FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

THE IMPACT OF ENERGY TRILEMMA (ENERGY EQUITY, ENERGY SECURITY, AND ENVIRONMENTAL SUSTAINABILITY) ON ECONOMIC GROWTH FOR THE VARIOUS WORLD ECONOMIES

A dissertation submitted in partial fulfillment of

the requirements for the degree of

DOCTOR OF BUSINESS ADMINISTRATION

by

Ijeoma Nnenna Odizuru-Abangwu

2024

To: Dean William G. Hardin
College of Business

This dissertation, written by Ijeoma Nnenna Odizuru-Abangwu and entitled The Impact of Energy Trilemma (Energy Equity, Energy Security, and Environmental Sustainability) on Economic Growth for the Various World Economies, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

Mark Thibodeau

Manjul Gupta

Mido Chang

Amin Shoja, Major Professor

Date of Defense: May 10, 2024

The dissertation of Ijeoma Nnenna Odizuru-Abangwu is approved.

Dean William G. Hardin
College of Business

Andrés G. Gil
Senior Vice President for Research and Economic Development
and Dean of the University Graduate School

Florida International University, 2024

DEDICATION

To God, who gives me the strength and courage to juggle my numerous responsibilities as a wife, a mother of 4, and a full-time worker through pregnancy, birth, post-partum challenges, and surgery in between; thank you, Jesus!

To my wonderful husband, Charles, who never complained but encouraged me, spurred me on, gave me the time I needed to study, filled in, and took care of the numerous logistical challenges of running a family of 4 children at different stages of life, from high school to an infant (now toddler), thank you for being the wind beneath my sails!

To my children, Thierry, Zina, Ihechi, and Chukwukaima, who have watched me labor, studying into the night alongside them sometimes, may this be an inspiration that all things are possible; they have borne with me, understanding that every little time I had was precious, and maximized the times I spent coaching, teaching, talking, praying.

To my mother-in-law, who held forth and served on the home front, taking charge of my baby while I studied, attended classes, and traveled for residencies, thank you so much.

To my late dad, Peter, who sowed this seed and wanted me to get a doctorate in my 20s, who would have been super proud to stand beside me on my graduation day, who taught me diligence, resilience, and responsibility, leaving an example and an indelible imprint on my heart - I did it!

To my mother and siblings, who cheered me on and reminded me that I could do it.

To many hardworking women who juggle their numerous hats and still find the courage to smile through it all, models of grit, strength, and resilience – Don’t give up - One day, it will all make sense!

ACKNOWLEDGMENTS

I want to thank my major professor, Dr. Amin Shoja, who coached and guided me through my dissertation, consistently checking in weekly and ensuring I had all I needed to complete it promptly. Thank you so much!

I also want to thank my other professors, who have supported my DBA journey, coaching, directing, and patiently guiding us through the coursework and research process. Indeed, I had to learn to Trust the Process.

Finally, my special thanks to my esteemed colleagues in class, who have made the journey enjoyable and worthwhile, and my wonderful girlfriends, who supported me during my pregnancy; I value and treasure the relationships I have built in these few years, the trust, friendships, and bonds we have developed, which have now formed part of my life's support system. Thank you!

ABSTRACT OF THE DISSERTATION

THE IMPACT OF ENERGY TRILEMMA (ENERGY EQUITY, ENERGY SECURITY, AND ENVIRONMENTAL SUSTAINABILITY) ON ECONOMIC GROWTH FOR THE VARIOUS WORLD ECONOMIES

by

Ijeoma Nnenna Odizuru-Abangwu

Miami, Florida

Professor Amin Shoja, Major Professor

Every country wants to grow, irrespective of its status as a developed or developing economy. Economic growth is usually measured by a country's GDP. Notable economists like Adam Smith have proven various factors to drive growth and productivity over the centuries. These factors include labor, capital, and trade. The impact of energy on economic development has been studied in recent times, and there is a very strong relationship between energy usage and the economic development of countries.

This study aims to understand the impact of the three aspects of energy trilemma (energy equity, energy security, and environmental sustainability) on the economic growth of various world economies. It will also examine the direct impact of oil prices and the moderating effect of energy security and oil prices on economic growth.

The analysis will use a 23-year panel dataset on 124 countries from renowned databases such as the World Bank, World Energy Council, and the International Energy

Agency. The study will be done on the whole dataset and, subsequently, on subsets of the data – Developed Countries, Developing Countries, and Least Developed Countries.

This research aims to underscore that given the importance of energy to economic development, energy policies for various countries need to be viewed through different lenses in order not to stifle economic growth, especially for developing and Least Developed Countries.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Problem Statement

The world population has grown from 3.7 billion to 7.9 billion, representing a more than 100% increase from 1970 to 2021[1]. Annual primary energy consumption per capita increased from 55.4 to 75.6 gigajoules (GJ) (BP, 2022). Over this corresponding period, total primary energy consumption in the world grew from 205 to 595 ExaJoules (EJ) (BP, 2022), representing an almost 300% percent increase. Energy usage has been proven to be a significant driver of development in different countries, as there is a strong positive correlation between energy usage and the level of development. According to the statistical review of world energy by British Petroleum (BP), 82.3% of the energy consumed in 2021 is made up of fossil fuels - oil, natural gas, and coal (BP, 2022).

Due to the pivotal importance of energy to economic development and sustainable development in general, the United Nations General Assembly in 2015 established Sustainable Development Goal (SDG) No. 7, which aims to ensure "access to affordable, reliable, sustainable and modern energy for all." It elevated the need for energy access in meeting sustainable development needs to provide access to affordable, reliable, sustainable, and modern energy for all by 2030 while calling for a substantial increase in the share of renewable energy in the global energy mix and for doubling the global rate of improvement in energy efficiency (Delina, 2017)

To meet the SDG7 goal, the availability of affordable and clean energy faces three major dilemmas, now popularly known as the energy trilemma. These are energy security,

[1] World Population 1950-2023 | MacroTrends

energy equity, and environmental sustainability. These three aspects of the energy challenge have become increasingly important as countries try to balance them while navigating the geo-political environment.

Energy security has been defined by the International Energy Agency (IEA) as the uninterrupted availability of energy sources at an affordable price[2]. According to the World Energy Council, energy security measures a nation's capacity to meet current and future energy demands reliably and withstand and bounce back swiftly from system shocks with minimal disruption to supplies[3]. The dimension covers the effectiveness of management of domestic and external energy sources and the reliability and resilience of energy infrastructure. Recently, energy security seems to have risen to the fore of the three energy dimensions, considering high energy prices and global energy crises precipitated partly by the Ukraine-Russian war. Countries are scrambling to be energy-sufficient, as it seems like a sure way to control their economic destinies, especially given geopolitical tensions.

The second dimension of achieving sustainable energy for all is the concept of energy equity. According to the World Energy Council (WEC), Energy Equity assesses a country's ability to provide universal access to reliable, affordable, and abundant energy for domestic and commercial use[4]. The dimension captures primary access to electricity

---

[2] Energy security - About - IEA

[3] World Energy Trilemma Index | World Energy Council

[4] World Energy Trilemma Index | World Energy Council

and clean cooking fuels and technologies, access to prosperity-enabling levels of energy consumption, and affordability of electricity, gas, and fuels (ibid).

The third dimension is the concept of environmental sustainability, which ensures that the energy produced is not only available or accessible but is not harmful to the environment. According to the World Energy Council, environmental sustainability of energy systems represents the transition of a country's energy system towards mitigating and avoiding potential environmental harm and climate change impacts (ibid). The dimension focuses on the productivity and efficiency of generation, transmission and distribution, decarbonization, and air quality (ibid). This third dimension is particularly important since in 2015, in response to rising carbon dioxide emissions and the impact of global warming, 196 Parties (countries) entered a legally binding international treaty on climate change at COP (Conference of Parties) 21 in Paris[5]. Its goal is limiting global warming to below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels (ibid). Therefore, environmental sustainability of the energy system is essential to combat global warming and the effects of climate change.

Significance of the Problem

The growth and economic development of any nation is usually one of the government's top priorities. Every nation in the world wants to grow and develop. Developed countries want to continue to see growth and improve the living standards of their citizens, while developing and least developed economies continuously seek

[5] The Paris Agreement | UNFCCC

avenues to grow and become more developed, aspiring to be in the “first world.” If energy is essential to growth, as posited by many researchers, it is then critical that it is available, reliable, and affordable for both developing and developed economies. Hence, energy security and energy equity are essential to all nations. However, given the focus on global warming and climate change, it is not just vital that it is available; it must be environmentally sustainable so that we don’t meet the world's needs today while jeopardizing future generations.

While these three dimensions of energy, known as the energy trilemma, are all important to the economic growth of all countries, as we have seen in literature, given the income level of these nations and where they are in their growth journey, these dimensions of energy could have different relationships to their economic growth, as one aspect of the trilemma could require more focus than the others. Hence, this research will focus on the various groups of countries – developed, developing, and least developed- to attempt to differentiate their unique relationships of the energy trilemma to economic growth. Economic and energy policies must be tailored differently to different groups of countries to ensure that economic growth is not stifled. While the world has set climate goals to stem global warming, it is imperative that those goals take full consideration of the growth journey in developing economies and the least developing countries and do not become tough choices for those governments to make, such as “to live and grow versus drive.” It is also essential to apply similar lenses towards countries that face significant energy access challenges, perhaps giving them room to grow instead of putting stringent barriers to financing their energy systems just because it is based mainly on what they have – fossil fuels.

Research Gap

There has been some research connecting the energy trilemma to economic growth. Specifically, I have only seen one research paper (Kang, 2022) discussing the impact of all three dimensions of the energy trilemma on the GDP and growth of countries. Earlier papers have focused primarily on the importance of energy on economic growth. A research paper (Le & Nguyen, 2019) examined the different dimensions of energy security and their effects on economic growth. In principle, although few research papers are available today, they do not fully show how these three energy dimensions impact the economic growth of the different strata of countries. Two research papers - Le and Nguyen (2019) and (Kang, 2022) analyzed the impact of energy security and other energy dimensions by income levels. However, the implications for each income level were not fully elaborated, although possible policy implications were suggested. Le and Nguyen (2019) used energy data up to 2013 and, hence, requires some updates, given that data is available now, up to 2022. Kang (2022) used energy data up to 2020, but he did not include the impact of political stability or oil prices on economic growth.

The other dimension of this research is to look at the impact of oil prices on economic growth. This could moderate the relationship between some elements of the energy trilemma and economic growth. While the effects of oil prices have been researched in the past, the focus has been on its direct impact on specific countries, including OECD countries. Only one of the papers (Le & Nguyen, 2019) referred to the oil price as an independent variable, among other energy variables impacting economic growth. No moderating effect on any aspect of the energy trilemma was analyzed in their research.

Research Question

Therefore, my research proposal seeks to answer the following questions

1. **"What are the factors driving the economic growth of various world economies?"**
2. **"What is the impact of energy equity, energy security, and environmental sustainability on economic growth for the various world economies?"**

Research Contributions

This study aims to investigate the impact of these three energy dimensions (also known as the energy trilemma) and oil prices on the economic growth of different economies, especially as countries and energy companies put a lot of focus on energy security, given the most recent energy crises and scramble for energy sufficiency. While energy security is important, the environmental sustainability dimension is critical to the future as the world reels from the impacts of global warming and climate change. Hence, the study will also be examining how these impact economic growth. Historical data from 122 countries will be used for this analysis. In addition, this study will subdivide the countries into three main classifications – Developed, Developing, and Least Developed countries. According to the United Nations (UN)[6], developed and developing countries are not defined within the UN system. However, these terms were introduced in earlier decades to represent a country's level of human development and economic empowerment. In HDR2010, developed countries were referred to as countries in the top quartile of the Human Development Index (HDI). In contrast, developing countries were referred to as countries in the bottom three quartiles[7]. “Although the UN does not specifically use those terms today, several users expressed the need to maintain the distinction between developed and developing regions based on the understanding that being part of either developed or developing regions is the sovereign decision of a state. Therefore, the UN created a list that contains an updated classification of developed and developing regions as of May 2022, in addition to the historical classification of December 2021”[8]. In addition to these two major classifications of countries, I will be specifically looking into a third category known as the Least Developed Countries (LDC), which represents very low-income countries confronting severe structural impediments to sustainable development, highly vulnerable to economic and environmental shocks and with low levels of human assets[9]. The list of the LDCs is determined by the United Nations Economic and Social Council and, ultimately, by the General Assembly based on

---

[6] UNSD — Methodology

[7] Classifications of Countries Based on their Level of Development: How it is Done and How it Could Be Done (imf.org)

[8] UNSD — Methodology

[9] Least Developed Countries (LDCs) | Department of Economic and Social Affairs

recommendations made by the Committee for Development Policy[10]. The primary criteria for inclusion require that certain thresholds be met concerning per capita GNI, a human assets index (HAI), and an economic vulnerability index[11]. As of December 2022, there were 46 LDCs[12].

The appendix contains the list of developed, developing, and Least Developed Countries (LDCs) used in this research. Out of the 122 countries, there are 43 Developed countries, 65 Developing countries, and 14 Least Developed Countries, with a complete dataset for this study.

The proposition is that these energy dimensions have different impacts on the economic development of the countries, depending on their classification as Developed, Developing, and Least Developed Countries (LDCs). The implication of this is that policymakers, governing bodies, and energy companies should adopt different approaches to meeting the energy demands of these countries, depending on their development levels, if there is any possibility of meeting the United Nations' sustainable goal 7 to provide clean, affording energy to all, by 2030, while not stifling the economic growth of the developing and the Least Developed economies of the world.

---

[10] World Economic Situation and Prospects (WESP) 2020 | United Nations

[11] Handbook on the Least Developed Country Category: Inclusion, Graduation and Special Support Measures (United Nations publication, Sales No. E.18.II.A.1). Available from 2018CDPhandbook.pdf (un.org)

[12] Least Developed Countries (LDCs) | Department of Economic and Social Affairs

2. BACKGROUND LITERATURE REVIEW AND THEORY

Many scholars have used various economic growth studies and theories over the centuries. Economic growth factors have been reviewed both theoretically and empirically. Growth theories that have been used historically include the classical theory, the neoclassical theory, and the endogenous growth theory. The classical growth theory was posited mainly by English classical economists such as Adam Smith, Thomas Malthus, and David Ricardo in the 18th and 19th centuries, which states that in a closed economy, there is an inevitable tendency for the rate of profit (growth) to fall (Harris, 2007). Hence, it implies that an increase in population leads to decreased economic growth. The major criticism of this theory is that it ignores the role of technology in the growth of an economy.

The second theory of growth is known as the neoclassical growth theory, which brings out the importance of technology to the growth equation. The most popular version of it was proposed by Robert Solow in 1956 and is known as the Solow Growth model. It is an exogenous growth model that states that physical capital accumulation was the main factor contributing to economic growth in the short run, but technological development played a crucial role in long-run growth (Robert M Solow, 1956). To complement physical capital, the stock of human capital was also considered another vital input for growth (Rahman, Vu, & Nghiem, 2022). The neoclassical models of Solow assumed that the long-run economic growth is not due to decisions made by economic agents (i.e., endogenous factors) but because of exogenous technological progress. This couldn't explain the growth rates seen in developed countries in the 1980s, and it couldn’t justify the observed facts corresponding to the assumption of diminishing returns on capital and labor, as some industries experienced no decrease in returns when they reached a certain level of capital (Thach, 2020). This led to the development of endogenous growth theories in the 1980s.

The endogenous growth model posits that growth is generated internally from an economy, not external factors. One of the endogenous theories, as set by Romer (1986), attributes sustainable long-run economic growth to new knowledge and decisions created by firms, which spills over to the whole economy, increasing a country's GDP. Hence, technical progress isn’t exogenous and “doesn’t just fall from heaven; it, like everything else in the economy, is the result of decisions and actions of optimizing players (Thach, 2020). This is known as the Arrow-Romer growth model as it combines Arrow’s “learning by doing” hypothesis (Arrow, 1962) with the “knowledge spillover hypothesis” (Thach, 2020).

Energy & Economic Growth

Four main hypotheses are associated with the relationship between energy and economic growth, known as the energy-growth nexus (Le & Nguyen, 2019). The first hypothesis is the growth hypothesis, which posits that energy consumption positively impacts growth. The second hypothesis is the feedback hypothesis, which suggests positive feedback between energy consumption and economic growth. Hence, there is a bidirectional relationship between the two. The third one is known as the neutrality hypothesis, which posits that there is no relationship between energy consumption and a country's economic output. The final hypothesis is known as the conservation hypothesis.

This asserts that there is unidirectional causality from economic growth to energy consumption. (Le & Nguyen, 2019). For this research paper, we will look at the relationship from the perspective of the energy growth hypothesis.

Economic growth in countries is often measured by Gross Domestic Product (GDP). GDP is an essential indicator for measuring economic growth and the standard of living of individuals in a nation (Salma, Hasan, & Sultana, 2020). From the literature, GDP per capita varies based on economic, social, and political changes (Ilter, 2017). These factors are represented by various World Bank indicators such as exports of goods and services, final consumption expenditure, foreign direct investment, net inflows, gross capital formation, total labor force, trade, and net income from abroad (Salma et al., 2020).

Simionescu and Naroş (2019) explain that foreign direct investment (FDI) has a vital influence on the economic growth of a nation as a condition to attract investors to develop and improve the economy and the quality of human resources. FDI brings additional foreign capital, advanced technology, and improved managerial skills; hence, it is considered essential to economic growth and financial globalization (Alfaro, 2017).

Numerous studies have investigated the relationship between energy and economic growth of various countries and geological regions. Le and Nguyen (2019) explored the relationship between energy security and economic growth. In that study, they evaluated 74 countries from 2002 to 2013 and used ten measures of energy security and their impact on economic growth. The results of their study show that energy security contributed significantly to the economic growth of the whole sample. They also got significant results for low- and middle-income groups when they broke down the sample into different income brackets, which aligned with World Bank classifications. While they looked at various energy security measures, they didn't specifically look at the relationship between the three dimensions of the energy trilemma, defined by the World Energy Council, and their relationship to energy growth.

A similar study was carried out by Kang (2022), who analyzed the relationship between the three dimensions of energy trilemma and economic growth. He concluded that each dimension contributed differently to economic growth, depending on their income level and regions. His study found that energy security and equity are positively related to economic growth. In contrast, environmental sustainability negatively affected economic growth for the entire dataset of 109 countries.

A study by Balitskiy, Bilan, and Strielkowski (2014) examined the relationship between natural gas consumption and economic growth in 26 EU countries, where natural gas consumption was used to measure energy consumption. The study found a long-run relationship between economic growth, natural gas consumption, labor, and capital. A bidirectional causality between natural gas consumption and economic growth was found in the short term. In one direction, it's a positive relationship; in the other, it is negative.

Gasparatos and Gadda (2009) examined environmental support, energy security, and economic growth in Japan. An exciting outcome of their study is the growing dependence of the Japanese economy on imported energy from developing nations and how it could severely affect the potential for unhindered economic growth. They saw that as a risk that could potentially jeopardize Japan's long-term economic sustainability. The Japanese economy is a major productive economy serving as a major exporter of petroleum products, chemicals, steel, and cars, and production of these items is very energy intensive. As a result, the country experienced negative economic growth during the first oil crisis and an economic slowdown in the second crisis (Gasparatos & Gadda, 2009).

Almeida Prado et al. (2016) explored the interconnection between energy security, economic growth, and climate change related to the hydropower expansion in Brazil. They posited that policy decisions must be made to balance the dilemmas between energy security requirements, projected economic growth, and climate change. It sees the ongoing dilemmas for emerging economies like Brazil balancing economic growth and energy supply with greenhouse gas emissions and other environmental goals.

Nepal, Paija, Tyagi, and Harvie (2021) conducted a study to examine the relationship between energy use, economic growth, Foreign Direct Investments (FDI), carbon emissions, and trade openness in India from 1978 to 2016. They found a bi-directional relationship between economic output and energy use in the long and short run. They observed a negative relationship between energy use and FDI in the long run. They also observed a bi-directional causality relationship between CO_2 emissions and energy usage.

Energy equity concerns a country's ability to provide access to reliable, affordable energy for domestic and commercial use. This represents a household's access to electricity and clean cooking fuels, in a nutshell, access to modern energy services.

Energy equity, therefore, measures the energy poverty of a country. Energy poverty means individuals have deficient or no access to modern energy services (Doganalp, Ozsolak, & Aslan, 2021). Energy poverty is the inability to access energy services to a socially and financially necessary level in a household (Bouzarovski, Petrova, & Sarlamanov, 2012) (Reddy et al., 2000) (Buzar, 2007). Energy access is essential for socioeconomic development (Johansson & Goldemberg, 2002) (Davidson & Sokona, 2002). Access to energy is also one component of the broader range of problematic issues those living in poverty face. Singh and Inglesi-Lotz (2021) defined energy poverty as the exclusion of people from primary access to energy. In their article, they examined the role of energy poverty in boosting economic development in 14 countries of Sub-Saharan Africa. They hypothesized that energy poverty positively contributes to economic growth in Sub-Saharan African countries.

Amin et al. (2020) investigated the interaction between energy poverty, employment, education, per capita income, inflation, and economic development in seven South Asian countries. Using Autoregressive distributed lag (ARDL), their analysis shows that energy poverty negatively influences long-term and short-term economic growth.

The relationship between environment and economic growth has been investigated historically using the Environmental Kuznets Curve (EKC). This curve describes the relationship as an inverted U-shaped pattern. It postulates that environmental degradation worsens at lower levels of economic growth, reaches its peak, and then starts to decline as growth further increases. The central idea of the EKC hypothesis is based on the “grow first and clean up later” argument: countries focus exclusively on their economic growth at early stages and pay attention to environmental issues at higher growth levels (Tenaw & Beyene, 2021). In their study, they confirmed the existence of a modified EKC hypothesis in Sub-Saharan Africa but posit that the linkage depends on the extent of the endowment of natural resources.

3. RESEARCH DESIGN

Numerous prior studies have used the extended Cobb-Douglas production function to study the relationship between energy and economic growth. The original Cobb-Douglas function posits that productivity is a function of labor (L) and capital (K), with a residual parameter known as A, which denotes technical changes that cannot be easily explained by labor and capital.

$$Q = AL^{a} C^{\beta} \quad (1)$$

Kang (2022) further used the extended Cobb-Douglas function to evaluate the relationship between economic growth and energy trilemma.

$$Y = f(A, L, K, ET) \quad (2)$$

Y is the Gross Domestic Product (GDP), A is Technology, L is labor, K is Capital, and ET is Energy Trilemma, representing the three dimensions of energy equity, energy security, and environmental sustainability. According to Shahbaz et al. (2013), the technology in the extended Cobb-Douglas production function can be endogenously determined by the levels of trade openness and financial development.

This was further modified by Le and Nguyen (2019) to include Political stability and Oil Prices, which impact economic growth. Hence, equation 2 above can be re-written as:

$$GDP_{it} = \alpha_{it} + \beta_1 Cap_{it} + \beta_2 Labor_{it} + \beta_3 Trade_{it} + \beta_4 PS_{it} + \beta_5 OP_{it} + \beta_6 EE_{it} + \beta_7 ES_{it} + \beta_8 ESUS_{it} + \beta_9 ES{*}OP_{it} + \varepsilon_{it}. \quad (3)$$

GDPpc is real GDP; Cap is gross capital formation; Trade is total trade value (% GDP); Labor is labor force (total); PS is the political stability. OP is

the mean oil price. EE is the Energy Equity Index. ES is the Energy Security Index, and ESUS is the Environmental Sustainability Index.

This equation includes a control variable in the model, political stability (PS), which might affect economic growth. When the leading oil or gas-producing countries are overwhelmed by political instability or in the context of difficult international cooperation, the risk of major oil or gas supply disruptions will likely increase (Correlje & Van der Linde, 2006).

Equation 3 above is represented in the research model figure below, which highlights the independent variables leading to economic growth and the control variables. This research paper focuses on the three dimensions of energy trilemma and their effects on economic growth. This paper further investigates the unique relationship of these three dimensions on economic growth for the different economies such as developed, developing, and Least Developed countries. Much of the impact of the other independent variables on economic growth has been proven by the Cobb-Douglas function and in various literature.

Conceptual Framework

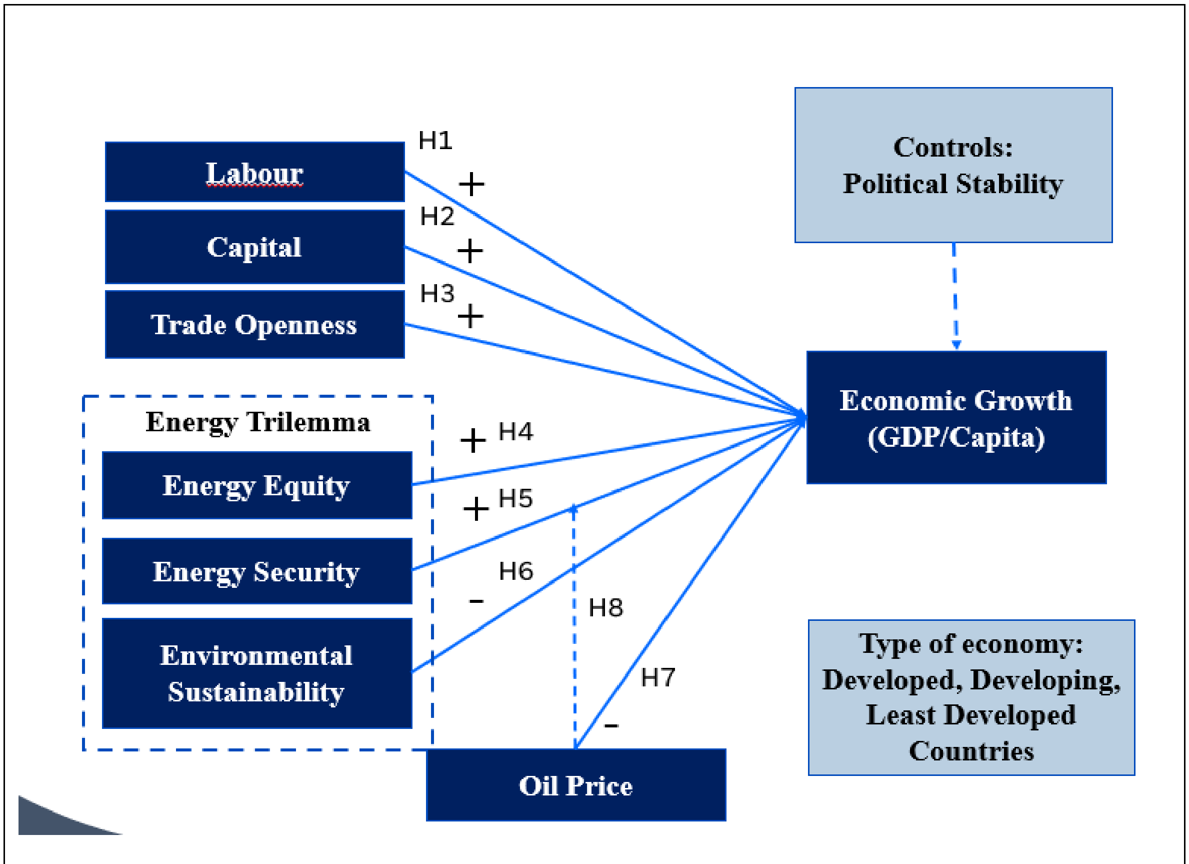

Figure 1 The Conceptual Research Model

Theoretical Development and Hypotheses

Economic growth is represented by the real GDP, which is used as a proxy for real output. This data is obtained from World Bank indicators for all countries.

Labor represents the total labor force of a country, as documented by the World Bank. In line with the Cobb-Douglas function, a nation's productivity is a function of its labor, and this has been discussed extensively by economists, starting from the classical economists. The classical view of production involves labor, means of production, and natural resources (Salvadori, 2003). Adam Smith, in his book "Wealth of Nations," stated that "income per capita must in every nation be regulated by two different circumstances: First, by the skill, dexterity, and judgment with which labor is generally applied; and secondly, by the proportion between the number of those who are employed in useful labor, and that of those who are not so employed."(Smith, 1776). This shows that the amount of people who are gainfully employed is an essential contributor to the productivity and growth of that country. Rostow and Kennedy (1990) state that according to Smith (1776), the main factors affecting the engine of economic growth are population growth, capital growth, the division of labor (technological progress,) and the institutional framework of the economy (competitive-free traded market economy) (Ucak, 2015). Other papers have shown the impact of quality labor on a nation's productivity and economic growth. Jajri and Ismail (2010) found a positive relationship between effective and physical labor on Malaysia's productivity and economic growth. Hence, the first hypothesis reads as follows:

H1: As the labor force increases, economic growth increases.

From the literature review in the previous chapter, all the models of economic growth are consistent in the role of capital in the economic growth of a country. This starts from the classical economists like Adam Smith of the $18^{th}/19^{th}$ century, who proposed the impact of labor and capital on productivity (as discussed in the prior paragraph), to the neoclassical theorists and subsequent researchers. Robert M. Solow (1962), in his paper where he tried to answer the question of how much fixed investment was necessary to support alternative rates of growth in the United States, stated that "I believe that a high rate of capital formation is required if the growth of aggregate productivity and output is to accelerate, but I do not believe that it is all that is required." He answered the question and proved it using the Cobb-Douglas Production function and data from the United States. He concluded that "capital formation is not the only source of productivity. Investment is at best a necessary condition for growth, surely not a sufficient condition" (Robert M. Solow, 1962). Several studies have been done on the impact of capital formation on the economic growth of different countries. Bal, Dash, and Subhasish (2016) studied the effects of capital formation on economic growth in India. They found that capital formation, trade openness, exchange rate, and total factor productivity affected economic growth positively, while inflation affected it negatively. Chow (2017) investigated the impact of capital formation in China on different sectors of the economy – agriculture, industry, construction, transportation, and commerce. Kanu and Ozurumba (2014) studied the impact of capital formation on Nigeria's economic growth. They found that it had no significant effect in the short run, but in the long run, it did, in addition to exports and the lagged GDP values.

Labor and capital remain the foundation of the Cobb-Douglas production function. As a result, the second hypothesis will read as follows:

H2: As capital increases, economic growth increases.

Busse and Königer (2012) set out to empirically test the causal linkage between trade and economic growth. They prove that both trade and the expansion of trade have an independent, positive, and significant impact on the income growth of a country. They also tested this hypothesis on a sample of developing countries and found it necessary to foster economic growth. Nepal et al. (2021) also found a causal relationship between trade openness and economic growth in India. The ratio of trade to GDP (% GDP) will be obtained from the World Bank database. As a result, hypothesis 3 is stated as follows:

H3: As trade openness increases, economic growth increases.

Energy Trilemma & Economic Growth

The International Energy Agency defines energy security as the uninterrupted availability of energy sources at an affordable price[13]. The World Energy Council's energy security measures a nation's capacity to meet current and future energy demands reliably and withstand and bounce back swiftly from system shocks with minimal disruption to supplies[14]. The dimension covers the effectiveness of management of domestic and external energy sources and the reliability and resilience of energy infrastructure (ibid). A few studies have examined the relationship between energy security and economic growth. Le and Nguyen (2019) explored the relationship between economic security and economic growth in 74 countries from 2002 to 2013. They looked at ten definitions of energy security, which included different dimensions of the energy trilemma, including availability, accessibility, acceptability, affordability, and developability. Their study concludes that energy security has a positive and significant relationship with economic growth. As a result, the following hypothesis is proposed:

H4: As energy security increases, economic growth increases.

---

[13] Energy security - About - IEA

[14] World Energy Trilemma Index | World Energy Council

As defined by the World Energy Council, energy equity assesses a country's ability to provide universal access to reliable, affordable, and abundant energy for domestic and commercial use. It captures primary access to electricity and clean cooking fuels and technologies, access to prosperity-enabling levels of energy consumption, and affordability of electricity, gas, and fuels. Again, this was investigated by Le and Nguyen (2019), although termed as an aspect of energy security. One of the ten dimensions of energy security explored is the accessibility and affordability of energy in countries. They also found a positive and significant relationship between the energy security dimension and economic growth. Kang (2022) also examined the impact of energy equity, energy security, and environmental sustainability in 109 countries. He found that energy equity and energy security positively impacted economic growth. As a result, the following hypothesis is proposed:

H5: As energy equity increases, economic growth increases.

The third dimension of the energy trilemma is known as environmental sustainability. In 1987, the United Nations Brundtland Commission defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."[15]. Environmental sustainability, therefore, measures the transition of a country's energy system toward mitigating and avoiding potential environmental harm and climate change impacts. Hence, it focuses on productivity and efficiency of generation, transmission and distribution, decarbonization,

[15] Sustainability | United Nations

and air quality. Again, numerous studies have been conducted to understand the relationship between environmental sustainability and economic growth. The EKC curve has defined it. It postulates that environmental degradation worsens at lower levels of economic growth, reaches its peak, and then starts to decline as growth further increases. Environmental sustainability is usually measured by a country's degree of carbon intensity and GHG emissions. Le and Nguyen (2019) found a negative relationship between the energy security dimension and economic growth in one of their definitions of energy security, which pertains to energy intensity and carbon intensity. Kang (2022) also found that Environmental sustainability is negatively related to economic growth. As a result, the following hypothesis is proposed:

H6: As environmental sustainability increases, economic growth reduces.

However, further research that has been carried out for different income levels has found that this relationship between energy sustainability and economic growth differs based on income levels. Developed countries with high energy equity (access and affordability) could see increased environmental sustainability as GDP increases. Their focus and concerns have shifted from achieving energy equity and access to environmental concerns and sustainability. Hence, this research will investigate the unique relationship between the different groups of economies – developed, developing, and Least Developed countries.

Oil Price & Economic Growth

Oil price refers to the average annual oil price during the years of interest. Various research has shown the impact of oil prices on the economy in different groups of countries. Akinsola and Odhiambo (2020) examined the effects of oil prices on the economy of seven low-income, oil-importing Sub-Saharan African countries. Their research shows that, in the long run, the oil price significantly negatively impacts economic growth.   In the short run, it showed significant but mixed effects. Other researchers have seen diverse impacts. Berument, Ceylan, and Dogan (2010) studied the effect of oil price shocks on the economic growth of selected Middle East and North African countries. They found that oil price increases have a statistically positive effect on the outputs of Algeria, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Syria, and the United Arab Emirates. However, it didn’t have statistically significant effects on the outputs of Bahrain, Djibouti, Egypt, Israel, Jordan, Morocco, and Tunisia. Ghalayini (2011) studied the interaction between oil prices and economic growth for OPEC countries, the G-7 group (USA, Canada, Japan, Germany, France, Italy, and the United Kingdom), Russia, China, and India. He concluded that most countries have no proven relationship between oil prices and economic growth. However, he found a relationship between oil prices and economic growth for G7 countries but attributed it primarily to their pre-existing dependency on oil. He suggests that G7 countries are interested in keeping the oil price low as increases affect their GDP and tend to lead to recession. He didn’t find a relationship between oil price increases and economic growth for oil exporting countries. He explained that inflows of funds from oil revenue tend to find their way outside those countries and do not contribute to the country's economic development. Mo, Chen, Nie, and Jiang (2019) studied the effects of oil prices on the economic growth of the BRICS countries (Brazil, Russia, India, China, and South Africa). They found that a rise in oil prices would boost their economic growth. However, they found mixed results in the short and long term. For Brazil and Russia, the positive effect of oil prices on economic growth weakens as oil prices rise. In India, the positive relationship between oil prices and economic growth weakens over time. In China, the positive effect is shown in the short and medium term, and then a negative impact occurs but stimulates economic growth in the long run. In South Africa, a negative effect is only observed in the short run but the positive effect reemerges although diminishes over time. Le and Nguyen (2019) found a negative relationship between oil prices and economic growth.

Jiménez-Rodríguez* and Sánchez (2005) looked at the effects of oil price shocks on the real GDP of the leading industrialized countries. He found out that oil price increases impact the GDPs with a larger magnitude when compared to oil price decreases, which show insignificance in most cases. “The effects of an increase in oil prices on real GDP growth are found to differ substantially from those of an oil price decrease, providing evidence against the linear approach that assumes that oil prices have symmetric effects on the real economy.” The impact of oil prices varied between oil-importing countries and oil-exporting countries. For the two oil-exporting countries they studied, they found that it had a positive effect on one country (Norway) while it negatively affected the second country (the UK). The negative impact on the UK was related to the standard “Dutch disease effect.” They found that for the importing countries, oil prices had a negative effect on all the countries except Japan. The authors explained that it could be due to “the special circumstances undergone by the Japanese economy.”

The authors found that these relationships were not easily explained using linear models, as noted by various authors (Mork, Olsen, & Mysen, 1994), (Lee, Ni, & Ratti, 1995), and (Hamilton, 2003). Hence, they did this study using both a linear model and various non-linear models.

In general, the increase in oil prices is expected to impact oil-exporting countries positively (since they earn from it) and have a negative impact on oil-importing countries, all things being equal. The effect of oil prices on the real economy can be viewed from a supply and demand angle (Jiménez-Rodríguez* & Sánchez, 2005). According to them, the perspective from the supply side is that oil is an input to most production. Hence, an increase in oil prices leads to higher production costs and lower production outputs. The demand perspective is that oil price increases affect consumption and investments, thereby reducing, in general, the individual's disposable income, especially if the oil price shock is deemed to be long-lasting. It also affects a firm's investments since its production costs increase, leaving less money available for investments (Jiménez-Rodríguez* & Sánchez, 2005). Mendoza and Vera (2010) studied the effect of unexpected changes in oil prices on the output of Venezuela, an oil-exporting economy. They found that oil shocks positively and significantly affected output growth in Venezuela from 1984 to 2008. They also found that the economy was more responsive to oil price increases than unexpected decreases. Hence, other researchers also referred to the asymmetric effects.

Hamilton (2003) shows strong support for the claim of a nonlinear relationship between oil prices and the economy. Hence, he posited that oil price increases affect the economy whereas decreases do not, and increases that come after a long period of stable prices have a more significant effect than those that simply correct previous decreases. He used lagged data on four quarters of growth and oil prices to demonstrate this relationship. Oil price shocks have been seen to have adverse effects on the economy. He proposes an acceptable measure of oil shock, specifying that an oil shock occurs when oil prices exceed their 3-year peak. A significant disruption in oil supplies causes uncertainties and temporary falls in spending on cars, housing, appliances, and investment goods (Hamilton, 2003). As reported by Hamilton (2003), "Bresnahan and Ramey (1993) documented that the oil shocks of 1974 and 1980 caused a significant shift in the mix of demand for different size classes of automobiles with an attendant reduction in capacity utilization at U.S. automobile plants. Sakellaris (1997) found that changes in the stock market valuation of different companies in response to the 1974 oil shock were significantly related to the vintage of their existing capital. Davis and Haltiwanger (2001) discovered a dramatic effect of oil price shocks on the rate of job loss in individual economic sectors, with the job destruction rising with capital intensity, energy intensity, product durability, and plant age and size". Schneider (2004) found out that since the 1970s, the correlation between oil price and GDP growth has weakened due to technological innovations, the development of cost-effective alternative energy sources, and sectoral changes that have diminished the ratio of oil imports to the GDP of industrialized countries. He posits that modeling the relationship has become increasingly difficult following the reduced influence of OPEC after 1980, more volatile oil prices since the introduction of forwards and futures markets in the 80s, and the reaction of central banks over time, diminishing the influence of oil prices on growth. Hence, simple linear models cannot explain the relationship between oil price and growth, underscoring the importance of nonlinear modeling.

Hence, for the oil price analysis and its effect on economic growth, I will group the countries into different groups of interest (net oil exporters and net oil importers) to understand the impact of oil prices on the economic growth of those sub-groups. As the literature review above shows, there will be possibly opposite or heterogeneous results across the two sub-groups.

From the above literature review, it is clear that the relationship between oil price and GDP is complicated and varies, depending on whether the country is a net exporter or net importer of oil. For net oil exporters, the impact on the GDP also depends on how diversified the economy is. If oil constitutes only a tiny percentage of the economy, the GDP might not significantly increase because of higher oil prices.

Hence, my hypothesis is as follows:

H7: As oil prices increase, economic growth decreases for net oil importers, while economic growth increases for net exporters in a mono-economy.

Periods of energy crises, usually characterized by high oil prices, impact energy security plans for nations. High oil prices tend to increase the scramble for alternate energy supplies to cushion the economic impact on a country. This was seen recently in the last two years when countries scrambled for alternative energy sources after the Ukraine-Russian war and supply disruptions to Europe that sent oil and gas prices above the roof. European countries scrambled for alternative energy sources, away from energy dependency on Russian gas, especially as they prepared for the winter. The proposition is that countries with higher energy security (with less dependence on energy imports, diversified domestic energy sources, or increased storage and refining capacity) will tend to scramble less than those countries with lower energy security, which are highly import-dependent. Those countries could have invested in technology, critical energy storage reserves, and diversification of their domestic sources to cushion the effects of high oil price regimes on their economy. Wealthier countries (akin to the developed countries) will tend to have the means to intervene during high oil price crises by way of government incentive programs and the release of strategic reserves, and hence, can reduce, to an extent, the impact the effect of high oil prices on the economy. The most vulnerable countries to high oil prices will tend to be the Least Developed Countries or Developing countries, with low energy security and import dependency. They also lack the means to directly intervene and cushion these effects on their economy. Hence, during high oil prices, low energy-secure countries (and net importers of oil) will have a more negative significant effect on the GDP of those countries.

H8: Oil price moderates the relationship between energy security and economic development such that an increase in oil price significantly impacts the relationship between energy security and economic development positively and strengthens that relationship, especially for low energy security countries.

Definitions of the Key Variables

Key definitions and sources for each of the variables are listed in the table below:

Table 3-1: Key Concept Definitions

Variable	**Definition**	**Source**
Gross Domestic Product	GDP (constant 2015 US$). GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or for the depletion and degradation of natural resources. Data are in constant 2015 prices, expressed in U.S. dollars. Dollar figures for GDP are converted from domestic currencies using 2015 official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.	World Bank Glossary | DataBank (worldbank.org)
Labor	Labor force (Total). The labor force comprises people ages 15 and older who supply labor for the production of goods and services during a specified period. It includes people who are currently employed, people who are unemployed but seeking work, and first-time job seekers. Not everyone who works is included, however. Unpaid workers, family workers, and students are often omitted, and some countries do not count as members of the armed forces. The size of the labor force tends to vary during the year as seasonal workers enter and leave.	World Bank Glossary | DataBank (worldbank.org)
Capital	Gross capital formation (% of GDP) Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods	World Bank Glossary | DataBank (worldbank.org)

	held by firms to meet temporary or unexpected fluctuations in production or sales and "work in progress." According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.	
Trade	Trade (% of GDP). Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.	World Bank. Glossary | DataBank (worldbank.org)
Energy Equity	Assesses a country's ability to provide universal access to reliable, affordable, and abundant energy for domestic and commercial use.	World Energy Council
Energy Security	The uninterrupted availability of energy sources at an affordable price measures a nation's capacity to reliably meet current and future energy demands and withstand and bounce back swiftly from system shocks with minimal disruption to supplies.	International Energy Agency & World Energy Council
Environmental Sustainability	Environmental sustainability of energy systems represents the transition of a country's energy system towards mitigating and avoiding potential environmental harm and climate change impacts.	World Energy Council
Oil Price	Average annual oil price per annum. Yearly average oil prices as recorded by the World Bank for Brent crude, West Texas Intermediate (WTI) Crude, and Dubai Crude.	World Bank. Commodity Markets (worldbank.org)
Political Stability	Political Stability and Absence of Violence/Terrorism Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and politically motivated violence, including terrorism. Estimate gives the country's score on the aggregate indicator in units of standard normal distribution, i.e., ranging from approximately -2.5 to 2.5.	World Bank. World Governance Indicators. Glossary | DataBank (worldbank.org)

Table 3-2: Structure of WEC's World Energy Trilemma indices & Key metrics [16]

Energy Trilemma	Key Metrics	What Is Measured
Energy Security	Import Independence	Country reliance on net imports for total energy consumption and the diversity of suppliers.
	Diversity of electric generation	Diversity of domestic electricity generation sources
	Energy Storage	The country's ability to meet demand for oil and gas considering GG capabilities, including storage and refining capacity.
Energy Equity	Access to Electricity	Percentage of the population with access to electricity.
	Electricity Prices	National electricity price per kilowatt hour as an indicator of affordable energy services for domestic and commercial uses.
	Gasoline and diesel Prices	Prices per liter are an indicator of access to affordable energy services for passenger and commercial vehicles.
Environmental Sustainability	Final energy intensity	The ratio of final energy consumption over GDP.
	Low-carbon electricity generation	Percentage of electricity generation from decarbonized sources.
	CO2 emissions per capita	CO2 emissions from fuel combustion per capita.

[16] WEC Energy Trilemma Index Tool (worldenergy.org)

4. RESEARCH METHODOLOGY

Cases and Procedure

This study will use Secondary data from renowned sources such as the International Energy Agency, World Bank, and World Energy Council databases. This study will use a complete dataset of the required variables from 122 countries from 2000 to 2022.

Relevant data will be imported from these sources and put into the required Excel format for data upload into SPSS for subsequent analysis. This data will be a time series covering 22 years from 2000 to 2022, constituting a panel dataset. Econometric methods will explore the relationships between the independent variables and the dependent variable (economic growth – GDP). Two types of regression equations will be used for the analysis - the pooled Ordinary Least Squares (OLS) and the fixed/random panel effects. These will allow for comparison between results from the different regression analyses.

Research Design

The data analysis will be done for the whole dataset, including all countries with a complete dataset. The whole-country analysis will be done with the full dataset of 124 countries. Subsequently, the dataset will be broken down into the different groups of economies (developed, developing, and least developed countries) based on the level of the Human Development Index and in line with the UN classification, extensively discussed in the first chapter. The dataset has 44 Developed countries, 65 Developing countries, and 15 Least Developed Countries. They are listed in the appendix. This analysis will enable the comparison of results between groups to draw clear conclusions on how these relationships differ across the three groups of countries.

In addition to the analysis based on development classification of the countries, another classification of the countries based on their fuel exporting status will be used to carry out regression analysis to examine hypothesis 7. For this study, an economy is classified as a fuel exporter if the share of fuel exports in its total merchandise exports is greater than 20 percent and the level of fuel exports is at least 20 percent higher than that of the country's fuel imports[17]. This criterion is drawn from the share of fuel exports in the total value of world merchandise trade. Fuels include coal, oil, and natural gas (ibid). Using this criterion, there are only 26 fuel-exporting countries as of 2023. The list of fuel-exporting countries is included in the Appendix.

Measurements

All the variables will be sourced from various secondary sources and databases, in line with Table 4-1 below. Key measurement sources for each of the variables are listed in the table.

[17] World Economic Situation and Prospects 2023 | Department of Economic and Social Affairs (un.org)

Table 4-1: Secondary Data Sources

Variable	Definition	Source
GDP	Gross Domestic Product GDP (constant 2015 US$).	World Bank Open data World Bank Open Data | Data World Development Indicators | DataBank (worldbank.org)
Labor	Labor force (Total).	World Bank Open data World Bank Open Data | Data
Capital	Gross capital formation (% of GDP)	World Bank Open data World Bank Open Data | Data
Trade	Trade (% of GDP).	World Bank Open data World Bank Open Data | Data
Energy Equity	Energy Equity Index (2000 = 100)	World Energy Council Energy Trilemma Index https://trilemma.worldenergy.org/
Energy Security	Energy Security Index (2000 = 100)	World Energy Council Energy Trilemma Index https://trilemma.worldenergy.org/
Environmental Sustainability	Environmental Sustainability Index (2000 = 100)	World Energy Council Energy Trilemma Index https://trilemma.worldenergy.org/
Oil Price	Average annual oil price per annum.	World Bank Commodity Markets (worldbank.org)
Political Stability	Political Stability and Absence of Violence/Terrorism	World Bank. World Governance Indicators. http://info.worldbank.org/governance/wgi/

Data Analysis

Data was mined from the various sources above for 127 countries. Reviewing the raw dataset showed missing data for multiple countries and specific variables. An analysis of the dataset showed the following:

The complete dataset was missing for the following countries:

- Malawi (2000-2022) – Trade & Capital
- Trinidad & Tobago (2000- 2022) – Trade & Capital
- Syria (2000-2022) – Capital

Incomplete Dataset was noted for the following:

- Ethiopia (2000 – 2010) – Trade & Capital
- Zambia (2000- 2009; 2022) – Capital only
- Sri Lanka missing data from 2010 – 2014 - Capital, Trade (5 entries)
- Panama (2018 – 2022) – Capital, Trade (5 entries)
- Jordan, (2020 – 2022) – Capital, Trade (3 entries)
- Kuwait (2020 – 2022) – Capital, Trade (3 entries)
- Libya (2020 – 2022) – Capital, Trade (3 entries)
- UAE (2021 – 2022) – Capital, Trade (3 entries)
- Iran (2019 – 2022) – Capital only (4 entries)
- Montenegro (2000-2005) – Pol Stability only

Three countries were removed for the subsequent data analysis to address the data gaps: Malawi, Trinidad & Tobago, and Syria. Those had missing data sets for two key variables—trade and capital. Although a few other countries had missing data for some variables across a few years, they were retained for the research. Hence, the study was done in a total of 124 countries.

For this research, a natural logarithm of the variables was taken and used for the regression models except for Political Stability, which was standardized. The log values were taken to ensure normalization of the variables. Log transformation makes the skewed original data more normal and improves linearity between the dependent and independent variables. This is an appropriate transformation for the variables of interest, as seen in other papers such as Kang, 2022.

Data Descriptives

The tables below summarize the description of the various variables, showing the Mean, Standard deviation, Minimum, and Maximum, as well as the number of Samples and missing data per variable. Table 4-2 shows the entire country dataset, while Tables 4-3, 4-4, and 4-5 describe the three subsets—developed countries, Developing countries, and Least Developed Countries.

Table 4-2: Full Country Dataset

Statistics

		Energy Security	Energy Equity	Environmental Sustainability	GDP (US $)	Labor	Capital	Trade	PolStability	OilPrice ($)
N	Valid	2852	2852	2852	2851	2851	2794	2801	2846	2852
	Missing	0	0	0	1	1	58	51	6	0
Mean		54.3636	64.1876	64.8442	532991247964.013500000000000	23732034.55	24.190386619407832	89.629929805822000	-.036639	63.635284
Std. Deviation		11.95454	29.41507	10.86266	1844388137782.128700000000000	81671534.311	7.311285781137147	57.929796256713765	.9311508	26.4800911
Minimum		19.96	2.12	33.75	2484984348.556712600000000	140212	.000000000000000	16.352187397776227	-3.1804	24.3518
Maximum		80.04	100.00	90.05	20952693656000.004000000000000	781831676	66.465990737983960	442.620019127299430	1.7587	105.0096

The critical differences in energy trilemma between developed, developing, and Least Developed countries can be found in their mean values of energy Security and Energy Equity. For developed countries, as can be seen from Table 4-3, Energy security has a mean of 58.8 with an SD of 11.95, while for Developing countries in Table 4-4, the mean value is 52.9 with an SD of 10.59, and for Least Developed countries in Table 4-5, it is 47.4 with SD of 12.79. While their means differ, the Standard deviation overlaps between the country classifications. The most significant difference between the countries is seen in Energy Equity, with significantly higher values for Developed countries than for Developing and Least Developed countries. While Developed countries (Table 4-3) have a mean of 80.5 with SD of 26.14, Developing countries (Table 4-4) have a mean of 59.5 with SD of 25.47, and the Least Developed Countries (Table 4-5) have a mean of 30, with SD of 26.34. For energy Sustainability, there is a main difference between Developed and Developing countries, with a mean of 71.16 for Developed countries (Table 4-3) compared to 61.59 for developing countries (Table 4-4). Still, we don’t see much difference for the Least Developed Countries (Table 4-5), with a mean of 60.39.

Table 4-3: Developed Countries

Statistics [a]

		Energy Security	Energy Equity	Environmental Sustainability	GDP (US $)	Labor	Capital	Trade	PolStability	OilPrice ($)
N	Valid	1012	1012	1012	1012	1011	1008	1009	1006	1012
	Missing	0	0	0	0	1	4	3	6	0
Mean		58.80	80.53	71.16	970955470294.80	13455495.82	23.55	102.86	0.61	63.64
Std. Deviation		11.94	26.15	9.03	2651383893648.51	27372601.51	4.55	58.78	0.65	26.49
Minimum		24.53	2.12	37.60	2680895445.11	154307.00	9.17	19.56	-1.64	24.35
Maximum		80.04	100.00	90.05	20952693656000.00	169229171.00	54.95	388.12	1.76	105.01

a. DevGroup = 1

Table 4-4: Developing Countries

Statistics [a]

		Energy Security	Energy Equity	Environmental Sustainability	GDP (US $)	Labor	Capital	Trade	PolStability	OilPrice ($)
N	Valid	1495	1495	1495	1494	1495	1455	1460	1495	1495
	Missing	0	0	0	1	0	40	35	0	0
Mean		52.97	59.51	61.59	352027554901.73	32758776.31	24.12	86.10	-0.32	63.64
Std. Deviation		10.59	25.48	10.66	1229663914030.16	109472232.76	7.76	59.97	0.87	26.48
Minimum		19.96	3.90	33.75	2484984348.56	140212.00	1.53	16.35	-3.18	24.35
Maximum		75.85	99.92	87.15	16325209299766.80	781831676.00	58.15	442.62	1.62	105.01

a. DevGroup = 2

Table 4-5: Least Developed Countries

Statistics [a]

		Energy Security	Energy Equity	Environmental Sustainability	GDP (US $)	Labor	Capital	Trade	PolStability	OilPrice ($)
N	Valid	345	345	345	345	345	331	332	345	345
	Missing	0	0	0	0	0	14	13	0	0
Mean		47.41	36.52	60.40	31947666619.93	14730880.10	26.46	64.94	-0.70	63.64
Std. Deviation		12.79	26.34	7.82	45022351210.11	16401957.62	10.84	28.48	0.76	26.51
Minimum		24.22	2.70	45.21	3133116396.65	693893.00	0.00	23.98	-2.47	24.35
Maximum		76.16	95.99	79.84	305522975082.01	74459362.00	66.47	162.41	0.82	105.01

a. DevGroup = 3

As expected, the level of GDP is different for the different groups of countries, with the Developed countries (Table 4-3) having a mean of $970.9 bln, compared to the Developing countries (Table 4-4) with a mean of $352bln and the Least Developed Countries (Table 4-5) with a mean of $31.9bln. Hence, the GDP of developed countries is three times more than that of Developing countries, and that of Developing countries is ten times more than that of Least Developed Countries. Hence, developed countries have a GDP 30 times more than the GDP of the least developed countries.

Correlation of Variables

A Pearson correlation model was run for all the variables. The results as seen in Table 4-6 show correlation numbers less than 0.6 and hence, are not considered high. However, given that most of the indicators are related to the energy system, although the values are not statistically high (<0.7), most are statistically significant. The highest correlation is found between energy security and energy equity, with a correlation coefficient of 0.584. This is expected as energy equity measures access to electricity, affordability of oil, gasoline prices, and electricity access while energy security measures uninterrupted availability of energy sources at an affordable price using import dependence, diversity of electric generation, and energy storage. Hence, both have measurement indicators related to affordability and availability of energy sources and are expected to be correlated.

Table 4-6: Correlation Results

Correlations

		EnergySecurity	EnergyEquity	Environmental Sustainability	GDP	Labour	Capital	Trade	PolStability	OilPrice
Energy Security	Pearson Correlation	1	.584**	.393**	.236**	.131**	.056**	-.212**	.242**	-.003
	Sig. (2-tailed)		<.001	<.001	<.001	<.001	.003	<.001	<.001	.856
	N	2852	2852	2852	2851	2851	2794	2801	2846	2852
Energy Equity	Pearson Correlation	.584**	1	.385**	.198**	-.041*	.036	.081**	.446**	.045*
	Sig. (2-tailed)	<.001		<.001	<.001	.028	.058	<.001	<.001	.017
	N	2852	2852	2852	2851	2851	2794	2801	2846	2852
Environmental Sustainability	Pearson Correlation	.393**	.385**	1	.004	-.210**	-.131**	.047*	.388**	.060**
	Sig. (2-tailed)	<.001	<.001		.845	<.001	<.001	.014	<.001	.001
	N	2852	2852	2852	2851	2851	2794	2801	2846	2852
GDP	Pearson Correlation	.236**	.198**	.004	1	.536**	.052**	-.173**	.070**	.023
	Sig. (2-tailed)	<.001	<.001	.845		<.001	.006	<.001	<.001	.222
	N	2851	2851	2851	2851	2850	2794	2801	2845	2851
Labour	Pearson Correlation	.131**	-.041*	-.210**	.536**	1	.232**	-.181**	-.147**	.010
	Sig. (2-tailed)	<.001	.028	<.001	<.001		<.001	<.001	<.001	.588
	N	2851	2851	2851	2850	2851	2793	2800	2845	2851
Capital	Pearson Correlation	.056**	.036	-.131**	.052**	.232**	1	.043*	.026	.089**
	Sig. (2-tailed)	.003	.058	<.001	.006	<.001		.022	.174	<.001
	N	2794	2794	2794	2794	2793	2794	2783	2788	2794
Trade	Pearson Correlation	-.212**	.081**	.047*	-.173**	-.181**	.043*	1	.391**	.076**
	Sig. (2-tailed)	<.001	<.001	.014	<.001	<.001	.022		<.001	<.001
	N	2801	2801	2801	2801	2800	2783	2801	2795	2801

PolStability	Pearson Correlation	.242**	.446**	.388**	.070**	-.147**	.026	.391**	1	-.026
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	.174	<.001		.172
	N	2846	2846	2846	2845	2845	2788	2795	2846	2846
OilPrice	Pearson Correlation	-.003	.045*	.060**	.023	.010	.089**	.076**	-.026	1
	Sig. (2-tailed)	.856	.017	.001	.222	.588	<.001	<.001	.172	
	N	2852	2852	2852	2851	2851	2794	2801	2846	2852

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

5. CHAPTER 5

Results

Multiple regression analyses were carried out to study the relationships between the independent variables – Energy security, Energy Equity, Environmental Sustainability, Capital, Trade, Labor, Oil Price, and the moderating effect of oil price on energy security, and the dependent variable economic growth (GDP), while statistically controlling for Political Stability. Two different types of regression were used for the analysis. They are the Pooled Ordinary Least Squares regression (POLS) and the Fixed Effects regression analysis. These were carried out for the complete dataset, including all 124 countries, and then done for the three sub-classifications of economies – Developing, Developed, and Least Developed Countries. These results are tabulated in Table 5-1 to Table 5-4 below, while Table 5-5 summarizes the results of this research's hypotheses testing.

Table 5-1 summarizes the results of the whole-country analysis involving 124 countries. The study used the Pooled Ordinary Least Squares (POLS) and fixed effects methodology while keeping the years and country as fixed effects. Hence, models one through three report on the POLS methodology, while models four to six report on the fixed effects methodology. Model one included only the control variable – Political Stability, with the dependent variable, GDP. Model two has both the control variable, the independent variables, and the dependent variable, while Model three is the total research model, which has the control variable, independent variable, moderating variable, and the dependent variables. Similarly, for the fixed effects models, model four includes only the control variable and dependent variable; model five has the control variable, the independent variables, and the dependent variable, while model six is the total research model, which has the control variable, independent variable, moderating variable, and the dependent variables. In addition, the table reports the adjusted R2 value, which measures the model's fitness and how well the model can predict the dependent variable. The results clearly show that the fixed effects model is a better predictor than the POLS model, as seen in the adjusted R2 values.

Table 5-1: Regression Results for Whole Country Analysis

Full Dataset (All Countries)

	Pooled Ordinary Least Squares (POLS)						**Fixed Effects Regression**					
	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**		**Model 6**	
	B	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**
Political Stability	0.207	<.001*	0.615	<.001*	0.615	<0.001*	0.085	<0.001*	0.084	<0.001*	0.083	<.001*
Labor			1.055	0.000*	1.055	0.000*			0.400	<0.001*	0.398	<.001*
Capital			-0.454	<0.001*	-0.453	<0.001*			0.128	<0.001*	0.128	<.001*
Trade			0.359	<0.001*	0.358	<0.001*			-0.089	<0.001*	-0.089	<.001*
Energy Security			0.137	0.133	-0.379	0.509			0.045	0.153	0.122	0.154
Energy Equity			0.682	<0.001*	0.683	<0.001*			0.222	<0.001*	0.219	<.001*
Energy Sustainability			-0.240	0.025*	-0.240	0.025*			0.013	0.750	0.011	0.777
Oil Price			0.137	<0.001*	-0.361	0.511	0.523	<0.001*	0.407	<0.001*	0.481	<.001*
EnergySec Oil Price*					0.126	0.363					-0.018	0.334
Adjusted R2	1.3%		79.4%		79.4%		99.5%		99.6%		99.6%	

The total N values are 2775. The total number of countries is 124.

Asterisked numbers are significant with P Values less than 5%

Models 4, 5, and 6 include country and year-fixed effects.

Table 5-2 summarizes the results for the Developed countries involving 44 countries. The analysis used the Pooled Ordinary Least Squares (POLS) methodology and the fixed effects methodology while keeping the years and country as fixed effects. Hence, models one through three report the POLS methodology, while models four to six report the fixed effects methodology. Model one included only the control variable – Political Stability, with the dependent variable, GDP. Model two has both the control variable, the independent variables, and the dependent variable, while Model three is the total research model, which has the control variable, independent variable, moderating variable, and the dependent variables. Similarly, for the fixed effects models, model 4 includes only the control variable and dependent variable; model 5 has the control variable, the independent variables, and the dependent variable, while model 6 is the total research model, which has the control variable, independent variable, moderating variable, and the dependent variables. In addition, the table reports the adjusted R2 value, which measures the model's fitness and how well the model can predict the dependent variable. The results clearly show that the fixed effects model is a better predictor than the POLS model, as seen in the adjusted R2 values.

Table 5-2: Regression Results for Developed Countries

Developed Countries

	Pooled Ordinary Least Squares (POLS)						**Fixed Effects Regression**					
	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**		**Model 6**	
	B	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**
Political Stability	0.430	<0.001*	0.814	<0.001*	0.818	<0.001*	0.114	<0.001*	0.107	<0.001*	0.104	<.001*
Labor			1.202	0.000*	1.202	0.000*			0.122	0.002*	0.111	0.005*
Capital			-0.628	<0.001*	-0.637	<0.001*			0.176	<0.001*	0.179	<.001*
Trade			0.043	0.445	0.039	0.484			-0.065	0.005*	-0.065	0.005*
Energy Security			-0.478	<0.001*	-2.315	0.004*			-0.065	0.170	0.169	0.163
Energy Equity			-0.006	0.892	0.001	0.987			0.066	0.002*	0.058	0.007*
Energy Sustainability			0.477	0.024*	0.470	0.026*			-0.018	0.788	-0.020	0.765
Oil Price			0.144	0.002*	-1.655	0.035*	0.383	<0.001*	0.382	<0.001*	0.598	<.001*
EnergySec* Oil Price					0.444	0.022*					-0.053	0.036*
Adjusted R2	2.4%		89.6%		89.7%		99.8%		99.9%		99.9%	

The total number of observations is 1000. The total number of countries is 44.

Asterisked numbers are significant with P Values less than 5%

Models 4, 5, and 6 include country and year-fixed effects.

Table 5-3 summarizes the results for the Developing countries involving 65 countries. The analysis used the Pooled Ordinary Least Squares (POLS) methodology and the fixed effects methodology while keeping the years and country as fixed effects. Hence, Models 1 through 3 report on the POLS methodology, while Models 4 to 6 report on the fixed effects methodology. Model 1 included only the control variable – Political Stability, with the dependent variable, GDP. Model 2 has both the control variable, the independent variables, and the dependent variable, while Model 3 is the total research model, which has the control variable, independent variable, moderating variable, and the dependent variables. Similarly, for the fixed effects models, model 4 includes only the control variable and dependent variable; model 5 has the control variable, the independent variables, and the dependent variable, while model 6 is the total research model, which has the control variable, independent variable, moderating variable, and the dependent variables. In addition, the table reports the adjusted R2 value, which measures the model's fitness and how well the model can predict the dependent variable. The results clearly show that the fixed effects model is a better predictor than the POLS model, as seen in the adjusted R2 values.

Table 5-3: Regression Results for Developing Countries

Developing Countries

	Pooled Ordinary Least Squares (POLS)						**Fixed Effects Regression**					
	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**		**Model 6**	
	B	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**
Political Stability	-0.345	<0.001*	0.266	<0.001*	0.265	<0.001*	0.092	<0.001*	0.080	<0.001*	0.077	<.001*
Labor			0.969	0.000*	0.969	0.000*			0.263	<0.001*	0.261	<.001*
Capital			-0.218	<0.001*	-0.217	<0.001*			0.061	<0.001*	0.064	<.001*
Trade			0.150	<0.001*	0.149	<0.001*			-0.057	0.006*	-0.060	0.003*
Energy Security			-0.313	<0.001*	-0.822	0.123			0.060	0.197	-0.428	<.001*
Energy Equity			1.026	<0.001*	1.028	<0.001*			0.223	<0.001*	0.234	<.001*
Energy Sustainability			-0.704	<0.001*	-0.702	<0.001*			0.242	<0.001*	0.263	<.001*
Oil Price			0.107	<0.001*	-0.384	0.450	0.578	<0.001*	0.453	<0.001*	-0.015	0.897
EnergySec* Oil Price					0.125	0.334					0.118	<.001*
Adjusted R2	3.8%		89.7%		89.7%		99.4%		99.5%		99.5%	

The total number of observations is 1454. The total number of countries is 65.

Asterisked numbers are significant with P Values less than 5%

Models 4, 5, and 6 include country and year-fixed effects.

Table 5-4 summarizes the results for the least developed countries, which are 15 countries. The analysis used the Pooled Ordinary Least Squares (POLS) methodology and the fixed effects methodology while keeping the years and country as fixed effects. Hence, models one through three report the POLS methodology, while models four to six report the fixed effects methodology. Model one included only the control variable – Political Stability, with the dependent variable, GDP. Model two has both the control variable, the independent variables, and the dependent variable, while Model three is the total research model, which has the control variable, independent variable, moderating variable, and the dependent variables. Similarly, for the fixed effects models, model four includes only the control variable and dependent variable; model five has the control variable, the independent variables, and the dependent variable, while model six is the total research model, which has the control variable, independent variable, moderating variable, and the dependent variables. In addition, the table reports the adjusted R2 value, which measures the model's fitness and how well the model can predict the dependent variable. The results clearly show that the fixed effects model is a better predictor than the POLS model, as seen in the adjusted R2 values.

Table 5-4: Regression Results for Least Developed Countries

Least Developed Countries (LDC)

	Pooled Ordinary Least Squares (POLS)						**Fixed Effects Regression**					
	Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**		**Model 6**	
	B	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**	**B**	**P Value**
Political Stability	-0.343	<.001*	0.020	0.652	0.016	0.710	0.043	0.002*	0.055	<.001*	0.052	<.001*
Labor			0.801	<.001*	0.800	<.001*			-0.080	0.558	-0.007	0.959
Capital			0.498	<.001*	0.512	<.001*			0.041	0.096	0.062	0.014*
Trade			0.127	0.157	0.126	0.156			-0.020	0.547	-0.046	0.185
Energy Security			0.508	0.003*	2.306	0.016*			0.190	0.001*	0.685	<.001*
Energy Equity			0.031	0.601	0.026	0.653			0.261	<.001*	0.246	<.001*
Energy Sustainability			-0.757	0.011*	-0.783	0.008*			-0.389	<.001*	-0.413	<.001*
Oil Price			0.129	0.067	1.802	0.039*	0.761	<.001*	0.745	<.001*	1.183	<.001*
EnergySec* Oil Price					-0.438	0.055					-0.121	0.003*
Adjusted R2	8.0%		71.3%		71.6%		99.1%		99.3%		99.3%	

The total number of observations is 319. The total number of countries is 15.

Asterisked numbers are significant with P Values less than 5%

Models 4, 5, and 6 include country and year-fixed effects.

Table 5-5: Summary of Hypotheses Support

	Hypotheses Statement	**Supported/ Not Supported**	**Dataset Providing Support**
H1	As the labor force increases, economic growth increases.	Supported	Whole dataset, Developed, Developing countries
H2	As capital increases, economic growth increases	Supported	Whole dataset, Developed, Developing, Least Developed Countries
H3	As trade openness increases, economic growth increases	Not Supported	The whole dataset, Developed and Developing Significant, but in the opposite direction.
H4	As energy security increases, economic growth increases	Supported	Least Developed Countries. Significant but in the opposite direction in Developing Countries
H5	As energy equity increases, economic growth increases	Supported	Whole dataset, Developed, Developing, Least Developed Countries
H6	As environmental sustainability increases, economic growth reduces	Supported	Least Developed Countries. Significant but in the opposite direction in Developing Countries
H7	As oil prices increase, economic growth decreases for net importers of oil, while economic growth increases for net exporters of oil, with a mono-economy.	Supported	Positive Significant results for the whole dataset, exporting and non-exporting countries.
H8	Oil price moderates the relationship between energy security and economic development such that an increase in oil price significantly impacts the relationship between energy security and economic development positively and makes that relationship stronger, especially for low energy security countries.	Supported	Developing Countries. Significant but in the opposite direction in Developed and Least Developed Countries.

Hypothesis 1 (H1):

A multiple regression analysis examined the relationship between GDP and Labor while statistically controlling for Political Stability. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Using the fixed effects regression analysis, the second model for the whole dataset was significant F (6, 2623) = 4906.7, p <.001), and this model explained 99.6% of the variance in GDP. Since the third model, which examined the moderation effect of oil price on energy security of GDP, wasn't significant F (1, 2622) = 4874.5, p .334), I proceeded to interpret the second model (model 5). Of interest to H1, the unstandardized coefficient for labor was 0.400, indicating that, while statistically controlling for political stability, each percent increase in Labor leads to an increase of 0.4% in GDP, in the same direction as predicted in the research model. This relationship is significantly different from zero [t (2623) = 18.218, p <.001], as seen in Table 5-1. This result supports the positive relationship between Labor and GDP, as predicted in H1.

I also found additional support for this relationship while running the same regression analysis for the subset of Developed Countries. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-2, using the fixed effects regression analysis, the whole model (model 6) containing the interaction term between oil price and energy security was found to be significant F (1, 927) = 8549.4, p <.036], and this model explained 99.9% of the variance in GDP. Of interest is H1, the unstandardized coefficient for labor was 0.111, indicating that, while holding political stability as a constant, each percent increase in Labor leads to an increase of 0.111% in

GDP, in the same direction as predicted in the research model. This relationship is significantly different from zero [t (927) = 2.795, p .005]. This result provides additional support for the positive relationship between Labor and GDP, as predicted in H1.

In addition, while running the same regression analysis for the subset of Developing Countries, I found support for this relationship. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-3, using the fixed effects regression analysis, the whole model (model 6) containing the interaction term between oil price and energy security was found to be very significant F (1, 1360) = 2909.4, p <.001] and this model explained 99.5% of the variance in GDP. Of interest is H1, the unstandardized coefficient for labor was 0.261, indicating that, while statistically controlling for political stability, each percent increase in Labor leads to an increase of 0.261% in GDP, in the same direction as predicted in the research model. This relationship is very significantly different from zero [t (1360) = 2.795, p <.001]. This result provides additional support for the positive relationship between Labor and GDP, as predicted in H1.

This result aligns with previous research demonstrated by both Kang 2022 and Le Thai (2019), whose panel dataset analysis shows a positive relationship between GDP and Labor, which aligns with the traditional production model.

Hypothesis 2 (H2):

A multiple regression analysis examined the relationship between Capital and GDP while statistically controlling for Political Stability. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-1, using the fixed effects regression analysis, the second model for the whole dataset was significant F (6, 2623) = 4906.7, p <.001), and this model explained 99.6% of the variance in GDP. Since the third model (model 6), which examined the moderation effect of oil price on energy security of GDP, wasn't significant F (1, 2622) = 4874.5, p .334), I proceeded to interpret the second model (Model 5). Of interest to H2, the unstandardized coefficient for Capital was 0.128, indicating that, while statistically controlling for political stability, each percent increase in Capital leads to an increase of 0.128% in GDP, in the same direction as predicted in the research model. This relationship is significantly different from zero [t (2623) = 11.070, p <.001]. This result supports the positive relationship between Capital and GDP, as predicted in H2.

I also found additional support for this relationship while running the same regression analysis for the subset of Developed Countries. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-2, using the fixed effects regression analysis, the whole model (model 6) containing the interaction term between oil price and energy security was found to be significant F (1, 927) = 8549.4, p <.036], and this model explained 99.9% of the variance in GDP. Of interest is H2, the unstandardized coefficient for Capital was 0.179, indicating that, while holding political stability as a constant, each percent increase in Capital leads to an increase of 0.179% in GDP, in the same direction as predicted in the research model. This relationship is very significantly different from zero [t (927) = 8.638, p <.001]. This result provides additional support for the positive relationship between Capital and GDP, as predicted in H2.

In addition, while running the same regression analysis for the subset of Developing Countries, I found support for this relationship. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-3, using the fixed effects regression analysis, the whole model (model 6) containing the interaction term between oil price and energy security was found to be very significant $F (1, 1360) = 2909.4, p < .001$] and this model explained 99.5% of the variance in GDP. Of interest is H2, the unstandardized coefficient for Capital was 0.064, indicating that, while statistically controlling for political stability, each percent increase in Capital leads to an increase of 0.064% in GDP, in the same direction as predicted in the research model. This relationship is very significantly different from zero [$t (1360) = 3.846, p < .001$]. This result provides additional support for the positive relationship between Capital and GDP, as predicted in H2.

Furthermore, while running the same regression analysis for the subset of Least Developed Countries, I found additional support for this relationship. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-4, using the fixed effects regression analysis, the whole model (model 6) containing the interaction term between oil price and energy security was found to be significant $F (1, 275) = 930.6, p\ .003$], and this model explained 99.3% of the variance in GDP. Of interest is H2, the unstandardized coefficient for Capital was 0.062, indicating that, while statistically controlling for political stability, each percent increase in Capital leads to an increase of 0.062% in GDP, in the same direction as predicted in the research model. This relationship is significantly different from zero [$t (275) = 2.476, p < .014$]. This result provides additional support for the positive relationship between Capital and GDP, as predicted in H2.

This result aligns with previous research demonstrated by both Kang 2022 and Le Thai (2019), whose panel dataset analysis shows a positive relationship between GDP and capital, which aligns with the traditional production model.

Hypothesis 3 (H3):

A multiple regression analysis examined the relationship between Trade and GDP while statistically controlling Political Stability. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-1, using the fixed effects regression analysis, the second model (model 5) for the whole dataset was significant F (6, 2623) = 4906.7, p <.001), and this model explained 99.6% of the variance in GDP. Since the third (full) model, which examined the moderation effect of oil price on energy security of GDP, wasn't significant F (1, 2622) = 4874.5, p .334), I proceeded to interpret the second model (model 5). Of interest to H3, the unstandardized coefficient for Trade was -0.089, indicating that, while statistically controlling for political stability, each percent increase in Trade leads to a decrease of 0.089% in GDP, in the opposite direction as predicted in the research model. This relationship is significantly different from zero [t (2623) = 11.070, p <.001]. Although the relationship is significant, this result doesn't support a positive relationship between Trade and GDP as predicted in H3. The same significant relationship was found for the Developed and developing dataset for a regression analysis between Trade and GDP, per Table 5-2 and Table 5-3. However, the relationship was also negative, as seen in the whole country dataset. Although a positive relationship was expected, this is in line with the observation by Kang 2022, where his results show that the relationship between Trade and GDP differed depending on the panel analysis method used. In his paper, the fixed effects regression shows a negative relationship between Trade and GDP, although the GMM analysis shows a positive relationship.

Hypothesis 4 (H4):

A multiple regression analysis examined the relationship between Energy Security (ES) and GDP while statistically controlling for Political Stability. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-4, for the Least Developed Countries, using the fixed effects regression analysis, the whole model (model 6) containing the interaction term between oil price and energy security was found to be significant $F(1, 275) = 930.6$, p .003]. This model explained 99.3% of the variance in GDP. Of interest is H4, the unstandardized coefficient for ES was 0.685, indicating that, while statistically controlling for political stability, each percent increase in ES leads to an increase of 0.685% in GDP, in the same direction as predicted in the research model. This relationship is significantly different from zero [$t(275) = 3.93$, $p < .001$]. This result provides additional support for the positive relationship between ES and GDP, as predicted in H4.

This result was also demonstrated by Kang 2022, who found a significant positive relationship between energy security and GDP for the whole country dataset and the three subsets of economies, differentiated by income levels. However, my research only found support for the positive relationship in the least developed economies and not in the entire dataset or other sub-sets. This will be further elaborated in the discussions.

Hypothesis 5 (H5)

A multiple regression analysis examined the relationship between Energy Equity (EE) and GDP while controlling for Political Stability. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Referencing Table 5-1, using the fixed effects regression analysis, the second model (model 5) for the whole dataset was significant F (6, 2623) = 4906.7, p <.001), and this model explained 99.6% of the variance in GDP. Since the third model (Model 6), which examined the moderation effect of oil price on energy security of GDP, wasn't significant F (1, 2622) = 4874.5, p .334), I proceeded to interpret the second model. Of interest to H5, the unstandardized coefficient for EE was 0.222, indicating that, while statistically controlling for political stability, each percent increase in EE leads to an increase of 0.222% in GDP, in the same direction as predicted in the research model. This relationship is very significantly different from zero [t (2622) = 12.336, p <.001]. This result supports the positive relationship between EE and GDP, as predicted in H5.

I also found additional support for this relationship while running the same regression analysis for the subset of Developed Countries. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-2, using the fixed effects regression analysis, the whole model (model 6) containing the interaction term between oil price and energy security was found to be significant F (1, 927) = 8549.4, p <.036], and this model explained 99.9% of the variance in GDP. Of interest is H5, the unstandardized coefficient for EE was 0.058, indicating that, while holding political stability as a constant, each percent increase in EE leads to an increase of 0.058% in GDP, in the same direction as predicted in the research model. This relationship is significantly different from zero [t (927) = 2.705, p .007]. This result provides additional support for the positive relationship between EE and GDP, as predicted in H5.

In addition, while running the same regression analysis for the subset of Developing Countries, I found support for this relationship. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-3, using the fixed effects regression analysis, the whole model (model 6) containing the interaction term between oil price and energy security was found to be very significant F (1, 1360) = 2909.4, p <.001] and this model explained 99.5% of the variance in GDP. Of interest is H5, the unstandardized coefficient for EE was 0.234, indicating that, while holding political stability as a constant, each percent increase in EE leads to an increase of 0.234% in GDP, in the same direction as predicted in the research model. This relationship is very significantly different from zero [t (1360) = 7.050, p <.001]. This result provides additional support for the positive relationship between EE and GDP, as predicted in H5.

Furthermore, while running the same regression analysis for the subset of Least Developed Countries, I found additional support for this relationship. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-4, using the fixed effects regression analysis, the whole model containing the interaction term between oil price and energy security was found to be significant F (1, 275) = 930.6, p .003], and this model explained 99.3% of the variance in GDP. Of interest is H5, the unstandardized coefficient for EE was 0.246, indicating that, while holding political stability as a constant, each percent increase in EE leads to an increase of 0.246% in GDP, in the same direction as predicted in the research model. This relationship is significantly different from zero [t (275) = 7.697, p <.001]. This result provides additional support for the positive relationship between EE and GDP, as predicted in H5.

Comparing my results with Kang's 2022 panel analysis, I found a significant positive relationship between the whole-country panel analysis and high-income countries. Still, he saw a negative relationship between low-income and upper-middle-income countries. In comparison, my results show that the relationship between energy equity and economic growth was positively significant for the whole dataset and all three subsets of economies.

Hypothesis 6 (H6):

A multiple regression analysis examined the relationship between Energy Sustainability (ESUS) and GDP while statistically controlling for Political Stability. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. Per Table 5-4, for the Least Developed Countries, using the fixed effects regression analysis, the whole model (model 6) containing the interaction term between oil price and energy security was found to be significant F (1, 275) = 930.6, p .003]. This model explained 99.3% of the variance in GDP. Of interest is H6, the unstandardized coefficient for ESUS was 0.413, indicating that, while holding political stability as a constant, each percent increase in ESUS leads to a decrease of 0.413% in GDP, in the same direction as predicted in the research model. This relationship is significantly different from zero [t (275) = -4.292, p <.001]. This result provides additional support for the negative relationship between ESUS and GDP, as predicted in H6.

Again, this result is not unexpected, as the impact of Energy Sustainability on economic growth differed depending on the subset of economies being analyzed. In his paper, Kang (2022) showed that ESUS performance negatively affected economic growth for low-income and upper-middle-income countries but had a positive relationship with high-income countries. My result showed a negative relationship for Least Developed economies (in line with Kang's result) but a positive relationship for Developing countries.

Hypothesis 7 (H7)

To examine Hypothesis 7, a multiple regression analysis was conducted to investigate the relationship between oil price (OP) and GDP while statistically controlling for political stability. This was carried out for the entire dataset of countries and subsequently, for fuel-exporting and non-fuel-exporting countries. The analysis used the Pooled Ordinary least Squares (POLS) and Fixed effects regression. The results of both regression methods can be seen in Table 5-6 below. While the POLS method supports most of the hypotheses, we choose to interpret the results from the fixed regression analysis to support our hypotheses. This is because this controls for the individual country and fixed effects, and models four, five, and six show a high predictive power, with R2 > 99%.

From Table 5-6 below, I found partial support for hypothesis 7. It is partially supported because an increase in oil prices results in an increase in GDP for all countries irrespective of their export or import status, slightly contrary to my hypothesis that says it increases for exporting countries and decreases for importing countries. Hence, the relationship between oil price and GDP is not delineated by the type of country (export versus import), as both show a significant direct relationship.

For exporting countries, using the fixed effects regression analysis, the whole model containing the interaction term between oil price and energy security was found to be insignificant F (1, 529) = 1,248.2, p .149], and this model explained 99.3% of the variance in GDP. Of interest is H7, the unstandardized coefficient for OP was 0.617, indicating that, while holding political stability as a constant, each percent increase in OP leads to an increase of 0.617% in GDP, in the same direction as predicted in the research model. This relationship is significantly different from zero [t (275) = 3.044, p .002]. This result supports the positive relationship between OP and GDP for exporting countries, as predicted in H7.

For non-exporting countries, using the fixed effects regressions, the whole model containing the interaction term between oil price and energy security was also found to be insignificant F (1, 1970) = 4,913.7, p .421], and this model explained 99.8% of the variance in GDP. Of interest is H7, the unstandardized coefficient for OP was 0.167, indicating that, while holding political stability as a constant, each percent increase in OP leads to an increase of 0.167% in GDP, in the opposite direction as predicted in the research model. This relationship is significantly different from zero [t (1970) = 2.149, p .032]. This result does not support a negative relationship between OP and GDP for importing countries, as predicted in H6.

Although both exporting and non-exporting countries show a significant relationship between oil price and GDP, it is worthy of note to see that the magnitude of the impact of a percent increase in oil price to an increase in GDP is at least five times more in magnitude, for fuel exporting countries than for non-fuel exporting countries. Hence, for exporting countries, a percent increase in OP increases GDP by 0.617%. In contrast, for non-fuel exporting countries, it increases GDP by 0.167%, showing that oil prices significantly increase GDP for exporting countries, up to four times more, compared to non-exporting countries.

Table 5-6: Oil Price Analysis

Analysis Using Export Country's Classifications

	Pooled Ordinary Least Squares (POLS)						Fixed Effects Regression					
	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Full Dataset		Exporting		Non-Exporting		Full Dataset		Exporting		Non-Exporting	
	B	P Value	B	P Value	B	P Value	B	P Value	B	P Value	B	P Value
Pol_Stab	0.615	<.001*	0.148	<.001*	0.748	<.001*	0.084	<.001*	0.084	<.001*	0.083	<.001*
Labor	1.053	0.000*	0.756	<.001*	1.189	0.000*	0.397	<.001*	0.308	<.001*	0.333	<.001*
Capital	-0.448	<.001*	-0.360	<.001*	-0.432	<.001*	0.128	<.001*	-0.043	0.108	0.196	<.001*
Trade	0.343	<.001*	-0.211	0.026*	0.403	<.001*	-0.088	<.001*	0.070	0.039*	-0.109	<.001*
Energy Security	-0.392	0.501	1.281	0.212	-1.560	0.012*	0.111	0.203	0.487	0.024*	-0.156	0.084
Energy Equity	0.695	<.001*	0.980	<.001*	0.404	<.001*	0.220	<.001*	0.324	<.001*	0.171	<.001*
Energy Sustainability	-0.259	0.017*	-1.143	<.001*	1.344	<.001*	0.002	0.962	0.204	0.027*	-0.046	0.279
Oil Price	-0.358	0.522	0.314	-0.847	0.152	0.012*	0.296	<.001*	0.617	0.002*	0.167	0.032*
ES*Oil Price	0.125	0.376	-0.040	0.872	0.237	0.111	-0.014	0.454	-0.073	0.149	0.015	0.421
Adjusted R2	79.4%		79.2%		83.4%		99.6%		99.3%		99.8%	
N	**2680**		**584**		**2095**		**2680**		**584**		**2095**	
Models 4, 5, and 6 include country and year-fixed effects.												

Hypothesis 8 (H8)

A multiple regression analysis was conducted to examine the interaction between Oil Price (OP) and Energy Security (ES) as predictors of GDP while controlling for Political Stability (PolStab). All results predicted are based on the natural logarithmic values of the predictors, as well as their product. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. For the subset of the Developing Countries, the whole model containing the interaction term between oil price and energy security was found to be significant $F(1, 1360) = 2909.4$, $p < .001$], and this model explained 99.5% of the variance in GDP. A reduced model, not containing the interaction between OP and ES, explained 99.5% of the variance in GDP. The change in explained variance of 0.00% between the reduced and full models was significant [$F(1,1360) = 2909.4$, P .000)], indicating the presence of a significant interaction between OP and ES, with an interaction coefficient of .118. A Plot of the relationship between ES, OP, and GDP indicated that the relationship between ES and GDP, which is negative, is increased (slope takes a steeper angle) for higher values of OP and reduced for lower values of OP.

A multiple regression analysis was conducted to examine the interaction between Oil Price (OP) and Energy Security (ES) as predictors of GDP while controlling for Political Stability (PolStab). All results predicted are based on the natural logarithmic values of the predictors, as well as their product. Neither Tolerance nor VIF statistics indicated the presence of marked collinearity. For the Least Developed Countries subset, the whole model containing the interaction term between oil price and energy security was found to be significant $F(1, 275) = 930.6$, p .003], and this model explained 99.3%

of the variance in GDP. A reduced model, not containing the interaction between OP and ES, explained 99.3% of the variance in GDP. The change in explained variance of 0.00% between the reduced and full models was significant [$F(1,275) = 930.6$, $P<.001$)], indicating the presence of a significant interaction between OP and ES, with an interaction coefficient of -.121. A Plot of the relationship between ES, OP, and GDP indicated that the relationship between ES and GDP, which is positive, is reduced (slope takes a flatter angle) for higher values of OP and increased for lower values of OP.

6. DISCUSSIONS

A total of 12 regression analyses were carried out in this study. Six were carried out using the Pooled Ordinary Least Squares regression (POLS) methodology, while six used the Fixed regression analysis. The regression analyses were done for the whole country dataset, developed, developing, least developed, fuel-exporting, and non-fuel-exporting countries. The results and discussions are based on the results of the six fixed effects regression analyses as those consistently had higher adjusted R2 values than the POLS regression. Table 6-1 summarizes the results from the six fixed regression analyses for the various groups of countries.

Table 6-1: Summary Results Table

Variables/ Factors (Hypothesis #)	**All Countries**	**Developed Countries**	**Developing Countries**	**Least Dev Countries**	**Fuel Exporting Countries**	**Non-Fuel Exporting Countries**
Labor (1)	+	+	+	NS (-)	+	+
Capital (2)	+	+	+	+	NS (-)	+
Trade Openness (3)	–	–	–	NS (-)	+	–
Energy Security (4)	NS (+)	NS (+)	–	+	+	NS (-)
Energy Equity (5)	+	+	+	+	+	+
Energy Sustainability(6)	NS (+)	NS (-)	+	–	+	NS (-)
Oil Price (7)	+	+	NS (-)	+	+	+
Oil Price *Energy Sec (8)	NS (-)	–	+	–	NS (-)	NS (+)
'+' refers to a significant (p value <5%) positive relationship between variable and GDP						
'-' refers to a significant (p-value < 5%) negative relationship between variable and GDP						
'NS (+)' refers to a non-significant positive relationship between variable and GDP						
'NS (-)' refers to a non-significant negative relationship between variable and GDP						

Full Dataset – Whole countries' analysis

For the full dataset involving 124 countries, I found support for five of the eight hypotheses using the fixed effects regression results, reference Table 6-1. In particular, I found support for Hypothesis 1, 2, 3, 5, and 7. However, the analysis from fixed effects failed to support hypotheses 4, 6, and 8. Hypotheses 1, 2, and 3 are related to the traditional factors, namely, Labor, Capital, and Trade, that have been validated to support the economic growth of countries, while Hypotheses 4 to 8 are related to the impact of energy trilemma and oil price on economic growth. Hence, with respect to the effect of Energy trilemma on the GDP of the 124 countries in particular, the analysis provided support for the impact of Energy Equity (EE) on the GDP of countries, showing that an increase in energy equity results in an increase in GDP. It also confirmed support for Hypothesis 7, which shows that the impact of oil prices on GDP is significant. However, it showed an opposite effect than the hypothesis proposed, showing that increasing oil prices leads to increased GDP for the collective group of countries. The study failed to support the hypothesis relating energy security and energy sustainability to GDP since the results were insignificant. It also failed to support the moderating relationship between oil price and energy security for the total dataset. While I couldn't find support for these hypotheses at the whole-country dataset level, I did find support for them at the sub-country level. For the three hypotheses it did not support, it is most likely because of the inherent heterogeneity amongst the countries. As we would see subsequently, I found support for some of these hypotheses in the analysis at the sub-group level of Developed, Developing, and Least Developed countries. Hence, energy security, energy sustainability, and the moderating effect of oil prices on energy security can only be explained at the sub-group level, in line with the overarching theme of my research, which proposes that a "one-size-fit" for all cannot be applied for all countries when developing economic policies that govern energy trilemma, as they have varied impacts on the growth and development of the countries. Another apparent reason why the three hypotheses were not supported using the entire dataset is that some of them were supported at the level of the sub-groups impact on GDP in opposite directions. Hence, their effects cancel out in the overall country analysis, leading to non-significant outcomes. Therefore, energy security, energy sustainability, and the moderating effect of oil prices on energy security affect the sub-groups of countries in various and opposing ways.

It is worth mentioning that using the Pooled Ordinary Least Squares methodology, I found support for six out of the eight hypotheses, which yielded significant results. Two of the hypotheses – the effect of energy security on GDP and the moderating effect of oil price- did not find support.

Developed Countries

Using the fixed effect regression method, I found support for 6 out of the eight hypotheses, particularly Hypotheses 1, 2, 3, 5, 7, and 8, but I saw no support for Hypotheses 4 and 6. Reference Table 6-1. Hypotheses 1, 2, and 3 are related to the traditional variables that lead to an increase in economic development. Hence, they posit that Labor, Capital, and Trade lead to an increase in economic development of the countries. Hypothesis five posits correctly that an increase in energy equity leads to an increase in economic growth (GDP). Trade shows a negative significant relationship between it and GDP. This result is consistent across the board (at the whole dataset level and for each of the three sub-groups, requiring more investigation). However, I did not find support for Hypotheses 4 and 6, which speak to the impact of energy security and energy sustainability on the economic development of Developed countries. Although I did not find support for the direct relationship between energy security and GDP, I found support for the direct relationship between oil price and GDP and the moderating effect of oil price on the relationship between energy security and GDP. What do these mean? Oil prices significantly impact the economic growth of developed countries, as the P value was <0.001. The impact of oil price significantly affects the relationship between energy security and GDP, weakening the direct impact of energy security on GDP and making that direct relationship insignificant in the presence of the oil price moderation effect. The direct relationship between oil price and GDP is positive, which means that an increase in oil price leads to an increase in GDP. However, the moderation effect of oil prices on energy security is negative, meaning that an increase in oil prices weakens the direct positive relationship between energy security and GDP. This could imply that high energy security indices do not necessarily result in high GDP, especially during high oil price regimes. High oil prices are, therefore, a more significant driver of GDP than energy security does for developed countries. An interpretation could be that high oil prices tend to drive more economic growth, as the whole economy is stimulated with a higher consumption rate and tends to buy more and more goods, leading to higher GDP. On the other hand, Energy Security measures import independence, diversity of electric supplies, and energy storage capacity. Hence, developed countries with higher average value for Energy security, who have already invested in diversified electricity sources, increased storage and refining capacity, and probably are not as import-dependent as others, do not see that direct impact on their economic growth as a result, compared to the effect of oil price on the GDP. High oil prices weaken the direct relationship between energy security and GDP, but that direct relationship is strengthened during low oil prices.

Developing Countries

Using the fixed-effect regression method, I found support for seven of the eight hypotheses, particularly Hypotheses 1, 2, 3, 4, 5, 6, and 8. Reference Table 6-1. Still, I found no support for Hypothesis 7, which discusses the direct effect of oil prices on economic development. That is understandable since there is support for the moderating effect of oil prices instead.

Most importantly, I found support for the hypotheses of interest (4, 5, and 6), which focus on the energy trilemma – energy equity, energy security, and energy sustainability and their impact on the economic growth of developing countries. It shows a negative significant direct effect of energy security on economic development. In contrast, it shows a positive, significant direct effect of energy equity and sustainability on developing countries' economic development. This could imply that developing countries spend substantial resources to ensure energy security, which impacts their economic growth and development (GDP). In contrast, energy equity and sustainability increase these countries' economic growth and development. The negative relationship between energy security and economic growth could imply that the countries heavily invested in energy independence, diversification of their electricity sources, or building their storage or refining capacity, all indicators of energy security, during the 23 years of investigation that negatively impacted their economic growth. Further investigation is required to understand the main driver for this negative relationship between energy security and GDP for developing countries. From the results, all three energy trilemma indices are significant and impact the economic growth of developing countries. This is in addition to the substantial impact of the traditional trio of Labor, Capital, and Trade on the economic growth of countries, as supported and seen in Hypotheses 1, 2, and 3.

The oil price moderating relationship on energy security shows a positive significant impact on economic growth, although the direct effect of energy security on economic growth is negative. This implies that an increase in oil prices positively strengthens the negative relationship between energy security and economic development. One possible explanation for that is that during high oil prices, countries scramble more for energy security, and for developing countries, who are still on their energy security journey, it means probably spending more to either import more oil or build more storage and refining capacity or diversify into other non-oil resources. These are capital intensive, further strengthening the negative relationship between energy security and GDP, negatively impacting the GDP. The opposite happens during low oil prices. There is less pressure to attain energy security, which probably reduces the pressure to spend more on energy security, positively improving GDP. Again, these are postulations based on this research as there has been limited study on the moderating effect of oil prices on the energy security of different countries. This requires further investigation, perhaps for a subset of these countries.

Least Developed Countries

Using the fixed effect regression method, I found support for six out of the eight hypotheses, particularly Hypotheses 2, 4, 5, 6, 7, and 8, but I saw no support for Hypotheses 1 and 3. Reference Table 6-1. The result for this sub-group of countries is unique as the traditional variables that impact economic growth, Labor, and Trade were not significant. Hence, there was no support for them. The positive relationship between capital and economic growth was supported, which aligns with hypothesis 2. However, support was established for the three arms of energy trilemma – energy security, energy equity, and energy sustainability. Energy security and energy equity showed a significant positive direct relationship to economic growth in line with Hypotheses 4 and 5. Hence, an increase in either leads to an increase in GDP. However, in direct support of Hypothesis 6, energy sustainability showed a negative significant relationship to economic growth. It suggests that a focus on energy sustainability, i.e., reduction of CO2 and emissions target for least developed countries, could be detrimental to their economic growth.

This implies that while economic growth is traditionally a function of Capital, Labor, and Trade for the Least Developed Countries, those variables do not significantly impact economic growth (except for capital), as does the energy trilemma indices, which show a significant relationship to economic growth. Hence, for least-developed countries, energy trilemma plays a more substantial role in GDP than the traditional factors of economic growth. Therefore, policies must be tailored to favor these indices as they could determine the growth and development of such countries.

In addition, I found support for both hypothesis 7, which shows the direct effect of oil prices on economic growth, and hypothesis 8, which shows the moderating effect of oil prices on energy security and the impact on economic growth. The direct effect of an increase in oil prices on economic growth positively impacts economic growth. In contrast, the moderating effect of oil price on energy security indicates a negative significant relationship. Hence, higher oil prices moderate and weaken the relationship between energy security and GDP, maybe because it impacts the costs to ensure energy security for those countries that might not have high energy security (to begin with, reference the mean energy security indices for LDC (table 4.5)). They would spend more to ensure energy security, weakening the usually positive relationship between energy security and GDP.

Exporting Countries Versus Non-Exporting Countries

The analysis carried out for fuel-exporting countries versus others yielded exciting results. Although this analysis was carried out to analyze Hypothesis 7, which distinguished between fuel exporters and non-exporters, the analysis presents significant outcomes for the energy trilemma investigation.

The first surprising result was noting that an increase in oil price significantly increased the GDP of all countries, irrespective of whether they were net exporters or not

- reference Table 5-6. However, it also showed that the impact of a unit increase in oil price on the GDP was about four times greater for fuel-exporting countries than for non-exporting countries. Hence, while both countries show a significant effect of oil prices on GDP, exporting countries have a more substantial impact than non-exporting countries.

The other interesting outcome of these two sets of countries was the impact of the energy trilemma on the countries' GDP. Fuel-exporting countries show that all three aspects of the energy trilemma have a significant positive effect on the GDP of their countries – reference Table 6-1. On the other hand, for non-exporting countries, only energy equity had a significant positive impact on GDP. This implies that the energy trilemma (energy equity, energy security, and environmental sustainability) plays a more substantial role in the GDP of fuel-exporting countries than it did for non-exporting countries. This makes logical sense as fuel exports for those countries would likely constitute a big part of their GDP and significantly impact their energy system. This area will require further research as energy trilemma has yet to be studied along this particular classification of countries, and other findings could be unearthed.

Implications for Practice

This study further underscores the overall objective of this research – the world cannot adopt the same policy approach to different countries with respect to the journey towards energy transition. Energy policies need to be developed with the development spectrum of the countries in mind in order not to stifle their growth and development. Importantly, special attention needs to be placed on balancing the energy trilemma –

energy security, energy equity, and energy sustainability, for these different groups of countries.

On an aggregate level, this research proves the underlying importance of energy equity on the economic growth of all the countries, irrespective of its classification. Hence, energy equity, which addresses access to electricity, electricity prices, and affordability of oil and gas prices, significantly impacts economic growth for all countries. It underscores the importance of the UN SDG7 goal – Access to affordable, reliable, sustainable, and modern energy for all by 2030[18], as it substantially determines the growth of countries. As a result, all hands must be on deck to ensure that countries with little access to electricity, mainly found amongst the Least Developed countries with an average energy equity of 30 compared to their Developed counterparts of 81 and developing counterparts of 60 (See Section 4 – Data Descriptives), are given all the "help," financial and otherwise, required to ensure they have access to clean, affordable, energy, as it's non-negotiable to their economic development.

On the other hand, this research shows different and even opposite effects of energy security and energy sustainability on the economic growth of the three classifications of the countries. Energy security has a significant positive relationship to economic growth for Least Developed Countries. In contrast, it has a significant negative relationship with economic growth for Developing countries and shows no significant effect for Developed countries. These are opposing effects for these three groups of countries. This could imply that developed countries have shored up their energy security

---

[18] THE 17 GOALS | Sustainable Development (un.org)

so that it has no direct significant impact on their economic growth. They have already achieved some level of energy security, which has made little difference to their economic growth. Developing countries, on the other hand, show that as their energy security increases, it reduces their economic growth, and this relationship is significant. This could imply that they could have significantly invested in their energy security over the past 22 years of analysis, such that it negatively impacted their economic growth. For least-developed countries, energy security has a significant positive relationship with economic growth. This could imply that improvements in energy security over the years have resulted in overall net positive economic growth. It could indicate how energy-impoverished they are, and hence, increased energy security has had a net positive effect on their economy despite the sunk investments to get more secure energy. The implication is that energy policies around energy security should be skewed more in favor of Least Developed Countries as this has a significant positive impact on their economic growth. Least Developed countries, on their part, should pay particular attention to their energy security as it is an essential factor of economic growth. For developing countries, the research indicates that the focus on energy security could hurt their economic growth as it increases and goes in the opposite direction of their economic growth. This area for further research could be specific to a particular set of countries within the classification of developing countries.

Energy Sustainability also shows mixed opposite effects on economic growth depending on the classification of countries in focus. There is no significant relationship between energy sustainability and economic growth in developed countries. However, for developing countries, it shows a significant positive effect of energy sustainability on economic growth, while it shows a significant negative effect for least developed countries. This could imply that an excessive focus on energy sustainability is hurting the growth of the Least Developed Countries, where they probably need to focus more on energy access and equity and not unduly on the sustainable component where GHG emissions, et al, are measured. The implication of this could mean that in the energy trilemma equation, for Least Developed countries to achieve economic growth, the focus should be on improving their energy access and energy security as those two have positive effects on their economic growth, with less emphasis on the energy sustainability component as that has a negative impact on their growth. Hence, a delicate balance of energy trilemma is required to achieve economic growth like the rest of the world. This could imply lesser insistence on complying with energy sustainability targets to allow them to grow first before insisting on stringent adherence. World energy policies and climate targets should be crafted to consider their growth journey fully. Hence, they shouldn't be given the same targets or policy expectations as the Developed economies whose energy sustainability indices do not impact their economic growth.

Finally, this research shows that energy is critical to the economic growth equation and plays different roles for different classifications of countries. It further buttresses the fact that there is no "one size fits all" approach to the energy trilemma for all countries, as it has unique impacts on economic growth depending on the classification of your country.

Implications for Theory, Limitations, and Future Research Areas

While this research has thrown more light on the energy trilemma and its impact on economic growth for whole countries and different classifications of countries, it has also thrown more questions than answers that need further research. Notably, the literature review is a developing area of study. Only a few papers have studied the impact of the energy trilemma on economic growth, as most economic growth studies have traditionally focused on the traditional factors affecting economic growth, such as Labor, capital, trade, etc.

While this study did the analysis based on three classifications of countries, it is possible that more unique relationships could be unearthed if the countries were grouped by their regions instead, as that could provide other valuable insights. The other potential area of interest is breaking down the countries into those with access to natural energy resources and those without that access, as that could be a differentiator in how they go about energy security and sustainability. The idea is that energy security and sustainability for countries with natural energy resources such as fossil fuels will differ from the energy security and sustainability indices and plans for countries with more access to renewable energy resources than fossil fuels.

Another exciting area for future research is a study on the direction of causality between the energy trilemma and economic growth. While this research shows the significant relationships between them, it will be essential to investigate the direction of causality further. Does energy equity lead to economic growth, or does economic growth lead to energy equity? Which one comes first, or do they continuously influence one another? Is there a direct or reverse causality? This same question applies to energy security and energy sustainability for those groups of countries where this study has found significant relationships.

Another area of interest is investigating this relationship based on countries' cultural orientation or classification. The relationship between energy trilemma and economic growth may differ for countries with different cultural backgrounds. This could unearth exciting discoveries.

Furthermore, a definite area of future research is the use of different regression types and analyses on the relationship between energy trilemma and economic growth. While this study focused on two regression methods – fixed regression analysis and pooled ordinary least squares analysis, other methods that could be useful include the Generalized Method of Moments (GMM) method. This study shows that the results could differ depending on the regression method. Hence, it is crucial to conduct further research on the possible best regression analysis for this type of study. An important and interesting question is, "What is the best regression methodology for economic country analysis?"

Some limitations I encountered in this study include the following. First is the use of real GDP as the measurement of the independent variable. The GDP variable could be chosen for further research in the future to control for macroeconomic variables such as inflation. Additionally, it was difficult to delineate between oil-exporting and non-oil-exporting countries because there is no database with consistent information for all the countries in a particular year. As a proxy, I used fuel-exporting countries (exporting oil, gas, and coal) instead of strictly oil-exporting countries.

7. CONCLUSION

Economic growth in countries is no longer only attributable to traditional factors that drive productivity, such as Labor, Capital, and trade. It is also strongly driven by other factors such as political stability, energy security, energy equity, energy sustainability, and even oil prices. These play varying roles depending on the type of country being investigated. One fact is clear from this research: energy equity is non-negotiable and fundamentally impacts economic growth irrespective of the kind of economy. Energy security and energy sustainability play varying roles in the economic growth equation, depending on the type of economy, and in some cases, even negatively affect economic growth, as can be seen in the relationship between energy sustainability and economic growth for Least Developed Countries.

The most important lesson from this study is that while the world works towards achieving the UN SDG7 goal by 2030 and towards the Paris climate change goals and agreements, energy policies must be tailored specifically to the economies under consideration since what works positively and fosters economic growth for a group of countries might have an opposite and negative effect on another group of countries. There is simply no “One size fits all!”. Countries must be given opportunities to grow and develop while trying to balance the energy trilemma.

REFERENCES

Akinsola, M. O., & Odhiambo, N. M. (2020). Asymmetric effect of oil price on economic growth: Panel analysis of low-income oil-importing countries. *Energy Reports, 6*, 1057-1066. doi:10.1016/j.egyr.2020.04.023

Alfaro, L. (2017). Gains from foreign direct investment: Macro and micro approaches. *The World Bank Economic Review, 30*(Supplement_1), S2-S15.

Almeida Prado, F., Athayde, S., Mossa, J., Bohlman, S., Leite, F., & Oliver-Smith, A. (2016). How much is enough? An integrated examination of energy security, economic growth, and climate change related to hydropower expansion in Brazil. *Renewable and Sustainable Energy Reviews, 53*, 1132-1136. doi:10.1016/j.rser.2015.09.050

Amin, A., Liu, Y., Yu, J., Chandio, A. A., Rasool, S. F., Luo, J., & Zaman, S. (2020). How does energy poverty affect economic development? A panel data analysis of South Asian countries. *Environ Sci Pollut Res Int, 27*(25), 31623-31635. doi:10.1007/s11356-020-09173-6

Arrow, K. J. (1962). The economic implications of learning by doing. *The review of financial studies, 29*(3), 155-173.

Bal, D. P., Dash, D. P., & Subhasish, B. (2016). The effects of capital formation on economic growth in India: Evidence from ARDL-bound testing approach. *Global Business Review, 17*(6), 1388-1400.

Balitskiy, S., Bilan, Y., & Strielkowski, W. (2014). Energy Security and Economic Growth in the European Union. *Journal of Security and Sustainability Issue, 4*(2), 123-130. doi:10.9770/jssi.2014.4.2(2)

Berument, M. H., Ceylan, N. B., & Dogan, N. (2010). The impact of oil price shocks on the economic growth of selected MENA1 countries. *The Energy Journal, 31*(1).

Bouzarovski, S., Petrova, S., & Sarlamanov, R. (2012). Energy poverty policies in the EU: A critical perspective. *Energy Policy, 49*, 76-82.

BP, B. (2022). Statistical review of world energy 2022. In: BP London, UK.

Bresnahan, T. F., & Ramey, V. A. (1993). Segment shifts and capacity utilization in the US automobile industry. *The American Economic Review, 83*(2), 213-218.

Busse, M., & Königer, J. (2012). Trade and economic growth: A re-examination of the empirical evidence. *Available at SSRN 2009939*.

Buzar, S. (2007). The 'hidden'geographies of energy poverty in post-socialism: Between institutions and households. *Geoforum, 38*(2), 224-240.

Chow, G. C. (2017). Capital formation and economic growth in China. In *Chinese Economic History Since 1949* (pp. 1186-1221): Brill.

Correlje, A., & Van der Linde, C. (2006). Energy supply security and geopolitics: A European perspective. *Energy Policy, 34*(5), 532-543.

Davidson, O. R., & Sokona, Y. (2002). *A new sustainable energy path for African development: Think bigger act faster*: Energy and Development Research Centre, University of Cape Town Cape Town ….

Davis, S. J., & Haltiwanger, J. (2001). Sectoral job creation and destruction responses to oil price changes. *Journal of Monetary Economics, 48*(3), 465-512.

Delina, L. L. (2017). *Accelerating Sustainable Energy Transition (s) in Developing Countries: The challenges of climate change and sustainable development*: Routledge.

Doganalp, N., Ozsolak, B., & Aslan, A. (2021). The effects of energy poverty on economic growth: a panel data analysis for BRICS countries. *Environ Sci Pollut Res Int, 28*(36), 50167-50178. doi:10.1007/s11356-021-14185-x

Gasparatos, A., & Gadda, T. (2009). Environmental support, energy security, and economic growth in Japan. *Energy Policy, 37*(10), 4038-4048. doi:10.1016/j.enpol.2009.05.011

Ghalayini, L. (2011). The interaction between oil price and economic growth. *Middle Eastern Finance and Economics, 13*(21), 127-141.

Hamilton, J. D. (2003). What is an oil shock? *Journal of Econometrics, 113*(2), 363-398.

Harris, D. J. (2007). The classical theory of economic growth. *The New Palgrave Dictionary of Economics*, 1-10.

Ilter, C. (2017). *What economic and social factors affect GDP per capita? A study on 40 countries*: SSRN.

Jajri, I., & Ismail, R. (2010). Impact of Labor quality on Labor productivity and economic growth. *African Journal of Business Management, 4*(4), 486.

Jiménez-Rodríguez*, R., & Sánchez, M. (2005). Oil price shocks and real GDP growth: empirical evidence for some OECD countries. *Applied Economics, 37*(2), 201-228.

Johansson, T. B., & Goldemberg, J. (2002). Energy for sustainable development: A policy agenda.

Kang, H. (2022). An Analysis of the Relationship between Energy Trilemma and Economic Growth. *Sustainability, 14*(7). doi:10.3390/su14073863

Kanu, S. I., & Ozurumba, B. A. (2014). Capital formation and economic growth in Nigeria. *Global Journal of human-social science: Economics, 14*(4), 43-58.

Le, T.-H., & Nguyen, C. P. (2019). Is energy security a driver for economic growth? Evidence from a global sample. *Energy Policy, 129*, 436-451. doi:10.1016/j.enpol.2019.02.038

Lee, K., Ni, S., & Ratti, R. A. (1995). Oil shocks and the macroeconomy: the role of price variability. *The Energy Journal, 16*(4).

Mendoza, O., & Vera, D. (2010). The asymmetric effects of oil shocks on an oil-exporting economy. *Cuadernos de economía, 47*(135), 3-13.

Mo, B., Chen, C., Nie, H., & Jiang, Y. (2019). Visiting effects of crude oil price on economic growth in BRICS countries: fresh evidence from wavelet-based quantile-on-quantile tests. *Energy, 178*, 234-251.

Mork, K. A., Olsen, O., & Mysen, H. T. (1994). Macroeconomic responses to oil price increases and decreases in seven OECD countries. *The Energy Journal, 15*(4).

Nepal, R., Paija, N., Tyagi, B., & Harvie, C. (2021). Energy security, economic growth and environmental sustainability in India: Does FDI and trade openness play a role? *J Environ Manage, 281*, 111886. doi:10.1016/j.jenvman.2020.111886

Rahman, M. M., Vu, X.-B., & Nghiem, S. (2022). Economic Growth in Six ASEAN Countries: Are Energy, Human Capital, and Financial Development Playing Major Roles? *Sustainability, 14*(8), 4540.

Reddy, A. K., Annecke, W., Blok, K., Bloom, D., Boardman, B., Eberhard, A., & Ramakrishna, J. (2000). Energy and social issues. *World energy assessment*, 39-60.

Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of political economy, 94*(5), 1002-1037.

Rostow, W. W., & Kennedy, M. (1990). *Theorists of economic growth from David Hume to the present: with a perspective on the next century*: Oxford University Press, USA.

Sakellaris, P. (1997). Irreversible capital and the stock market response to shocks in profitability. *International Economic Review*, 351-379.

Salma, U., Hasan, M. M., & Sultana, M. I. (2020). *A regression model-based approach to identifying determining factors for GDP growth in Bangladesh.* Paper presented at the 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE).

Salvadori, N. (2003). *The theory of economic growth: A 'classical'perspective*: Edward Elgar Publishing Limited.

Schneider, M. (2004). The impact of oil price changes on growth and inflation. *Monetary Policy & the Economy, 2*, 27-36.

Simionescu, M., & Naroş, M.-S. (2019). The role of Foreign Direct Investment in human capital formation for a competitive Labor market. *Management Research and Practice, 11*(1), 5-14.

Singh, K., & Inglesi-Lotz, R. (2021). The role of energy poverty on economic growth in sub-Saharan African countries. *Economics of Energy & Environmental Policy, 10*(1), 105-122.

Smith, A. (1776). 1976. An Inquiry into the Nature and Causes of the Wealth of Nations. *The Glasgow edition of the works and correspondence of Adam Smith, 2*.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The quarterly journal of economics, 70*(1), 65-94.

Solow, R. M. (1962). Technical Progress, Capital Formation, and Economic Growth. *The American Economic Review, 52*(2), 76-86. Retrieved from http://www.jstor.org/stable/1910871

Tenaw, D., & Beyene, A. D. (2021). Environmental sustainability and economic development in sub-Saharan Africa: A modified EKC hypothesis. *Renewable and Sustainable Energy Reviews, 143*. doi:10.1016/j.rser.2021.110897

Thach, N. N. (2020). Endogenous economic growth: The arrow-romer theory and a test on Vietnamese economy. *WSEAS Transactions on Business and Economics, 17*, 374-386.

Ucak, A. (2015). Adam Smith: The inspirer of modern growth theories. *Procedia-Social and Behavioral Sciences, 195*, 663-672.

APPENDICES

List of Developed Countries[19]

S/No	Country	Type of country
1	Albania	Developed
2	Australia	Developed
3	Austria	Developed
4	Belgium	Developed
5	Bosnia and Herzegovina	Developed
6	Bulgaria	Developed
7	Canada	Developed
8	Croatia	Developed
9	Cyprus	Developed
10	Czech Republic	Developed
11	Denmark	Developed
12	Estonia	Developed
13	Finland	Developed
14	France	Developed
15	Germany	Developed
16	Greece	Developed
17	Hungary	Developed
18	Iceland	Developed
19	Ireland	Developed
20	Israel	Developed
21	Italy	Developed
22	Japan	Developed
23	Latvia	Developed
24	Lithuania	Developed
25	Luxembourg	Developed
26	North Macedonia	Developed
27	Malta	Developed
28	Moldova	Developed
29	Montenegro	Developed
30	Netherlands	Developed
31	New Zealand	Developed
32	Norway	Developed

[19] UNSD — Methodology

33	Poland	Developed
34	Portugal	Developed
35	Romania	Developed
36	Russia	Developed
37	Serbia	Developed
38	Slovakia	Developed
39	Slovenia	Developed
40	Spain	Developed
41	Sweden	Developed
42	Switzerland	Developed
43	United Kingdom	Developed
44	United States	Developed

List of Developing Countries[20]

S/No	Country	Type of country
1	Algeria	Developing
2	Argentina	Developing
3	Armenia	Developing
4	Azerbaijan	Developing
5	Bahrain	Developing
6	Barbados	Developing
7	Bolivia	Developing
8	Botswana	Developing
9	Brazil	Developing
10	Cameroon	Developing
11	Chile	Developing
12	China	Developing
13	Colombia	Developing
14	Costa Rica	Developing
15	Côte d'Ivoire	Developing
16	Dominican Republic	Developing
17	Ecuador	Developing
18	Egypt	Developing
19	El Salvador	Developing
20	Eswatini	Developing
21	Gabon	Developing
22	Georgia	Developing
23	Ghana	Developing
24	Guatemala	Developing
25	Honduras	Developing
26	Hong Kong, China	Developing
27	India	Developing
28	Indonesia	Developing
29	Iran (Islamic Republic)	Developing
30	Iraq	Developing
31	Jamaica	Developing
32	Jordan	Developing
33	Kazakhstan	Developing
34	Kenya	Developing
35	Korea (Republic)	Developing

[20] UNSD — Methodology

36	Kuwait	Developing
37	Lebanon	Developing
38	Libya	Developing
39	Malaysia	Developing
40	Mauritius	Developing
41	Mexico	Developing
42	Mongolia	Developing
43	Morocco	Developing
44	Namibia	Developing
45	Nicaragua	Developing
46	Nigeria	Developing
47	Oman	Developing
48	Pakistan	Developing
49	Panama	Developing
50	Paraguay	Developing
51	Peru	Developing
52	Philippines	Developing
53	Qatar	Developing
54	Saudi Arabia	Developing
55	Singapore	Developing
56	South Africa	Developing
57	Sri Lanka	Developing
58	Tajikistan	Developing
59	Thailand	Developing
60	Tunisia	Developing
61	Turkey	Developing
62	United Arab Emirates	Developing
63	Uruguay	Developing
64	Vietnam	Developing
65	Zimbabwe	Developing

List of Least Developed Countries (LDC) [21]

S/No	Country	Type of country
1	Angola	Least Developed Countries
2	Bangladesh	Least Developed Countries
3	Benin	Least Developed Countries
4	Cambodia	Least Developed Countries
5	Chad	Least Developed Countries
6	Congo (Democratic Republic)	Least Developed Countries
7	Ethiopia	Least Developed Countries
8	Madagascar	Least Developed Countries
9	Mauritania	Least Developed Countries
10	Mozambique	Least Developed Countries
11	Nepal	Least Developed Countries
12	Niger	Least Developed Countries
13	Senegal	Least Developed Countries
14	Tanzania	Least Developed Countries
15	Zambia	Least Developed Countries

[21] Least Developed Countries (LDCs) | Department of Economic and Social Affairs

List of Fuel-Exporting Countries (2023)[22]

Fuel Exporting Countries:		
1	Norway	Developed Countries
2	Bolivia	Developing countries
3	Ecuador	Developing countries
4	Algeria	Developing countries
5	Angola	Developing countries
6	Cameroon	Developing countries
7	Chad	Developing countries
8	Congo	Developing countries
9	Gabon	Developing countries
10	Ghana	Developing countries
11	Libya	Developing countries
12	Mozambique	Developing countries
13	Nigeria	Developing countries
14	Indonesia	Developing countries
15	Mongolia	Developing countries
16	Iran	Developing countries
17	Bahrain	Developing countries
18	Iraq	Developing countries
19	Kuwait	Developing countries
20	Oman	Developing countries
21	Qatar	Developing countries
22	Saudi Arabia	Developing countries
23	United Arab Emirates	Developing countries
24	Azerbaijan	Economies in transition
25	Kazakhstan	Economies in transition
26	Russia	Economies in transition

[22] World Economic Situation and Prospects 2023 | Department of Economic and Social Affairs (un.org)

VITA

IJEOMA NNENNA ODIZURU-ABANGWU

	Born, Enugu, Nigeria
1998-2003	B.Eng. Electrical & Electronics Engineering The Federal University of Technology Owerri, Nigeria
2006-2007	Certificate in Oil & Gas Technologies GE Oil & Gas University Florence, Italy
2009-2010	Executive Masters in Energy Management École Supérieure de Commerce de Paris – ESCP, Paris. BI Norwegian School of Management, Oslo, Norway French Institute of Petroleum (IFP), Paris
2021-2024	Doctor of Business Administration Florida International University Miami, Florida

PUBLICATIONS

Olumide, A., Adeyemi, O., Odizuru-Abangwu, I.N., & Iyegoe, I. (2016, August). Resource Volume Estimation; Dynamically Guided Volumetric Evaluation Using Streamlines. In *SPE Nigeria Annual International Conference and Exhibition*. OnePetro.

Odizuru-Abangwu, I. N. (2011, July). Energy Resources in Africa: Curse or Blessing? In *Nigeria Annual International Conference and Exhibition*. OnePetro.

Odizuru-Abangwu, I. (2010, July). Biofuels: Green Energy for the Century? In *Nigeria Annual International Conference and Exhibition*. OnePetro. SPE Best Technical Paper Award (SPE NAICE 2010)

Odizuru-Abangwu, I., Suleiman, A., & Nwosu, C. (2010, July). The impact of different shaly sand models on in-place volumes and reservoir producibility in niger delta reservoirs-the dual water and normalized Waxman-Smits saturation models. In Nigeria's annual international conference and exhibition. OnePetro. SPE-140627

Thomas, A. O., Oke-oghene, U., Odizuru-Abangwu, I.N., Nnamdi, D., Boniface, M., Gbenga, F., & Patricia, K. (2010, July). SPE-140624. Maximising Value from Integrated Well and Reservoir Management and Facilities Reviews: A 2-Field Case Study from the Niger Delta. In *Nigeria Annual International Conference and Exhibition*. OnePetro.

Energy Supply Chain: Problem or Opportunity; An Industry Perspective on Nigeria's Gas Sector – 2010 (BI, Norway, IFP Paris)

Energy Usage and Ambient Protection (Acid gas Compression and CO_2 sequestration) – 2007 (Florence – Italy)

Data Acquisition and Supervisory Control Systems (2003) – Federal University of Technology, Owerri, Nigeria