examine the dynamic causal linkages between carbon emissions, energy consumption, income, and foreign trade in the context of the Turkish economy. Specifically, he conducted a test for cointegration using the ARDL bound test. According to the findings of the bound test, the variables were involved in two distinct kinds of long-term connections. In the first model version that looked at long-term relationships, energy consumption, income, and international commerce were all shown to influence carbon emissions significantly. The first form of study was more straightforward, while the second type of long-term study suggested that income was connected to carbon emissions, energy use, and international commerce. According to the findings of Halicioglu's (2009) study, Turkey's wealth, energy consumption, and international commerce significantly contribute to the country's overall carbon emissions. The quantity of energy that was used was the third most essential component. Also, Olimpia (2019) investigates the long-term relationship between economic complexity, energy consumption structure, and greenhouse gas emission for a panel of European Union countries and two subpanels: I European economies with a higher degree of economic complexity and (ii) European economies with a lower level of economic complexity.). They employ a heterogeneous panel technique, which incorporates complete (FMOLS) and dynamic ordinary least squares (DOLS) panel estimates to account for the wide range of European countries. In all three panels, empirical evidence reveals a long-term equilibrium between economic complexity, energy consumption structure, and greenhouse gas emissions. Economic complexity and energy consumption structure have a statistically significant impact on greenhouse gas emissions in all panels, but the influence is more significant in the subpanel of countries with a lower level of economic complexity, indicating a greater risk of pollution as economic complexity increases and as the energy balance tilts toward nonrenewable energy consumption. Consequently, their article proposes that economic complexity is a factor that must be considered when formulating national economic and energy policy. Then, Ismail et al. (2022) Utilizing the Augmented Mean Group (AMG), resistant to cross-sectional dependency, non-stationarity, heterogeneity, and structural discontinuities, they examine the impacts of using non-renewable and renewable energy on ecological footprint. They find that non-renewable energy consumption significantly worsens the environment in both country groups. However, because of their heavy dependence on crude oil, poor research and deployment of renewable energy sources, and inefficient energy use, the impact is particularly noticeable for countries that are net oil exporters. On the other hand, only countries that are net oil importers take into account the use of renewable energy. The coefficient, which is unfavorable as expected, shows a decrease in environmental harm. A further justification for its weak economy and high oil consumption is its insignificance among net oil-exporting countries. Using data from 1972-2016, Ghazouani (2021) analyses the symmetric and asymmetric impacts of real GDP per capita, FDI inflow, and crude oil price on Tunisia's CO_2 emissions. The ARDL and NARDL bound tests for cointegration results show that the variables are linked through time. The long-term estimates provided by both methods are consistent with the EKC hypothesis applying to Tunisia. A simplified study shows that rising GDP and oil prices adversely affect the environment, whereas FDI inflows have a long-term positive effect by reducing CO_2 emissions. When crude oil prices rise, it has detrimental effects on the environment, as shown by asymmetry research. In contrast, a decrease in the price of crude oil has positive benefits for the environment. Moreover, the causality analysis shows a two-way link between GDP growth and carbon emissions but only a one-way relationship between FDI inflows, crude oil prices, and carbon emissions. Therefore, they have these policy recommendations to help Tunisia cut its carbon output and boost its economy. Using cutting-edge, trustworthy estimation approaches of co-integration, Tang et al. (2013) bolster the case for a connection between CO2 emissions, economic development, and coal use in China and India. They run the Granger causality test to dig further into the correlations between the variables. Their data shows that the elements are cointegrated for China rather than India. That is to say, China's coal consumption, economic development, and carbon dioxide emissions are interconnected in the long run. The findings of the Granger causality test for China suggest a significant one-way causal connection between economic growth and CO2 emissions. Also, CO2 emissions, coal usage, economic development, and coal consumption are all interconnected in the long and short term. For India, we can only find evidence of a correlation in the near term. Therefore, the study found a correlation between economic growth and CO2 emissions and coal use and CO2 emissions. However, the Granger causation between India's coal use and economic growth is simply one-way. Al-Mulali et al. (2022) examined the asymmetric effects of oil price shocks on environmental deterioration from 1996 to 2016 for six panels of Gulf Cooperation Council (GCC) nations. Using the dynamic seemingly unrelated regressions (DSUR) technique, which accounts for cross-sectional dependency, they evaluate the links between oil price shocks and carbon dioxide (CO2) emissions. The findings show that adverse oil price shocks did not affect CO2 emissions; positive oil price shocks had a significant and unfavorable effect on CO2 emissions. Specifically, the beneficial oil price shocks have significantly influenced CO2 emissions in Oman, Qatar, Bahrain, Saudi Arabia, and the United Arab Emirates. In turn, Saudi Arabia and Qatar are the regions seeing the most extreme negative consequences. The adverse shocks to the price of oil have a statistically significant impact on the amount of carbon dioxide that Oman and Saudi Arabia emit. In contrast, it does not significantly affect other nations. Furthermore, the data from the UAE, Qatar, Kuwait, and Saudi Arabia support an environmental Kuznets curve. On the other hand, the findings in Bahrain and Oman provide evidence against the hypothesis. This research might assist decision-makers in implementing energy-saving technology and renewable energy regulations to support economic growth and enhance environmental quality. From 1980 to 2014, Achuo (2022) explores the relationship between crude oil price shocks and environmental quality in sub-Saharan Africa. The researcher used the PMG-ARDL model and found a significant positive association between crude oil prices and carbon emissions. Meanwhile, this suggests that increases in the price of crude oil degrade environmental quality in the context of Sub-Saharan Africa. Then, Agbanike et al. (2019) analyze oil prices, energy use, and CO2 emissions in Venezuela from 1971 to 2013. The study's results reveal a significant positive association between oil prices and energy usage, increasing environmental degradation. Additionally, the study found that a rise in crude oil prices leads to a rise in energy consumption per capita in the Venezuelan economy.

Then, Barreto et al. (2021) used the ARDL bound testing method to analyze the relationship between fossil fuel usage and carbon dioxide emissions in G7 nations from 1965 to 2018. The findings of their investigation indicate that positive causation was discovered in the sense that the use of fossil fuels causes an increase in carbon dioxide emissions. Short-term elasticities show that increasing oil, coal, and natural gas consumption by one percentage point results in increases in carbon dioxide emissions of 0.4823%, 0.3140%, and 0.1717%, respectively. In the long term, increasing oil, coal, and natural gas consumption by one percentage point would increase carbon dioxide emissions by 0.4924%, 0.2692%, and 0.1829%, respectively. In a study published, Narayan et al. (2016) classified 181 countries into five income categories based on their annual time series data from 1960 to 2008: high-income OECD countries, high-income non-OECD countries, upper-middle-income countries, lower-middle-income countries, and low-income countries. More than 42% of high-income nations were found to have evidence consistent with the EKC theory; however, this percentage dropped sharply for less-developed nations. About 27% of the nations in their sample, mainly the ones with high incomes, will see emissions decrease as income increases, according to their future analysis. Co2 (carbon dioxide) emissions and GDP growth were tracked for 181 nations during this study. According to the research, a decrease in CO2 emissions was predicted due to rising living standards. If there were a positive relationship between GDP and CO2 emissions in the past and a negative relationship between GDP and CO2 emissions in the future, this would lend credence to the environmental Kuznets curve (EKC) theory. There are two primary takeaways from the research. The EKC hypothesis, first, has factual data backing it up in 21 of 181 nations (12%). Second, the analysis concludes that 49 nations (27%) will be able to lower their emissions due to future GDP development. Moreover, a recent article by Arouri et al. builds on the research of Liu (2005), Ang (2007), Apergis et al. (2009), and Payne (2009) to examine the connection between CO2 emissions, energy consumption, and real GDP for 12 MENA countries from 1981 to 2005 using panel unit root bootstrap tests and cointegration techniques (2010). The research found that prolonged energy use significantly reduced CO2 emissions. Further, the study reveals an intriguing quadratic link between regional CO2 emissions and actual GDP. The tipping thresholds range from negligible to very high. Even though the long-run coefficients of income and its square match with the EKC hypothesis in most nations analyzed, this evidence is poor for the EKC theory. Even though the MENA area had economic expansion between 1981 and 2005, CO2 emission reductions per capita have been made. According to the econometric correlations discovered in the study, future CO2 emissions per capita reductions may be accomplished even if the region's GDP per capita continues to increase. Another subject that has attracted much interest in recent decades is the connection between oil prices and carbon emissions. The cost of energy is essential to a country's economic growth. Changes in crude oil prices have very different effects on oil-exporting and oil-importing economies, with the latter incurring a high cost due to oil consumption. Countries that significantly depend on oil for energy incur profound implications when oil prices fluctuate. Increases in oil costs, according to a significant number of studies, cause people to use less oil, which lowers carbon emissions. This research includes the assessment (Mensah et al., 2019; Wong et al., 2013). On the other side, an increase in energy costs signals an oil shortage, which motivates oil-importing nations to switch to less expensive options, lowering carbon emissions (Li et al., 2019). Regulation of oil imports from specific suppliers (OPEC) and concerns about climate change are additional reasons that lead oil-importing nations to diversify their energy mix by using greener alternatives (Jones & Warner, 2016; Troster et al., 2018). Jarallah et al. (2017) also investigated the years 1980-2011 and found that the EF was used to quantify the environmental decline in Qatar over this time. The environmental Kuznets curve (EKC) theory is the subject of this research. An ARDL estimate with structural breakdowns supports the idea that the relevant variables are intertwined over a long period. Additionally, the co-integration vector suffered a notable shift in 1996. After looking over all the data, this conclusion seemed clear. No evidence was found to support the EKC theory in studies addressing both the short- and long-term effects of income elasticity in Qatar. According to the researchers, Qatar is an anomaly that does not meet the study's criteria. Real GDP per capita has a monotonic relationship with the EF since the influence of income over a more extended period is larger than the effect over a shorter period. The long-term impact of human actions on the environment, the cost of oil, and the ease of international commerce have positive and negative correlations, respectively. We further examine the reliability of the findings by applying the estimate using the regime method and the Toda-Yamamoto causality tests. First, we need to be sure of the final findings. Using the Toda-Yamamoto causality test, we can see that the cost of oil and a person's disposable income majorly impact their environmental footprint. Results from the second regime (1997-2011) are consistent with ARDL estimates, suggesting that real GDP has a more significant impact on the EF than it did in the first (1980-1996). Comparisons between periods led to these findings. Moreover, Umar et al. (2022) explore the asymmetric nonlinear relationship between these variables and CO2 emissions in Gulf Cooperation Council countries using FDI and oil prices data. As direct investment is positively related to carbon emissions in the long term and oil prices have positive, substantial impacts on CO2 emissions, our results support the pollution-haven theory. In addition, the pollution-haven hypothesis predicts that these variables will have an asymmetric nonlinear connection. We also show that reductions in FDI have a positive, statistically significant effect on emissions of carbon dioxide in the near term, suggesting that foreign companies use eco-friendly practices in their production. In the long term, however, adverse fluctuations in oil prices are positively related to carbon emissions. These results should assist Gulf Cooperation Council countries to concentrate on policies that promote foreign direct investment in green rather than dirty sectors to maintain the environmental sustainability. Samour et al. (2022) examined France's environmental Kuznets curve (EKC) hypothesis from 1977 to 2017 to determine its validity. Using co-integration and causality tests with Fourier transforms to assess the impacts of nuclear and renewable energy on the ecological footprint, carbon dioxide (CO2) emissions, and load capacity factor. In addition to the conventional markers of environmental deterioration, they offer a significant contribution to the scientific literature by measuring the effect of nuclear energy on the load capacity factor for the first time. Their empirical research suggests no U-shaped link between CO_2 emissions and income but rather a relationship consistent with the EKC hypothesis for the load capacity factor. Renewable energy has a little long-term effect on environmental circumstances. However, nuclear energy decreases CO_2 emissions and raises the load capacity factor, enhancing environmental quality. The results demonstrate the significance of nuclear energy for green sustainability. Additionally, Boukhelkhal A. (2022) employs many economic indicators to research the variables that influence ecological footprint as a proxy for environmental quality in Algeria from 1980 to 2017. Another objective of this research is to investigate how social factors such as education level and life expectancy may impact the standard of the natural environment. The autoregressive distributed lags (ARDL) approach was used to provide an estimation of the constructed environmental degradation models. The findings, which were in line with expectations, indicate that import is a critical element that minimizes the ecological footprint in both the short and long term. This compares economic growth, energy consumption, export levels, and the revenue generated from natural resource rents. In addition, the findings demonstrate that both education and life expectancy contribute to the acceleration of short-term environmental degradation. However, as life expectancy continues to rise, less harm is done to the environment since more people are being educated. In light of these findings, the present research recommends more effective management of the natural and human resources of the nation. These proposals help authorities lead the nation toward sustainable growth. Using an ARDL bound test, Likhachev et al. (2022) analyze the relationships between CO_2 emissions and their primary drivers in the Russian Federation, including GDP growth, financial development, trade openness, energy consumption, and population. The study covers the years 1990 through 2020. The findings reveal that energy consumption and population growth contribute to increased CO_2 emissions, economic development, better banking, and broader commercial activity all have a moderating influence. The study also shows that the Russian economy grows at a "U" shape angle to CO_2 emissions. This demonstrates that EKC is applicable in the Russian Federation up to a particular income level and that if this level is surpassed, a positive association will begin to develop between economic expansion and environmental damage. However, Gong et al. (2021) used the (ARDL) bound test method to examine both long-run and short-run elasticities.

As a result, the researchers use Pakistan's GDP growth squared fossil energy consumption, GDP, FDI net inflow, and carbon dioxide emissions from 1975 to 2014. The results of the co-integration test indicate a persistent connection between the variables. Both static analysis and dynamic simulations have shown that economic expansion and CO2 emissions follow an inverted U-shaped connection. Using the ARDL model's long- and short-term coefficients, they see that burning fossil fuel increases CO2 emissions. Foreign direct investment (FDI) also significantly affects atmospheric carbon dioxide levels. The findings point to the need to increase renewable energy production, direct foreign direct investment (FDI) towards environmentally friendly technology in Pakistan, and promote sustainable development via energy efficiency. According to Ogundipe et al. (2019), Nigeria's economy has depended significantly on fossil fuels since oil was found there in 1956, resulting in unsustainable carbon dioxide emissions. Given this backdrop, they do a study on how the usage of fossil fuels impacts Nigeria's environment. For their study, they used secondary data from the World Development Indicator (WDI) using the Johansen cointegration approach. According to the conclusions of this research, burning fossil fuels accounts for almost 80% of Nigeria's carbon emissions. Pollution was also shown to rise as a function of income and population density across the study period. The study urges urgent action to establish a sustainable energy framework and promote awareness of the far-reaching negative repercussions of consuming fossil fuels.

Also, C02 emissions in Turkey were studied by Seker et al. (2015), who looked between 1974-2010 and the correlations between FDI, GDP, GDP squared, and energy consumption. In the co-integration study, they apply both the limits test technique, which has better characteristics in small samples and the Hatemi-J test, which considers structural breakdowns. Due to the co-integration connection between CO2 emissions and other variables, the autoregressive distributed lag (ARDL) model is used to study the variables' short- and long-run elasticity. The long-run coefficients of the ARDL model imply that the influence of FDI on CO2 emissions is positive but relatively modest. In contrast, the effects of GDP and energy consumption on CO2 emissions are substantial. In addition, the error correction model (ECM) yields short-run coefficients comparable to the long-run model. The results support the environmental Kuznets curve (EKC) theory across both periods. The Granger causality test based on vector ECM is also used to analyze the causal relationship. The findings of the causality test suggest the presence of a long-term causal relationship between all explanatory factors and CO_2 emissions. The findings suggest that Turkey should support more substantial FDI inflows, particularly in technology-intensive and environmentally friendly enterprises, to improve environmental quality.

Then, Jabarullah et al. (2019) used annual time series data from 1978 to 2016 to test the Environmental Kuznets Curve in Malaysia. They look at how hydropower energy use affects the curve. In this research, advanced econometrics were utilized to determine what was going on, and the (ARDL) bound approach was employed to determine if the variables had a long-term connection. The ARDL bound technique results show an excellent long-term relationship between Malaysia's use of hydropower energy, economic growth, and carbon dioxide emissions. The study confirms that hydropower energy consumption and the square of economic growth significantly and negatively affect CO_2 emissions. In contrast, economic growth significantly and positively affects CO_2 emissions. In addition, the results show that Malaysia has an inverted U-shaped curve. Henceforth, the results recommend that policymakers in Malaysia focus on how much energy is used from hydropower when making plans to prevent further deterioration of the environment. Khan et al. (2020) utilize panel data from 1991 to 2016 to examine the environmental deterioration in 22 nations based on two metrics: CO_2 per capita and CO_2 emissions from liquid fuels. Their research examines the link between agricultural and economic issues using panel regression (non-additive effects) and quantile regression—the disparity between developing and developed nations as CO_2 emitters. In addition to harming overall emissions of CO_2 by 19.12%, the results of agricultural activities have a positive and enormous influence on CO_2 emissions from liquid, which in turn increases environmental degradation by 36.75 percent. Deforestation for feed cropping, biomass burning, and deep soil cropping are only some ways agriculture harms the environment, especially in less developed nations. In addition, the quantiles decomposition process in agricultural production symbolizes the diversity of low and high CO_2 emitters as causes of environmental deterioration.

Table 1. A Succinct Description of available Existing Literature

Author's Info	Place of Study	Research objective	Time of Study	Methodology	Brief Results	Contribution to EKC
Barra and Zotti (2018)	120 Countries	This article investigates how national wealth (real GDP per capita) affects environmental pollution (per capita CO2 emissions).	2000-2009	GMM	The research results indicate that environmental strain will increase when population and industrial productivity increase, leading to an increase in emissions.	Does not Supports the EKC hypothesis
Rabnawaz Khan (2020)	22 countries (9 developing and 13 developed)	This article aims to determine the relationship between agricultural output and CO2 emissions in developing and industrialized nations.	1991-2016	Panel quantile decomposition techniques with FMOLS	The results suggest agriculture has a favorable and significant effect on CO2 emission from liquid, with a 36.75 percent rise in environmental degradation and a 19.12 percent decrease in overall CO2 emissions. In addition, agricultural production's quantiles decomposition approach indicates low and high CO2 emitters heterogeneity.	Supports the U-Shape EKC between Agriculture and CO2 emission
Mikayilov et al. (2018)	Azerbaijan	This paper examines the relationship	1992-2013	DOLS, FMOLS	The findings from the various co-integration	Does not support EKC hypothesis.

		between Azerbaijan's economic growth and CO2 emissions.			techniques agree with one another and demonstrate that economic expansion has a long-term, positive, and statistically significant impact on emissions, indicating that the EKC hypothesis is false for Azerbaijan.	
Halicioglu F. (2009)	Turkey	This research seeks investigate the dynamic causal links between carbon emissions, energy consumption, income, and international trade in Turkey.	1960-2005	ARDL	The study finds that Turkey's wealth, energy consumption, and international commerce significantly contribute to the country's overall carbon emissions.	Supports EKC hypothesis
Al-Mulali et al. (2022)	GCC (Gulf cooperation Council	This article examines the asymmetric effect of oil price shocks on c02 emissions in six GCC nations.	1996-2016	DSUR Model	The findings show that adverse oil price shocks did not affect CO2 emissions; positive oil price shocks had a significant and unfavorable effect on CO2 emissions.	Supports the EKC hypothesis.
Ghazouani (2021	Tunisia	The study examines GDP per capita, FDI inflow, and crude	1972-2016	NLARDL	The result shows that rising GDP and oil prices adversely affect the	Supports EKC hypothesis

		oil price on Tunisia's CO2 emissions.			environment, whereas FDI inflows have a long-term positive effect by reducing CO2 emissions.	
Gyamfi et al. (2021)	E-7 countries.	This research examines the N-shaped EKC utilizing data from 1995–2018 in E-7 nations.	1995-2018	PMG	The finding reveals that there is a positive link between carbon emissions and renewable and nonrenewable energy sources.	Supports EKC Hypothesis
Beyene et al. (2020)	East African countries	The purpose of the research was to test the EKC hypothesis on East African countries.	1990 - 2013	PMG	The results demonstrate a bell-shaped relationship between per capita income and CO2 emissions, a proxy for environmental degradation.	Does not support EKC hypothesis
Neagu Olimpia (2019)	12 EU countries	The study aimed to evaluate the long-run relationship between economic complexity and greenhouse gas emissions in selected European economies.	1995-2017	FMOLS and DOLS	The result illustrates a significant positive correlation between energy intensity and CO2 emissions. In addition, the panel co-integration test shows a long-term causal relationship between economic complexity, energy intensity, and carbon emissions.	Supports the EKC hypothesis between economic complexity and CO2 emission
Mikayil	Azerbaijan	This study	1992-	Johansen,	Consistent findings	Does not

ov et al. (2018		explores the correlation between economic development and CO2 emissions in Azerbaijan.	2013	ARDLBT, DOLS, FMOLS and CCDR model	across co-integration techniques reveal that economic expansion positively affects emissions in the long term, suggesting that the EKC hypothesis does not validate Azerbaijan. Depending on the methodology used, the income elasticity of CO2 emissions is determined to be between 0.7 and 0.8. To add, we discover that any imbalance in the short run may be corrected towards the long run equilibrium route in less than a year.	support the EKC hypothesis for the case of Azerbaijan
Samour et al. (2022)	France	The research aimed at checking the validity of the EKC hypothesis in France.	1977-2017	ARDL	Our empirical research suggests no U-shaped link between CO2 emissions and income but a relationship consistent with the EKC hypothesis for the load capacity factor. Renewable energy has a little long-term effect on	Does not support the EKC hypothesis. No inverted U-shaped relationship between CO2 emissions and income.

					environmental circumstances. However, nuclear energy decreases CO_2 emissions and raises the load capacity factor, enhancing environmental quality. The results demonstrate the significance of nuclear energy for green sustainability.	
Belloumi et al. (2017)	Saudi Arabia	The research looked at evaluating the EKC hypothesis in Saudi Arabia.	1971-2011	ARDL	The study suggest that the inverse-U link between transport CO_2 emissions and economic development in Saudi Arabia has yet to be seen. In addition, there is a short- and long-term bidirectional causal relationship between transport CO_2 emissions and road transport energy consumption. Long-term, however, there is only a unidirectional causal relationship between economic	Does not support an inverted-U relationship between CO_2 emissions and economic growth in Saudi Arabia

					development and transport CO2emissions and road transport energy consumption.	
Demissew et al. (2019)	12 East African Countries	The purpose of this investigation is to test the existence of the EKC hypothesis in selected East African countries.	1990-2013	Pooled Mean Group (PMG)	The research indicates that the link between per capita income and CO2 emissions (a proxy for environmental degradation) is bell-shaped. However, extending the original U-shaped association between economic activity and environmental degradation. Thus, economic activity in East African nations does not result in CO2emissions.	Does not support an inverted U-shape EKC.
Gill et al. (2018)	Malaysia	The research seeks to test the hypothesis of the EKC in Malaysia.	1970-2011	ARDL	The negligible relationship between GHG emissions and GDP2 suggests that the EKC transition for carbon emission in Malaysia does not exist in the short or long term.	Does not support the EKC hypothesis

					Accordingly, Malaysia should not wait for economic development to automatically reverse the process of environmental deterioration, as the EKC theory suggests.	

Author's computation

CHAPTER III

Thesis Methodology

In this part of the research effort, the primary objective is to provide an in-depth summary of the approaches, processes, and strategies used to obtain the essential data for the study. This section also presents a comprehensive examination and explanation of the many statistical approaches used to analyze the secondary data gathered over the course of this research.

Types of Data and Sources:

It is worth knowing that most research data is collected from two primary sources: the primary source for data acquisition and the secondary source for data collection. The Author of this research should have selected the second option. Instead, the Author gathered data from secondary sources, including the World Bank DataBase and Statistical Review of World Energy database, which are accessible online. The research was conducted over 50 years, beginning in 1970 and finishing in 2020, for oil exporting and importing nations; the data collected were yearly time series data. CO2 emission as a proxy for environmental degradation, GDP per capita and GDP per capita squared, Price of oil, Fossil fuel usage, and FDI are the data sources for this study.

Variables and the Measurement of Variables:

This analysis used secondary data from the World Bank Development Indicators database and the British petroleum statistics repository. For the research aim, the data obtained were grouped into dependent factors and independent variables. As our dependent variable, we utilized CO_2 emissions as a proxy for ecological deterioration. Our regressors include GDP per capita, per capita GDP squared, oil price, fossil fuel usage, and foreign direct investment.

CO_2 Emission

CO_2 is a naturally occurring, non-flammable gas produced during respiration, the chemical reaction between carbonates and ambient acids, and the burning of organic matter. Carbon dioxide emissions, often known as CO_2 emissions, are produced from the combustion of fossil fuels and cement manufacture. Carbon dioxide emissions also include the carbon dioxide generated by the combustion of solid, liquid, and gaseous fuels, as well as the flaring of gas.

Fossil fuel consumption

Fossil fuels are nonrenewable because it takes millions of years to produce them, and there are not enough of them to go around. Consumption of energy is proportional to developing high-tech industries in developing countries (industry, motorized transport, and urban regions). Population health is also affected by the region's climate, topography, and economy (such as the relative price of energy). More energy is used per person in low and medium-income nations. The energy utilized before it is transformed into fuels for ultimate use is called primary energy use (such as refined petroleum products). This landfill is home to municipal and industrial waste, biomass, and animal byproducts. Generating power, heat, or fuel from plant matter is known as "biomass."

GDP per capita

The GDP per capita is calculated by taking the mid-year population, adding any goods taxes (minus any subsidies) that were not included in the production value, and dividing by the midyear population. The GDP at constant prices is used to compute local currency growth. Prolonged growth of the economy increases average incomes and has a substantial relationship with the eradication of poverty. Therefore, gross Domestic Product (GDP) may be seen as an indirect indication of per capita income since it is an essential measure of the value of production per person. There are two primary measures of economic growth:

GDP per capita square

Calculating a country's GDP per capita (GDPpc) involves dividing its GDP in a given fiscal year by the total square number of its people. For this research, the gross domestic product (GDP) per capita was squared to quantify the connection between CO2 emissions and sustainable development more precisely.

FDI

The net inflow of funds used to buy a company's long-term management ownership (10 percent or more of voting shares) in another nation is known as a foreign direct investment (FDI). The sum includes both short-term and long-term capital. To calculate net foreign investment inflows, subtract outflows from inflows (new investment) and divide the result by GDP.

World oil price

Light, sweet crude oil at the current spot price is the most popular unit of discussion when referring to oil pricing. On the spot market, buyers and sellers of crude oil and gas oil negotiate a price for the commodity. Oil price data came from a database maintained by British Petroleum.

Model specification

This study uses the ARDL PMG method created by (Pesaran, Shin, and Smith 1999) to examine the short- and long-term correlations between carbon emissions and economic development. In this procedure, the sample observations are collected and averaged. Using the co-integration form of an ARDL model, the PMG estimator lets the slope and short-run coefficients and co-integration terms change across cross-sections. In this model, the short-run coefficients and error variances may also be changed freely among groups (heterogeneous). However, long-term coefficients should ideally be the same or homogeneous. The simple average of individual coefficient units provides accurate estimates of the mean of the short-run coefficient. Regardless of the order of integration, whether I (1) or mutually integrated (I (0) and I (1)), this approach is advantageous since it can examine likely long-term correlations (1). However, order 2 (I (2)) does not function with this strategy. Furthermore, this method offers consistent and efficient estimators for endogenous and exogenous variables by incorporating lag time since it eliminates endogeneity-related concerns. Moreover, the PMG estimator combines coefficient pooling and averaging. According to Pesaran et al. (Pesaran et al. 199), the economic policies of the analyzed economies vary. In their view, the PMG was superior to alternative panel data models because it permits short-run responses to be flexible and unconstrained between groups while imposing limits in the long run by combining individual groups. In other words, the likelihood-based PMG estimator restricts the long-run elasticity across all panels to be equal, giving efficient and consistent results only when the homogeneity limitation is actual. In addition, when the sample size is small, the PMG estimator is less susceptible to outliers and may simultaneously solve the serial autocorrelation issue and the problem of endogenous regressors by selecting a suitable lag structure for both dependent and independent variables (Pesaran et al., 1999).

However, the ARDL PMG model was used to estimate the short-run and long-run model link between the independent variables and the dependent variable, CO2 emission. The income per capita, income per capita squared, price of oil, fossil energy consumption, foreign direct investment, and the test for co-integration are the variables that are taken into consideration in this model. According to (Pesaran et al. 1999), the ARDL (p, q) model, which incorporates the long-term relationship between variables, is as follows:

$$\Delta \boldsymbol{Y_t} = \boldsymbol{y_{oi}} + \sum_{i=1}^{p} \boldsymbol{\beta_i Y_{t-1}} + \sum_{i=0}^{q} \boldsymbol{\beta_1 X_{t-1}} + \boldsymbol{\mu_{it}} \dots\dots\dots\dots\dots\dots\dots\dots \quad \textbf{EQ1}$$

Where Y t is the vector and the variables in X t can be a pure mix of I(0) and I(1) or co-integrated. I and _1 are the slope coefficients; y is a constant; i=1 p,q is the optimal lag orders; and _it is the vector of the error terms, which is an unobservable zero mean white noise vector process (serially uncorrelated or independent). In the above equation, however, the letter "p" stands for the lag value of the dependent variable. In contrast, the letter "q" stands for the lag value of the regressors. The current and lagged values of an exogenous variable in the model are used to determine if the regressor variable also has lagged values. So, a VAR model's lag time for p and q might not always be the same. Moreover, Δ stands for the difference operator and $\boldsymbol{\mu_{it}}$ is the random disturbance error term. However, in the instance where C02 emission is the dependent variable, the Panel ARDL equation for such variable can be stated as follows:

$\Delta C02_{it} + \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta C02_{it-j} + \sum_{i=0}^{q} \alpha_2 \Delta GDP_{it-j} +$

$\sum_{i=0}^{q} \alpha_3 \Delta GDP^2{}_{it-j} + \sum_{i=0}^{q} \alpha_4 \Delta FEC_{it-j} + \sum_{i=0}^{q} \alpha_4 \Delta FDI_{it-j} +$

$\sum_{i=0}^{q} \alpha_5 \Delta WOP_{it-j} + \beta_{0iC02_{t-1}+\beta_{1i}GDP_{t-1}+\beta_{2i}GDP^2{}_t+\beta_3 iFEC_{t-1}+\beta_4 FDI_{t-1}+\beta_5 WOP_t+\mu_{it....}}$

………**EQ2**

Selecting a lagging variable is done using the Akaike Information Criteria (AIC) and the Schwarz criterion. The implementation of classic cointegration tests in the presence of variables I (0) and I (1), as done by Pedroni (1995, 1999, 2004); Kao (1999); and Bai and Ng (2001), remains unwarranted for testing the existence of potential long-term linkages between variables. In contrast, the ARDL bound test provides the possibility to assess the presence of potential long-run links based on the alternative hypotheses listed below:

$H_0: \beta_{1i} = \beta_{2i} = \beta_{3i} = 0$

$H_1: \beta_{1i} \neq \beta_{2i} \neq \beta_{3i} \neq 0$ where i=(123)

The bound testing approach relies on the Fisher (F) or Wald (W) statistic. Pesaran et al. (2001) have evaluated two critical value limits for a given degree of significance. The first assumes that all variables in the ARDL model are I (0). In contrast, the second assumes that the variables are I (1). Therefore, the decision criteria are to reject the H0 null hypothesis if the calculated F-statistics exceed the critical value of the upper bound. If this criterion holds, it concludes the existence of a robust long-run connection among the variables. It is impossible to draw any firm or valid conclusions from a cointegration test if the F-statistic is within the acceptable range. However, if the F-statistic is less than the lower limit, the research failed to reject the null hypothesis of no cointegration. The second phase estimates the long-term equation if the co-integration connections have been identified. Nevertheless, we can determine the short-term dynamic relationship by estimating the error correction model (ECM). Then, we can specify the ECM as follows:

$\Delta C02_{it} = \beta_{0i} + \sum_{i=1}^{p-1} \beta_1 \Delta C02_{t-i} + \sum_{i=0}^{q-1} \beta_{2i} \Delta GDP_{t-i} +$

$\sum_{i=0}^{q-1} \beta_{3i} \Delta GDP\hat{}2_{t-1} + \sum_{i=0}^{q-1} \beta_{4i} \Delta FEC_{t-1} + \sum_{i=0}^{q-1} \beta_{5i} \Delta FDI_{t-1} +$

$\sum_{i=0}^{q-1} \beta_{6i} \Delta WOP_{t-1} + \epsilon_{1i} ECT_{it-1} + \mu_{it} \dots \dots \dots$ ……………………… **EQ3**

Where ε_{it} is the coefficient of the error correction model, which represents the speed of adjustment in the long run. As was indicated before, this estimator holds the long-term parameters constant across distinct clusters of countries while permitting variation in the short-term estimates, error variance, and intercepts. The ARDL model's current popularity stems from the fact that it can be utilized whether the series in question is I(1) or I(0). It can also be used to provide both long- and short-term estimates simultaneously. We estimated the long-term and short-term coefficients and causalities among the variables by employing an intermediate econometric estimator (PMG estimator) developed by Pesaran et al. (1999). Nevertheless, this imposes the similarity of long-term parameters while allowing the short-term coefficients to vary across country groups using the ARDL model. The PMG approach assumes heterogeneity of the short-term coefficients while assuming that the long-term coefficients are homogeneous for all individuals in the panel. In contrast to the MG (mean group) approach proposed by Pesaran and Smith (1995), which assumes heterogeneity of both the short- and long-term coefficients, the adjustment parameter errors, and the variances. In conclusion, the Hausman probability test, an essential diagnostic test, was carried out to establish if the long-term pooling coefficients are suitable and effective.

Econometric framework

In academic research, the use of model estimate methods may be determined, to some extent, by the goals of the investigation and by the extent to which the model constraints bind the model variables. In this investigation, PMG Autoregressive distributed and lag (ARDL) models are used to investigate many issues, including carbon emissions, economic growth, and the usage of fossil fuels. Furthermore, these models are utilized to investigate these and other subjects. According to Godfrey (1978), entering the ARDL model parameters effectively in various orders is effective. Consequently, this indicates that the model variables are integrated at a mixture of I(0) and I (1). Consequently, the researcher developed the following econometric equation:

$$\Delta lnc02_{it} = \beta_{0i} + \sum_{i=1}^{p} \beta_{1i} lnGDPC_{t-1} + \sum_{i=1}^{q_1} \beta_{2i} lnGDPSQ_{t-1} + \sum_{i=1}^{q_2} \beta_{3i} lnFEC_{t-1} + \sum_{i=1}^{q3} \beta_{4i} lnFDI_{t-1} + \sum_{i=1}^{q_4} \beta_{5i} WOP_{t-1} + \mu_{it} + \varepsilon_{it}$$

..EQ4

Where C02; represents carbon emission

GDPC= Gross domestic product per capita

GDPSQ= Gross domestic product per capita square

FEC= Fossil fuel consumption

FDI= Foreign direct investment, net inflow

WOP= World oil price

i= Numbers of variable use in the model

j= Number of lags

P= lag value of the dependent variable

q= lag value of the explanatory variable

ε_{it}= Vector of the random disturbance error term

μ_{it}= Error term

Residual diagnostics

Regression diagnostics aims to determine whether the estimated model, underlying data, and model assumptions are compatible with the observed data. Diagnostic procedures are numerical and visual techniques for determining the adequacy of data assumptions and model form. For example, identifying extreme points (outliers) that may be prevailing the regression and potentially distorting the results, as well as determining whether or not solid relationships between the explanatory variables (collinearity) affect the results. Finally, using a diagnostic test known as the residual diagnostic test, researchers may determine the dependability of the models and variables used for regression. This test allows researchers to evaluate the accuracy of the used models. In addition to the diagnostic tests previously stated, additional diagnostic tests are being used in this inquiry to assess the model's reliability. The residual normality test, the autocorrelation test (also known as the serial correlation test), and the white (heteroskedasticity) test are examples of these types of analyses. The degree of association between the data points may be gauged by plotting a chart showing the residuals' value concerning the anticipated and projected values. Then, the null hypothesis is rejected, and heteroskedasticity is declared when the probability value is compared to the obtained F-statistics.

Cross-sectional dependency

In panel analysis, Cross-sectional dependency and homogeneity between variables exhibit significance for the selection of further econometric tests used in empirical analysis, such as co-integration and stationarity tests. The statistical characteristics of panel unit root tests are expected to be significantly influenced by cross-sectional dependency. However, avoiding dependency and using first-generation panel unit-root tests to a data series with cross-sectional dependence results in size distortions and poor power (O'Connell, 1998), i.e., a high likelihood of rejecting the correct hypothesis. Therefore, due to the influence of cross-sectional dependency on test results, we must account for this characteristic in our panel analysis. In addition, a cross-sectional dependency test can also be employed to determine whether first- or second-generation panel unit root testing should be utilized. In order to do this, three tests were conducted: the Breusch-Pagan Lagrange Multiplier (LM), the Pesaran Scaled Lagrange Multiplier (LM), and the Pesaran Cross-sectional Dependence Test (CD). For cross-sectional dependence, the Breusch-Pagan Lagrange Multiplier (LM) test is often employed (Breusch & Pagan, 1980). This test is applicable when the number of cross-sections is small. However, the number of periods is large enough, as is the case with the dataset utilized in this research. In contrast, the Breusch-Pagan test is based on the seemingly unrelated regression equation (SURE) technique, which needs a previously stated model specification. We use the test established by Pesaran (2004) to determine if data exhibit cross-sectional dependency. The test computes the correlation coefficients for each correlation between state I and state j variable series. A greater correlation coefficient value indicates a larger cross-sectional reliance between residuals. If the null hypothesis is rejected, we accept that the panel is cross-sectionally correlated; otherwise, we do not. Moreover, Pesaran (2004) suggests an alternative CSD test that does not need a preexisting model and may be used for many model parameters. The Pesaran CD test statistic has the following characteristics under the null hypothesis of no cross-sectional dependence:

$$CD = \sqrt{\frac{2T}{N(N-1)}\left(\sum_{i=1}^{n-1}\sum_{j=i+j}^{n} P_{ij}\right) \rightarrow \widehat{N}(0,1)} \quad \textbf{EQ5}$$

Pesaran, 2004, p. 9)

Pesaran (2015) developed the LM test for CD, which may tolerate slope heterogeneity and cross-sectional difficulties in a relatively small sample. Generally, it assumes that the observed test statistics for the analyzed residuals (u) are asymptomatically distributed so that CD N. (0, 1). The result discussion section shows the outcomes of combined CD testing using the Pesaran (2015) and Pesaran (2007) techniques.Therefore, a unit root test that accounts for CD constraints must be used to validate a long-run connection between the variables. Since this research required a unit root test, the CADF and CIPS panel unit root test developed by Pesaran (2007) was used. This is an improved version of the IPS unit root test developed by Im et al. (2003).

Panel unit root test

Considering the evidence of cross-sectional dependency in our panel, we cannot proceed with the conventional panel unit root tests (also known as the first-generation panel unit root tests) for the reasons described above. Therefore, we use unit root tests of the second generation that account for cross-sectional data dependency. The panel second-generation stationarity tests aim to remedy the deficiency of cross-sectional dependency in the first generation. Regarding this particular aspect, all studies, except those carried out by Harris et al. (2005), assume the existence of a unit root within the data. The second generation of tests is predicated on the premise of heterogeneity. Consequently, the series lacks a common autoregressive (AR) structure, and the panels are heterogeneous. However, examining the stationarity characteristics of the panel series under discussion is a traditional approach in the literature. Here, we choose the Cross-sectionally Augmented Dickey-Fuller (CADF) and Cross-sectionally Augmented Im, Pesaran, and Shin (CIPS) unit root tests based on their superior power performance when there is evidence of dependency among panel members. The CADF test developed by Pesaran (2007) enables us to test for unit roots when a single common factor is present. This test accounts for cross-sectional dependency based on a single factor shared by all states that affect government expenditures and revenues. This test has the benefit that we are not required to estimate the components. The common factor ft may be approximated by the cross-section means of the lagged levels and the variable's initial difference. The study introduces an ADF panel unit root test that accounts for CSD. In addition, we utilize the test's statistics (Cross-sectionally

Augmented Dickey-Fuller, or CADF) to build a revised version of the original IPS test (Im et al., 2003). Finally, the CADF provides further support to the conventional ADF test by averaging the cross-sections, as seen below:

$$\Delta y_{it} = \alpha_0 + \alpha_1 y_{it-1} + \alpha_2 \bar{y}_{t-1} + \sum_{j=1}^{m} \beta_{1ij} \Delta \bar{y}_{i,t-j} + \sum_{k=0}^{n} \beta_{2ij} \Delta y_{t-j} + \mu_{it}$$

…………….**EQ6**

For which, $\bar{y}_{t-k}$ *and* $\Delta\bar{y}_{t-k}$ capture the lagged level-form and first difference-form cross-sectional means, respectively. Hence, the equation for the CIPS test can be specified as follows:

$$CIPS = \frac{1}{N}\sum_{i=1}^{N} CADF_i$$

………………………………………………………………….**EQ7**

According to (Kassouri et al., 2020), the CIPS test is renowned for functioning well even when the panel series exhibit autocorrelation. The null hypothesis posits that all series are non-stationary, while the alternative hypothesis proposes that particular series are stationary. Notably, one of the critical limitations of panel unit root testing is the formulation of the null and alternative hypotheses. While the null hypothesis presupposes that every series has a unit root, it may be rejected if even one series is stationary (Asteriou, 2015). Consequently, the Hadri (2000) panel unit root test with an alternative null hypothesis must also be done (on demeaned data) to assess the robustness of the findings. In economics, it is usual for variables to be non-stationary and become stationary after the first difference (integrated of order one). If this is the case, the variables may be cointegrated. Considering that our data imply cross-sectional dependence, we conducted second-generation panel unit root tests. It varies from first-generation panel unit root tests because they allow cross-section units to be associated. Panel unit root tests with a single common factor and multiple common factors show that all variables are I (1) processes. The inclusion of specific deterministic terms does not affect the outcomes. Consequently, the following study phase is to test for cointegration in the data.

However, this study also applies the Karavias and Tzavalis (2014) unit root test that allow for structural breaks. Karavias and Tzavalis (2014) demonstrate that the Karavias and Tzavalis tests are extensively applicable and contain certain distinctive qualities of optimality (2017, 2019). They are applicable in both small-T and large-T scenarios, where T is the quantity of time-series observations. They permit many common breaks, the dates of which may be known or unknown. In the latter scenario, they may be determined endogenously from the data. Errors may be nonnormal, cross-sectionally heteroskedastic, and dependent. Under the alternative, the autoregressive coefficients may be homogeneous or heterogeneous, meaning they can be identical in all units or vary across units. Regarding their optimality qualities, the tests are invariant under the null to the starting condition, which implies that, unlike other fixed-T tests, no initial observation assumptions are required. In addition, the tests are independent of the coefficients of the deterministic components and are robust when linear trends are present. This thesis presents xtbunitroot, a new tool that executes the panel-data unit-root tests of Karavias and Tzavalis (2014). The command may set one or two breaks at specified or arbitrary times. The conventional xtunitroot command and the community-contributed (Eberhardt, 2011), (Merryman, 2005), and (Lewandowski, 2007) commands are complemented by this new command, the first to allow panel unit-root tests with structural breaks. As a result of the interruptions, the linear trends or the series' intercepts may change. Therefore, the critical value and p-value for the test are determined using a bootstrap method, as described by Karavias and Tzavalis (2019), if the dates of the breaks are unknown. Other possibilities include the admission of cross-section heteroscedasticity, cross-section dependency as in O'Connell (1998), and standard errors. Additionally, support is provided for imbalanced panels. For example, Karavias and Tzavalis (2014) propose two models for panels with N cross-section units, T time-series data, and one standard break. The first model may be used to compare the null hypothesis of a random walk to the alternative theory of a stationary process with a break in the series intercepts (means).

$$H_0: w_{i,t} = w_{i,t-1} + \mu_{i,t}$$

$$H_1: w_{i,t} = \theta w_{i,t-1} + (1-\theta)\{\beta_{1,i} I(t \le b) + \beta_{2,i} I(t > b)\} + \mu_{i,t}$$

Denoting I = 1,…,N and t = 1….,T. in the above model, the autoregressive parameter is shown by θ *and* $\beta_{1,i}$ and $\beta_{2,i}$ shows fixed effects before and after the break. The break occurs on date b, and I(.) represents an indicator function The following model depicts and considers the break in intercept and linear trends at time b.

$$H_0: w_{i,t} = w_{i,t-1} + \delta_i + \mu_{i,t}$$

$$H_1: w_{i,t} = \theta w_{i,t-1} + \theta\{\delta_{1,i} I(t \leq b) + \delta_{2,i} I(t > b)\} + (1-\theta)\{\beta_{1,i} I(t \leq b) + \beta_{2,i} I(t > b)\} + (1-\theta)\{\delta_{1,i} I(t \leq b) + \delta_{2,i} I(t > b)\} + \mu_{i,t}$$

……………………………………………**EQ8**

In the above equation, the drift under null hypothesis is δ_i, while the trend coefficient are δ_i and $\delta_{2,i}$.

The tests of Harris and Tzavalis (1999) and Karavias and Tzavalis (2014) are fixed-T tests with a broad variety of deterministic component requirements including, individual unit intercepts, linear trends and common structural breakdowns. This enables us to examine the effect of missing data in different contexts.

We concentrate on panel unit root tests with many cross-section units N and a small number of time series observations T. However, the original dynamic panel data framework introduced by Holtz-Eakin, Newey, and Rosen (1988), as well as the framework of the first-panel data unit root test, is that of Breitung and Meyer (1992) and (1994). In terms of applications, it is also one of the most prevalent; see, for example, Karavias et al (2021). The unit root tests for panel data developed by Harris and Tzavalis (1999) and Karavias and Tzavalis (2014) are prevalent in applied research and have been included into statistical tools. In addition to being applicable to short panels, they offer numerous other advantages: they are invariant under beginning circumstances, they provide flexible and generic trend functions, and they permit cross-section heteroskedasticity.

Panel co-integration

Westerlund Cointegration test

Following the unit root tests, the empirical approach determines the long-run relationship in an empirical model. This research uses the panel cointegration test Westerlund (2007) developed to assess cointegration. The selection of the Westerlund panel cointegration test is based on the fact that it is applicable in the presence of cross-sectional dependency and is unaffected by a common factor when it comes to producing valid and accurate results (Khan et al., 2020; Kapetanios et al., 2011). This is required, however, if the series remains stable in part or whole after the initial differentiation, indicating an order I(0) or I. (1). A more robust model is used in this work to assess the cointegration of the panel data. In addition, 100 bootstrapped samples are used to give error correction, long-run and short-run equilibrium correlations, mean-group estimates, country-specific outputs, and four additional test statistics. The use of panel cointegration approaches to test for the existence of long-run correlations among integrated variables having both a time-series dimension, T, and a cross-sectional dimension, N, has garnered a great deal of interest in recent years, particularly in the empirical literature. However, in addition to accounting for the time-series dimension, it is also crucial to account for the cross-sectional dimension to maximize the analysis's power. Despite considerable theoretical evidence of a long-run connection between the variables, several studies have accepted the null assumption of no cointegration. Most residual-based cointegration tests, whether applied to pure time series or panels, emphasize the assumption that the long-run parameters for the variables' levels are equal to the short-run parameters for the variables' differences. Thus, Westerlund (2007) developed four new panel cointegration tests that are not bound by the existence of a common component since they are based on structural rather than residual dynamics. This exercise aims to deduce if the error-correction term in a conditional panel error-correction model is equal to zero, thereby testing the null hypothesis of no cointegration. All new tests follow a standard normal distribution and are flexible enough to account for unit-specific short-run dynamics, trend and slope parameters, and cross-sectional dependencies. Two tests examine the alternative hypothesis that the panel as a whole is cointegrated. In comparison, the remaining two tests examine the alternative that at least one element is cointegrated. The error-correction tests assume the following procedure for creating data:

$$\Delta_{yit} = \delta_i d_t + \alpha_i\left(y_{i,t-1} - \beta_{ixi,t-1}\right) + \sum_{j=1}^{p_i} \alpha_{ij} \Delta y_{i,t-j} + \sum_{j=-q_i}^{p_i} \gamma_{ij} \Delta_{xi,t-j} + \varepsilon_{it}$$

………**EQ9**

In this equation, t = 1,…, T and I = 1,….N represents the time series and cross-sectional units, whereas d_t comprises the three deterministic components. In the first situation, d_t = 0. so the equation above has no deterministic terms. In the second case, d_t = 1. Thus, Δy_{it} is created with a constant. We describe the K-dimensional vector x_{it} as a pure random walk in which Δx_{it} is independent of ε_{it}. We further assume that these mistakes are independent across both I and t for the sake of simplicity. We will manage any dependencies across I using bootstrap techniques.

$\Delta_{yit} = \delta_i d_t + \alpha_i y_{i,t-1} + \varphi_i x_{i,t-1} + \sum_{j=1}^{p_i} \alpha_{ij} \Delta y_{i,t-j} + \sum_{j=-q_i}^{p_i} \gamma_{ij} \Delta_{xi,t-j} + \varepsilon_{it}$

…………**EQ10**

Where φ_i = -$\alpha_i \beta_i$. However, the factor α_i denotes the velocity at which equilibrium relationship is achieved when there is a distortion or shock. Thus, if $\alpha_i < 0$, then the existence of error correction is proven in the model. This means, y_{it} and x_{it} are co integrated. If α_i= 0, then there is no error correction and thus, no co-integration. Hence, we can argue that the null hypothesis of no co-integration as H_0: $\alpha_i = 0 \ for \ all \ i$. The alternative hypothesis focuses on the homogeneity assumptions for α_i. However, two of the tests, called group-mean test, does not need the α_{is} to be congruent, which implies H_0 is evaluated against H_1: $\alpha_{i<0}$ for at-least one i. Nevertheless, the panel statistics assumes α_i are congruent for all i_s and are consequently, meant to examine H_0 against H_1: $\alpha_i = \alpha < 0 \ for \ all \ i_s$. Meanwhile, the group-mean test can be represented by the following equations: Furthermore, compared to cointegration tests based on residuals, the test produces consistent findings with a small sample size and has excellent power (Bhattacharya et al., 2018). The research generates four statistical tests; group-mean statistics (Ga and GT) and panel-mean statistics (Ga and Gt) (Pa and Pt). The equation for the test is as follows:

$G_T = \frac{1}{N} \sum_{i=1}^{N} \frac{\widehat{\alpha_i}}{SE(\hat{\alpha}_i)}$

…………………………………………………………………..**EQ11**

$G_\alpha = \frac{1}{N} \sum_{i=1}^{N} \frac{T\widehat{\alpha}_i}{\widehat{\alpha}_i(1)}$

……………………………………………………………………….**EQ12**

Where $SE(\hat{\alpha}_i)$ represents the conventional standard error of α_i.

Also, the panel statistics can be express as follows:

$P_T = \frac{\hat{\alpha}}{SE(\widehat{\alpha})}$

……………………………………………………………………………..**EQ13**

$P_\alpha = T\hat{\alpha}$

…………………………………………………………………………………….**EQ14**

The statistical significance of these test statistics refutes the null hypothesis, indicating the existence of long-term relationships between the model's variables. Co integrating connections are a prerequisite for predicting long-run estimates using suitable regression techniques.

CHAPTER IV

Empirical results

Table 2. Descriptive statistics (OPEC)

	LNC02	LNGDPC	LNGDPSQ	LNFEC	LNWOP	LNFDI
Mean	17.55286	8.718517	81.32289	5.065546	3.244426	2.381670
Median	17.95032	8.755351	76.65627	5.060152	3.316365	2.330773
Maximum	20.42894	12.61828	159.2209	8.088934	4.715545	3.90259 2
Minimum	12.68365	-6.74E-06	4.55E-11	1.786373	0.587787	3.13E-07
Std. Dev.	1.619749	2.306305	35.21676	1.464140	0.951696	0.274206
Skewness	-0.814240	-1.118801	-0.105463	0.035656	-0.817526	-0.176504
Kurtosis	3.268588	4.583131	2.879093	2.036466	3.880591	22.30892
Jarque-Bera	69.46429	191.5857	1.507265	23.80381	87.94531	9510.454
Probability	0.000000	0.000000	0.470654	0.000007	0.000000	0.000000
Sum	10742.35	5335.732	49769.61	3100.114	1985.589	1457.582
Sum Sq. Dev.	1603.012	3249.937	757774.6	1309.803	553.3987	45.94042

Observations	612	612	612	612	612	612

Author's computation (using Evies 12)

The table above explains the traits and features of the variables used by the researcher in this work. In addition, the following values have been given to the mean, which calculates the sample average of the data in the series based on the table's contents: The relative mean or average for the variables (lnC02, lnGDPC, lnGDPSQ, lnFEC, lnWOP, and LNFDI) are listed respectfully: (17.55286), (8.718517), (81.32289), (5.065546), (3.244426) and (2.381670). Standard deviation, which measures dispersion and estimates how far individual observations are distant from their sample average, shows that LNGDPSQ has a sizeable and highest standard deviation in the series. In contrast, (lnWOP) has the lowest standard deviation. That is to say, lnGDPSQ observations deviate more from the dataset mean than (lnWOP) observations, which are more in line with the mean. Furthermore, kurtosis measures the normality often used to the normal distribution to quantify the degree to which a distribution is skewed toward its peak. A leptokurtic distribution, for instance, is characterized by an extraordinarily tall height and comprises the distributions of LNWOP (3.880591), LNGDPC (4.583131), and LNFDI (22.30892). In contrast, it is evident from the distribution that LNFEC and LNGDPsq follow an exact platykurtic shape because its value, 2.036466 and 2.879093, correspond to a completely flat curve for the variable under investigation. Nevertheless, the distribution shows that LNc02 (3.268588) is nearly mesokurtic or has a normal distribution. *Skewness* is a metric that may be used to assess how much a distribution differs from perfect symmetry. Thus, the distribution has negative left-tail skewness for all other variables except lnFEC , for which it has positive right-tail skewness. Additionally, it is characteristic of asymmetric distributions for the difference between the mean and the sample average to cluster on one side of the mode, in agreement with the mode itself, which boosts distributional variability. Accordingly, the distribution reports 612 observations.

Table 3. Cross-sectional dependency test for OPEC.

Test	Statistics	p-value
Breusch-Pagan LM	601.2342	0.0000

Pesaran scaled LM	46.58616	0.0000
Pesaran CD	5.838096	0.0000

Author's computation (using Eviews 12)

In the above Table, we provide the results of the CSD analysis. For oil-Mproducing nations, in particular, the findings contradict the assumption of no CSD. Therefore, the OPEC nations are CSD-positive. Hence, we reject the null hypothesis of no cross-sectional dependence and conclude that solid evidence of cross-sectional dependence is found within the series since the probability value is small and the tests are less than 5% at all conventional levels of significance. That is, because of economic cooperation, cultural exchange, political integration, and globalization, a shock in one country might have repercussions in others. After testing and proving the existence of CSD, Pesaran, 2007's "CIPS and Bai and Ng "PANIC unit root tests" are applied. First, however, we access the second-generation unit root test because the results of the first-generation unit root are not valid after evidence of CSD is found in the series. Nonetheless, both tests take CSD and serial correlation into account.

As a result of cross-sectional dependency, the research utilizes the procedural second-generation panel unit root (CADF and CIPS) (see appendix II). However, the outcome of these tests was not suitable for this analysis; therefore, we specify and rely on the Karavias and Tzavalis (2014) unit root, which is valid under cross-sectional dependency.

OPEC Unit Root

Table 4. Karavias and Tzavalis unit root

Variable	**Constant**				**Constant and Trend**				**Integrations Order**
	level		1st difference		level		1st difference		
	Z-statistic	p-value	Z-statistic	p-value	Z-Statistic	P-Value	Z-statistic	P-Value	
lnC02	-0.1118	0.2400	-9.8987	0.0300	-0.4134	0.0800	-6.7263	0.0200	I(1)

lnGDPC	-0.9618	0.3000	-44.705	0.000	-0.6281	0.2600	-26.4262	0.000	I(1)
lnGDPsq	-3.6910	0.2200	-41.783	0.000	-1.3101	0.5900	-24.8371	0.000	I(1)
lnFEC	0.0127	1.000	-4.5925	0.0200	-0.1063	0.2700	-3.2328	0.0100	I(1)
lnWOP	-2.2981	0.0000	-------	------	-1.7269	0.0000	----------	-------	I(0)
lnFDI	-27.535	0.000	--------	-----	-16.956	0.0000	------------	-------	I(0)

Author's computation (using Stata 13)

In the table above, we conduct panel unit-root tests that account for structural breakdowns in the abovementioned variables. Furthermore, the tests are cross-sectionally heteroskedasticity-invariant since they are based on the normalcy assumption. The first model may test the null hypothesis of a random walk versus the alternative hypothesis of a stationary series with a break in the series intercepts (means). The results indicate that variables were integrated at I(0) and I(1), resulting in mixed variable outcomes. The null hypothesis that the series has a non-stationary level should be rejected based on the unit root test results conducted at constant with the trend. The unit root test conducted at a level and the first difference at a significance level of 5% indicate that variables are stationary. In contrast to the CADF and CIPS tests, the Xtbunit root test demonstrated that lnC02, lnGDPC, lnGDPsq, and lnFEC are integrated after the first difference. The other variables included in this study are integrated at their respective level values.

Table 5. Westerlund Cointegration test (OPEC countries)

Statistics	Value	Z-Value	P-Value	Robust P-Value
Gt	-3.808	-2.984	0.001	0.000
Ga	-22.253	-1.128	0.130	0.000
Pt	-13.301	-3.666	0.000	0.010
Pa	-21.788	-2.345	0.009	0.000

Author's computation (using Stata 13)

The table illustrated above shows the result of the Westerlund co-integration test of the selected OPEC member states. The null hypothesis of this test posits that no co-integration is found within the series, which opposes the position of the alternative hypothesis of the existence of the long-run association. When cross-sectional dependence and structural fractures are present, a co-integration connection exists between variables. Because of this, over time, the variables tend to converge. Hence, the p-values obtained from the panel and group-mean test indicate that the null hypothesis of no long-run equilibrium should be rejected for OPEC nations. This indicates that per capita CO2 emissions, per capita GDP, fossil fuel consumption, the price of oil on the global market, and the measure of foreign direct investment are interdependent. Therefore, long-run equilibrium relationships exist between these variables for the study sample.

Table 6. Long-run PMG Result OPEC

Variables	Coefficients	Std. error	P-value
LNGDPC	6.188090	1.072192	0.0000
LNGDPSQ	-0.280968	0.051827	0.0000
LNWOP	0.409742	0.066867	0.0000
LNFDI	0.594767	0.249019	0.0177
LNFEC	0.153305	0.088887	0.0858

Author's computation (using Eviews 12)

The data shown above are the Long-run ARDL findings for Oil exporting nations. The data illustrate the link between the dependent variable CO2 emission, GDP per capita as a proxy for income and income squared, price of Oil, fossil fuel usage, and FDI. The findings indicate that all factors influence CO2 emission over the long run and are statistically significant at all conventional significance levels except the 10% significance level for fossil fuel energy consumption. This research used the variable lnGDPC, which has a positive coefficient and a statistically significant link with CO2 emission. However, the research findings reveal the long-run correlation between CO2 emissions and the independent variables. Our target variables, the GDP per capita and its square, have a considerable beneficial effect on CO2 emissions. If all else stays the same, a 1% increase in GDPC will result in a 6.188090% growth in carbon dioxide emissions. However, the quadratic form of GDPC displays a significant negative relationship with environmental deterioration, such that a percent increase in GDPsq produces a 0.280968% decrease in c02 emission. This confirms the existence of the environmental Kuznets curve hypothesis in oil-exporting nations. Oil price also has a significant positive correlation with carbon dioxide emissions. If the price of oil increases by 1%, environmental degradation will increase by 0.409742%.When the price of oil rises, exporting nations get more money in terms of revenues, which stimulates and spurs economic expansion, leading to more pollution. A percent increase in FDI raises C02 emissions by 0.594767 percent if all other factors remain constant. Since the FDI coefficient is positive and statistically significant, we deduce a robust positive correlation between carbon emissions and FDI. Furthermore, foreign direct investment (FDI) substantially impacts investors from other nations who do not adhere to environmental reduction policies and practices. Results also reveal that a rise in FDI leads to an increase in the marginal emission of carbon emissions. Moreover, the empirical findings shown in the table above indicate that the usage of fossil fuels significantly positively affects carbon dioxide emissions. For example, it is revealed that a percentage increase in fuel consumption increases c02 emissions by 0.153305% if the ceteris-paribus assumption holds. The reason is that most OPEC members are developing nations whose economic progress relies on fossil fuel usage, which exacerbates environmental deterioration.

Table 7. Short run PMG result (OPEC)

Variables	**Coefficients**	**Std. error**	**P-value**
D(LNGDPC(-3))	2.462575	7.124143	0.0507
D(LNGDPSQ(-3))	-0.860613	0.456504	0.0606
D(LNFEC) (-1)	0.262428	0.347455	0.0408
D(LNWOP(-2))	-0.067571	0.038277	0.0787
D(FDI(-2))	-0.113576	0.052956	0.0330
ECM(-1)	-0.158852	0.069328	0.0228

Author's computation (using Eviews 12)

The table above explains the short-term association among the variables measured in this analysis. Similar to the findings obtained in the long run, those obtained in the short run also show that our target variables (the first difference of GDP per capita and its square) positively and negatively influence CO2 emissions, respectively. The connection between the GDPC and environmental deterioration is positive in the short term but becomes negative or diminishes after a turning point is reached. Consequently, this suggests that in the short run, the connection between rising economic output and rising CO2 emissions takes the form of an upside-down U shape which implies support for EKC. The result illustrates that a percentage rise in lnGDPC will lead to a rise of 2.462575% in CO2 emission, which is a favorable outcome. Moreover, concerning lnGDPSQ, a one percent shift in GDPsq will result in a -0.860613 percentage point shift in CO2 emission reduction. A 1% rise in oil prices is related to a 0.067571% reduction in carbon emissions in oil-exporting countries. Thus, rising oil prices enable these countries to spend their oil income on diversification strategies, which has net positive environmental impacts. Ceteris-paribus, according to the law of demand, there will be an increase in demand for oil as the price of oil continues to plummet. This will inevitably lead to a rise in the use of energy derived from fossil fuels, which will hasten the destruction of the environment. Also, there is a significant short-run negative relationship between FDI and environmental degradation. For example, if FDI increases by one percent, C02 emission will decrease by -0.113576%. Because of corruption and political instability, FDI does not spur or promote economic growth in these countries. A significant positive relationship exists between fossil fuel consumption and environmental deterioration, such that a percentage increase in FEC elevates c02 emissions by 0.262428%. The coefficient of the error correction term delayed by one period (ECM) is negative (between 0 and 1) and statistically significant at the 5% significance level. This verifies the co-integration connection between the model's variables. Furthermore, it represents the speed of adjustment necessary to restore equilibrium in a dynamic model after a disruption. The error correction term has a coefficient of -0.158852; because of the significant inverse relationship, we can separate the short and long run. In other words, the statistically significant error correction term indicates that about 15.8852 percent of the previous year's disequilibrium or distortion is rectified and corrected in the current year.

Table 8. Descriptive statistics (oil importing countries)

	LNC02	LNGDPC	LNGDPSQ	LNFEC	LNWOP	FDI
Mean	19.72892	2.648035	7.073458	3.544793	7.383343	3.726816
Median	19.76739	2.656781	7.058485	3.570568	7.330075	3.689454
Maximum	22.53720	3.224370	10.39656	4.621290	10.06803	4.829845
Minimum	16.60517	3.32E-05	1.10E-09	1.651009	4.326750	5.41E-07
Std. Dev.	1.211910	0.247928	1.144995	0.702112	1.114207	0.209828
Skewness	0.248826	-3.226283	-1.022532	-0.621242	0.382537	-8.299240

Kurtosis	3.298710	29.44335	8.443920	3.145681	3.774942	166.7581
Jarque-Bera	8.590548	18892.60	862.3730	39.90727	30.23977	690851.6
Probability	0.013633	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	12074.10	1620.598	4328.956	2169.414	4518.606	2280.811
Sum Sq. Dev.	897.3909	37.55716	801.0298	301.1995	758.5309	26.90091
Observations	612	612	612	612	612	612

Author's computation (using Eviews 12)

The table shows the descriptive statistics of the variables relating to the 12 oil-importing countries. For example, the mean of LNCO2 emissions is 19.72892, and the range is between 16.60517 and 22.53720, showing that the variation is not large. Similarly, the mean values of our target variables (LNGDPC and LNGDPSQ) slightly vary in their range. For example, the mean values of LNGDPC and LNGDPSQ are 2.648035 and 1.124832, respectively. Further, the value of the range of LNGDPPC is between 3.32E-05 and 3.224370, and the range of LNGDPSQ is between 0.000626 and 106.3601. Generally, the ranges of our dependent and independent variables show low variation; the descriptive statistics of the other variables appear in the table above. Moreover, the above table reveals that four of our variables in the distribution are positively skewed, except the natural logarithm of LNWOP and LNGDPC, which shows negative skewness. In addition, all the variables have positive kurtosis. However, the table shows a leptokurtic positive kurtosis which shows higher values than the sample average of all variables except for LNC02, which values are below the sample average. Finally, the deviation of the variables from their means, as shown by the standard deviation, indicates a small growth rate (fluctuation) of these variables over the study period.

Table 9. Cross-sectional dependency test for Oil importing countries:

Test	**Statistics**	**p-value**
Breusch-Pagan LM	652.3879	0.0000
Pesaran scaled LM	51.03851	0.0000
Pesaran CD	10.67223	0.0000

Author's computation (using Eviews 12)

In the Table above, we provide the results of the CSD analysis. For oil-importing nations, in particular, the findings contradict the assumption of no CSD. Therefore, the oil-importing nations are CSD-positive. However, since the probability values are less than 5%, we reject the null hypothesis of cross-sectional independence and conclude strong evidence of cross-section dependency within the series. That is, because of economic cooperation, cultural exchange, political integration, and globalization, a shock in one country might have repercussions in others. After testing and proving the existence of CSD, Pesaran, 2007's "CIPS and Bai and Ng "PANIC unit root tests" are applied. Hence, the study accesses 2nd generation unit root test because the results of the first-generation unit root are not valid after evidence of CSD is found in the series. Nonetheless, both tests take CSD and serial correlation into account.

Due to the existence of cross-sectional dependence, the study utilizes the procedural second-generation panel unit root (CADF and CIPS) (see appendix III). However, the results from these examinations could have been more optimal due to structural breaks faced by one of the regressors. Hence, we have chosen to define and rely on the unit root proposed by Karavias and Tzavalis (2014), which is valid even when considering cross-sectional dependence.

Unit root for Oil importing economies.

Table 10. Karavias and Tzavalis unit root.

variable	**Constant**				**Constant and Trend**				**Integrations Order**
	level		1st difference		level		1st difference		
	Z-statistic	p-value	Z-statistic	p-value	Z-Statistic	P-Value	Z-statistic	P-Value	
lnC02	-0.0121	0.4700	-44.829	0.0000	-1.5122	0.3900	-26.6371	0.0000	I(1)
lnGDPC	-5.1945	0.0000	-------	------	-4.1169	0.0000	-------	------	I(0)
lnGDPsq	-35.166	0.0000	-------	------	-24.796	0.0000	--------	-------	I(0)
lnFEC	0.0090	1.000	-0.5980	0.0000	0.0006	0.9600	-0.4369	0.0000	I(1)

lnWOP	-2.5212	0.0000	------	-------	-1.0915	0.0000	-------	------	I(0)
lnFDI	-18.942	0.0000	---------	--------	-15.135	0.0490	-----	-------	I(0)

Author's computation (using Stata 13)

In this investigation, we used the panel unit root test that Karavias and Tzavalis (2014) developed to verify that all variables were stationary after accounting for the structural breaks. Since we do not know where the breaks are, we have to use the data to figure them out. All panel time series have a unit root; this is the null hypothesis to be tested. After accounting for the gaps, we used Stata's xtbunitroot command to ensure the series was stationary. Assuming no unit root exists in the series, we reject the null hypothesis if the p-value is less than 0.05. Results from the panel unit root test conducted by Karavias and Tzavalis (2014) are shown in the table above. The findings demonstrate that lnC02 and lnFEC are stationary at the initial difference I{1} in the presence of a structural break. Thus, our variables are integrated at different orders since the remaining variables are stationary in a level form I {0}.

Table 11. Westerlund Cointegration test (Oil importing countries)

Statistics	Value	Z-Value	P-Value	Robust P-Value
Gt	-3.021	-1.361	0.087	0.030
Ga	-8.187	2.853	0.997	0.150
Pt	-13.560	-4.940	0.000	0.020
Pa	-29.350	-5.284	0.077	0.049

Author's computation (using Stata 13)

To study the long-run connection between the variables when CSD is present, the researchers utilize the Westerlund panel cointegration test introduced by Westerlund (2007). The results of error-correction-based panel cointegration tests by Westerlund are shown in the table above. The P-value of the G_t and G_α test statistics uses the individually weighted averages of the estimated α_i's and t ratios. The P-value of the P_t and P_α test statistics pool information over the entire cross-sectional units and are significant at the 5% and 10% level, thus rejecting the null hypothesis of no cointegration. Two of them are derived by combining the error correction information along the cross-sectional dimension of the panel; they are referred to as panel statistics and denoted by P_t and P_α. The null hypothesis of panel statistics is that there is no cointegration. However, this opposes the alternative theory that the entire panel is cointegrated. The mean group statistics G_t and G_α do not use information about errors to compensate for them. In mean group statistics, the absence of cointegration serves as the null hypothesis. Conversely, the alternative hypothesis posits that some units are cointegrated. As a sensitivity analysis, the research evaluates the potential influence of cross-sectional dependencies in the panel data by utilizing the bootstrapping technique for 100 samples with robust probability values shown in the table above. The null hypothesis that no cointegration occurs is rejected based on results from the bootstrapping approach, which verifies earlier findings. Therefore, the outcome of the table rejects the null hypothesis of no cointegration, which reveals or suggests a long-run relationship between model variables.

Table 12. Long-run PMG Result Oil-importing countries

Variables	Coefficients	Std. error	P-value
LNGDPC	1.966178	0.505227	0.0001
LNGDPSQ	-0.364106	0.098018	0.0003
LNFDI	0.069738	0.018521	0.0002
LNFEC	1.187626	0.027360	0.0000
LNWOP	-0.007644	0.004484	0.0898

Author's computation (using Eviews 13)

The table above depicts the long-term relationship between CO2 emissions and the aforementioned independent factors. GDP per capita and GDP per capita square have positive and negative effects on CO2 emissions, making them two of our primary variables of interest. The result reveals that for every percentage rise in GDPC, it is expected that c02 emission increases by 1.966178%. Additionally, a one percent increase in GDP per capita square would result in a 0.364106 percent decline in CO2 emissions. Therefore, it does support the EKC's existence (inverted U-shape). That is to say, in advanced countries, the ratio of carbon emissions to economic growth (polluting intensity) was higher in the early stages of economic expansion, but it declines beyond a certain level of economic growth. This means that industrialized nations will produce and consume more environmental pollution commodities at the early stage of development. Energy-related businesses and industries will also see substantial growth but decline after reaching a certain threshold or turning point. Fossil fuel usage is positively correlated with environmental deterioration since it is a leading source of carbon dioxide (CO2) emissions. The effect of FEC is shown by the fact that a 1% increase in fossil fuel usage results in a 1.187626% increase in carbon emissions. Accordingly, the PMG ARDL outcome demonstrates a significant negative relationship between oil price and c02emission, such that a percentage increase in oil price would result in a 0.007644 percent decline in environmental degradation. Moreover, the report also shows a significant positive relationship between FDI and C02 emission, such that a percentage rise in FDI increases pollution by 0.069738% if the ceteris-paribus assumption holds.

Table 13. Short run PMG result (oil-importing countries)

Variables	Coefficients	Std. error	P-value
D(LNGDPC(-3))	0.278276	0.384629	0.0472
D(LNGDPSQ(-1))	-0.062864	0.070062	0.0377
D(LNFEC)	0.677411	0.173292	0.0001
D(LNWOP)	0.013648	0.007004	0.0527
D(FDI(-1))	-0.394225	0.208624	0.0603
ECM(-1)	-0.267481	0.150420	0.0769

Author's computation (using Eviews 12)

The factors used by the researcher in this inquiry are shown in the table above as their short-term effects. Following the long-term findings, in the short term, our variables of interest GDP per capita and its square) had a positive and negative effect on CO2 emissions, respectively.

Hence, the short-run result implies that the relationship between growing economic production and rising CO_2 emissions has the shape of an inverted U, which supports EKC. As a major determinant of c02 emissions, this estimation finds a significant positive association between fossil fuel energy consumption and environmental degradation in the short run. A percentage rise in fossil fuel energy consumption increases environmental damage by 0.677411%. On the other hand, oil price has a positively significant connection with c02 emission. Environmental deterioration increases by 0.013648% if the oil price increases by one percent if the ceteris-paribus assumption holds. LNFDI finds a significantly negative short-run connection with c02 emissions such that a percent rise in FDI diminishes c02 emissions by 0.394225%. The error correction model (ECM) is negative and statistically significant at 10% conventional significance levels. However, this implies that for any short-run distortion and deviation, the economy converges to the long-run equilibrium at 26.7481%.

CHAPTER V

Result and Discussions:

In this fifth section, the researchers seek to present, discuss and interpret the PMG ARDL and Westerlund cointegration test results. In addition, it presents and discusses a unit root examination that allows for structural breaks in determining the stationarity of the series used in this analysis. Finally, regarding the significance of economic growth and its impact on the environment, the current study investigates the nexus between environmental deterioration and economic growth within the framework of the EKC hypothesis by analyzing C02 emission, per capita GDP, fossil fuel consumption, and oil price for two panels of oil-exporting and oil-importing nations from 1970 to 2020. Countries and periods were chosen based on the availability of data. These parts aim to summarize each category of the country's findings, connect them to the EKC hypothesis examined in the first chapter, and assess if the study goals and questions were well addressed. Finally, the outcomes of the panel of oil-exporting and oil-importing economies are discussed in the following sections:

Findings and hypothesis of Oil-Exporting economies:

The analysis employed for the panel of oil exporting countries reveals that as income increases during the early stages of economic expansion, so do C02 emissions until they decrease as income moves to income-squared. According to the results, GDP per capita has a significant positive effect on carbon emissions, while GDP per capita squared has an inverse and significant effect on CO2 emissions. The study shows a long-term link between CO2 emissions and independent variables, as shown by the PMG-ARDL output of table 6. Our target variables, GDP per capita and its square, reduce CO2 emissions significantly. For example, a 1% GDPC rise will raise CO2 emissions by 6.188090%. Table 6 further reports that a percentage rise in GDPsq decreases C02 emissions by 0.280968%. Thus, the finding supports the EKC hypothesis. The outcome of the study's findings is consistent with the empirical investigation by Halicioglu F. (2009) and Ghazouani (2021). Therefore, investments in clean energy technology and sources are achievable as these OPEC nations continuously get wealthier. The PMG-ARDL result in table 6 reveals a significant positive association between oil price and CO2 emissions. Environmental deterioration will rise by 0.409742% if oil prices rise by 1%. When oil prices rise, exporting countries get more income, boosting economic growth and pollution. Nevertheless, since this increment in revenue will increase income, these oil-exporting countries will tend to diversify to improve environmental quality since they are getting richer. Meanwhile, this research finding is consistent with a study by

Achuo (2022) and Agbanike et al. (2019) in south Saharan Africa and Venezuela. If all conditions stay unchanged, FDI increases C02 emissions by 0.594767 percent. Since the FDI coefficient is positive and statistically significant, carbon emissions and FDI are strongly correlated. Foreign direct investment (FDI) also affects investors from countries without environmental legislation. As a result, FDI may raise the volume of economic activity in the host nation, diversify exports, and cause structural changes in the economy by introducing new sectors. Thus, the result of this study conforms to Seker et al. (2015) examination of the effects of GDP, FDI, and energy consumption in Turkey. Also, the Long-run result of table 6 reports that fossil fuels considerably increase carbon dioxide emissions. If the ceteris-paribus assumption holds, fossil fuel consumption raises CO_2 emissions by 0.153305%. This is because; consumption of fossil fuel energy consumption is one of the prominent causes of environmental deterioration. Compared to the other determinants of environmental pollution, energy consumption has a more prominent role in degrading the environment because fossil fuels often create emissions. However, the outcome of this finding is consistent with the work of Gong et al. (2021) and Ogundipe et al. (2019).

Thus, this work's central argument and finding support the EKC hypothesis for oil-exporting countries. As oil exports rise in oil-exporting countries, so does the creation of money. However, an increase in such revenue will increase the nation's wealth. Consequently, these nations will focus more on environmental preservation by implementing stringent rules for a sustainable environment. This conclusion has pivotal ramifications for our understanding of environmental quality in OPEC nations because demand for it grows with per capita wealth. Energy-efficient technology adoption, strengthened environmental regulations and institutions, and trade liberalization all play vital roles in facilitating this shift.

H0: There is no significant relationship between economic growth and environmental deterioration in Oil exporting economies:

NO: When tested against the results for these OPEC countries, this null hypothesis should be rejected because the results reveal a statistically significant relationship or association between environmental degradation and various stages of economic development.

H1: A strong association exists between environmental degradation and economic expansion in oil-exporting nations:

Yes: The alternative hypothesis will be accepted because it shows a positive but significant relationship between income and environmental degradation. Furthermore, this relationship turns negative as income rises to income-squared, which fits with the theory that the environmental Kuznets curve is usually an inverted U-shaped curve.

H0: There is no significant relationship between oil prices and environmental degradation in Oil-exporting economies.

NO: This hypothesis, when examined, should be rejected in the context of oil-exporting countries because the result shows a positive long-run association between oil prices and environmental degradation.

H1: A strong positive correlation exists between oil prices and environmental degradation in oil-exporting nations.

YES: When evaluated, this hypothesis should be accepted in the context of oil-exporting nations because the result shows a strong positive long-run correlation between oil prices and environmental degradation.

H0: No increasing association exists between foreign direct investment and C02 emissions in oil-exporting economies.

No: This theory should be rejected in the case of oil-exporting countries since the finding demonstrates a solid positive long-run link between FDI and environmental deterioration.

H1: A strong positive correlation exists between foreign direct investments and environmental degradation in oil-exporting economies.

YES: The empirical findings of this research suggest that this hypothesis should be accepted since the result reveals an increasing association between FDI and C02 emissions.

Findings and hypothesis of Oil-importing countries:

The EKC hypothesis is the most well-known theory that attempts to explain the connection between economic activity and environmental deterioration. The primary reason for doing this research was to see whether the PMG estimate approach would be suitable for testing the EKC hypothesis for OPEC and oil-importing nations from 1970 to 2020. Foreign direct investment was introduced to the model with GDP per capita, GDP per capita squared, fossil fuel use, and the price of oil in order to assess its impact on CO2 emissions in these nations. However, based on the findings of this work, the EKC hypothesis was also supported in the context of oil-importing countries. The analysis found that long-term correlations between GDP growth and CO2 emissions follow a inverted U-curve that Kuznets predicted. So, the correlation between GDP per capita and CO2 emissions is positive until GDP per capita reaches (the tipping point) but negative afterward.

However, the report in table 12 reveals the result of the PMG-ARDL for oil-importing countries. The table's result shows statistical significance at all conventional levels of per capita GDP and its quadratic form. However, GDP per capita and GDP per capita square have positive and negative effects on CO2 emissions, making them two of our primary variables of interest. The result shows that for every percentage increase in GDPC, c02 emission increases by 1.966178%. Also, a one percent rise in Per capita GDP square diminishes c02 emissions by 0.364106%. Thus, the result of this finding supports the EKC hypothesis. In advanced oil-importing economies, the ratio of carbon emissions to economic growth (polluting intensity) was higher in the early stages of economic expansion but declined beyond a certain level of economic growth. This indicates that developed countries would create and consume more environmental pollution goods during the first stages of their growth. Similarly, energy-related firms and sectors will see rapid expansion followed by a collapse at a given threshold or turning point**.** Moreover, because these nations are rich, they invest heavily in clean energy technologies by diversifying their energy portfolios**,** reducing oil consumption growth. Thus, this study is consistent with previous work done by Narayan et al. (2016) when they compare OECD and non-OECD nations. Moreover, the study's findings conform to the previous contribution to the literature**. Al-Mulali et al. (2015), Alam et al. (2021), and Nordin & Sek (2021).** Also, the table depicts that fossil fuel energy consumption positively correlates with environmental deterioration since it is a prominent source of carbon dioxide (CO2) emissions. The effect of FEC is shown by the fact that a 1% increase in fossil fuel usage results in a 1.187626% increase in carbon emissions. This result corroborates the findings of Barreto et al. (2021), addressing the correlation between oil consumption and c02 emissions in G7 nations. Furthermore, Ismail et al. (2022) argue that non-renewable energy consumption significantly increases environmental pollution, which this study's finding also confirms. Also, table 12 reports that the PMG ARDL outcome demonstrates a significant negative relationship between oil price and c02 emission. Accordingly, the findings indicate that a percentage increase in oil price would result in a 0.007644 percent decline in environmental degradation. The implication is that as energy costs increase, these wealthy nations demand less oil and invest in other energy sources, resulting in reduced c02 emissions. Moreover, the report also shows a significant positive relationship between FDI and C02 emission, such that a percentage rise in FDI increases pollution by 0.069738% if the ceteris-paribus assumption holds.

Therefore, for the economic expansion of oil-importing nations to effectively decrease CO2 emissions in the long term, intentional measures such as environmental conservation legislation, the adoption of new technologies that minimize pollution, and the modernization of the current industries are necessary and significant. Moreover, because these nations are rich, they invest heavily in clean energy technologies by diversifying their energy portfolios**,** reducing oil consumption growth. Emission efficiency increases with time due to technological advancements; hence, this study detects an evident decline in carbon pollution in oil-importing countries.

H0: There is no significant relationship between economic growth and environmental deterioration in Oil importing economies:

No: This null hypothesis should be rejected when evaluated against the data for these oil-importing nations since the results demonstrate a statistically significant link between environmental deterioration.

H1: A strong association exists between economic expansion environmental degradation and in oil-importing nations:

YES: The alternative hypothesis will be accepted since it exhibits a strong and statistically significant correlation between per capita GDP and environmental deterioration.

H0: There is no significant relationship between oil prices and environmental degradation in Oil-importing economies.

NO: This hypothesis, when tested, should be rejected in the context of oil-importing countries because the result shows a negative long-run association between oil prices and environmental degradation.

YES: Upon evaluation, this hypothesis should be accepted in the context of oil-importing countries since the outcome exhibits a significant negative long-term link between oil prices and environmental deterioration.

H0: No increasing association exists between foreign direct investment and C02 emissions in oil-importing and importing economies.

NO: A significant positive long-run correlation between FDI and environmental degradation was found, suggesting that this hypothesis should be rejected in the case of oil-importing nations.

H1: A strong positive correlation exists between foreign direct investments and environmental degradation in oil- importing economies.

YES: The empirical findings of this research suggest that this hypothesis should be accepted since the result reveals an increasing association between FDI and C02 emissions in oil-importing countries.

CHAPTER VI

Conclusion and Recommendation:

Introduction:

This chapter concludes the study by summarizing the key research findings regarding the research aims and questions and the value and contribution thereof. It will also review the study's limitations and propose opportunities for future research.

Conclusion

In this research, we aim to examine and compare the validity of the environmental Kuznets curve and the relationship between c02 emissions, Per capita GDP, per capita GDP square, fossil fuel consumption, oil price, and foreign direct investment in advanced oil-importing countries and oil-exporting economies from 1970 to 2020. Due to economic cooperation, cultural interaction, political integration, and globalization, a shock in one nation might have implications for other nations. Hence, we conducted the cross-sectional dependency test for both panels of countries. The result provides substantial evidence of cross-sectional dependency, which leads to adopting the second-generation unit root. Therefore, we employed the CADF and CIPS unit root tests, as well as the xtbunitroot test with structural break dates, to accomplish the goals of this research. The study employed Westerlund's (2007) bootstrap cointegration technique for the group of nations undertaken by the investigation to test the existence of long-run association among the variables. The result reveals the existence of cointegration in oil-exporting and oil-importing countries, and because of this, we conclude that there is a long-run relationship between the variables. The methodology employed for this research is the PMG-ARDL model established by Pesaran et al. (1999), which assesses the short- and long-run nexus between the regressand and the variables of interest. It allows long-run coefficients to be homogeneous while short-run coefficients differ across cross-sections. The present study contributes to the empirical literature by evaluating the EKC hypothesis and comparing oil-exporting and oil-importing economies using the PMG-ARDL model testing method. The impact of evaluating economic development and environmental pollution variables may have different outcomes on both country groups because of different economic structures and environmental approaches related to natural energy resources. Therefore, investigating the EKC hypothesis on oil-exporting and oil-importing countries separately to understand the effect of variables employed in this analysis is more valuable. The empirical finding of this research indicates a statistically significant association among the variables measured in both the short-run and long-run for the panel of oil-exporting countries. In the long run, the coefficient estimated for per capita GDP is 6.188090%. This implies a 6.188090% increment in environmental degradation for every percent increase in per capita GDP. However, deterioration of the environment reduces by 0.280968% if per capita GDP square increases by one percent. Therefore, the present research findings support the EKC theory because the level of environmental pollution rises in tandem with expanding economic activity, which reaches a stable level and then begins to fall. The acceptance to support this hypothesis is because these countries heavily depend on oil exportation as a significant source of revenue generation. Hence, as the exportation of oil increases, so thus income and production. However, income stimulation makes these nations wealthy and, consequently, focuses more on environmental preservation by implementing stringent rules for a sustainable environment. This result has crucial implications for our knowledge of environmental quality in OPEC countries, given that the demand for it increases as per capita income rises. In addition, the development of energy-efficient technologies, the strengthening of environmental rules and institutions, and the liberalization of international commerce all played crucial roles in aiding this transformation. The outcome of the study's findings is consistent with the empirical investigation by Halicioglu F. (2009), Zoundi (2017), Al-Mulali et al. (2022), and Ghazouani (2021). Therefore, investments in clean energy technology and sources are achievable as these OPEC nations continuously get wealthier. For oil-importing countries, the result reports a statistically significant connection between the variables undertaken by this investigation. The result reveals that for every percentage rise in GDPC, it is expected that c02 emission increases by 1.966178%. Additionally, a one percent increase in GDP per capita square would result in a 0.364106 percent decline in CO_2 emissions. Also, the EKC hypothesis is supported in the context of advanced oil-importing countries. The evidence established by this work accepting this hypothesis is because oil is imported into these advanced economies to increase production, and as the level of production increases, so does income. With a higher income level, they acquire more money and tend to invest in clean energy. In other words, in developed nations, the ratio of carbon emissions to economic growth (polluting intensity) was more extensive in the early stages of economic development. Consequently, it decreased beyond a certain degree of economic expansion. Hence, the result indicates that industrialized countries would create and consume more environmental pollution goods during the first stages of their growth. Energy-related firms and sectors will also experience rapid expansion, followed by a specific threshold or turning point decrease. Thus, this study is consistent with previous work done by Narayan et al. (2016) when they compare OECD and non-OECD nations. Moreover, the study's findings conform to the previous contribution to the literature. Al-Mulali et al. (2015), Alam et al. (2021), and Nordin & Sek (2021).Henceforth, when we compare the EKC hypothesis in both country groups, it is evident that the significant similarity is that both panels of countries support the EKC framework. In addition, FDI and fossil fuel consumption have the same long-run positive effects on c02 emissions. The main difference between both country groups is that oil prices positively affect CO_2 emissions in exporting countries while negatively affecting environmental degradation in oil-importing countries.

Policy implication and recommendation:

In the context of policy ramifications, this analysis offers intriguing approaches to reaching carbon neutrality objectives. First, we recommend that there should be an immediate need to regulate climate change policies and reduce greenhouse gas emissions (GHGs). However, based on the study's findings, we propose that increasing green growth is an efficient means of reducing CO_2 emissions and achieving sustainable development. This modification is crucial because they redirect limited resources to reducing pollution emissions rather than manufacturing things for sale. Second, the investment in nuclear power plants needs to be enhanced since nuclear energy contributes to environmental quality. Moreover, nuclear energy is a steady and cost-effective resource. Since nuclear power is ecologically beneficial, it might solve oil-exporting and advanced nations' expanding energy demands and help reduce reliance on imported energy. Additionally, they should encourage substituting fossil fuels with nuclear energy and building technologically advanced new reactors. Meanwhile, these nations' governments should encourage the nuclear energy industry by enacting low-tax policies and providing tax exemptions and incentives for importing nuclear energy technology. In addition, nuclear energy providers, both at home and abroad, should be incentivized by policymakers to undertake green energy investments. Finally, due to the positive effects of nuclear power on the environment, advanced countries should employ more nuclear power to generate electricity.

Limitation of the study:

The researchers could not get several control variables that the study would have benefited from using. Future research may examine the association by including other control variables for various nation groups using various approaches. Despite this, the tests demonstrated that the variables in the research and the rigorous technique used are adequate.

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Appendix: (Oil-exporting Countries)

Descriptive Statistics (OPEC)

	LNC02	LNGDPC	LNGDPQ	LNWOP	LNFEC	LNFD1
Mean	17.55286	8.718517	81.32289	3.544793	5.065546	2.381670
Median	17.95032	8.755351	76.65627	3.570568	5.060152	2.330773
Maximum	20.42894	12.61828	159.2209	4.621290	8.088934	3.902592
Minimum	12.68365	-6.74E-06	4.55E-11	1.651009	1.786373	3.13E-07
Std. Dev.	1.619749	2.306305	35.21676	0.702112	1.464140	0.274206
Skewness	-0.814240	-1.118801	-0.105463	-0.621242	0.035656	-0.176504
Kurtosis	3.268588	4.583131	2.879093	3.145681	2.036466	22.30892
Jarque-Bera	69.46429	191.5857	1.507265	39.90727	23.80381	9510.454
Probability	0.000000	0.000000	0.470654	0.000000	0.000007	0.000000
Sum	10742.35	5335.732	49769.61	2169.414	3100.114	1457.582
Sum Sq. Dev.	1603.012	3249.937	757774.6	301.1995	1309.803	45.94042
Observations	612	612	612	612	612	612

Cross-sectional dependency test:

Residual Cross-Section Dependence Test

Null hypothesis: No cross-section dependence (correlation) in residuals

Equation: Untitled

Periods included: 51

Cross-sections included: 12

Total panel observations: 612

Note: non-zero cross-section means detected in data

Cross-section means were removed during computation of correlations

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	580.2067	66	0.0000
Pesaran scaled LM	44.75595		0.0000
Pesaran CD	5.882418		0.0000

CADF unit root test:

```
. pescadf lC02, lag(1)
Pesaran's CADF test for lC02
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -2.422   -2.150    -2.250    -2.430   -2.416     0.008


pescadf d.lC02, lag(1)
Pesaran's CADF test for D.lC02
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -5.238   -2.140    -2.250    -2.440  -12.782     0.000


. pescadf lC02, lag(1) trend
Pesaran's CADF test for lC02
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
   t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -2.733   -2.660    -2.760    -2.930   -1.203     0.049

. pescadf d.lC02, lag(1) trend
Pesaran's CADF test for D.lC02
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
   t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -5.341   -2.660    -2.760    -2.930  -11.813     0.000
```

```
. pescadf lGDPC, lag(1)
Pesaran's CADF test for lGDPC
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
   t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
  -2.493   -2.150    -2.250    -2.430   -2.683     0.004
```

```
. pescadf d.lGDPC, lag(1)
Pesaran's CADF test for D.lGDPC
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -4.218   -2.140    -2.250    -2.440   -9.022     0.000
```

```
. pescadf lGDPC, lag(1) trend
Pesaran's CADF test for lGDPC
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -3.164   -2.660    -2.760    -2.930   -3.319     0.000
```

```
. pescadf d.lGDPC, lag(1) trend
Pesaran's CADF test for D.lGDPC
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -4.273   -2.660    -2.760    -2.930   -7.610     0.000
```

```
. pescadf lGDPsq, lag(1)
Pesaran's CADF test for lGDPsq
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -2.455   -2.150    -2.250    -2.430   -2.542     0.006

. pescadf d.lGDPsq, lag(1)
Pesaran's CADF test for D.lGDPsq
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
   t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -3.946   -2.140    -2.250    -2.440   -8.021     0.000


. pescadf lGDPsq, lag(1) trend
Pesaran's CADF test for lGDPsq
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -3.117   -2.660    -2.760    -2.930   -3.130     0.001


. pescadf d.lGDPsq, lag(1) trend
Pesaran's CADF test for D.lGDPsq
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -4.001   -2.660    -2.760    -2.930   -6.538     0.000
```

```
. pescadf lFEC, lag(1)
Pesaran's CADF test for lFEC
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
   t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -1.612   -2.150    -2.250    -2.430    0.632     0.736
```

```
. pescadf d.lFEC, lag(1)
Pesaran's CADF test for D.lFEC
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -4.795   -2.140    -2.250    -2.440  -11.148     0.000
```

```
. pescadf lFEC, lag(1) trend
Pesaran's CADF test for lFEC
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -2.332   -2.660    -2.760    -2.930    0.031     0.512
```

```
. pescadf d.lFEC, lag(1) trend
Pesaran's CADF test for D.lFEC
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -5.034   -2.660    -2.760    -2.930  -10.604     0.000
```

```
. pescadf lWOP, lag(1)
Pesaran's CADF test for lWOP
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
    2.610   -2.150    -2.250    -2.430   16.530     1.000


. pescadf d.lWOP, lag(1)
Pesaran's CADF test for D.lWOP
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
    2.610   -2.140    -2.250    -2.440   16.141     1.000

. pescadf lWOP, lag(1) trend
Pesaran's CADF test for lWOP
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
    1.700   -2.660    -2.760    -2.930   16.273     1.000


. pescadf d.lWOP, lag(1) trend
Pesaran's CADF test for D.lWOP
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
    1.700   -2.660    -2.760    -2.930   15.903     1.000

. pescadf lFDI, lag(1)
Pesaran's CADF test for lFDI
Cross-sectional average in first period extracted and extreme t-values
truncated
```

```
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -2.773   -2.150    -2.250    -2.430   -3.740     0.000

. pescadf d.lFDI, lag(1)
Pesaran's CADF test for D.lFDI
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -6.021   -2.140    -2.250    -2.440  -15.667     0.000

. pescadf lFDI, lag(1) trend
Pesaran's CADF test for lFDI
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
   t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -2.821   -2.660    -2.760    -2.930   -1.937     0.026

. pescadf d.lFDI, lag(1) trend
Pesaran's CADF test for D.lFDI
Cross-sectional average in first period extracted and extreme t-values
truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -6.192   -2.660    -2.760    -2.930  -15.162     0.000
```

CIPS UNIT ROOT:

```
. xtcips lC02, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lC02
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
H0 (homogeneous non-stationary): bi = 0 for all i
```

```
CIPS =    -2.411        N,T = (12,51)
----------------------------------------------------
                   |       10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.15      -2.25      -2.43
----------------------------------------------------

. xtcips d.lC02, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lC02
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.145        N,T = (12,50)
----------------------------------------------------
                   |       10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.14      -2.25      -2.44
----------------------------------------------------

. xtcips lC02, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lC02
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS =    -2.810        N,T = (12,51)
----------------------------------------------------
                   |       10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.66      -2.76      -2.93
----------------------------------------------------

. xtcips d.lC02, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lC02
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
```

```
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.359        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------

. xtcips lGDPC, maxlag(2) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lGDPC
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -2.432        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.15      -2.25      -2.43
-----------------------------------------------------

. xtcips d.lGDPC, maxlag(2) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lGDPC
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -5.226        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.14      -2.25      -2.44
-----------------------------------------------------

. xtcips lGDPC, maxlag(2) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lGDPC
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
```

```
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -3.065        N,T = (12,51)
----------------------------------------------------
                   |       10%         5%         1%
-------------------+--------------------------------
Critical values at |     -2.66      -2.76      -2.93
----------------------------------------------------

. xtcips d.lGDPC, maxlag(2) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lGDPC
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -5.343        N,T = (12,50)
----------------------------------------------------
                   |       10%         5%         1%
-------------------+--------------------------------
Critical values at |     -2.66      -2.76      -2.93
----------------------------------------------------

. xtcips lGDPsq, maxlag(2) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lGDPsq
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -2.496        N,T = (12,51)
----------------------------------------------------
                   |       10%         5%         1%
-------------------+--------------------------------
Critical values at |     -2.15      -2.25      -2.43
----------------------------------------------------

 . xtcips d.lGDPsq, maxlag(2) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lGDPsq
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
```

```
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -5.096        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.14      -2.25      -2.44
-----------------------------------------------------

. xtcips lGDPsq, maxlag(2) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lGDPsq
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -3.087        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------

. xtcips d.lGDPsq, maxlag(2) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lGDPsq
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -5.138        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------
. xtcips lFEC, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lFEC
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
```

```
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -1.706        N,T = (12,51)
---------------------------------------------------
                   |        10%         5%         1%
-------------------+-------------------------------
Critical values at |      -2.15      -2.25      -2.43
---------------------------------------------------

. xtcips d.lFEC, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lFEC
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -5.773        N,T = (12,50)
---------------------------------------------------
                   |        10%         5%         1%
-------------------+-------------------------------
Critical values at |      -2.14      -2.25      -2.44
---------------------------------------------------
```

```
. xtcips lFEC, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lFEC
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -2.368        N,T = (12,51)
---------------------------------------------------
                   |        10%         5%         1%
-------------------+-------------------------------
Critical values at |      -2.66      -2.76      -2.93
---------------------------------------------------

. xtcips d.lFEC, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lFEC
Deterministics chosen: constant & trend
```

```
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.051        N,T = (12,50)
----------------------------------------------------
                   |        10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.66      -2.76      -2.93
----------------------------------------------------
. xtcips lWOP, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lWOP
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =     2.610        N,T = (12,51)
----------------------------------------------------
                   |        10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.15      -2.25      -2.43
----------------------------------------------------

. xtcips d.lWOP, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lWOP
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =     2.610        N,T = (12,50)
----------------------------------------------------
                   |        10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.14      -2.25      -2.44
----------------------------------------------------


. xtcips lWOP, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lWOP
Deterministics chosen: constant & trend
```

```
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =     1.700        N,T = (12,51)
----------------------------------------------------
                   |        10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.66      -2.76      -2.93
----------------------------------------------------

. xtcips d.lWOP, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lWOP
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =     1.700        N,T = (12,50)
----------------------------------------------------
                   |        10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.66      -2.76      -2.93
----------------------------------------------------
. xtcips lFDI, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lFDI
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -3.717        N,T = (12,51)
----------------------------------------------------
                   |        10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.15      -2.25      -2.43
----------------------------------------------------


. xtcips d.lFDI, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lFDI
Deterministics chosen: constant
```

```
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.190        N,T = (12,50)
----------------------------------------------------
                   |        10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.14      -2.25      -2.44
----------------------------------------------------

. xtcips lFDI, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for lFDI
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS =    -3.811        N,T = (12,51)
----------------------------------------------------
                   |        10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.66      -2.76      -2.93
----------------------------------------------------

. xtcips d.lFDI, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first difference mean
included for D.lFDI
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F joint
test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.408        N,T = (12,50)
----------------------------------------------------
                   |        10%         5%         1%
-------------------+--------------------------------
Critical values at |      -2.66      -2.76      -2.93
----------------------------------------------------
```

Xtbunitroot for OPEC:

```
. xtbunitroot lC02
Karavias and Tzavalis (2014) panel unit root test for lC02
---------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
---------------------------------------------------------------------------
--
Number of panels:                  12        Avrge number of periods: 51.00
Number of breaks:                  1         Bootstrap replications:  100
Cross-section dependence:          No        Linear time trend:       No
Cross-section heteroskedasticity: No         Normal errors:           No
---------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
---------------------------------------------------------------------------
--
 minZ-statistic      -0.1118            -0.2659                0.2400
---------------------------------------------------------------------------
--
Result: the null is not rejected
Significance level of test:  .05


. xtbunitroot d.lC02
Karavias and Tzavalis (2014) panel unit root test for D.lC02
---------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
---------------------------------------------------------------------------
--
Number of panels:                  12        Avrge number of periods: 50.00
Number of breaks:                  1         Bootstrap replications:  100
Cross-section dependence:          No        Linear time trend:       No
Cross-section heteroskedasticity: No         Normal errors:           No
---------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
---------------------------------------------------------------------------
--
 minZ-statistic      -9.8987            -9.4021                0.0300
```

```
----------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1971
Significance level of test:  .05


. xtbunitroot lC02, trend
Karavias and Tzavalis (2014) panel unit root test for lC02
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                  12        Avrge number of periods: 51.00
Number of breaks:                  1         Bootstrap replications:  100
Cross-section dependence:          No        Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value        p-value
----------------------------------------------------------------------------
--
 minZ-statistic      -0.4134            -0.4552                 0.0800
----------------------------------------------------------------------------
--
Result: the null is not rejected
Significance level of test:  .05


. xtbunitroot d.lC02, trend
Karavias and Tzavalis (2014) panel unit root test for D.lC02
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                  12        Avrge number of periods: 50.00
Number of breaks:                  1         Bootstrap replications:  100
Cross-section dependence:          No        Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
```

```
                    Statistic   Bootstrap critical-value       p-value
----------------------------------------------------------------------------
--
 minZ-statistic      -6.7263            -6.1310                0.0200
----------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1972
Significance level of test:  .05

. xtbunitroot lGDPC
Karavias and Tzavalis (2014) panel unit root test for lGDPC
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 51.00
Number of breaks:                 1         Bootstrap replications:  100
Cross-section dependence:         No        Linear time trend:       No
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
----------------------------------------------------------------------------
--
 minZ-statistic      -0.9618            -2.5728                0.3000
----------------------------------------------------------------------------
--
Result: the null is not rejected
Significance level of test:  .05

. xtbunitroot d.lGDPC
Karavias and Tzavalis (2014) panel unit root test for D.lGDPC
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 50.00
Number of breaks:                 1         Bootstrap replications:  100
Cross-section dependence:         No        Linear time trend:       No
Cross-section heteroskedasticity: No        Normal errors:           No
```

```
--------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
--------------------------------------------------------------------------
--
 minZ-statistic     -44.7052           -4.0893                0.0000
--------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1972
Significance level of test:  .05

. xtbunitroot lGDPC, trend
Karavias and Tzavalis (2014) panel unit root test for lGDPC
--------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 51.00
Number of breaks:                 1         Bootstrap replications:  100
Cross-section dependence:         No        Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
--------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
--------------------------------------------------------------------------
--
 minZ-statistic      -0.6281           -1.4700                0.2600
--------------------------------------------------------------------------
--
Result: the null is not rejected
Significance level of test:  .05

. xtbunitroot d.lGDPC, trend
Karavias and Tzavalis (2014) panel unit root test for d.lGDPC
--------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 50.00
Number of breaks:                 1         Bootstrap replications:  100
Cross-section dependence:         No        Linear time trend:       Yes
```

```
Cross-section heteroskedasticity: No        Normal errors:           No
-----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
-----------------------------------------------------------------------------
--
 minZ-statistic     -26.4262             -5.8830                 0.0000
-----------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1973
Significance level of test:  .05

. xtbunitroot lGDPsq
Karavias and Tzavalis (2014) panel unit root test for lGDPsq
-----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
-----------------------------------------------------------------------------
--
Number of panels:                  12        Avrge number of periods: 51.00
Number of breaks:                  1         Bootstrap replications:  100
Cross-section dependence:          No        Linear time trend:       No
Cross-section heteroskedasticity: No        Normal errors:           No
-----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
-----------------------------------------------------------------------------
--
 minZ-statistic      -3.6910             -6.8686                 0.2200
-----------------------------------------------------------------------------
--
Result: the null is not rejected
Significance level of test:  .05

. xtbunitroot d.lGDPsq
Karavias and Tzavalis (2014) panel unit root test for D.lGDPsq
-----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
-----------------------------------------------------------------------------
--
Number of panels:                  12        Avrge number of periods: 50.00
Number of breaks:                  1         Bootstrap replications:  100
```

```
Cross-section dependence:         No        Linear time trend:       No
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
----------------------------------------------------------------------------
--
 minZ-statistic     -41.7829            -18.2514               0.0000
----------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1972
Significance level of test:  .05

. xtbunitroot lGDPsq, trend
Karavias and Tzavalis (2014) panel unit root test for lGDPsq
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 51.00
Number of breaks:                 1         Bootstrap replications:  100
Cross-section dependence:         No        Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
----------------------------------------------------------------------------
--
 minZ-statistic      -1.3101            -6.0102                0.5900
----------------------------------------------------------------------------
--
Result: the null is not rejected
Significance level of test:  .05

. xtbunitroot d.lGDPsq, trend
Karavias and Tzavalis (2014) panel unit root test for D.lGDPsq
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 50.00
```

```
Number of breaks:                  1        Bootstrap replications:  100
Cross-section dependence:          No       Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
----------------------------------------------------------------------------
--
 minZ-statistic     -24.8371            -9.8703                0.0000
----------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      2015
Significance level of test:  .05

. xtbunitroot lFEC
Karavias and Tzavalis (2014) panel unit root test for lFEC
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                  12       Avrge number of periods: 51.00
Number of breaks:                  1        Bootstrap replications:  100
Cross-section dependence:          No       Linear time trend:       No
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
----------------------------------------------------------------------------
--
 minZ-statistic       0.0127            -0.0506                1.0000
----------------------------------------------------------------------------
--
Result: the null is not rejected
Significance level of test:  .05

. xtbunitroot d.lFEC
Karavias and Tzavalis (2014) panel unit root test for D.lFEC
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
```

```
Number of panels:                  12       Avrge number of periods: 50.00
Number of breaks:                  1        Bootstrap replications:  100
Cross-section dependence:          No       Linear time trend:       No
Cross-section heteroskedasticity: No       Normal errors:           No
---------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
---------------------------------------------------------------------------
--
 minZ-statistic      -4.5925             -4.0108               0.0200
---------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      2018
Significance level of test:  .05

xtbunitroot lFEC, trend
Karavias and Tzavalis (2014) panel unit root test for lFEC
---------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
---------------------------------------------------------------------------
--
Number of panels:                  12       Avrge number of periods: 51.00
Number of breaks:                  1        Bootstrap replications:  100
Cross-section dependence:          No       Linear time trend:       Yes
Cross-section heteroskedasticity: No       Normal errors:           No
---------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
---------------------------------------------------------------------------
--
 minZ-statistic      -0.1063             -0.1839               0.2700
---------------------------------------------------------------------------
--
Result: the null is not rejected
Significance level of test:  .05

. xtbunitroot d.lFEC, trend
Karavias and Tzavalis (2014) panel unit root test for D.lFEC
---------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
```

```
--------------------------------------------------------------------------
--
Number of panels:                  12       Avrge number of periods: 50.00
Number of breaks:                  1        Bootstrap replications:  100
Cross-section dependence:          No       Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
--------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
--------------------------------------------------------------------------
--
 minZ-statistic      -3.2328            -2.8625               0.0100
--------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      2017
Significance level of test:  .05

. xtbunitroot lWOP
Karavias and Tzavalis (2014) panel unit root test for lWOP
--------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------------
--
Number of panels:                  12       Avrge number of periods: 51.00
Number of breaks:                  1        Bootstrap replications:  100
Cross-section dependence:          No       Linear time trend:       No
Cross-section heteroskedasticity: No        Normal errors:           No
--------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
--------------------------------------------------------------------------
--
 minZ-statistic      -2.2981            0.0001               0.0000
--------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1973
Significance level of test:  .05


. xtbunitroot d.lWOP
Karavias and Tzavalis (2014) panel unit root test for D.lWOP
```

```
--------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------------
--
Number of panels:                  12        Avrge number of periods: 50.00
Number of breaks:                  1         Bootstrap replications:  100
Cross-section dependence:          No        Linear time trend:       No
Cross-section heteroskedasticity: No        Normal errors:           No
--------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
--------------------------------------------------------------------------
--
 minZ-statistic     -32.5417            0.3746                 0.0000
--------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      2018
Significance level of test:  .05


. xtbunitroot lWOP, trend
Karavias and Tzavalis (2014) panel unit root test for lWOP
--------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------------
--
Number of panels:                  12        Avrge number of periods: 51.00
Number of breaks:                  1         Bootstrap replications:  100
Cross-section dependence:          No        Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
--------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value       p-value
--------------------------------------------------------------------------
--
 minZ-statistic      -1.7269            -0.0318                0.0000
--------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1973
Significance level of test:  .05
```

```
. xtbunitroot d.lWOP, trend
Karavias and Tzavalis (2014) panel unit root test for D.lWOP
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 50.00
Number of breaks:                 1         Bootstrap replications:  100
Cross-section dependence:         No        Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value        p-value
----------------------------------------------------------------------------
--
 minZ-statistic     -21.2579            0.2249                  0.0000
----------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1974
Significance level of test:  .05

. xtbunitroot lFDI
Karavias and Tzavalis (2014) panel unit root test for lFDI
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 51.00
Number of breaks:                 1         Bootstrap replications:  100
Cross-section dependence:         No        Linear time trend:       No
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value        p-value
----------------------------------------------------------------------------
--
 minZ-statistic     -27.5254            -4.0295                 0.0000
----------------------------------------------------------------------------
--
```

```
Result: the null is rejected
Estimated break date(s):      2014
Significance level of test:  .05

. xtbunitroot d.lFDI
Karavias and Tzavalis (2014) panel unit root test for D.FDI
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 50.00
Number of breaks:                 1         Bootstrap replications:  100
Cross-section dependence:         No        Linear time trend:       No
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value        p-value
----------------------------------------------------------------------------
--
 minZ-statistic     -77.5777             -2.3687                0.0000
----------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1971
Significance level of test:  .05

. xtbunitroot lFDI, trend
Karavias and Tzavalis (2014) panel unit root test for FDI
----------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------------
--
Number of panels:                 12        Avrge number of periods: 51.00
Number of breaks:                 1         Bootstrap replications:  100
Cross-section dependence:         No        Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
----------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value        p-value
----------------------------------------------------------------------------
--
 minZ-statistic     -16.9560             -2.2423                0.0000
```

```
--------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      2014
Significance level of test:  .05

. xtbunitroot d.lFDI, trend
Karavias and Tzavalis (2014) panel unit root test for D.FDI
--------------------------------------------------------------------------
--
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------------
--
Number of panels:                  12       Avrge number of periods: 50.00
Number of breaks:                  1        Bootstrap replications:  100
Cross-section dependence:          No       Linear time trend:       Yes
Cross-section heteroskedasticity: No        Normal errors:           No
--------------------------------------------------------------------------
--
                    Statistic   Bootstrap critical-value        p-value
--------------------------------------------------------------------------
--
 minZ-statistic     -47.7618            -1.7435                0.0000
--------------------------------------------------------------------------
--
Result: the null is rejected
Estimated break date(s):      1972
Significance level of test:  .05
```

Westerlund Co-integration test:

```
. xtwest lC02 lGDPC lGDPsq lFEC lWOP lFD, constant trend lags(0) leads(0)
lrwindow(1) bootstrap(100)
Bootstrapping critical values under H0..........
Calculating Westerlund ECM panel cointegration tests..........
Results for H0: no cointegration
With 12 series and 5 covariates
```

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-3.808	-2.984	0.001	0.000
Ga	-22.253	-1.128	0.130	0.000
Pt	-13.301	-3.666	0.000	0.010
Pa	-21.788	-2.345	0.009	0.000

PMG-ARDL Appendix (OPEC)

Dependent Variable: D(LNC02)

Method: ARDL

Date: 12/07/22 Time: 08:27

Sample: 1975 2020

Included observations: 552

Dependent lags: 4 (Fixed)

Dynamic regressors (5 lags, fixed): LNGDPC LNGDPQ LNWOP LNFD1 LNFEC

Fixed regressors: C

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
	Long Run Equation			
LNGDPC	6.188090	1.072192	5.771439	0.0000
LNGDPQ	-0.280968	0.051827	-5.421218	0.0000
LNWOP	0.409742	0.066867	6.127701	0.0000
LNFD1	0.594767	0.249019	2.388441	0.0177
LNFEC	0.153305	0.088887	1.724713	0.0858
	Short Run Equation			
COINTEQ01	-0.158852	0.069328	-2.291329	0.0228
D(LNC02(-1))	-0.137513	0.077741	-1.768853	0.0782
D(LNC02(-2))	-0.176934	0.074327	-2.380478	0.0180
D(LNC02(-3))	-0.112004	0.051726	-2.165314	0.0313
D(LNGDPC)	21.71529	22.29478	0.974007	0.3310
D(LNGDPC(-1))	-7.544185	18.36299	-0.410836	0.6815
D(LNGDPC(-2))	13.99158	5.541851	0.444360	0.6572
D(LNGDPC(-3))	2.462575	7.124143	1.963967	0.0507
D(LNGDPC(-4))	-5.382009	7.376362	-0.729629	0.4663
D(LNGDPQ)	-1.215135	1.317551	-0.922268	0.3573
D(LNGDPQ(-1))	0.398086	1.101707	0.361336	0.7182
D(LNGDPQ(-2))	-0.078546	0.341122	-0.230258	0.8181
D(LNGDPQ(-3))	-0.860613	0.456504	-1.885225	0.0606
D(LNGDPQ(-4))	0.293142	0.435385	0.673295	0.5014
D(LNWOP)	-0.050584	0.049711	-1.017564	0.3099
D(LNWOP(-1))	-0.064809	0.041474	-1.562648	0.1194
D(LNWOP(-2))	-0.067571	0.038277	-1.765334	0.0787
D(LNWOP(-3))	-0.039841	0.046096	-0.864286	0.3883
D(LNWOP(-4))	0.052819	0.043262	1.220908	0.2233
D(LNFD1)	-0.029734	0.123250	-0.241251	0.8096
D(LNFD1(-1))	-0.143427	0.115117	-1.245921	0.2140
D(LNFD1(-2))	-0.113576	0.052956	-2.144700	0.0330
D(LNFD1(-3))	-0.092114	0.076927	-1.197411	0.2323

D(LNFD1(-4))	-0.074730	0.046535	-1.605896	0.1096
D(LNFEC)	0.057899	0.167437	0.345797	0.7298
D(LNFEC(-1))	0.262428	0.347455	0.755287	0.0408
D(LNFEC(-2))	0.073535	0.266685	0.275737	0.7830
D(LNFEC(-3))	0.046688	0.276021	0.169146	0.8658
D(LNFEC(-4))	0.397243	0.347044	1.144645	0.2535
C	-2.917017	1.299245	-2.245163	0.0256

Root MSE	0.079362	Mean dependent var	0.027666
S.D. dependent var	0.177902	S.E. of regression	0.124922
Akaike info criterion	-1.145920	Sum squared resid	3.854565
Schwarz criterion	1.488242	Log likelihood	715.6516
Hannan-Quinn criter.	-0.121405		

*Note: p-values and any subsequent tests do not account for model selection.

Appendix: (Oil-importing Countries)

Descriptive Statistics: Oil-Importing countries

	LNC02	LNGDPC	LNGDPSQ	LNWOP	LNFEC	LNFDI
Mean	19.72892	2.648035	7.073458	3.544793	7.383343	3.726816
Median	19.76739	2.656781	7.058485	3.570568	7.330075	3.689454
Maximum	22.53720	3.224370	10.39656	4.621290	10.06803	4.829845
Minimum	16.60517	3.32E-05	1.10E-09	1.651009	4.326750	5.41E-07
Std. Dev.	1.211910	0.247928	1.144995	0.702112	1.114207	0.209828
Skewness	0.248826	-3.226283	-1.022532	-0.621242	0.382537	-8.299240
Kurtosis	3.298710	29.44335	8.443920	3.145681	3.774942	166.7581
Jarque-Bera	8.590548	18892.60	862.3730	39.90727	30.23977	690851.6
Probability	0.013633	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	12074.10	1620.598	4328.956	2169.414	4518.606	2280.811
Sum Sq. Dev.	897.3909	37.55716	801.0298	301.1995	758.5309	26.90091
Observations	612	612	612	612	612	612

Cross-sectional dependency test: Oil-importing Countries:

Residual Cross-Section Dependence Test
Null hypothesis: No cross-section dependence (correlation) in residuals
Equation: Untitled
Periods included: 51
Cross-sections included: 12
Total panel observations: 612
Note: non-zero cross-section means detected in data
Cross-section means were removed during computation of correlations

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	821.5287	66	0.0000
Pesaran scaled LM	65.76033		0.0000
Pesaran CD	16.68755		0.0000

CADF Unit root:

```
Pesaran's CADF test for lC02
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 576
Augmented by 2 lags (average)
 t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
 -1.976   -2.150    -2.250    -2.430   -0.737     0.231

Pesaran's CADF test for D.lC02
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 564
Augmented by 2 lags (average)
  t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
  -3.977   -2.140    -2.250    -2.440   -8.132     0.000
pescadf lC02, lag(2) trend
Pesaran's CADF test for lC02
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 576
Augmented by 2 lags (average)
 t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
 -2.258   -2.660    -2.760    -2.930    0.332     0.630

pescadf d.lC02, lag(2) trend
Pesaran's CADF test for D.lC02
Cross-sectional average in first period   extracted   and extreme t-
values      truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs =   564
Augmented by 2 lags (average)
t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
-4.430   -2.660    -2.760    -2.930 -8.228      0.000

pescadf lGDPC, lag(1)
Pesaran's CADF test for lGDPC
```

```
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -4.119   -2.150    -2.250    -2.430   -8.808     0.000
pescadf d.lGDPC, lag(1)
Pesaran's CADF test for D.lGDPC
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -5.893   -2.140    -2.250    -2.440  -15.194     0.000

pescadf lGDPC, lag(1) trend
Pesaran's CADF test for lGDPC
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -4.301   -2.660    -2.760    -2.930   -7.899     0.000
pescadf d.lGDPC, lag(1) trend
Pesaran's CADF test for D.lGDPC
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -6.080   -2.660    -2.760    -2.930  -14.721     0.000

pescadf lGDPsq, lag(2)
Pesaran's CADF test for lGDPsq
Cross-sectional average in first period   extracted   and extreme t-
values      truncated
Deterministics chosen: constant
```

```
t-bar test, N,T = (12,51)         Obs =   576
Augmented by 2 lags (average)
t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
-3.526   -2.150    -2.250    -2.430 -6.576      0.000

pescadf d.lGDPsq, lag(1)
Pesaran's CADF test for D.lGDPsq
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -6.004   -2.140    -2.250    -2.440  -15.602     0.000

pescadf lGDPsq, lag(1) trend
Pesaran's CADF test for lGDPsq
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -4.378   -2.660    -2.760    -2.930   -8.211     0.000
pescadf d.lGDPsq, lag(1) trend
Pesaran's CADF test for D.lGDPsq
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -6.180   -2.660    -2.760    -2.930  -15.115     0.000

pescadf lFEC, lag(1)
Pesaran's CADF test for lFEC
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
```

```
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -1.850   -2.150    -2.250    -2.430   -0.265     0.395

. pescadf d.lFEC, lag(1)
Pesaran's CADF test for D.lFEC
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -4.577   -2.140    -2.250    -2.440  -10.344     0.000
. pescadf lFEC, lag(1) trend
Pesaran's CADF test for lFEC
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -2.419   -2.660    -2.760    -2.930   -0.319     0.375

pescadf d.lFEC, lag(1) trend
Pesaran's CADF test for D.lFEC
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -4.912   -2.660    -2.760    -2.930  -10.123     0.000

. pescadf lWOP, lag(1)
Pesaran's CADF test for lWOP
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
    2.610   -2.150    -2.250    -2.430   16.530     1.000
```

```
. pescadf d.lWOP, lag(1)
Pesaran's CADF test for D.lWOP
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
    2.610   -2.140    -2.250    -2.440   16.141     1.000

. pescadf lWOP, lag(1) trend
Pesaran's CADF test for lWOP
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
    1.700   -2.660    -2.760    -2.930   16.273     1.000

. pescadf d.lWOP, lag(1) trend
Pesaran's CADF test for D.lWOP
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
    1.700   -2.660    -2.760    -2.930   15.903     1.000
```

```
pescadf lFDI, lag(1)
Pesaran's CADF test for lFDI
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -2.867   -2.150    -2.250    -2.430   -4.092     0.000
```

```
. pescadf d.lFDI, lag(1)
Pesaran's CADF test for D.lFDI
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -5.803   -2.140    -2.250    -2.440  -14.864     0.000
```

```
. pescadf lFDI, lag(1) trend
Pesaran's CADF test for lFDI
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,51)         Obs = 588
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -3.657   -2.660    -2.760    -2.930   -5.304     0.000
```

```
. pescadf d.lFDI, lag(1) trend
Pesaran's CADF test for D.lFDI
Cross-sectional average in first period extracted and extreme t-
values truncated
Deterministics chosen: constant & trend
t-bar test, N,T = (12,50)         Obs = 576
Augmented by 1 lags (average)
    t-bar     cv10      cv5       cv1   Z[t-bar]    P-value
   -5.913   -2.660    -2.760    -2.930  -14.066     0.000
```

CIPS Unit Root

```
. xtcips lC02, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lC02
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS =    -2.249        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.15      -2.25      -2.43
-----------------------------------------------------
xtcips d.lC02, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lC02
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i

CIPS* =    -6.104        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.14      -2.25      -2.44

. xtcips lC02, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lC02
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS =    -2.675        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
```

```
xtcips d.lC02, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lC02
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.333        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------
```

```
xtcips lGDPC, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lGDPC
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -5.316        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.15      -2.25      -2.43
-----------------------------------------------------
```

```
xtcips d.lGDPC, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lGDPC
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
```

```
CIPS* =    -5.967        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.14      -2.25      -2.44
-----------------------------------------------------
```

```
xtcips lGDPC, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lGDPC
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -5.495        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------
```

```
xtcips d.lGDPC, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lGDPC
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.179        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------
```

```
. xtcips lGDPsq, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lGDPsq
```

```
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -5.399        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.15      -2.25      -2.43
-----------------------------------------------------

. xtcips d.lGDPsq, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lGDPsq
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.166        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.14      -2.25      -2.44
-----------------------------------------------------


. xtcips lGDPsq, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lGDPsq
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -5.619        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
```

```
-----------------------------------------------------


xtcips d.lGDPsq, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lGDPsq
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.376        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------

. xtcips lFEC, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lFEC
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS =    -2.230        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.15      -2.25      -2.43
-----------------------------------------------------


. xtcips d.lFEC, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lFEC
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
```

```
CIPS* =    -6.077        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.14      -2.25      -2.44
-----------------------------------------------------


. xtcips lFEC, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lFEC
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS =    -2.732        N,T = (12,51)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------



. xtcips d.lFEC, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lFEC
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.220        N,T = (12,50)
-----------------------------------------------------
                   |        10%         5%         1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------

. xtcips lWOP, maxlag(1) bglags(1)
```

```
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lWOP
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i

CIPS* =     2.610        N,T = (12,51)
-----------------------------------------------------
                   |        10%          5%         1%
-------------------+---------------------------------
Critical values at |      -2.15      -2.25      -2.43
-----------------------------------------------------

. xtcips d.lWOP, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lWOP
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =     2.610        N,T = (12,50)
-----------------------------------------------------
                   |        10%          5%         1%
-------------------+---------------------------------
Critical values at |      -2.14      -2.25      -2.44
-----------------------------------------------------

. xtcips lWOP, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lWOP
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =     1.700        N,T = (12,51)
-----------------------------------------------------
                   |        10%          5%         1%
```

```
------------------+-----------------------------------
Critical values at |      -2.66      -2.76      -2.93
------------------------------------------------------

. xtcips d.lWOP, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lWOP
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =     1.700        N,T = (12,50)
------------------------------------------------------
                   |        10%          5%          1%
------------------+-----------------------------------
Critical values at |      -2.66      -2.76      -2.93
------------------------------------------------------


. xtcips lFDI, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lFDI
Deterministics chosen: constant
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -4.030        N,T = (12,51)
------------------------------------------------------
                   |        10%          5%          1%
------------------+-----------------------------------
Critical values at |      -2.15      -2.25      -2.43
------------------------------------------------------


. xtcips d.lFDI, maxlag(1) bglags(1)
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lFDI
Deterministics chosen: constant
```

```
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.190        N,T = (12,50)
-----------------------------------------------------
                   |        10%          5%          1%
-------------------+---------------------------------
Critical values at |      -2.14      -2.25      -2.44
-----------------------------------------------------

. xtcips lFDI, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for lFDI
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -4.745        N,T = (12,51)
-----------------------------------------------------
                   |        10%          5%          1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------

. xtcips d.lFDI, maxlag(1) bglags(1) trend
Pesaran Panel Unit Root Test with cross-sectional and first
difference mean included for D.lFDI
Deterministics chosen: constant & trend
Dynamics: lags criterion decision General to Particular based on F
joint test
Individual ti were truncated during the aggregation process
H0 (homogeneous non-stationary): bi = 0 for all i
CIPS* =    -6.420        N,T = (12,50)
-----------------------------------------------------
                   |        10%          5%          1%
-------------------+---------------------------------
Critical values at |      -2.66      -2.76      -2.93
-----------------------------------------------------
```

.

Karavias and Tzavalis unit root (Xtbunitroot)

```
. xtbunitroot lC02
Karavias and Tzavalis (2014) panel unit root test for lC02
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
51.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
No
Cross-section heteroskedasticity: No        Normal errors:
No
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
----------------------------------------------------------------------
----------
 minZ-statistic      -0.0121            -0.0956         0.4700
----------------------------------------------------------------------
----------
Result: the null is not rejected
Significance level of test:  .05
```

```
. xtbunitroot d.C02
Karavias and Tzavalis (2014) panel unit root test for D.lC02
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
```

```
--------------------------------------------------------------------
Number of panels:                  12        Avrge number of periods:
50.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
No
Cross-section heteroskedasticity: No         Normal errors:
No
--------------------------------------------------------------------
   Statistic          zBootstrap critical-value        p-value
--------------------------------------------------------------------
 minZ-statistic     -44.8293             -16.0435       0.0000
--------------------------------------------------------------------
Result: the null is rejected
Estimated break date(s):       2018
Significance level of test:  .05

. xtbunitroot lC02, trend
Karavias and Tzavalis (2014) panel unit root test for lC02
--------------------------------------------------------------------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
51.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
Yes
Cross-section heteroskedasticity: No         Normal errors:
No
--------------------------------------------------------------------
                    Statistic   Bootstrap critical-value   p-value
--------------------------------------------------------------------
 minZ-statistic      -0.0461             -0.1343          0.3400
--------------------------------------------------------------------
----------
Result: the null is not rejected
Significance level of test:  .05
```

```
. xtbunitroot d.lC02, trend
Karavias and Tzavalis (2014) panel unit root test for D.C02
---------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
---------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
50.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
Yes
Cross-section heteroskedasticity: No        Normal errors:
No
---------------------------------------------------------------------
----------
                   Statistic   Bootstrap critical-value   p-value
---------------------------------------------------------------------
----------
 minZ-statistic     -26.6371            -10.1926        0.0000
---------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2017
Significance level of test:  .05
```

```
. xtbunitroot lGDPC
Karavias and Tzavalis (2014) panel unit root test for lGDPC
---------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
```

```
----------------------------------------------------------------------
----------
Number of panels:                  12         Avrge number of periods:
51.00
Number of breaks:                  1          Bootstrap replications:
100
Cross-section dependence:          No         Linear time trend:
No
Cross-section heteroskedasticity: No          Normal errors:
No
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
----------------------------------------------------------------------
----------
 minZ-statistic      -5.1945             -3.1364          0.0000
----------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2019
Significance level of test:  .05

. xtbunitroot d.lGDPC
Karavias and Tzavalis (2014) panel unit root test for D.lGDPC
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------
----------
Number of panels:                  12         Avrge number of periods:
50.00
Number of breaks:                  1          Bootstrap replications:
100
Cross-section dependence:          No         Linear time trend:
No
Cross-section heteroskedasticity: No          Normal errors:
No
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
```

```
----------------------------------------------------------------------
----------
 minZ-statistic     -26.3483             -8.3272         0.0000
----------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2018
Significance level of test:  .05

. xtbunitroot lGDPC, trend
Karavias and Tzavalis (2014) panel unit root test for lGDPC
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------
----------
Number of panels:                12        Avrge number of periods:
51.00
Number of breaks:                1         Bootstrap replications:
100
Cross-section dependence:        No        Linear time trend:
Yes
Cross-section heteroskedasticity: No       Normal errors:
No
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
----------------------------------------------------------------------
----------
 minZ-statistic      -4.1169             -2.8677           0.0000
----------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      1972
Significance level of test:  .05


. xtbunitroot d.lGDPC, trend
Karavias and Tzavalis (2014) panel unit root test for D.lGDPC
```

```
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
50.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
Yes
Cross-section heteroskedasticity: No         Normal errors:
No
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
----------------------------------------------------------------------
----------
 minZ-statistic     -17.6175             -5.2795          0.0000
----------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2017
Significance level of test:  .05

. xtbunitroot lGDPsq
Karavias and Tzavalis (2014) panel unit root test for lGDPsq
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
51.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
No
```

```
Cross-section heteroskedasticity: No       Normal errors:
No
--------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
--------------------------------------------------------------------
----------
 minZ-statistic     -35.1662             -4.3654           0.0000
--------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2019
Significance level of test:  .05

. xtbunitroot d.lGDPsq
Karavias and Tzavalis (2014) panel unit root test for D.lGDPsq
--------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
50.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
No
Cross-section heteroskedasticity: No       Normal errors:
No
--------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
--------------------------------------------------------------------
----------
 minZ-statistic     -67.5538             -2.9545           0.0000
--------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2018
Significance level of test:  .05
```

```
. xtbunitroot lGDPsq, trend
Karavias and Tzavalis (2014) panel unit root test for lGDPsq
--------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
51.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
Yes
Cross-section heteroskedasticity: No         Normal errors:
No
--------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value     p-value
--------------------------------------------------------------------
----------
 minZ-statistic     -24.7963             -3.4896          0.0000
--------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      1972
Significance level of test:  .05


. xtbunitroot d.lGDPsq, trend
Karavias and Tzavalis (2014) panel unit root test for D.lGDPsq
--------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
50.00
```

```
Number of breaks:                1        Bootstrap replications:
100
Cross-section dependence:        No       Linear time trend:
Yes
Cross-section heteroskedasticity: No       Normal errors:
No
--------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
--------------------------------------------------------------------
----------
 minZ-statistic     -40.5636             -1.9124         0.0000
--------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2017
Significance level of test:  .05

. xtbunitroot lFEC
Karavias and Tzavalis (2014) panel unit root test for lFEC
--------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------
----------
Number of panels:                12       Avrge number of periods:
51.00
Number of breaks:                1        Bootstrap replications:
100
Cross-section dependence:        No       Linear time trend:
No
Cross-section heteroskedasticity: No       Normal errors:
No
--------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value    p-value
--------------------------------------------------------------------
----------
 minZ-statistic       0.0090             -0.0220            1.0000
```

```
----------------------------------------------------------------------
----------
Result: the null is not rejected
Significance level of test:  .05


. xtbunitroot d.lFEC
Karavias and Tzavalis (2014) panel unit root test for D.lFEC
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
50.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
No
Cross-section heteroskedasticity: No         Normal errors:
No
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
----------------------------------------------------------------------
----------
 minZ-statistic      -0.5980            -0.2539           0.0000
----------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2018
Significance level of test:  .05

. xtbunitroot lFEC, trend
Karavias and Tzavalis (2014) panel unit root test for lFEC
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
```

```
------------------------------------------------------------------------------
Number of panels:                  12        Avrge number of periods:
51.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
Yes
Cross-section heteroskedasticity: No        Normal errors:
No
------------------------------------------------------------------------------
                    Statistic   Bootstrap critical-value   p-value
------------------------------------------------------------------------------
 minZ-statistic       0.0006            -0.0264          0.9600
------------------------------------------------------------------------------
Result: the null is not rejected
Significance level of test:  .05

. xtbunitroot d.lFEC, trend
Karavias and Tzavalis (2014) panel unit root test for D.lFEC
------------------------------------------------------------------------------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
------------------------------------------------------------------------------
Number of panels:                  12        Avrge number of periods:
50.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
Yes
Cross-section heteroskedasticity: No        Normal errors:
No
------------------------------------------------------------------------------
                    Statistic   Bootstrap critical-value   p-value
```

```
---------------------------------------------------------------------
----------
 minZ-statistic      -0.4369             -0.1902        0.0000
---------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2017
Significance level of test:  .05

. xtbunitroot lWOP
Karavias and Tzavalis (2014) panel unit root test for lWOP
---------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
---------------------------------------------------------------------
----------
Number of panels:                12        Avrge number of periods:
51.00
Number of breaks:                1         Bootstrap replications:
100
Cross-section dependence:        No        Linear time trend:
No
Cross-section heteroskedasticity: No       Normal errors:
No
---------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
---------------------------------------------------------------------
----------
 minZ-statistic      -2.5212             0.0131            0.0000
---------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      1972
Significance level of test:  .05

. xtbunitroot d.lWOP
Karavias and Tzavalis (2014) panel unit root test for D.lWOP
---------------------------------------------------------------------
----------
```

```
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------
----------
Number of panels:                 12        Avrge number of periods:
50.00
Number of breaks:                 1         Bootstrap replications:
100
Cross-section dependence:         No        Linear time trend:
No
Cross-section heteroskedasticity: No        Normal errors:
No
--------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
--------------------------------------------------------------------
----------
 minZ-statistic     -33.8812             0.4061           0.0000
--------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2018
Significance level of test:  .05

. xtbunitroot lWOP, trend
Karavias and Tzavalis (2014) panel unit root test for lWOP
--------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------
----------
Number of panels:                 12        Avrge number of periods:
51.00
Number of breaks:                 1         Bootstrap replications:
100
Cross-section dependence:         No        Linear time trend:
Yes
Cross-section heteroskedasticity: No        Normal errors:
No
```

```
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
----------------------------------------------------------------------
----------
 minZ-statistic      -1.0915             -0.0233           0.0000
----------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      1973
Significance level of test:  .05

. xtbunitroot d.lWOP, trend
Karavias and Tzavalis (2014) panel unit root test for D.lWOP
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
50.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
Yes
Cross-section heteroskedasticity: No        Normal errors:
No
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
----------------------------------------------------------------------
----------
 minZ-statistic     -21.8118             0.2409            0.0000
----------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      1974
Significance level of test:  .05
```

```
. xtbunitroot lFDI
Karavias and Tzavalis (2014) panel unit root test for lFDI
--------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
51.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
No
Cross-section heteroskedasticity: No         Normal errors:
No
--------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
--------------------------------------------------------------------
----------
 minZ-statistic     -18.9420             -12.3519        0.0000
--------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2017
Significance level of test:  .05


. xtbunitroot d.lFDI
Karavias and Tzavalis (2014) panel unit root test for D.lFDI
--------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
--------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
50.00
Number of breaks:                  1         Bootstrap replications:
100
```

```
Cross-section dependence:         No        Linear time trend:
No
Cross-section heteroskedasticity: No        Normal errors:
No
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value    p-value
----------------------------------------------------------------------
----------
 minZ-statistic     -63.9686             -11.0471           0.0000
----------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2018
Significance level of test:  .05


. xtbunitroot lFDI, trend
Karavias and Tzavalis (2014) panel unit root test for lFDI
----------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
----------------------------------------------------------------------
----------
Number of panels:                 12        Avrge number of periods:
51.00
Number of breaks:                 1         Bootstrap replications:
100
Cross-section dependence:         No        Linear time trend:
Yes
Cross-section heteroskedasticity: No        Normal errors:
No
----------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value        p-
value
----------------------------------------------------------------------
 minZ-statistic     -15.1353             -16.6485           0.0490
----------------------------------------------------------------------
----------
```

```
Result: the null is not rejected
Significance level of test:  .05

. xtbunitroot d.lFDI, trend
Karavias and Tzavalis (2014) panel unit root test for D.lFDI
---------------------------------------------------------------------
----------
H0: All panel time series are unit root processes
H1: Some or all of the panel time series are stationary processes
---------------------------------------------------------------------
----------
Number of panels:                  12        Avrge number of periods:
50.00
Number of breaks:                  1         Bootstrap replications:
100
Cross-section dependence:          No        Linear time trend:
Yes
Cross-section heteroskedasticity: No        Normal errors:
No
---------------------------------------------------------------------
----------
                    Statistic   Bootstrap critical-value   p-value
---------------------------------------------------------------------
----------
 minZ-statistic     -39.5792             -6.6690          0.0000
---------------------------------------------------------------------
----------
Result: the null is rejected
Estimated break date(s):      2016
Significance level of test:  .05
```

Panel co-integration test (Westerlund)

```
. xtwest lC02 lGDPC lGDPsq lFEC lWOP lFDI, constant trend lags(0) leads(0)
lrwindow(0) bootstrap(100)
Bootstrapping critical values under H0..........
Calculating Westerlund ECM panel cointegration tests..........
Results for H0: no cointegration
With 12 series and 5 covariates
```

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-3.021	-1.361	0.087	0.030
Ga	-8.1870	2.853	0.997	0.150
Pt	-13.560	-4.940	0.000	0.020
Pa	-29.350	-5.248	0.777	0.049

PMG-ARDL Estimation: Appendix for oil-importing country

Dependent Variable: D(LNC02)
Method: ARDL
Date: 12/01/22 Time: 22:14
Sample: 1977 2020
Included observations: 528
Dependent lags: 7 (Fixed)
Dynamic regressors (5 lags, fixed): LNGDPC LNGDPSQ LNFDI LNFEC LNWOP
Fixed regressors: C

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
		Long Run Equation		
LNGDPC	1.966178	0.505227	3.891672	0.0001
LNGDPSQ	-0.364106	0.098018	-3.714689	0.0003
LNFDI	0.069738	0.018521	3.765336	0.0002
LNFEC	1.187626	0.027360	43.40702	0.0000
LNWOP	-0.007644	0.004484	-1.704749	0.0898
		Short Run Equation		
COINTEQ01	-0.267481	0.150420	-1.778232	0.0769
D(LNC02(-1))	0.064835	0.117220	0.553103	0.5808
D(LNC02(-2))	0.055424	0.093069	0.595508	0.5522
D(LNC02(-3))	0.061571	0.117455	0.524212	0.6007
D(LNC02(-4))	-0.043696	0.111599	-0.391542	0.6958
D(LNC02(-5))	-0.005807	0.049085	-0.118314	0.9059
D(LNC02(-6))	0.033093	0.026516	1.248045	0.2135
D(LNGDPC)	-0.532808	0.406724	-1.309999	0.1917

D(LNGDPC(-1))	0.291423	0.356867	0.816614	0.4151
D(LNGDPC(-2))	0.257155	0.399821	0.643176	0.5209
D(LNGDPC(-3))	0.278276	0.384629	0.723493	0.0472
D(LNGDPC(-4))	-0.005158	0.296340	-0.017407	0.9861
D(LNGDPSQ)	0.102305	0.078043	1.310881	0.1914
D(LNGDPSQ(-1))	-0.062864	0.070062	-0.897261	0.0377
D(LNGDPSQ(-2))	-0.053403	0.076914	-0.694321	0.4883
D(LNGDPSQ(-3))	-0.055593	0.073711	-0.754201	0.4516
D(LNGDPSQ(-4))	0.003388	0.057819	0.058595	0.9533
D(LNFDI)	-0.047120	0.113142	-0.416469	0.6775
D(LNFDI(-1))	-0.394225	0.208624	-1.889649	0.0603
D(LNFDI(-2))	0.010987	0.137169	0.080099	0.9362
D(LNFDI(-3))	-0.169393	0.136125	-1.244391	0.2148
D(LNFDI(-4))	-0.028771	0.030162	-0.953911	0.3413
D(LNFEC)	0.677411	0.173292	3.909079	0.0001
D(LNFEC(-1))	-0.187832	0.160103	-1.173194	0.2421
D(LNFEC(-2))	-0.080011	0.118036	-0.677850	0.4987
D(LNFEC(-3))	-0.022616	0.116552	-0.194046	0.8463
D(LNFEC(-4))	0.069339	0.130271	0.532267	0.5951
D(LNWOP)	0.013648	0.007004	1.948784	0.0527
D(LNWOP(-1))	0.001598	0.005795	0.275772	0.7830
D(LNWOP(-2))	-0.018937	0.011160	-1.696899	0.0913
D(LNWOP(-3))	-0.010366	0.007399	-1.400992	0.1628
D(LNWOP(-4))	0.000905	0.014733	0.061436	0.9511
C	2.328417	1.284308	1.812973	0.0713
@TREND	-0.006812	0.004900	-1.390180	0.1660

Root MSE	0.019825	Mean dependent var	0.001328
S.D. dependent var	0.074233	S.E. of regression	0.034767
Akaike info criterion	-4.474926	Sum squared resid	0.240539
Schwarz criterion	-1.494354	Log likelihood	1782.327
Hannan-Quinn criter.	-3.315680		

*Note: p-values and any subsequent tests do not account for model selection.

APPENDIX II

Table 14. CADF unit root (OPEC countries)

variable	**Constant**				**Constant and Trend**				**Integrations Order**
	level		1st difference		level		1st difference		
	T statistic	p-value	T statistic	p-value	T Statistic	P-Value	T-statistic	P-Value	
lnC02	-2.422	0.008	------	------	-2.733	0.049	-------	----	I(0)
lnGDPC	-2.493	0.004	------	------	-3.164	0.000	-------	------	I(0)
lnGDPsq	-2.455	0.006	------	-----	-3.117	0.001	--------	------	I(0)
lnFEC	-1.612	0.736	-4.795	0.000	-2.332	0.512	-5.034	0.000	I(1)

Table 15. CIPS unit root test (OPEC Countries)

Variable	**Constant**		**Constant and Trend**		Order of integration
	Level	1stDifference	Level	1stDifference	
lnC02	-2.411**	-------	-2.810**	------	I(0)
lnGDPC	-2.432**	-------	-3.065**	------	I(0)
lnGDPsq	-2.496**	-------	-3.087**	------	I(0)
lnFEC	-1.706	-5.773**	-2.368	-6.051**	I(1)
lnWOP	2.610	2.610	1.700	1.700	I(2)
lnFDI	-3.717**	-------	3.811**	------	I(0)

Appendix III

Table 16. CADF unit root (oil importing countries)

variable	Constant				Constant and Trend				Integrations Order
	level		1^{st} difference		level		1^{st} difference		
	T statistic	p-value	T statistic	p-value	T Statistic	P-Value	T-statistic	P-Value	
lnC02	-1.976	0.231	-3.977	0.000	-2.258	0.630	-4.430	0.000	I(1)
lnGDPC	-4.119	0.000	-----	------	-4.301	0.000	------	------	I(0)
lnGDPsq	-3.999	0.000	------	----	-4.450	0.000	------	-------	I(0)
lnFEC	-1.850	0.395	-4.577	0.000	-2.419	0.375	-4.912	0.000	I(1)
lnWOP	2.610	1.000	2.610	1.000	1.700	1.000	1.700	1.000	I(2)
lnFDI	-2.912	0.000	------	-----	-3.355	0.000	--------	-------	I(0)

Table 17. CIPS unit root test (oil importing Countries)

Variable	Constant		Constant and Trend		Order of integration
	Level	1stDifference	Level	1^{st}Difference	
lnC02	-2.249	-6.104**	-2.675	-6.333**	I(1)
lnGDPC	-5.316**	-------	-5.495**	--------	I(0)
lnGDPsq	-5.265**	------	-5.561**	-------	I(0)
lnFEC	-2.230	-6.077**	-2.732	-6.220**	I(1)
lnWOP	2.610	2.610	1.700	1.700	I(2)

lnFDI	-4.398**	------	-4.952**	-------	I(0)

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NEAR EAST UNIVERSITY

SCIENTIFIC RESEARCH ETHICS COMMITTEE

21.11.2022

Dear Joseph Tuakolon Tokpah

Your project “**Carbon Emıssıon And Economıc Growth Nexus: An Empırıcal Evaluatıon On Testıng The Envıronmental Kuznets Curve(Ekc) Hypothesıs In Oıl Exportıng And Importıng Economıes**” has been evaluated. Since only secondary data will be used the project does not need to go through the ethics committee. You can start your research on the condition that you will use only secondary data.

Prof. Dr. Aşkın KİRAZ

The Coordinator of the Scientific Research Ethics Committee

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