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# ENERGY INTENSITY, OIL PRICES AND ECONOMIC GROWRTH IN MENA COUNTRIES.

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# DEDICATIONS

This thesis is dedicated to the incredible people who have shaped my journey. To my mother, Nabawanda Betty, whose love and support have been my guiding light. To my uncles, whose wisdom and guidance have been invaluable. To my siblings, for their unwavering love, laughter, and the constant reminder that I am never alone. To my friends and classmates, for the companionship, encouragement, and shared experiences that made this journey richer. To the memory of my dear friend William, whose spirit continues to inspire me. May his soul rest in peace. And finally, to myself, for the courage, perseverance, and dedication it took to reach this milestone.

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## GENERAL ABBREVIATIONS

**BP**: British Petroleum Company

**EKC:** Environmental Kuznets Curve

**FDI:** Foreign Direct Investment

**FE:** Fixed Effects

**FGLS:** Feasible Generalized Least Squares

**GCC:** Gulf Cooperation Council

**GDP:** Gross Domestic Product

**GMM:** Generalized Method of Moments

**IEA:** International Energy Agency

**IRENA:** International Renewable Energy Agency

**LNG:** Liquefied Natural Gas

**MENA:** Middle East and North Africa

**OPEC:** Organization of the Petroleum Exporting Countries

**PPP:** Purchasing Power Parity

**RE:** Random Effects

**STEM:** Science, Technology, Engineering, and Mathematics

### VARIABLE SHORT FORMS:

**lenerint:** Logarithm of Energy Intensity Level of Primary Energy (MJ/$2017 PPP GDP)

**lgdp:** Logarithm of GDP (constant 2015 US$)

**lgfcf:** Logarithm of Gross Fixed Capital Formation (% of GDP)

**lhci:** Logarithm of Human Capital Index

**lprices:** Logarithm of Oil Prices

**lprienecons:** Logarithm of Primary Energy Consumption per Capita

# GENERAL INTRODUCTION

## BACKGROUND

The Middle East and North Africa (MENA) holds a significant position on the global energy map. Endowed with vast reserves of oil and natural gas, MENA countries have long been a crucial source of energy for the world. This abundance of fossil fuels has undoubtedly fuelled economic growth in the region. However, this very dependence on hydrocarbons presents a complex challenge for MENA countries as they navigate the 21st century.

The global energy landscape is undergoing a significant transformation. Concerns about climate change and environmental sustainability are driving a push towards renewable energy sources and energy efficiency. At the same time, the geopolitical landscape and technological advancements are bringing about changes in oil prices, adding a layer of uncertainty to the economic equation for MENA countries.

## PROBLEM STATEMENT

Despite their hydrocarbon wealth, many of MENA countries struggle with inefficient energy consumption, often referred to as high energy intensity[1]. This inefficiency translates into wasted resources, hinders economic productivity, and undermines efforts towards sustainable development. The paradox of plenty – possessing abundant energy resources yet struggling with inefficient use – creates a significant barrier to long-term economic growth in the region.

Further complicating the economic growth is the volatility of oil prices. Oil revenues constitute a major source of income for many MENA governments. Fluctuations in oil prices can have a dramatic impact on government budgets, public spending, and overall economic activity. When oil prices are high, MENA economies experience a boost. However, periods of low oil prices can trigger economic hardship and instability[2].

Understanding the intricate relationship between energy intensity, oil prices, and economic growth is critical for MENA countries. By analysing these factors and their interactions, policymakers can develop targeted strategies to address the challenges and unlock the region's full economic potential.

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[1] https://link.springer.com/chapter/10.1007/978-3-031-30705-8_3

[2] https://www.imf.org/external/np/pp/eng/2016/042916.pdf

## RESEARCH QUESTION

The central research question guiding this study is:

**"What is the impact of energy intensity and oil prices on the economic growth of MENA countries?"**

By exploring this question, the research seeks to identify patterns, and the nature of relationships between the studied variables that can inform policy decisions aimed at promoting energy efficiency, fostering economic resilience, and ultimately achieving sustainable economic development in the MENA region.

## OBJECTIVES OF THE STUDY

This research aims to investigate the relationship between energy intensity, oil prices, and economic growth in MENA countries. The specific objectives are:

- To examine the current state of energy intensity in MENA countries and identify the key drivers of energy inefficiency.
- To analyse the impact of oil prices on economic growth in MENA economies, considering both positive and negative effects.
- To investigate how MENA countries can manage oil price volatility to achieve sustained economic growth.

To identify opportunities for MENA countries to transition towards a more sustainable and diversified energy mix, reducing their dependence on fossil fuels.

## RESEARCH HYPOTHESES ($\boldsymbol{H_i}$)

Building upon the established relationship between energy intensity and economic growth, this study proposes the following hypotheses:

$\boldsymbol{H_1}$**:** There exists a negative relationship between energy intensity and economic growth in MENA countries. This suggests that higher energy intensity (requiring more energy per unit of economic output) hinders economic growth.

$\boldsymbol{H_2}$**:** Fluctuations in oil prices have a negative impact on economic growth in MENA countries. This is particularly true for oil-exporting countries where government revenue is heavily reliant on oil prices.

## SIGNIFICANCE OF THE STUDY

The findings of this research hold significant importance for MENA countries, policymakers, and the broader international community. Understanding the interplay between energy intensity, oil prices, and economic growth is crucial for formulating effective strategies that can:

- Enhance energy security and reduce dependence on volatile oil markets.
- Promote economic diversification and create new opportunities for growth in MENA countries.
- Advance the transition towards a more sustainable and environmentally friendly energy mix in the region.
- Contribute to global efforts to address climate change and mitigate the environmental impact of energy consumption.

By providing valuable insights into this complex issue, this study can empower policymakers in MENA countries to make informed decisions that lead to a future of stable, sustainable, and prosperous economies.

## SCOPE

This research focuses on the impact of energy intensity and oil prices on economic growth in MENA countries. It will analyse data from a representative selection of MENA nations, encompassing both major oil producers and net oil importers. The study will consider various economic indicators to assess growth patterns and trends.

While the research aims to provide a comprehensive analysis, it acknowledges certain limitations. The economic landscape is inherently complex, and numerous factors beyond energy and oil prices influence growth. The study will acknowledge these limitations and strive to isolate the specific effects of energy intensity and oil prices to the best of its ability. Additionally, the future is inherently uncertain, and oil price volatility is difficult to predict. The research will focus on historical data and established trends while acknowledging the limitations of forecasting future oil price movements.

## RESEARCH METHODOLOGY OVERVIEW

This research employs a panel data modelling to investigate the relationship between energy intensity, oil prices, and economic growth in MENA countries.

The first chapter establishes groundwork by exploring the broader context of energy and oil in the global economy. Divided into two sections, the first delves into the concept of energy intensity and its connection to economic growth on a global scale. The following section dissects the factors influencing oil prices and their subsequent impact on economic growth worldwide. By drawing upon a comprehensive literature review, Chapter 1 aims to establish a solid foundation for the empirical investigation to follow.

Shifting the focus to the specific region of interest, Chapter 2 examines energy intensity and oil price trends within MENA countries. Divided into two sections, the first provides a foundational understanding of the MENA region, encompassing its geographical makeup, historical and current economic context related to oil, and the current state of energy intensity across the region. Building upon this groundwork, the second section utilizes data analysis to explore the evolution of energy intensity and oil prices in a selection of MENA countries chosen as case studies. Data spanning a period from 2000 to 2021 will be extracted from reputable sources like the World Bank national accounts and Penn World Table 10.0, and bp energy outlook.

Chapter 3 marks a shift towards a more quantitative approach, employing panel data analysis to empirically explore the research question. This chapter begins by outlining the rationale behind using panel data analysis, a statistical technic particularly suited for examining relationships across multiple countries and time periods. Following the methodological explanation, the chapter delves into the details of the data sources and the specific variables chosen for analysis. These variables will represent key metrics related to energy intensity, oil prices, and economic growth.

To ensure robust analysis, Chapter 3 equips the reader with foundational knowledge of two key panel data regression models: fixed effects and random effects models. Additionally, the chapter introduces the Hausman test, crucial statistical tools that assist in selecting the most appropriate model for the specific characteristics of our data.

Armed with the chosen methodology and a thorough understanding of the data sources and variables, Chapter 3 embarks on a detailed exploration of the data for the selected MENA countries. This section introduces the specific case study countries and elaborates on the chosen variables used in the analysis. With a clear understanding of the data, the chapter proceeds to construct and estimate the chosen model.

Following model construction and estimation, Chapter 3 meticulously validates the model's accuracy. This validation process is essential to ensure the robustness of the findings and enhance the reader's confidence in the drawn conclusions. Finally, Chapter 3 culminates in unveiling the insights gleaned from the analysis. This section presents the key findings regarding the relationship between energy intensity, oil prices, and economic growth in MENA countries. By interpreting the results of the empirical analysis, the chapter addresses the research question and provides valuable insights for policymakers and stakeholders in the region.

# CHAPTER 1: LITERATURE REVIEW RELATED TO ENERGY INTENSITY, OIL PRICES AND ECONOMIC GROWTH.

## INTRODUCTION

The global economy relies heavily on energy consumption with fossil fuels, particularly oil, playing a crucial role as it is a major source of energy for various sectors including transportation, manufacturing, and power generation. The efficiency of energy and oil prices have a significant effect on different economic activities worldwide and the global economy at large. This chapter is divided into two sections where the first section explores the world of energy, focusing on energy intensity and its relationship with economic growth. We will then dissect the factors influencing oil prices and their subsequent impact on economic growth in the second section. Through a comprehensive literature review, we aim to establish a foundation for further investigation via an empirical study.

## Section 1: Literature review on energy intensity and economic growth

Understanding the intricate relationship between energy intensity and economic growth is critical for formulating sustainable development strategies. This section delves into the existing notions of energy and energy intensity and later explores the existing theoretical and empirical reviews.

### 1. Notions of Energy and energy intensity

### 1.1 Definitions of Energy

Energy is defined as the ability to cause change[3]. This is the most fundamental definition of energy as it signifies the potential to create a transformation in the state of an object or system at its core. This change can manifest in various forms.

Economically, energy is primarily viewed as a critical input used in the production of goods and services. It is a resource that fuels economic activity and influences various economic factors.

### 1.1.1 Sources of energy

As the world's population and technological advancements continue to grow, our demand for energy rises ever higher. The world relies on a diverse mix of energy sources which include[4]:

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[3] https://www.khanacademy.org/science/biology/energy-and-enzymes/the-laws-of-thermodynamics/a/types-of-energy

[4] https://www.energy.gov/energy-sources

- Fossil Fuels: They provide most of the world's energy needs but contribute significantly to greenhouse gas emissions. Examples of fossil fuels include coal, oil, and natural gas. Fossil fuels can play a role in a sustainable future by providing a reliable energy source during the transition to renewable alternatives, but long-term reliance needs to be curbed to mitigate climate change.
- Renewable Energy: This type of energy is derived from naturally refilling sources and hold immense potential for a sustainable future. They boast minimal environmental impact and reduce dependence on finite resources. Renewable energy is key to sustainability and by constantly improving storage solutions and becoming more cost-effective, renewables can become the dominant energy source, mitigating climate change, and ensuring a secure energy future for generations to come. Examples of renewable energy include solar, wind, hydro, and geothermal.
- Nuclear Power: Nuclear energy offers a powerful low-carbon energy source, producing vast amounts of electricity with minimal greenhouse gas emissions during operation. Additionally, nuclear fuel is incredibly dense, requiring minimal space compared to fossil fuels. However, limitations include the risk of accidents, the challenge of safely storing radioactive waste for millennia, and the potential for nuclear proliferation. Despite these concerns, nuclear energy can play a significant role in a sustainable future by providing a reliable baseload source of power alongside renewables. Technological advancements in reactor safety and waste management can further improve its sustainability profile. It generates electricity through nuclear fission, raising concerns regarding safety and radioactive waste disposal.

### 1.1.2 Types of energy

There exist several types of energy depending on the criteria of **application** as described below:

- **Primary energy:** This comprises all energy sources directly available in nature, with a subdivision into exhaustible sources like natural gas and renewable sources such as solar and wind energy.
- **Secondary energy:** It is obtained through the transformation of primary energy using a conversion system. For instance, the production of electricity (secondary energy) derived from coal (primary energy).
- **Final energy:** It corresponds to the ultimate consumption of energy by the end-user.

### 1.1.3 Forms of energy

Energy exists in many forms, all of which can be transformed from one kind to another. Here are some of the most common types of energy[5]:

- **Kinetic energy**: This is the energy of motion possessed by an object due to its mass and velocity. A moving car, a running person, and a spinning top all have kinetic energy. The faster an object moves, the greater its kinetic energy.
- **Potential energy:** This is the energy stored due to an object's position or configuration in a force field. An object held above the ground has potential energy due to gravity. A stretched spring also has potential energy because of the elastic forces within it. The higher an object is lifted or the more a spring is stretched, the greater its potential energy.
- **Thermal energy:** This is the total energy of microscopic random motions of the atoms and molecules in a substance. Thermal energy is what we experience as heat. The higher the temperature of a substance, the greater its thermal energy.
- **Sound energy:** This is the energy of vibrations traveling through a medium such as air or water. When an object vibrates, it creates sound waves that transfer energy from one place to another. The louder the sound, the greater the sound energy.
- **Light energy:** This is a form of radiant energy that travels in waves. Light is visible to the human eye, but there are also forms of radiant energy that are invisible, such as ultraviolet and infrared radiation.
- **Electrical energy:** This is the energy associated with the flow of electric charges. Electrical energy can be used to power lights, appliances, and motors.
- **Chemical energy:** This is the energy stored in the bonds between atoms and molecules. Chemical energy is what powers many biological processes, such as the breakdown of food in our bodies. It is also the energy source for batteries and fuels such as gasoline and natural gas.

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[5] https://www.eia.gov/energyexplained/what-is-energy/forms-of-energy.php

- **Nuclear energy:** This is the energy stored in the nucleus of an atom. Nuclear energy can be released in a process called nuclear fission, which is the process used in nuclear power plants.

### 1.1.4 Definition of Energy intensity

Energy intensity refers to the amount of energy required to produce **a specific unit** of economic output[6]. For example, imagine two factories producing the same good let us say a pen. Factory A uses ten units of energy to achieve this output, while Factory B uses only ten units. In this scenario, Factory B has **a lower energy intensity** compared to Factory A, signifying its superior efficiency in converting energy into economic output.

N.B Whether we measure it in joules per dollar of GDP or kilowatt-hours per industrial output, the core idea remains consistent: how much energy does it take to generate economic activity?

### 1.1.5 Measures of energy intensity

- Energy intensity is measured by calculating the amount of energy used per unit of economic output. Various methods, indicators can be used to measure energy intensity and here are two common approaches to measuring energy intensity[7]:
- **Energy Intensity as Energy per Unit of GDP**

  It is a measure that indicates how efficiently an economy uses energy to produce a unit of economic output. It is calculated by dividing the total energy consumption of a country or region by its Gross Domestic Product.

  The **formula** for calculating energy intensity based on GDP is:

$$\boldsymbol{Energy\ Intesity} = \frac{\boldsymbol{Total\ Energy\ Consumption}}{\boldsymbol{Gross\ Domestic\ Product\ (GDP)}}$$

  By measuring energy intensity in terms of GDP, analysts can assess the efficiency with which a country or industry uses energy to generate economic output. A decrease in energy intensity over time indicates improved energy efficiency.

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[6] https://www.sciencedirect.com/topics/economics-econometrics-and-finance/energy-intensity

[7] https://www.sciencedirect.com/topics/economics-econometrics-and-finance/energy-intensity

- **Energy Intensity as Energy per Unit of Physical Output**

  It is a metric that measures the efficiency of energy use in relation to a specific physical quantity of goods or services produced. This form of measurement helps assess the energy efficiency of industrial processes, manufacturing, or other activities where the focus is on the amount of energy required to generate a certain level of output.

  The formula for calculating energy intensity based on physical output is:

$$\boldsymbol{Energy\ Intesity = \frac{Total\ Energy\ Consumption}{Physical\ Output}}$$

  Measuring energy intensity based on physical output provides insights into the energy efficiency of specific industrial processes or sectors.

### 1.1.6 Sectors of energy intensity

Energy intensity varies significantly across different sectors of the economy. Here is a breakdown of the major sectors and their relative energy intensity:

- **Industrial Sector:**

  This sector encompasses various industries involved in manufacturing, processing, and construction activities such as steel production, chemical manufacturing, glass, and pottery. Energy intensity is high due to the use of energy-intensive processes like metal production, chemical processing, and heavy machinery operation.
- **Transportation Sector:**

  This sector includes all modes of transportation, including personal vehicles, freight transport, and aviation. It varies depending on the mode of transport, with **airplanes** being the most energy-intensive and **electric vehicles** being the least.
- **Residential Sector:**

  This sector encompasses energy consumption in homes and dwellings for various purposes like space heating, cooling, water heating, lighting, and appliances. It can vary significantly depending on factors like climate, building age, and energy efficiency practices.
- **Commercial Sector:**

This sector includes energy consumption in buildings used for commercial activities like offices, retail stores, restaurants, and hotels. Like the residential sector, it can vary depending on factors like building type, size, and energy efficiency measures employed.

### 1.1.7 Factors influencing energy intensity.

- **Technological advances:** The development and adoption of more energy efficient technologies can significantly reduce energy intensity for example the use of energy efficient appliances, LED lighting and advance manufacturing processes can help lower energy consumption.
- **Energy policies and regulations:** Government policies and regulations play a crucial role in influencing energy intensity. Measures such as energy efficiency standards, carbon pricing and incentives for renewable energy can encourage industries and individuals to reduce their energy consumption.
- **Economic factors:** Economic conditions can impact energy intensity. During the periods of economic growth, energy consumption tends to increase as industries and individuals use more energy for production and consumption and vice versa.
- **Energy prices:** the cost of energy intensity. Higher energy prices can incentivize businesses and individuals to adopt energy efficient practices and technologies to reduce costs.
- **Behavioural changes:** Individuals and collective behavioural changes can have a significant impact on energy intensity. Simple actions like turning of lights when not in use, using public transportation and practising energy conservation habits can help lower energy consumption.

## 1.2: Theoretical literature review on energy intensity and economic growth

The debate surrounding energy use and economic growth has shifted its focus in recent years. While traditionally concerned with total energy consumption, the concept of energy intensity, the amount of energy used per unit of economic output, has become increasingly important. Understanding the theoretical underpinnings of the relationship between energy intensity and economic growth is crucial for formulating sustainable development strategies.

One prominent theory is the Environmental Kuznets Curve (EKC) hypothesis (Grossman & Krueger, 1991). This theory proposes an inverted U-shaped relationship between economic development and environmental pollution, including energy intensity. Initially, as economies grow, they tend to rely on energy-intensive industries, leading to rising energy intensity. However, as countries become wealthier, they invest in cleaner technologies and improve efficiency, resulting in a decline in energy intensity.

Growth theories offer contrasting perspectives. The neoclassical growth model (Solow, 1956) suggests a positive correlation between economic growth and energy intensity. As economies expand, the demand for energy to fuel production increases. However, technological advancements can decouple this link, allowing for economic growth with decreasing energy intensity (Grübler, 1998). Endogenous growth models (Romer, 1994) further emphasize the role of technological progress. Investment in research and development can lead to innovations that improve energy efficiency, even as economic activity expands.

The conservation hypothesis (Waggoner, 1971) argues that economic growth necessitates a reduction in energy intensity. As economies mature, they shift towards service sectors that require less energy compared to manufacturing. Additionally, resource scarcity and environmental concerns can spur policies promoting energy efficiency, further accelerating the decline in energy intensity.

However, the rebound effect challenges the idea of a straightforward decline in energy intensity. This theory, put forward by Khazzoom (1980), suggests that efficiency gains from technological advancements might be offset by behavioural changes. For example, if energy becomes cheaper due to efficiency improvements, consumers might use more energy, negating the initial gains.

Several key points remain open for discussion. The direction of causality between economic growth and energy intensity is a complex issue. Do economic changes drive shifts in energy intensity, or do energy price fluctuations and technological advancements influence economic growth patterns? Additionally, the role of technological advancements and government policies in accelerating the decline in energy intensity needs further exploration. Finally, the influence of different economic structures, with varying proportions of energy-intensive industries, on overall energy intensity requires further investigation.

By examining these theoretical frameworks, we gain a deeper understanding of the intricate relationship between energy intensity and economic growth. However, it is crucial to complement these theoretical perspectives with empirical studies using real-world data. This will allow us to evaluate the validity of these hypotheses and formulate effective policies that promote sustainable economic development while managing energy consumption effectively.

### 1.3: Empirical Literature review on energy intensity and energy growth

Studies on the relationship between energy intensity and economic growth are numerous and several survey papers have been carried out in the global context over the years. Below are some of the research works diving into the relationship between energy intensity and energy growth.

A study by Besma Talbi (2012) analyzes energy intensity for a panel of six MENA countries from the period of 1980-2007. It is based on panel data econometrics heterogeneous according to co- integration tests developed by Pedroni (1999,2004) and the PMG estimator (Pooled Mean Group) of Pesaran, shin and Smith (1999). The results show that the energy intensity of the GDP in MENA depends largely on the level of investment, the structure of economies and the rate of urbanization.

Another investigation by Sahbi Farhani and Jaleleddine Ben Rejeb (2012) applies the panel unit root test, panel co- integration method, and panel causality test to investigate the relationship between energy consumption, economic growth, and carbon dioxide emissions for the fifteen MENA countries covering the annual period of 1973-2008. The findings of this study reveal that there is no causal link between economic growth and energy consumption, and between carbon dioxide emissions and energy consumption in the short run. However, in the long run, there is unidirectional causality running from economic growth and carbon dioxide emissions to energy consumption.

Thirdly, a study by Monstassar Kahia, Mehdi Ben Jebli and Mounir Belloumi (2019) aimed at exploring the impacts of renewable energy consumption, economic growth and foreign direct investment inflows and trade on carbon dioxide emissions for a panel of twelve MENA countries over a period of 1980- 2012. The results from Granger causality test reveal a bidirectional causality relationship between the candidate variables supporting the feedback hypothesis. The findings show that economic growth leads to environmental degradation while renewable energy, international trade and foreign direct investment inflows lead to decrease in carbon dioxide emissions. A serious shift towards more renewable energy resources, international trade and foreign direct investment inwards is recommended to improve environmental quality and attain the sustainable growth in the region.

Another study by Najia Saqib (2021) aims at exploring the causal relationship between energy consumption and economic growth. As economic growth is closely linked to energy consumption since high level of energy consumption leads to high economic growth and more efficient energy use requires a higher level of economic growth. This paper examines the causal relationship between energy consumption and economic growth of the fourteen MENA countries over the period 1987-2019 by using the bivariate Vector Auto- regression model and Granger causality approach. The study shows the existence of unidirectional, bidirectional, or no causal relationship between energy consumption and economic growth of the different countries in the MENA region. The study also suggests the environment and energy policies should recognize the relationship between energy consumption and economic growth to maintain sustainable economic growth in MENA region.

Lastly, a study by Benmohad and Hamza Taibi (2023) examines the relationship between energy consumption and economic growth for a sample of fourteen MENA countries during the period of 1980-2017. The countries were divided into two groups: group of Energy Exporting countries (OPEC countries) and a group of poor countries in terms of energy sources by using recently developed panel unit root, panel co- integration techniques. They adopted four stage approach consisting of panel unit root, panel co- integration, Granger causality and estimated the Kuznets curve between the 2 variables.

The results show that GDP and energy consumption move together in the long run. By estimating the long run relationship and testing for the causality using panel co- integration techniques they found bidirectional causality between energy consumption and economic growth. They also estimated the Kuznets curve between the two studied variables, as they found that the curve hypothesis is fulfilled in the case of the countries combined, and in the case of the energy exporting countries (involved in the OPEC) while it is different for other countries.

## Section 2: Oil prices and economic growth.

### 2.1: Literature review on oil prices and economic growth.

The relationship between oil prices and economic growth has attracted interests from many researchers, policymakers, and international institutions, motivated by the importance of oil as an input during the production process of all goods and, as a final good for all economic sectors (transport, agriculture, and service).

Oil price fluctuations can be defined as the upward and downward movement in the price of crude oil over time. The upward movement is often referred to as price spikes or oil booms while downward movement is called price drops or oil busts. These changes are not always predictable and can be influenced by a complex interplay of a range of factors[8] which include:

- **Supply dynamics:** Oil production levels are subject to various influences. The Organization of the Petroleum Exporting Countries (OPEC)'s decisions have a significant impact on global oil production, with their determinations on quotas capable of exerting a significant impact on prices. Geopolitical events, such as conflicts or political instability in major oil-producing regions, have the potential to disrupt production and result in price spikes. Additionally, the discovery of new oil reserves can temporarily augment supply, leading to lower prices, whereas the depletion of existing reserves may contribute to long-term price increases.
- **Demand dynamics:** Oil prices are intricately tied to global demand dynamics. Economic growth and industrial activity increase the demand for oil, pushing prices higher, while economic downturns and energy efficiency measures can lead to lower demand and reduced prices.
- **Currency exchange rate:** Oil is traded in US dollars, so changes in currency exchange rates can indirectly impact oil prices if a value of a currency decreases relative to the US dollar, it takes more of that currency to buy a barrel of oil which can drive up prices in the country.
- **Market speculation:** Spectators in the oil market can influence prices through their buying and selling activities. They may anticipate future price movements based on varied factors for example market trends, economic indicators, or geopolitical events.

Numerous studies and research have been conducted by economists to analyse the effects of oil price changes to the different economies of countries. Despite the large studies examining the influence of oil price fluctuations on different economies, the relationship between oil price fluctuations and economic growth is a complex issue with competing theoretical and empirical perspectives.

### 2.2: Theoretical literature review on oil prices and economic growth

Oil prices and economic growth have a complex and multifaceted relationship, as explored through various theoretical lenses.

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[8] https://www.investopedia.com/ask/answers/012715/what-causes-oil-prices-fluctuate.asp

The Dutch Disease theory (Corden & Neary, 1982) suggests that oil price increases, while beneficial, can have negative long-term consequences. A surge in oil revenue can lead to an appreciating exchange rate, making exports from other sectors less competitive and hindering economic diversification. This can cause stagnation despite overall growth in oil income.

Similarly, the Resource Curse theory (Sachs & Warner, 1995) argues that dependence on oil can be detrimental. It highlights potential issues like corruption and a neglect of investment in crucial sectors for sustainable development. Oil price fluctuations can exacerbate these problems, creating uncertainty and discouraging investment in areas necessary for long-term growth.

However, Endogenous Growth Theory (Romer, 1994) offers a more optimistic perspective. It emphasizes the role of government policies in promoting economic growth. Strategic investments in education, infrastructure, and technology using oil revenue can enhance productivity and innovation, leading to sustainable growth even with volatile oil prices.

Beyond these theoretical frameworks, economic diversification and government policies managing oil revenue also play crucial roles. Countries with a strong non-oil sector are less vulnerable to the negative aspects of the Dutch Disease and Resource Curse. Wise investments in human capital, infrastructure, and technology can further promote long-term economic growth. By understanding these theoretical perspectives and additional considerations, we can gain a deeper understanding of the potential impacts of oil price fluctuations on economic growth in different contexts, which the empirical literature review will further explore through real-world studies.

### 2.3: Empirical literature review on oil prices and economic growth

The connection between these two phenomena still sparks debates despite the existing studies and below are some of the investigations that have been conducted to deeply understand the interplay between these two.

A study by Mamdouh (Abdelmoula Mohamed Abdelsalam 2020) aims to explore the extreme effect of crude oil price fluctuations and its volatility on the economic growth of Middle East and North Africa (MENA) countries. It also investigates the asymmetric and dynamic relationship between oil price and economic growth. Further, a separate analysis for each MENA oil-export and oil-import countries is conducted. Furthermore, it studies to what extent the quality of institutions will change the effect of oil price fluctuations on economic growth.

The paper uses a panel quantile regression approach with other linear models such as fixed effects, random effects and panel generalized method of moments as the effect of oil price fluctuations is not the same over different business cycles. The panel quantile methodology is an extension of traditional linear models, and it has the advantage of exploring the relationship over the different quantiles of the whole distribution.

In his research, he concludes that changes in oil price have an opposite effect for each oil-export and oil-import countries; for the former, changes in oil prices have a positive impact but the volatility a negative effect. While for the latter, changes in oil prices have a negative effect but volatility a positive effect. Further, the impact of oil price changes and their uncertainty are different across different quantiles. Furthermore, there is evidence about the asymmetric effect of the oil price changes on economic growth. Finally, accounting for institutional quality led to a reduction in the impact of oil price changes on economic growth.

Another investigation by (Mourad Zmami, Ousama Ben-Salha 2020) on the impact of crude oil price on economic activity in the Gulf Cooperation Council oil-exporting countries covers a lengthy period spanning from 1960 to 2018.

The empirical investigation accounts for structural breaks, nonlinearity, and nonnormal distribution of data. The Kapetanios (2005) structural breaks unit root test and Saikkonen–Lütkepohl (2000a, b, c) cointegration test with structural shifts are implemented to examine the stationary properties of data and the presence of cointegration between variables, respectively. Moreover, the quantile regression is employed to assess whether the impact of oil price on real GDP differs across different states of the economy.

The results suggest the absence of long run cointegrating relationships between oil price and GDP in all countries. The quantile regression reveals that oil price does not affect real GDP in the same way across countries and for different business cycle phases. More specifically, the symmetric quantile regression findings reveal that oil price exerts a positive impact on GDP in all countries and that the effect is higher during the recession than expansion states. The asymmetric quantile regression shows that GDP reacts to positive oil price changes in all countries. However, only the Emirati and Omani economies are affected by negative oil price changes.

Many studies argue that higher oil prices benefit exporting countries by boosting their income, leading to more investment, consumption, and higher GDP growth (Akpan, 2009; Foudeh, 2017; Jahangir & Dural, 2018; Dabachi et al., 2020). However, other studies find the opposite, particularly for oil-importing nations where oil is a crucial expense (Arouri & Nguyen, 2010; Filis et al., 2011; Murshed & Tanha, 2020; Rahman & Majumder, 2020). These researchers argue that rising oil prices reduce income in importing countries, with the severity depending on oil dependence and price changes (Ghalayini, 2011). Additionally, attempts by central banks to control domestic price increases can further restrict economic activity. Studies by Papapetrou (2001) in Greece and Miguel et al. (2003) in Spain support this negative impact, while Bouzid (2012) found a 10% oil price rise led to a 3.4% decline in GDP growth for Tunisia.

## CONCLUSION

It is crucial to remember that these studies represent a portion of the existing research in this complex and multifaceted field. The findings are not always conclusive and can vary depending on the specific context, methodology, and data employed. Further research is necessary to fully understand the intricate relationships between energy intensity, oil price fluctuations, and economic growth, allowing for the development of effective policies fostering sustainable development and economic prosperity.

# CHAPTER 2: DATA OF STUDIED COUNTRIES

## INTRODUCTION

This chapter examines the energy intensity and evolution of prices of oil in the MENA countries. To do this, we have divided the chapter into two sections. In the first section, we present an overview of the region i.e., geographical overview, oil and economic background, and the state of the energy intensity of the region. In the second section, we will closely look at the evolution of energy intensity and oil prices in a few chosen countries from the region. This is done by analysing data of the chosen case study countries extracted from the World Bank national accounts, and OECD National Accounts data for a period ranging from 2000 to 2021.

## Section 1: Overview of the MENA region

### 1.1: Geographical overview

The Middle East and North Africa (MENA) region is a vast and diverse area encompassing 21 countries, according to the world bank. It is important to note that different United Nation agencies define the region with contradictions amongst each other. For example, a 2010 UNHCR report said that the region is made up of 18 countries while as of 2021, the UNICEF groups a set of 20 countries as MENA. The IMF 2003 report emphasizes 24 MENA countries. It is important to note that no exact boundaries can be fluid, but it includes countries bordering the Eastern Mediterranean Sea, the Arabian Peninsula, and North Africa.

The MENA region has a population of around **493 million** as of (Wikipedia, 2022), which is equal to 6.16 percent of the world population. The economic performance of this region has been dreadful since the last decade, such as the global financial crisis and the political transitions in some countries. Today, conflicts in some countries affect the MENA region's development. Moreover, low oil prices in the last few years have weakened the economies of Arab countries, especially those which depend on oil export to sustain their fiscal balances, particularly the GCC countries (Chigunta, F.; Chisup, N.; Elder, S., 2014). In addition, the MENA region has the highest unemployment rates in the world, according to the data presented by the International Labor Organization.

### 1.2: Oil and Economic background.

The MENA region has vast reserves of petroleum and natural gas that make it a vital source of global economic stability. A publication in the Oil and Gas journal shows that the region has 60% of the world's oil reserves and 45% of the world's natural gas of 1st January 2009. The reserves form of 810.98 billion barrels (128.936 $km^3$) of oil reserves and 2,868,886 billion cubic feet (81,237.8 $km^3$) of natural gas. With these percentages of oil and gas reserves, exportation of oil and gas products has been a primary driver of economic growth of many MENA states as an increase in oil prices leads to the booming of their economies as generally experienced in the pre 2010s with many states experiencing decent economic growth due to high oil prices for much of the 20th and early 21st centuries.

The economic picture of the Middle East and North Africa (MENA) region is a mixed bag, marked by both recent growth and lingering challenges. The MENA region saw a growth spout in 2022, with economies expanding at the fastest rate since 2016, at around 5.4% [World Bank MENA Economic Update]. This upswing was fuelled by rising oil prices helping oil-exporting countries. Economic growth is unevenly distributed across the region with oil-exporting countries, particularly those in the Gulf Cooperation Council (GCC), expected to fare better due to continued high energy prices while oil importers face different headwinds.

While growth is expected to continue, the road ahead is likely to be bumpy due to various internal and external challenges. The region faces problems such as double-digit food inflation, which is a major concern, especially for developing economies. This disproportionately affects the poor who spend a larger share of their income on food. Equally, the COVID-19 pandemic's economic scars have not fully healed in many MENA countries. Recovery is still fragile. Also, the ongoing wars in Ukraine and Palestine, are rising global interest rates, and potential slowdowns in major economies like the US and China are casting a shadow on the MENA region's economic prospects.

The region's heavy reliance on oil exports makes it vulnerable to oil price fluctuations with economic diversification beyond oil very crucial for long-term sustainable growth. High unemployment and stagnant living standards can also fuel social unrest which is why governments need to address these issues to keep stability.

Overall, the MENA region's economic outlook is cautiously optimistic. The region's long-term economic health hinges on addressing these challenges and diversifying its economies. The region's growth is expected to moderate in 2024, settling around 2.7%, according to World Bank forecasts [World Bank Middle East and North Africa Economic Update]. This is a return to the pre-pandemic low growth pattern.

### 1.3: Overview of energy intensity in the MENA region

The Middle East and North Africa (MENA) region presents a unique situation about energy intensity. Here is a breakdown of the key points with citations:

Compared to many regions globally, the MENA region boasts a **lower energy intensity**, according to the World Bank (2022). This means its economies use less energy per unit of economic output, on average. This is primarily attributed to the region's dominant fuel mix, which relies heavily on natural gas, a cleaner and more efficient fuel source compared to coal International Energy Agency. (2023).

Despite this advantage, there's significant potential for **enhanced energy efficiency** across the MENA region. Energy efficiency has not been a top priority for many MENA countries, as reported by the International Renewable Energy Agency in 2022, which translates to a lack of robust policies and infrastructure investments to promote efficient energy use in various sectors like industry, buildings, and transportation. Also, energy subsidies in some MENA countries distort prices, making energy seem cheaper than it is. This discourages consumers and businesses from adopting energy-saving practices, as highlighted by the World Bank. (2020).

Looking Ahead**,** the MENA region can further reduce its energy intensity and strengthen its position by implementing effective energy efficiency policies that incentivize conservation efforts across various sectors, as recommended by IRENA. They can also shift towards renewable energy sources like solar and wind power which can also contribute to lower energy intensity eventually, as highlighted by the World Bank in 2023.

By addressing these aspects, the MENA region can not only enhance its energy security but also reduce its environmental footprint and contribute to a more sustainable future.

### 1.4: Overview of chosen countries

**1. Algeria:** Algeria, found in the North of Africa, is the largest country in Africa stretching from the Mediterranean coast where most of its 46 million people reside to the vast Sahara Desert in the south. Hydrocarbons have long been the backbone of Algeria’s economy, accounting for 60% of budget revenues, 30% of GDP, and 87.7% of export earnings (Wikipedia). Oil and gas are the main sources of energy in Algeria with the government investing billions toward research programs meant to advance alternative energy production, especially solar and wind power. Algeria is estimated to have the largest solar energy potential in the Mediterranean, so the government has funded the creation of a solar science park in Hassi R'Mel which is destined for alternative energy production.

**2. Morocco:** Morocco, situated in the northwestern corner of Africa, boasts a rich tapestry of landscapes, from the snow-capped Atlas Mountains to the vast Sahara Desert. Its thirty-six million people are concentrated in the fertile coastal plains and major cities like Marrakesh. Unlike its oil-rich neighbours, Morocco's economy relies on agriculture, tourism, and growing technology sectors. While it has some oil and gas reserves, they are not a major driver of the economy. Morocco is looking towards renewable energy sources like solar and wind power to meet its growing energy demands.

**3. Egypt:** Egypt, the cradle of ancient civilizations, straddles the northeastern corner of Africa and the Sinai Peninsula in Western Asia. With a population exceeding one hundred million, it is the most populous Arab country. The mighty Nile River sustains agriculture, a cornerstone of the economy. Tourism, centred around the iconic pyramids and pharaonic monuments, plays a significant role. Egypt has some oil and gas reserves in the Suez Canal region and the Western Desert, but they are not as vast as those found in neighbouring countries. The government is investing in exploration and development of these resources to meet domestic energy needs and potentially for export.

**4. Saudi Arabia:** Saudi Arabia, occupying most of the Arabian Peninsula, is the largest country in the Middle East. Its vast oil reserves, the world's second largest, have fuelled its economic growth, making it a major player in the global energy market. Saudi Arabia is a founding member of OPEC and a major oil exporter, with state-owned Saudi Aramco being one of the largest oil companies in the world. Oil revenue plays a critical role in funding government programs and infrastructure development. The kingdom is working towards diversifying its economy away from oil dependence, but hydrocarbons are still expected to be a dominant energy source for the near future.

**5. UAE:** The United Arab Emirates (UAE), a federation of seven emirates on the eastern coast of the Arabian Peninsula, has appeared as a global centre for commerce and finance. Dubai, with its futuristic skyscrapers and luxurious resorts, is a major tourist destination. Unlike its larger neighbour, Saudi Arabia, the UAE has a more limited oil wealth concentrated in Abu Dhabi emirate. However, it has successfully used its oil revenue to develop other sectors of its economy and prove itself as a regional business hub. The UAE is also investing in renewable energy sources to meet its growing energy demands and reduce reliance on fossil fuels.

**6. Iraq:** Iraq, found in the heart of Mesopotamia, is the birthplace of influential civilizations like the Babylonians and Assyrians. War and political instability have plagued the country in recent decades. Despite vast oil reserves, the fifth largest proven reserves globally, Iraq struggles to rebuild its infrastructure and fully exploit its oil wealth. Corruption and political conflict have hampered oil production and exports. Rebuilding and expanding the oil sector is crucial for Iraq's economic recovery.

**7. Iran:** Iran, a regional power bordering the Persian Gulf, boasts a rich cultural heritage and a well-educated population. Its economy is heavily reliant on oil exports, with the world's fourth-largest proven reserves. However, international sanctions have hampered growth in recent years. Iran is a major producer of oil and natural gas, but sanctions have limited its ability to export and develop its energy sector. Iran is also investing in nuclear energy, a program that has been a source of tension with the international community.

**8. Qatar**: Qatar, a small peninsula jutting into the Persian Gulf, is the world's richest country per capita due to its immense natural gas reserves, the third largest globally. It has used its wealth to become a significant player in global politics and sports, hosting the 2022 FIFA World Cup. Unlike its neighbour Saudi Arabia, Qatar's economy relies heavily on natural gas production and export. Liquefied natural gas (LNG) is Qatar's primary export, and the country has invested heavily in developing its LNG infrastructure. Qatar is also exploring renewable energy sources to diversify its energy mix and reduce reliance on natural gas.

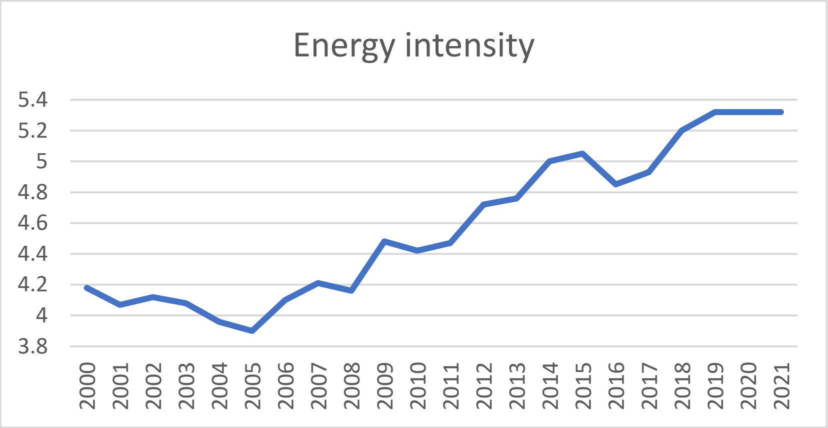
## Section 2: Descriptive analysis of the energy intensity evolution in MENA countries

In this section, we are going to look at the state/evolution of energy intensity for our case study countries. To this, we have traced graphs for each country using data from the world bank data accounts about **energy intensity level of primary energy (MJ/$2017 PPP GDP)** for different years ranging from 2000 to 2021. For all the graphs in this section, the energy intensity level of primary energy consumption in represented on the vertical axis while their corresponding periods are represented on the horizontal axis. We shall also look at the state and the evolution of the prices of oil over the same period. This analysis will help us to comprehensively understand the characteristics and uncover hidden patterns that can lead to valuable insights and help with the next stages of our research.

## I. Energy intensity level of primary energy for Algeria

Algeria's energy intensity level for primary energy shows moderate variability with a standard deviation of 0.42 MJ/dollar (PPP) over the period 2000-2021. There is no consistent upward or downward trend with the data showing fluctuations throughout the period, with some years experiencing significant increases followed by decreases or stagnation. Below is a graph showing the evolution of Algeria's energy intensity over the period 2000-2021.

***Figure 1: Algeria's energy intensity (2000-2021)***



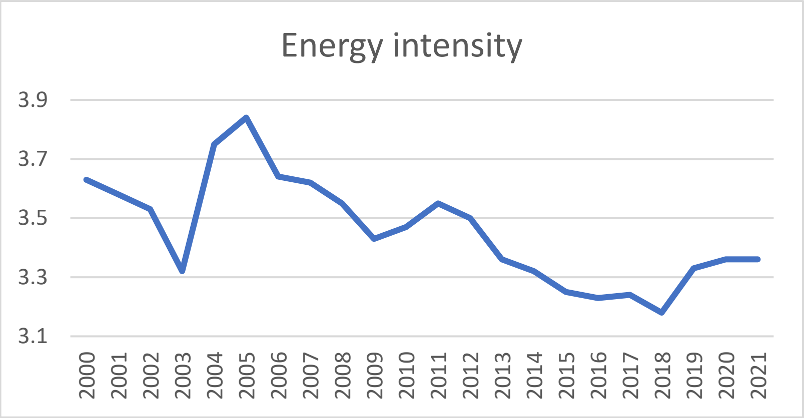
***Source: Created by authors using data coming from woels development indcators database***

From the graph above shows a gradual (slight) decrease of the energy intensity level in Algeria from **2000 to 2005**, which could be due to factors like improvements in energy efficiency or a shift towards less energy-intensive economic activities.

This is later followed by a period of fluctuation between **2006 and 2015**, with a slight overall increase. This could be due to a combination of factors, potentially including economic growth leading to higher energy consumption and potentially some inefficiencies that offset gains elsewhere. The energy intensity levels fluctuate around 5 MJ/dollar (PPP) from **2016 to 2018** and later stabilize to 5.32 MJ/$2017 PPP GDP from **2019 to 2021.**

## II. Energy intensity level of primary energy for Morocco

*Figure 2 : Morocco's energy intensity (2000-2021)*



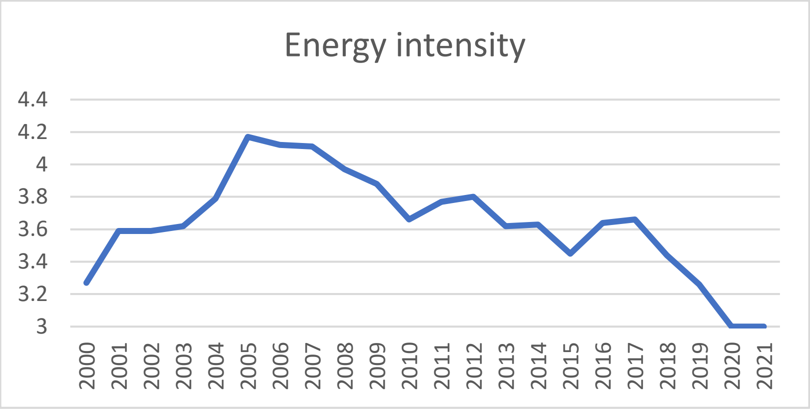
***Source: Created by authors using data coming from woels development indcators database***

Morocco averaged an energy intensity level of 3.46 MJ/$2017 PPP GDP across the period of 2000 to 2021. The variability around this mean value is reflected in the standard deviation of 0.18 MJ/$2017 PPP GDP, suggesting fluctuations from the average by +/- 0.18 MJ/$2017 PPP GDP in any given year.

From 2000 to 2005, energy intensity increased from 3.63 to 3.84, showing that the country was becoming less energy efficient during this period. This could be attributed to factors such as rapid economic growth, increased industrialization, and a reliance on fossil fuels to meet the growing energy demand. However, after 2005, energy intensity began to decline, dropping to 3.25 by 2015 suggesting that Morocco made efforts to improve energy efficiency during this time, through the implementation of energy efficiency policies, the promotion of renewable energy sources, and investments in more energy-efficient technologies and infrastructure. The downward trend continued, with energy intensity reaching 3.18 in 2018, the lowest point in the observed period. In the last few years, from 2019 to 2021, energy intensity has remained stable, fluctuating around 3.33-3.36. This suggests that Morocco has been able to keep its energy efficiency gains, even in the face of potential challenges such as the COVID-19 pandemic. Overall, the data suggests that Morocco has made considerable progress in improving its energy efficiency and reducing its energy intensity, which is a crucial step towards a more sustainable and low-carbon economy.

## III. Energy intensity level of primary energy for Egypt

*Figure 3 : Egypt's energy intensity (2000-2021)*



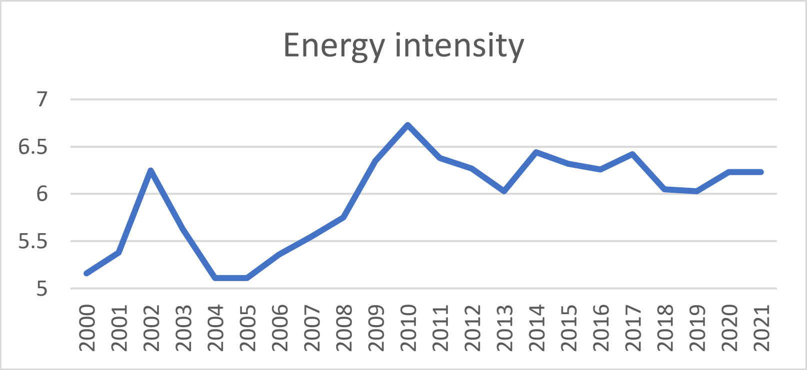
***Source: Created by authors using data coming from woels development indcators database***

The average energy intensity in Egypt over the period of 2000 to 2021 was 3.64 fluctuating between 3.00 and 4.17 over the years. It shows moderate variability with a standard deviation of 0.32 MJ/dollar (PPP) over the studied period.

From the year 2000 to 2005, the average energy intensity was 3.67 reaching the country's highest energy intensity of 4.17 MJ/$2017 PPP GDP in 2005. The country later experienced a gradual decline in the levels of energy intensity averaging 3.62 MJ/$2017 PPP GDP for the period of 2006 to 2021 with the last two years having the same intensity implying a slight level of stability for the period. Overall, the energy intensity in Egypt shows a downward trend over the period. This could be due to several factors, such as improvements in energy efficiency technologies and policies.

## IV. Energy intensity level of primary energy for Saudi Arabia

*Figure 4 : Saudi Arabia's energy intensity (2000-2021)*



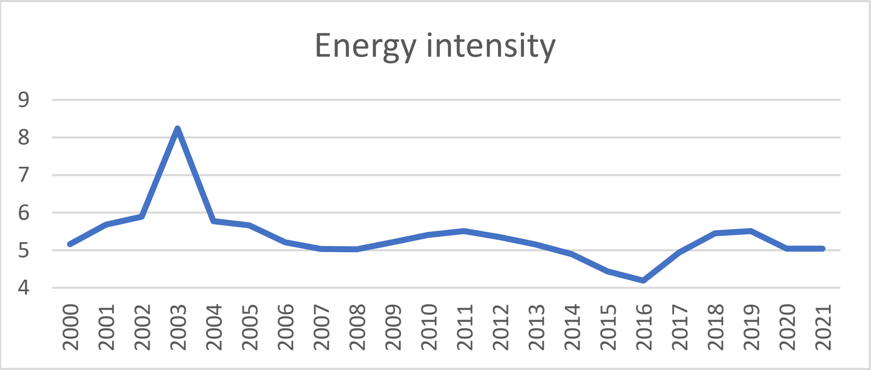
***Source: Created by authors using data coming from woels development indcators database***

The energy intensity in Saudi Arabia has fluctuated over the period of 2000 to 2021, but there seems to be an overall upward trend for the first decade where the country recorded a sharp increase from 2000 to 2002 (5.16 – 6.25) MJ and later a sharp decrease to 5.11 in 2004 which is the countries lowest energy intensity level for the studied period. The country experienced a gradual increase thereafter recording its highest energy intensity level of 6.73 MJ in 2010.For the second decade, the country records a slow and gradual decrease averaging an intensity of 6.24 for the period (2011-2021).

In general, the country averages an intensity level of 5.96 across all the years with a standard deviation of 0.49 MJ, which shows that there is moderate variability in the energy intensity from year to year.

### V. Energy intensity level of primary energy for Iraq

***Figure 5 : Iraq's energy intensity (2000-2021)***



***Source: Created by authors using data coming from woels development indcators database***

Iraq averaged an energy intensity of 5.35MJ over the studied period with a standard deviation of 0.76MJ suggesting a high variability of the data from its mean. There is a gradual increase in energy intensity from 2000 to 2003, followed by a general decrease until 2016. The values then fluctuate but show a slight increase by 2021.

The significant difference between 2002 (5.89) and 2003 (8.24) suggests a major event affecting energy use. The first increase (2000-2002) could be due to factors like economic growth or increased industrial activity while the sharp increase in energy intensity in 2003 (8.24) is likely due to the US invasion of Iraq and disruptions to infrastructure. It shows that in 2003, Iraq used the most amount of energy per unit of economic output compared to any other year. After 2003, there was a general decrease of energy intensity with Iraq recording its least intensity level in 2016 (4.19). The decrease after could be due to improvements in energy efficiency or a decline in economic activity. From 2017 to 2021, there was a slight increase in the energy intensity averaging an intensity of 5.19 MJ.

### VI. Energy intensity level of primary energy for Iran

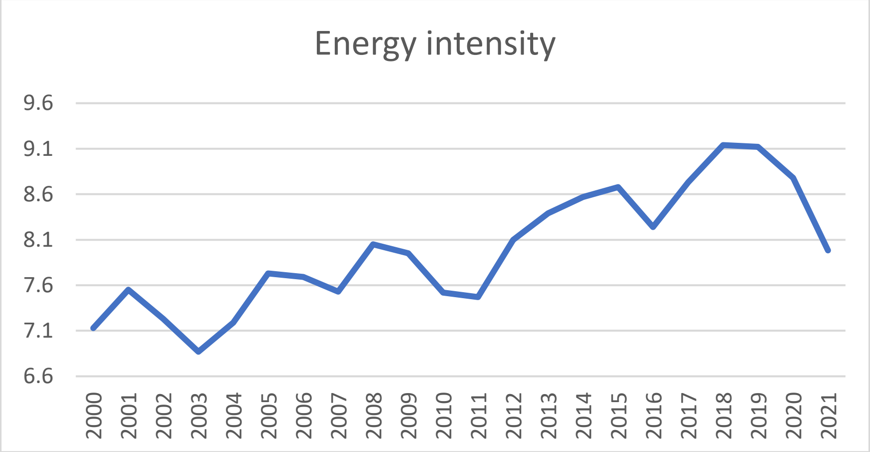


*Figure 6 : Iran’s energy intensity (2000-2021)*

The data shows that Iran's energy intensity has fluctuated over the 2000-2021 period. From 2000 to 2005, the energy intensity increased from 7.13 to 7.73, showing that the country was becoming less energy efficient during this period. This could be due to factors such as increased industrialization, lack of energy efficiency measures, or reliance on energy-intensive industries. However, from 2005 to 2011, the energy intensity decreased from 7.73 to 7.47, suggesting that Iran was becoming more energy efficient during this time. This could be attributed to the implementation of energy efficiency policies, technological improvements, or a shift towards less energy-intensive economic activities.

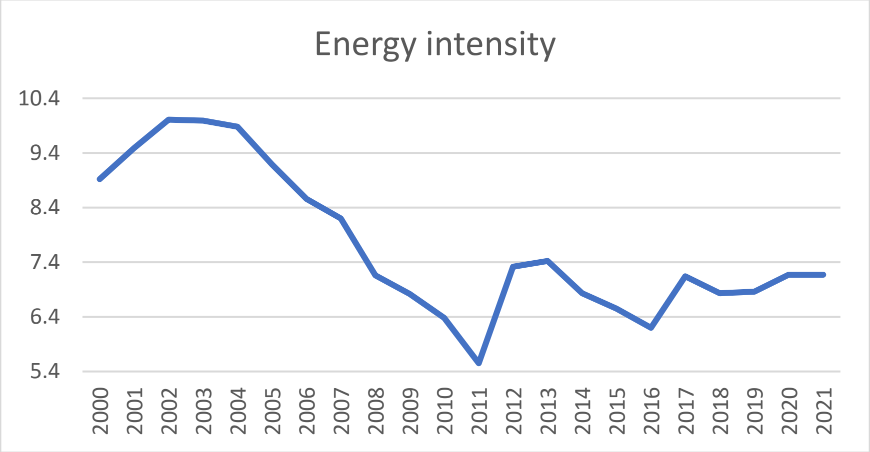
After 2011, the energy intensity started to rise again, reaching a peak of 9.14 in 2018. This upward trend could be explained by factors such as increased energy demand due to economic growth, lack of investment in energy efficiency, or the impact of international sanctions on the country's ability to access modern energy technologies.

In the most recent years, from 2018 to 2021, the energy intensity has shown a slight decrease, going from 9.14 to 7.98 showing that Iran has made some progress in improving its energy efficiency, possibly through the implementation of energy-saving measures or the adoption of more efficient technologies.

Overall, the data suggests that Iran's energy intensity has been fluctuating over the years, with periods of both improvement and deterioration in energy efficiency. The reasons for these fluctuations could be related to a combination of economic, policy, and technological factors that have influenced the country's energy consumption patterns.

### VII. Energy intensity level of primary energy for Qatar

***Figure 7 : Qatar's energy intensity (2000-2021)***



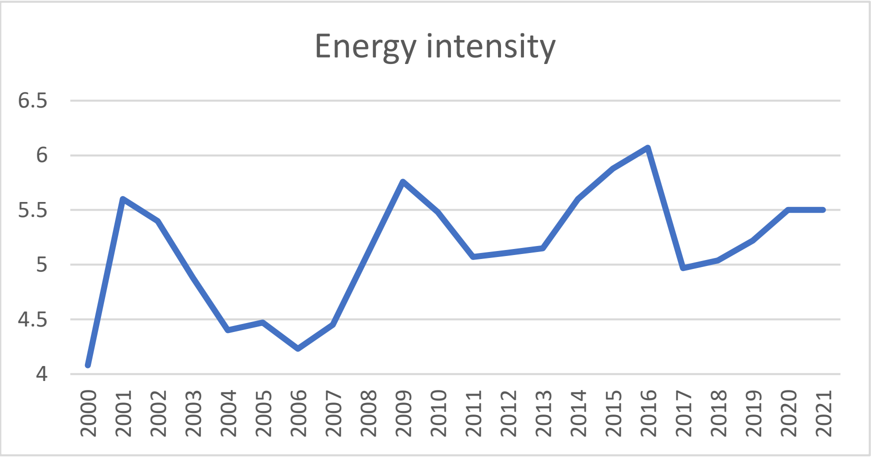
***Source: Created by authors using data coming from woels development indcators database***

The data suggests that Qatar's energy intensity has been fluctuating over the years, with periods of both improvement and deterioration in energy efficiency. Qatar averaged an intensity of 7.71 over the studied period and a standard deviation of 1.34 suggesting high variability.

From 2000 to 2002, the energy intensity increased from 8.92 to 10.01 which was its peak for the studied period. This increase shows that the country was becoming less energy efficient during this period. This could be due to factors such as rapid economic growth, increased energy demand from the industrial and residential sectors. However, from 2002 to 2011, the energy intensity decreased from 10.01 to 5.55, suggesting that Qatar was becoming more energy efficient during this time. This could be attributed to the implementation of energy efficiency policies, technological improvements, or a shift towards less energy-intensive economic activities. After 2011, the energy intensity started to rise again, reaching 7.17 in 2020 and 2021. This upward trend could be explained by factors such as increased energy demand due to economic growth or lack of investment in energy efficiency.

## VIII. Energy intensity level of primary energy for the United Arab Emirates

***Figure 8 : United Arab Emirates' energy intensity (2000-2021)***

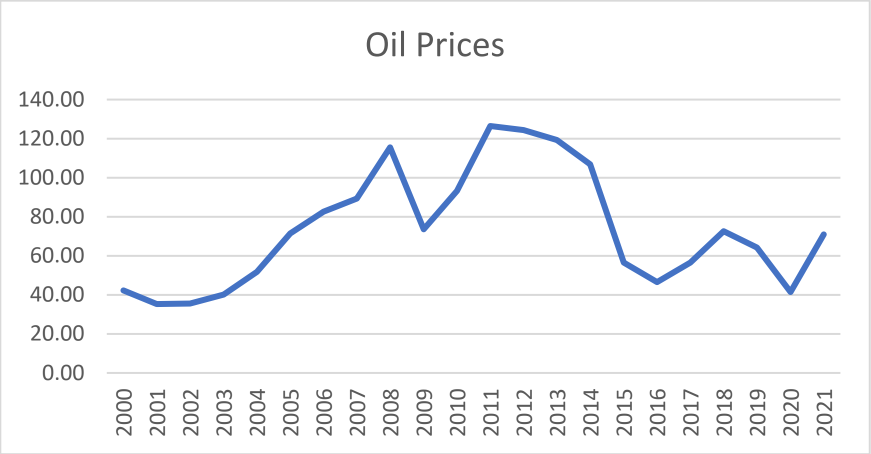


***Source: Created by authors using data coming from woels development indcators database***

From 2000 to 2001, the energy intensity increased from 4.08 to 5.6, showing that the country was becoming less energy efficient during this period. This could be due to factors such as rapid economic growth, increased energy demand from the industrial and residential sectors, or lack of energy efficiency measures. However, from 2001 to 2007, the energy intensity decreased from 5.6 to 4.45, suggesting that the UAE was becoming more energy efficient during this time. After 2007, the energy intensity started to rise again, reaching a peak of 6.07 in 2016. This upward trend could be explained by factors such as increased energy demand due to economic growth, lack of investment in energy efficiency, or the impact of international events on the country's energy consumption patterns. In the most recent years, from 2016 to 2021, the energy intensity has shown a slight decrease, going from 6.07 to 5.5. This could show that the UAE has made progress in improving its energy efficiency, through the implementation of energy-saving measures or the adoption of more efficient technologies.

## IX. Analysis of oil prices for the MENA region

**Figure 9 : Oil price fluctuations in the MENA region (2000-2021)**



***Source: Created by authors using data coming from woels development indcators database***

The graph above shows the evolution of oil prices in the MENA region with time, and it is important to note that the oil price data provided is the same for all the MENA countries, as this represents the regional average prices. The MENA region is a major oil-producing and exporting area, and the oil prices shown would be applicable to all the case study countries in this region.

So, to start with, the oil prices were relatively stable in the early 2000s, ranging between $35-$42 per barrel from 2000 to 2003. However, starting in 2004, oil prices began a steady climb, increasing from $51.79 in 2004 to a peak of $126.45 in 2011. This sharp rise in oil prices during the mid-2000s was driven by factors such as growing global demand, supply disruptions, and geopolitical tensions in the MENA region. After reaching the $126.45 peak in 2011, oil prices began to decline, falling to $56.51 in 2015. This drop was largely attributed to increased production from non-OPEC countries, as well as weaker global economic growth. From 2016 to 2018, oil prices fluctuated between $46.59 and $72.60 per barrel, reflecting the volatility in the global oil market during this period. In 2020, oil prices plummeted to $41.48 per barrel, the lowest level in the period covered, due to the COVID-19 pandemic and the resulting collapse in global demand. Finally, in 2021, oil prices rebounded to $70.91 per barrel as the global economy began to recover from the pandemic. Overall, the data shows significant volatility in oil prices in the MENA region over the past two decades, with periods of sharp increases and decreases driven by a complex interplay of supply, demand, and geopolitical factors.

## CONCLUSION

This chapter examined the energy intensity and evolution of oil prices in the MENA region. The analysis of energy intensity across the eight case study countries revealed a diverse landscape. While some countries, like Morocco, exhibited a clear downward trend indicating improvements in energy efficiency, others, like Saudi Arabia, showed a fluctuating pattern. These variations highlight the influence of country-specific factors like economic growth, industrial activity, energy policies, and investments in energy efficiency technologies.

The analysis of oil prices over the past two decades underscored significant volatility in the MENA region. The sharp rise in prices during the mid-2000s, followed by a decline and subsequent fluctuations, demonstrates the complex interplay of global demand, supply disruptions, geopolitical tensions, and most recently, the impact of global pandemics.

Understanding these dynamics of energy intensity and oil prices is crucial for further investigation into the effects of these two factors to the economic growth in the MENA region. Chapter 3 will delve deeper into this aspect, and by analysing the trends presented in this chapter, we aim to gain a comprehensive understanding of the energy landscape in the MENA region and identify potential pathways for a more sustainable energy future.

# CHAPTER 3: RELATIONSHIP BETWEEN ENRGY INTENSITY, OIL PRICES AND ECONOMIC GROWTH IN MENA COUNTRIES: METHODOLOGY AND ECONOMETRIC ANALYSIS

## INTRODUCTION

In this chapter, we empirically analyse the relationship between energy intensity, oil prices, and economic growth in MENA countries. We'll begin by outlining our research methodology, including the approach we've taken and the power of panel data analysis for this specific investigation. Following that, we will detail the data sources and the variables we've chosen to analyse. Next, we'll equip ourselves with the knowledge of panel data regression models, including the fixed effects and random effects models. We'll even introduce the Hausman test, a crucial tool for selecting the most appropriate model for our study. Equipped with this foundation, we'll embark on a journey through our data, introducing the chosen MENA countries and the used variables. Finally, we'll construct and estimate the functional form of the model, rigorously validate its accuracy, and unveil the insights gleaned from our analysis.

## Section 1: Methodology

For our analysis, we shall employ a panel data analysis approach which combines cross-sectional data (observations from multiple MENA countries) with time-series data (observations from each country over several years - 2000 to 2021 in this case) to identify the relationships between energy intensity, oil prices, and economic growth in MENA countries. This econometric modelling allows us to control for unobserved country-specific factors that might influence economic growth.

This study will utilize data coming from different sources; like the World Development Indicators of World Bank, Bp database and Penn Word Table 10.0. The data will encompass different variables for each MENA country over the period 2000-2021.

Then we will utilize panel regression models to estimate the relationship between Gross Domestic Product (GDP) at constant prices, as dependant variable, and at set of explanatory variables namely, energy intensity, oil prices, gross fixed capital formation as proxy of physical capital investment, and human capital, analyse the collected data. We will employ different panel regression models (e.g., fixed effects, random effects) to account for potential country-specific effects and serial correlation within the data. Based on existing economic theory, we can formulate specific hypotheses about the relationships between our variables which will be tested using the estimated panel model

Thereafter, we will evaluate and validate the model's performance based on standard statistical criteria (e.g., R-squared, significance of coefficients, heteroscedasticity tests, etc) where after we will interpret the estimated coefficients to understand the direction and strength of the relationships between energy intensity, oil prices, and economic growth in MENA countries.

### 1.1: Panel data analysis

This research uses a method called panel data analysis. This is a good fit for studies that combine data observed over time (time series) with data for different groups (cross-section). Our data is a perfect example because we have information on eight MENA countries (cross-section) from 2000 to 2021 (time series). By using panel data, we can analyse how energy use (energy intensity) and changes in oil prices affect economic growth while controlling other factors that vary among countries and yet are not observed in the data.

[9]A panel data regression differs from a regular time-series or cross-section regression in that it has a double subscript on its variables. i.e.

$$\boldsymbol{y_{it} = \beta_0 + \beta_1 x_{it} + \varepsilon_{it}} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (\mathbf{1})$$

With, **y** representing the dependent variable, $\boldsymbol{\beta_0}$ is constant for all variables, $\boldsymbol{\beta_1}$is the coefficient estimated of independent variable, $\boldsymbol{x}$ represents independent variables and **ε** is the error term that captures random variation and unobserved factors. The $\boldsymbol{i}$ subscript, therefore, denotes the cross-section dimension whereas $\boldsymbol{t}$ denotes the time-series dimension.

The error term of a panel data regression is decomposed into two components: A person-specific error and an idiosyncratic error.

$$\boldsymbol{\varepsilon_{it} = u_i + z_{it}} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (\mathbf{2})$$

The term $\boldsymbol{u_i}$ represents the person-specific time constant unobserved heterogeneity and it is important to note that it does not change over time. $\boldsymbol{z_{it}}$ represents the idiosyncratic error sometimes referred to as the random error.

When delving into panel data analysis, researchers typically consider various models.

a) **Fixed Effects (FE) models**

These are models that aim to isolate the effect of a specific variable (e.g., oil price fluctuations) on another variable (e.g., economic growth) while controlling for unobserved factors that are

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[9] **Gujarati, D. N. (2011). Basic Econometrics (5th ed.).** New York, NY: McGraw-Hill.

constant over time for each individual/entity (country effect) but may differ between them. They assume that unobserved factors are **fixed** for each entity and control for them using dummy variables. These unobserved factors can be things like a country's political system, cultural norms, or geographical features. They can significantly influence the dependent variable (economic growth) but aren't directly measured in the data.

The model includes a dummy variable for each individual (e.g., a dummy for each country) which captures all the time-invariant unobserved factors specific to each entity. By including these dummy variables, the model essentially focuses on the **changes** in the variables within each entity over time. This removes the effect of the constant unobserved factors, allowing us to isolate the true effect of the independent variable on the dependent variable. The basic FE model equation can be written as:

$$\boldsymbol{y_{it} = u_i + \beta_1 x_{it} + z_{it}} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \mathbf{(3)}$$

**where:**

- $\boldsymbol{y_{it}}$: Dependent variable (e.g., economic growth) for individual i at time t.
- $\boldsymbol{u_i}$**:** Fixed effect for individual i (e.g., country effect). This captures all the time-invariant unobserved factors specific to country i.
- $\boldsymbol{\beta_1}$: Coefficient of the independent variable (e.g., energy intensity). This represents the average effect of the independent variable on the dependent variable.
- $\boldsymbol{x_{it}}$: Independent variable (e.g., energy intensity) for individual i at time t.
- $\boldsymbol{z_{it}}$: Error term capturing random, time-varying influences not included in the model.

In a standard regression model without panel data, the constant term represents the average intercept for all observations. It reflects the expected value of the dependent variable when all the independent variables are zero whereas In FE models, each individual has its own dummy variable. These dummy variables effectively capture the constant effect of the unobserved factors specific to each entity meaning that the constant term in FE models is redundant because the individual effects capture the average level of the dependent variable for each entity. FE models focus on the **changes** within entities over time, not the overall average level across all entities.

### b) Random Effects (RE) Models

Like fixed effects (FE) models, random effects models aim to analyse the relationship between variables while accounting for unobserved factors that influence individual entities (like countries) over time. The **RE models** assume that unobserved factors are **random** effects that vary across entities and over time. They account for these effects statistically, not through individual dummy variables.

The RE model includes a random intercept term for each entity which captures the unobserved effect specific to each entity, but it's assumed to be randomly distributed and not correlated with the independent variables. The basic RE model equation can be written as:

$$y_{it} = \beta_0 + \beta_1 x_{it} + u_i + z_{it} \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (4)$$

where:

- $y_{it}$: Dependent variable (e.g., economic growth) for individual i at time t.
- $\beta_0$: Overall constant term (intercept).
- $\beta_1$: Coefficient of the independent variable (e.g., oil price fluctuation). This represents the average effect of the independent variable on the dependent variable.
- $x_{it}$: Independent variable (e.g., oil price fluctuation) for individual i at time t.
- $u_i$: Random effect specific to individual i. This captures the unobserved effect for each entity and is assumed to be randomly distributed with a mean of zero.
- $z_{it}$: Error term, consisting of the random individual effect (αi) and a standard error term.

Unlike FE models, RE models include an **overall constant term ($\beta_0$)** in the equation. This term represents the average level of economic growth across all countries **net of the random effects**.

### 1.2: Model selection (Hausman Test)

The Hausman Test is a crucial tool in model selection within panel data analysis. This test is used to determine whether the individual effects in a Random Effects (RE) model are correlated with the regressors, which helps researchers choose between Fixed Effects (FE) and RE models. The null hypothesis of the Hausman Test is that the individual effects are uncorrelated with the regressors. If the null hypothesis is rejected, indicating that the individual effects are indeed correlated with the regressors, then the FE model is preferred over the RE model. This test is essential in addressing the issue of unobserved heterogeneity and ensuring the chosen model is appropriate for the panel data being analysed.

$$\boldsymbol{H_0: E(\varepsilon_{it}/x_{it}) = 0}$$

$$\boldsymbol{H_1: E(\varepsilon_{it}/x_{it}) \neq 0}$$

By performing the Hausman test, you get a p-value. If the p-value is less than a chosen significance level (usually 0.05), you reject the null hypothesis. This suggests that the random effects model might be suffering from biased estimates due to violated assumptions. In such a case, the fixed effects model, though potentially less efficient, is considered a more reliable choice. The Hausman test helps you decide between two models. One model (random effects) is generally better if its assumptions hold, but the other model (fixed effects) is reliable even if those assumptions are broken. The test result guides you towards the more trustworthy model for your specific data.

### 1.3: Validation of the chosen model

After specifying the model in panel data analysis, we conduct validation tests to ensure the robustness and reliability of their results. Several validation tests are commonly employed in panel data analysis:

1. **Serial Correlation Tests**: These tests, such as the Wooldridge test for FE models and the Arellano-Bond test for Generalized Method of Moments (GMM) models, check for serial correlation in errors. Detecting serial correlation is crucial as it can impact the efficiency and consistency of the estimates.
2. **Heteroskedasticity Tests**: Validation tests for heteroskedasticity, like the Modified Wald test for FE models, help identify group-wise heteroskedasticity. Addressing heteroskedasticity is essential to ensure the reliability of the model estimates.

By conducting these validation tests, we can assess the assumptions of panel data models, identify potential issues like serial correlation and heteroskedasticity. The presence of heteroscedasticity, autocorrelation and multicollinearity leads to biased and inefficient coefficient estimates, unreliable standard errors, and incorrect statistical inferences. To adequately address these problems, the FGLS (Feasible Generalized Least Squares) technique is a suitable approach for estimation, the retained model can be re-estimated for the analysis with FGLS technique in order to solve for these problems and ensure the robustness of their findings in panel data analysis.

## Section 2: Models-Estimation

### 2.1: Data presentation

Our study uses data from seven Middle East and North African countries. The choice of these countries depends on; Firstly, the specific research objectives and hypotheses to determine which countries align best with the research focus. Additionally, factors such as the availability and quality of data for the chosen countries, the representativeness of the sample in relation to the research question, and the comparability of data across countries are crucial aspects to consider.

***Table 1 : Case study countries***

| | |
|---|---|
| Algeria | Iraq |
| Morocco | Iran |
| Egypt | United Arab Emirates |
| Saudi Arabia | |

***Source: Created by authors using Ms Word***

**The chosen variables**

**Dependent Variable:**

- **GDP (constant 2015 US$) from WDI data base:** GDP, or Gross Domestic Product, is the total monetary value of all finished goods and services produced within a country's borders during a specific period, typically a year. It encompasses everything from consumer spending on goods and services to government spending, investment in new capital, and exports minus imports.

  GDP (constant 2015 US$) represents a country's total economic output adjusted for inflation, expressed in 2015 US dollars. It's a measure of real economic activity, meaning it reflects changes in the quantity of goods and services produced, rather than just price fluctuations. By holding the value of the dollar constant at 2015 levels, it removes the effects of inflation, allowing for more accurate comparisons of economic growth across different years and regions.

While GDP per capita is a commonly used indicator of economic well-being, I've chosen to focus on GDP (constant 2015 US$) as my dependent variable because it provides a clearer picture of a country's overall economic output, adjusted for inflation. Unlike GDP per capita, which only reflects the average economic output per person, GDP (constant 2015 US$) captures the total economic activity of a country, allowing for a more comprehensive understanding of its economic performance and growth over time. By standardizing the currency to 2015 US dollars, it enables accurate comparisons across different countries and periods, mitigating the impact of fluctuating exchange rates and inflation.

**Explanatories, Independent, Variables:**

- **Gross fixed capital formation (% of GDP) from WDI data base:** This refers to the stock of man-made assets used in production, like buildings, machinery, and equipment. A higher level of gross fixed capital allows for increased efficiency and productivity, potentially leading to higher GDP.
- **Human Capital from Penn World Table 10.0**: This encompasses the knowledge, skills, and experience of the workforce. A more educated and skilled population can contribute to innovation, better use of technology, and ultimately, economic growth.
- **Energy Intensity Level of Primary Energy (MJ/$2017 PPP GDP) from WDI data base**: This measures the amount of energy (in Megajoules) required to produce a unit of GDP (adjusted for purchasing power parity). A higher energy intensity suggests a less efficient economy, potentially leading to lower GDP. This variable is of particular interest of study as it aims to explain the impact of energy use on economic growth.
- **Primary Energy from WDI data base:** Consumption per Capita: This variable captures the amount of energy consumed per person in a country. While related to energy intensity, it provides a different perspective. High per capita consumption could indicate a less efficient use of energy or a more energy-intensive lifestyle, potentially impacting economic growth.
- **Oil Prices from Bp database**: This variable reflects the global price of oil. Since oil is a major energy source, its price fluctuations can significantly impact MENA economies. Higher oil prices can benefit oil-exporting countries but can burden oil-importing ones, impacting overall economic growth.

The following table shows the studied variables for our regression analysis in a concise and descriptive to avoid potential confusion with standard econometric notation. These variables are transformed into logarithmic form before to be analysed to address issues such as non-linearity, skewed distributions, or heteroscedasticity, which can violate standard regression assumptions and affect the model's performance. While GDP per capita provides insights into individual well-being, choosing GDP as the dependent variable in regression analysis can be more appropriate when studying the overall economic performance of a nation. GDP reflects the total value of goods and services produced within a country, providing a comprehensive picture of its economic activity and scale. This is particularly relevant when analysing government policies, macroeconomic trends, or international comparisons where the absolute size of the economy holds significance. Moreover, using GDP avoids potential biases introduced by population size fluctuations, making it a more stable and reliable indicator for analysing economic growth and its determinants.

***Table 2 : Summary of chosen variables***

| Variables | Description | Log-form | Expected sign |
|---|---|---|---|
| gdp | GDP (constant 2015 US$) | lgdp | Dependant variable |
| enerint | Energy intensity level of primary energy (MJ/$2017 PPP GDP) | lenerint | - |
| primenecons | Primary energy: Consumption per capita | lprimenecons | +/- |
| gfcf | Gross fixed capital formation (% of GDP) | lgfcf | + |
| hci | Human capital Index | lhci | + |
| prices | Oil prices | lprices | +/- |

***Source: Created by authors***

**Descriptive statistics**

*Table 3 : Descriptive statistic of the studied variables*

| Variable | Obs | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| **lgdp** | 154 | 26.13 | 0.65 | 24.75 | 27.29 |
| **lenerint** | 154 | 1.60 | 0.28 | 1.10 | 2.21 |
| **lprienecons** | 154 | 4.43 | 1.10 | 2.69 | 6.43 |
| **lprices** | 154 | 4.22 | 0.41 | 3.56 | 4.84 |
| **lhci** | 154 | 0.80 | 0.15 | 0.44 | 1.02 |
| **lgfcf** | 154 | 3.06 | 0.41 | 1.07 | 3.76 |

***Source: By authors using Stata 17 and Ms word***

Table above shows the summary of the statistic description (mean, minimum, maximum, and standard deviation) of the variables used in this study over seven countries in the MENA region in the period of 22 years. The number of observations is 154 for all the variables (the panel is balanced).

### 2.2: Model specification.

Having mentioned and described the variables above, we shall use them to estimate equation basing on the specific research question and data availability. These are the variables that were highly likely to influence and significantly impact the economic growth (GDP) in the chosen MENA countries: Therefore, our theoretical specification of the model takes this general linear functional form:

$$\boldsymbol{gdp = f(enerint, prienercons, gfcf, hci, prices)} \cdots\cdots\cdots\cdots\cdots\cdots \mathbf{(5)}$$

We employ a panel data regression. This is a balanced macro panel with a sample of 7 countries observed over the period of 22 years starting from 2000 to 2021. Balanced because there are no missing observations, Macro because N is greater than 6, N=7 countries with T varying from a minimum of 20 years and in this case, T=22years making it a balanced macro panel. As mentioned before the variables are in log form, it can be denoted as **(logarithm=Log=l).** Thus, the linear regression form of the equation to be estimated is written as follows:

$$\boldsymbol{lgdp_{it} = \beta_0 + \beta_1 lene\_int_{it} + \beta_2 lprim\_enercons_{it} + \beta_3 lprices_{it} + \beta_4 lhci_{it} + \beta_5 lgfcf_{it} + \varepsilon_{it}} \cdots\cdots (6)$$

where:

- i represents the country.
- t represents the time
- β are the coefficients to be estimated which will tell the direction of the relationships between the variables.
- ε is the error term capturing unexplained factors.

The model has six variables with gdp as the dependent variable and the remaining five variables as independent ones. Gdp stands for economic growth for the individual country i studied over a time t. This specification is the general form for the model and the appropriate model between the two models will be chosen after the estimation.

## 2.3: Estimation and Interpretation of results

Estimation of equation 6 using the fixed effects model and the random effects model

***Table 4: Panel data models (Re, Fe)***

| **Dependant variable (lgdp)** | | | | | | |
|---|---|---|---|---|---|---|
| **Independent variables** | **Coefficients** | **Std. errs.** | **P-value** | **Coefficients** | **Std. errs.** | **P-value** |
| **C** | 24.31 | 0.42 | 0.000 | 24.05 | 0.42 | 0.000 |
| **lenernt** | -0.41 | 0.11 | 0.000 | -0.39 | 0.11 | 0.000 |
| **lprienecons** | -0.01 | 0.12 | 0.870 | 0.05 | 0.10 | 0.622 |
| **lprices** | 0.05 | 0.02 | 0.030 | 0.05 | 0.02 | 0.031 |
| **lhci** | 2.45 | 0.21 | 0.000 | 2.35 | 0.20 | 0.000 |
| **lgfcf** | 0.11 | 0.04 | 0.006 | 0.11 | 0.04 | 0.006 |

| Model | Fixed Effects | Random Effects |
|---|---|---|
| No. Obs | 154 | 154 |
| No. Groups | 7 | 7 |
| R-Squared | 0.7516 | 0.7509 |
|  | F (5, 142) = 85.93 | Wald chi2(5) = 4333.90 |
|  | Prob > F = 0.0000 | Prob > chi2 = 0.0000 |

***Source: By authors using Stata 17***

The analysis includes 154 observations (7 groups with 22 observations each), indicating a complete and balanced panel dataset without any missing data. The Mc Fadden R-squared values, serving as a quality adjustment metric, are close to 1 for both the fixed effects (0.7516) and random effects (0.7509) models. This suggests that both models are suitable for estimations.

The presented table summarizes the results of the panel regression. The first column identifies the independent variables, the estimated model (fixed or random effects), the total number of observations, the number of groups, and the corresponding R-squared value. The second big and third columns provide the estimated coefficients for each variable in the respective models, along with their standard errors. The significance of each independent variable is determined by the P-values, which are assessed at a significance level of 5% for both models.

The analysis reveals distinct constant coefficients for the fixed effects and random effects models, with values of 24.31 and 24.05 respectively. Notably, the coefficients associated with the level of energy intensity exhibit negative values in both models. The fixed effects model yields a coefficient of -0.41, while the random effects model produces a coefficient of -0.39. The p-values corresponding to these energy intensity coefficients are less than 0.05, specifically 0.000, indicating statistical significance at the 5% significance level. This implies that energy intensity level has a negative impact on economic growth.

Examining the impact of primary energy consumption per capita on GDP reveals contrasting results between the fixed effects and random effects models. The fixed effects model presents a negative coefficient of -0.0198, suggesting a negative relationship between primary energy consumption per capita and GDP. However, the associated p-value of 0.870 exceeds the 0.05

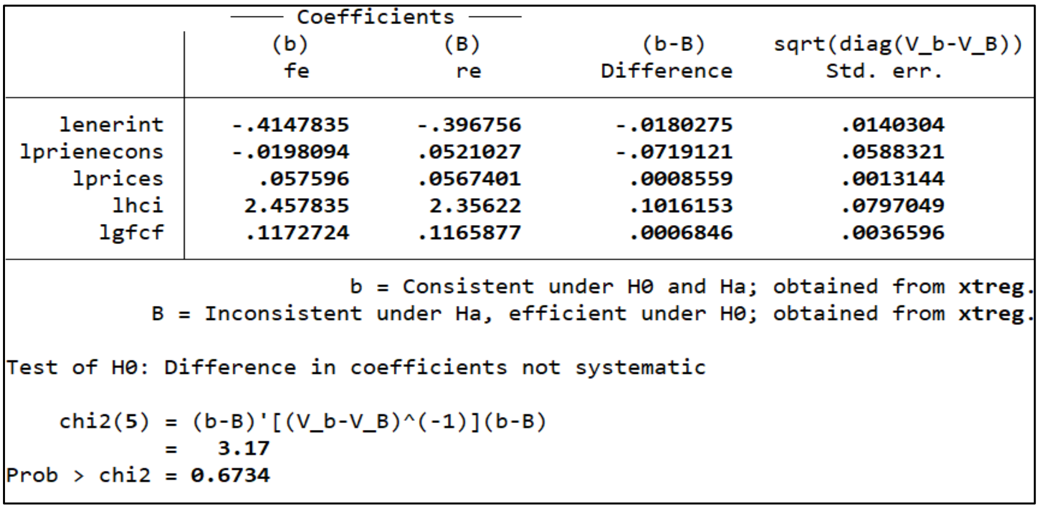
threshold for statistical significance at the 5% level. Conversely, the random effects model yields a positive coefficient of 0.052indicating a positive relationship between primary energy consumption per capita and GDP. However, like the fixed effects model, the p-value of 0.622 fails to reach statistical significance at the 5% level meaning that both coefficients are statistically not significant at a 5% level.

The analysis reveals a consistent and statistically significant positive relationship between oil prices and economic growth, as evidenced by both the fixed effects and random effects models. In the fixed effects model, the coefficient associated with oil prices is 0.057596, while the random effects model yields a coefficient of 0.056. Furthermore, the statistical significance of this relationship is confirmed by the p-values, which are less than 0.05 in both models. The fixed effects model exhibits a p-value of 0.030, while the random effects model shows a p-value of 0.031. These p-values, being below the 0.05 threshold, demonstrate that the two coefficients are statistically significant.

Both the fixed effects and random effects models provide evidence for a strong positive relationship between the human Capital Index and economic growth. The estimated coefficients for the Human Capital Index are positive and highly statistically significant in both models having a p-value < 0.05. The fixed effects model reveals a coefficient of 2.457835 for the Human Capital Index, while the random effects model yields a coefficient of 2.35622. The magnitude of these coefficients indicates a substantial positive impact of human capital on economic growth.

The analysis of the relationship between gross fixed capital formation and economic growth reveals a consistent and statistically significant positive association, as demonstrated by both the fixed effects and random effects models. The fixed effects model exhibits a coefficient of 0.1172724 for gross fixed capital formation, while the random effects model yields a coefficient of 0.1165877. Both p-values corresponding to these gross fixed capital formation coefficients are less than 0.05, specifically 0.006, indicating statistical significance at the 5% significance level.

### 2.3.1: Hausman Specification test (1978) results



```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      fe           re          Difference       Std. err.
-------------+----------------------------------------------------------------
    lenerint |  -.4147835    -.396756        -.0180275        .0140304
  lprienecons|  -.0198094    .0521027        -.0719121        .0588321
     lprices |    .057596    .0567401         .0008559        .0013144
        lhci |   2.457835     2.35622         .1016153        .0797049
       lgfcf |   .1172724    .1165877         .0006846        .0036596
------------------------------------------------------------------------------
                          b = Consistent under H0 and Ha; obtained from xtreg.
           B = Inconsistent under Ha, efficient under H0; obtained from xtreg.

Test of H0: Difference in coefficients not systematic

    chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =   3.17
Prob > chi2 = 0.6734
```

*Table 5: Hausman test results*

$$H_0: Random\ effects\ model$$

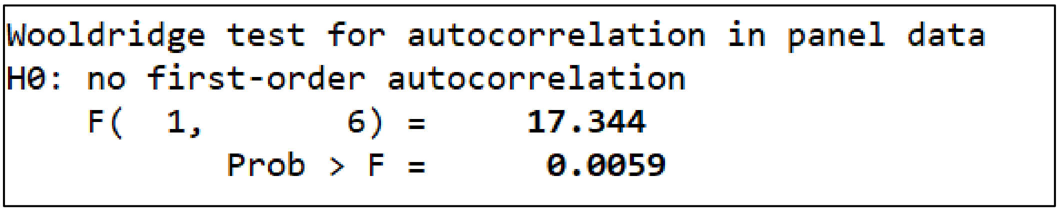
$$H_1: Fixed\ effects\ model$$

According to the test, there are two hypothesizes. The null hypothesis($H_0$) where the random effects model is retained if the p-value > 0,05 and the hypothesis ($H_1$) where the fixed effects model is retained if the p-value < 0,05. In this case, the value of Hausman test is 3.17 and the probability value is 0.6734 which is greater than 0.05 at 5% significance level. The null hypothesis is rejected hence retaining the Random effects model as the most appropriate model.

### 2.3.2: Validation tests

Different validation tests were run on the Random effects model in order to know if there are no problems of serial correlation, cross section interdependence, multicollinearity and heteroskedasticity.

#### a) Wooldridge test for autocorrelation



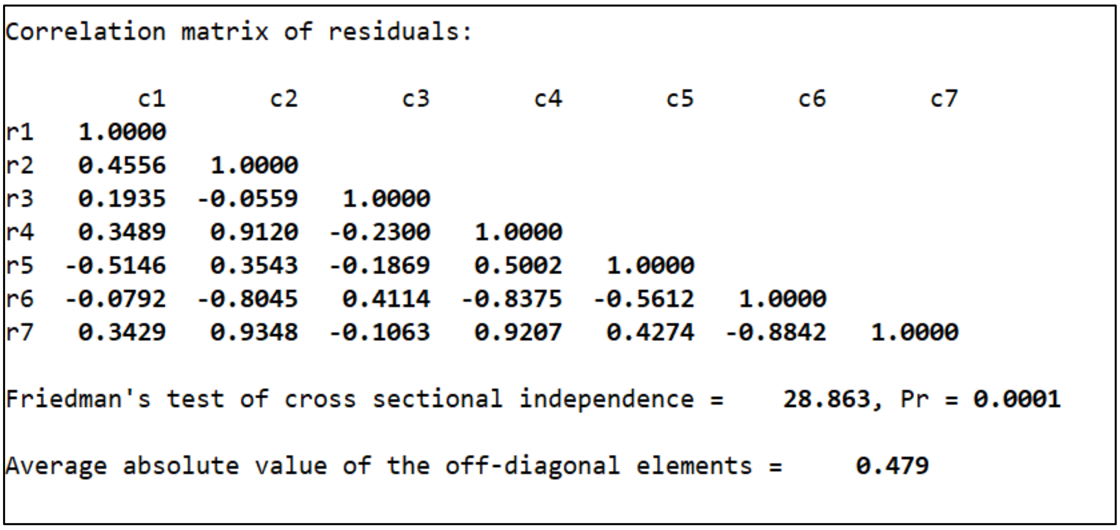
```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,       6) =     17.344
           Prob > F =      0.0059
```

$$H_0: \quad No\ autocorrelation\ between\ variables$$

$$H_1: There\ exists\ autocorretaion\ of\ variables$$

The Wooldridge test for autocorrelation examines whether there is a correlation between error terms from one time period to the next in panel data. The null hypothesis states that no autocorrelation exists. However, the test yielded an F-statistic of 17.344 with a p-value of 0.0059, which is less than the 0.05 significance level. This result leads to the rejection of the null hypothesis, indicating strong evidence of autocorrelation in the panel data.

### b) Friedman's Test



```
Correlation matrix of residuals:

         c1       c2       c3       c4       c5       c6       c7
r1   1.0000
r2   0.4556   1.0000
r3   0.1935  -0.0559   1.0000
r4   0.3489   0.9120  -0.2300   1.0000
r5  -0.5146   0.3543  -0.1869   0.5002   1.0000
r6  -0.0792  -0.8045   0.4114  -0.8375  -0.5612   1.0000
r7   0.3429   0.9348  -0.1063   0.9207   0.4274  -0.8842   1.0000

Friedman's test of cross sectional independence =    28.863, Pr = 0.0001

Average absolute value of the off-diagonal elements =     0.479
```

$$\boldsymbol{H_0}: \qquad \textbf{\textit{No cross sectional dependence}}$$

$$\boldsymbol{H_1}: \ \textbf{\textit{There is cross sectional dependance}}$$

The Friedman test is a non-parametric test that examines the ranks of the residuals across different cross-sectional units over time. If there is no cross-sectional dependence, the ranks should be random, and there should be no systematic patterns. The Correlation Matrix of Residuals provides a visual representation of the cross-sectional dependence present in the data. The presence of numerous large off-diagonal elements, such as the 0.9115 correlation between units c2 and c4, clearly indicates a strong correlation between the error terms of different cross-sectional units. This suggests that unobserved factors are simultaneously influencing multiple units, violating the assumption of independence. The average absolute value of off-diagonal elements being 0.438 further reinforces the presence of substantial cross-sectional correlation. These observations from the correlation matrix signal the inadequacy of standard panel data models that rely on the independence assumption.

Friedman's Test provides a formal statistical test for cross-sectional independence. The test yielded a high chi-squared statistic of 30.069, accompanied by an extremely low p-value of

0.0000. This minute p-value, falling well below the conventional 0.05 significance level, resoundingly rejects the null hypothesis of no cross-sectional dependence. Therefore, the Friedman test statistically confirms the presence of cross-sectional correlation, corroborating the observations derived from the correlation matrix and demanding the adoption of appropriate econometric techniques to account for this dependence.

All the above tests show that the model is not robust to examine the impact of the explanatory variables on the GDP of MENA countries. To solve these technical problems, there is need to re-estimate the regression equation using a better and more advanced approach called FGLS (Feasible Generalized Least Squares) considering heteroskedasticity with cross sectional correlation, and serial correlation. The obtained results are given in Table below:

***Table 6: Estimation of the FGLS model***

| **Dependant variable GDP** | | | |
|---|---|---|---|
| **Independent variables** | **Coefficients** | **Std. Err.** | **P-values** |
| **C** | 23.49 | .081 | 0.000 |
| **lenernt** | -.25 | .030 | 0.000 |
| **lprienecons** | .23 | . 025 | 0.000 |
| **lprices** | 0.024 | 0.009 | 0.009 |
| **lhci** | 1.985 | 0.153 | 0.000 |
| **lgfcf** | 0.028 | . 0152 | 0.067 |
| **Number of obs** | | | 154 |
| **Number of groups** | | | 7 |
| **Time periods** | | | 22 |
| **Wald chi2(5)** | | | 1553.01 |

| | |
|---|---|
| **Prob > chi2** | 0.0000 |

***Source: By authors using Stata 17***

**2.4: Interpretation and discussion of the obtained results.**

**Energy intensity (lenerint):** The econometric analysis reveals a significant and negative relationship between energy intensity (lenerint) and GDP growth, as evidenced by a coefficient of -0.259 with a p-value of 0.000, well below the 10% significance threshold. This means that as energy intensity increases, indicating less efficient energy use (requiring more energy per unit of economic output), GDP growth tends to decrease.

This finding shows that MENA countries with lower energy intensity (meaning they're more energy efficient) tend to grow faster. This indicates they're making better use of their energy resources, essentially achieving more output per unit of energy input. The results provide empirical support for the Neoclassical emphasis on technological progress showing that in the context of energy, using it more efficiently (a form of technological progress) is strongly linked to better economic performance. This reinforces the message that investing in energy efficiency isn't just good for the planet, it's also a smart economic strategy, particularly for a region like the MENA which often faces resource constraints.

**Primary energy consumption (lprienecons):** The positive coefficient (0.238) suggests that there is a positive relationship between primary energy consumption and GDP growth. Its p-value (0.000) indicates that the coefficient of primary energy consumption is statistically significant. The results show that a 1% increase in Primary energy consumption leads to a 0.238 increase to economic growth.

**Oil prices (lprices):** The positive coefficient (0.024) suggests that oil prices have a positive, impact on GDP growth. The p-value (0.009) suggests that this coefficient is also statistically significant because it is less than the 0.1 threshold. While this finding may seem intuitive, it highlights the complex role of oil in the MENA region. For oil-exporting countries, higher oil prices generally lead to increased revenues, boosting economic activity. However, oil-importing nations may experience adverse effects from price increases, as they face higher energy costs.

**Human capital (lhci):** The positive coefficient (1.985) of lhci suggests that there is a positive relationship between human capital and GDP growth. This means that as human capital increases (indicating higher levels of education and health), GDP growth tends to increase. Furthermore, the p-value of 0.000, which is significantly less than the 10% threshold, indicates that the coefficient is statistically significant. The results show that a 1% increase in human capital leads to a 1.985 increase to economic growth.

Gross fixed capital formation (lgfcf): The positive coefficient of 0.028 indicates that there is a direct positive relationship between investment levels and GDP growth. This means that as investment increases, GDP growth tends to increase. The p-value of 0.067 is lower than the 0.10 significance threshold indicating that the relationship is statistically significant. The results show that a 1% increase in Gross fixed capital formation leads to a 0.028 increase to economic growth.

## CONCLUSION

This chapter aimed to investigate the interconnectedness of energy intensity, oil prices, and economic growth within the region, employing a panel data regression approach. While initially planned to include eight countries, data limitations for Qatar necessitated a focus on seven. Our findings revealed an inverse relationship between energy intensity and economic growth, implying that prioritizing energy efficiency could significantly boost economic performance for these nations. Furthermore, the analysis demonstrated a positive association between oil prices and economic growth, highlighting the crucial role oil plays in the region's economic landscape.

# GENERAL CONCLUSION

This study investigated the relationship between energy intensity, oil prices, and economic growth in the Middle East and North Africa (MENA) countries where energy intensity indicates a negative relationship to economic growth whereas oil prices indicate both positive and negative relationship to economic growth.

By using panel data analysis, higher energy intensity, indicating lower energy efficiency, tend to hinder economic growth, emphasizing the need for efficiency improvements. Conversely, higher oil prices generally boost growth in oil exporting countries by increasing revenues, while negatively impacting oil importing nations by raising production costs.

Policymaker should focus on reducing energy intensity through modernization and conservation efforts, managing oil revenues prudently, and diversifying energy sources to enhance economic resilience and sustainability. This approach ensures stable economic growth and better management of energy resources in the Middle East and North Africa (MENA) region.

## Summary of Findings

The key findings of this research can be summarized as follows:

- **Energy Efficiency Matters:** The study found a strong negative relationship between energy intensity and economic growth, emphasizing the crucial role of energy efficiency in driving economic prosperity within the MENA region.
- **Oil Prices and Economic Performance**: Fluctuations in oil price were found to have a positive impact on economic growth, particularly for oil-exporting countries. However, oil-importing nations may experience negative effects from price increases.
- **Human Capital and Infrastructure Investment:** The study highlighted the importance of investing in human capital (education and healthcare) and infrastructure development for achieving sustainable economic growth in the MENA region.

## Implications of Results

These findings have significant implications for policymakers and stakeholders within the MENA region:

- **Prioritizing Energy Efficiency:** The results strongly suggest that MENA countries should prioritize energy efficiency policies and investments to enhance economic growth and optimize resource utilization. Investing in energy-saving technologies, implementing efficiency standards, and providing incentives for energy conservation across various sectors can drive positive economic outcomes.

- **Navigating Oil Price Volatility:** The MENA region's dependence on oil necessitates policies aimed at managing oil price volatility. Countries should strive for economic diversification, reducing their reliance on oil exports and developing alternative sources of income. This will help to shield economies from the negative consequences of oil price fluctuations.
- **Investing in Human Capital and Infrastructure:** Investing in education, healthcare, and infrastructure development is essential for fostering a skilled workforce and creating a supportive environment for economic growth. These investments will enable the MENA region to unlock its full economic potential.

**Recommendations**

Based on the findings and implications of this study, the following recommendations are proposed for policymakers and stakeholders in the MENA region:

- The policy makers should implement energy efficiency standards across all sectors to encourage businesses and households to adopt energy-saving practices.
- Promote the development and adoption of energy-efficient technologies, such as LED lighting, smart appliances, and high-efficiency building materials.
- Provide financial incentives, tax breaks, or subsidies to encourage businesses and individuals to invest in energy efficiency upgrades.
- Investing in Renewable Energy Sources: Develop policies that promote the development and deployment of renewable energy sources, such as solar, wind, and geothermal power.
- Provide financial support for renewable energy projects through subsidies, tax breaks, or feed-in tariffs.
- Invest in research and development of advanced renewable energy technologies to improve efficiency and cost-effectiveness.
- Fostering Economic Diversification: Create a supportive environment for entrepreneurship and innovation in non-oil sectors, such as technology, tourism, agriculture, and manufacturing.

- Invest in infrastructure development to enhance connectivity and facilitate trade in non-oil sectors.
- Implement policies that encourage foreign direct investment in non-oil industries.
- Investing in Human Capital Development by expanding access to quality education at all levels through focusing on STEM fields and vocational training programs.
- Upgrade communication infrastructure, including broadband internet access, to support technological advancements and economic growth.
- Development of a reliable and efficient energy infrastructure to support economic activity and meet growing energy demands.

**Limitations**

This research acknowledges several limitations:

- **Data Availability**: The study was limited by the availability of data for certain countries and variables, potentially affecting the generalizability of the findings. Future research could explore alternative data sources and expand data collection efforts.
- **Focus on a Specific Period:** The analysis covered the period from 2000 to 2021. This time frame may not fully capture the impact of recent events and potential future trends. Further research should explore the relationship between energy intensity, oil prices, and economic growth over a longer timeframe.
- **Simplified Model:** The econometric model used in the analysis, while capturing key variables, simplified the complex interactions within the MENA economy. Future research could investigate the relationship between these variables using more sophisticated models that capture nonlinear relationships and time-varying parameters.
- **Focus on Macroeconomic Variables**: The study primarily analysed macroeconomic variables and did not delve into specific sectors or microeconomic factors that may play a role in economic growth. Future research could investigate the relationship between energy intensity, oil prices, and economic growth at the sectoral level, providing a more nuanced understanding of the impacts on different industries.
- **Focus on a Limited Number of Countries:** The study analysed data from seven MENA countries. Expanding the analysis to include more countries, particularly those with different economic structures and oil dependence levels, would enhance the study's generalizability and provide a more comprehensive view of the MENA region.

## Future Research

Despite these limitations, this research provides a valuable foundation for future exploration of energy intensity, oil price fluctuations, and their impact on economic growth in the MENA region.

Future research could address these limitations by:

- **Expanding Data Collection:** Efforts should be made to expand data collection to encompass more MENA countries and include additional variables relevant to economic growth, such as environmental factors, political stability, and social indicators.
- **Addressing Data Gaps:** Alternative data sources and methodologies could be explored to fill gaps in available data. This could include utilizing data from international organizations, government sources, and industry reports.
- **Developing More Complex Models:** Incorporating more complex econometric models, including nonlinear relationships and time-varying parameters, could provide deeper insights into the dynamic interactions within the MENA economy.
- **Analysing Sectoral Influences:** Future studies could focus on specific sectors within the MENA economy, investigating how energy intensity and oil price fluctuations affect sectoral performance and economic growth. This could reveal how different industries are impacted by these factors and how policies should be tailored accordingly.
- **Investigating Policy Impacts:** Further research could assess the impact of specific policies and interventions on energy intensity, oil price volatility, and economic growth. This would provide valuable insights into the effectiveness of different policy approaches and identify promising strategies for achieving sustainable economic development.

By addressing these research gaps and exploring new avenues of investigation, future research can provide a more comprehensive and nuanced understanding of the factors driving economic growth in the MENA region. This knowledge will be crucial for policymakers and stakeholders to develop effective strategies for achieving sustainable economic development and a more resilient and prosperous future.

This research provides a valuable foundation for policymakers and stakeholders in the MENA region to understand the complex interplay of energy intensity, oil price, and economic growth.

By implementing the recommendations outlined in this study, the region can work towards achieving a more sustainable and prosperous future.

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# ABSTRACT

This study examines the intricate relationship between energy intensity, oil price fluctuations, and economic growth in the Middle East and North Africa (MENA) region. Using panel data from 2000 to 2021 across seven MENA countries, the research explores the impact of these factors on economic performance.

The econometric analysis reveals a significant negative relationship between energy intensity and economic growth, highlighting the importance of energy efficiency strategies for the region. Oil price fluctuations demonstrate a positive impact on economic growth, particularly for oil-exporting countries. However, oil-importing nations may experience adverse effects from price increases. Additionally, the study emphasizes the positive contributions of human capital and infrastructure development to sustainable economic growth.

Based on these findings, the research proposes recommendations for policymakers and stakeholders in the MENA region. These include prioritizing energy efficiency, promoting renewable energy sources, fostering economic diversification, investing in human capital, and strengthening infrastructure. The study concludes by acknowledging limitations and suggesting directions for future research to further refine the understanding of these complex interrelationships and develop effective strategies for achieving sustainable economic development in the MENA region.

## RESUME

Cette étude examine la relation complexe entre l'intensité énergétique, les fluctuations des prix du pétrole et la croissance économique dans la région du Moyen-Orient et de l'Afrique du Nord (MENA). Utilisant des données de panel de 2000 à 2021 sur sept pays de la MENA, la recherche explore l'impact de ces facteurs sur la performance économique.

L'analyse économétrique révèle une relation négative significative entre l'intensité énergétique et la croissance économique, soulignant l'importance des stratégies d'efficacité énergétique pour la région. Les fluctuations des prix du pétrole démontrent un impact positif sur la croissance économique, en particulier pour les pays exportateurs de pétrole. Cependant, les pays importateurs de pétrole peuvent subir des effets négatifs de la hausse des prix. De plus, l'étude met en évidence les contributions positives du capital humain et du développement des infrastructures à la croissance économique durable.

Sur la base de ces conclusions, la recherche propose des recommandations aux décideurs et aux parties prenantes de la région MENA. Celles-ci comprennent la priorité à l'efficacité énergétique, la promotion des sources d'énergie renouvelables, la promotion de la diversification économique, l'investissement dans le capital humain et le renforcement des infrastructures. L'étude se termine en reconnaissant les limites et en suggérant des pistes de recherche futures pour affiner la compréhension de ces interactions complexes et élaborer des stratégies efficaces pour atteindre un développement économique durable dans la région MENA.

## Used panel data

| **Countries** | **Years** | **id** | **GDP** | **Enint** | **encons** | **prices** | **HCI** | **capital** |
|---|---|---|---|---|---|---|---|---|
| Algeria | 2000 | 1 | 96577839449 | 4.18 | 34.8 | 42.31 | 1.89 | 20.67724 |
| Algeria | 2001 | 1 | 99475174632 | 4.07 | 35.6 | 35.29 | 1.90 | 22.83977 |
| Algeria | 2002 | 1 | 1.05046E+11 | 4.12 | 36.4 | 35.56 | 1.92 | 24.57141 |
| Algeria | 2003 | 1 | 1.12609E+11 | 4.08 | 37.6 | 40.06 | 1.93 | 24.08773 |
| Algeria | 2004 | 1 | 1.17451E+11 | 3.96 | 38.5 | 51.79 | 1.95 | 24.01813 |
| Algeria | 2005 | 1 | 1.24381E+11 | 3.9 | 39.8 | 71.37 | 1.96 | 22.37032 |
| Algeria | 2006 | 1 | 1.26495E+11 | 4.1 | 40.6 | 82.61 | 1.98 | 23.16564 |
| Algeria | 2007 | 1 | 1.30796E+11 | 4.21 | 42.1 | 89.26 | 1.99 | 26.32475 |
| Algeria | 2008 | 1 | 1.33935E+11 | 4.16 | 43.9 | 115.48 | 2.01 | 29.23243 |
| Algeria | 2009 | 1 | 1.36078E+11 | 4.48 | 45.7 | 73.49 | 2.02 | 38.23645 |
| Algeria | 2010 | 1 | 1.40977E+11 | 4.42 | 43.8 | 93.20 | 2.04 | 36.28319 |
| Algeria | 2011 | 1 | 1.45065E+11 | 4.47 | 45.6 | 126.45 | 2.08 | 31.67082 |
| Algeria | 2012 | 1 | 1.49998E+11 | 4.72 | 48.9 | 124.35 | 2.11 | 30.79911 |
| Algeria | 2013 | 1 | 1.54198E+11 | 4.76 | 50.7 | 119.25 | 2.15 | 34.18382 |
| Algeria | 2014 | 1 | 1.60057E+11 | 5 | 54.2 | 106.85 | 2.19 | 36.81533 |
| Algeria | 2015 | 1 | 1.65979E+11 | 5.05 | 56.0 | 56.51 | 2.22 | 42.25688 |
| Algeria | 2016 | 1 | 1.71291E+11 | 4.85 | 54.8 | 46.59 | 2.26 | 43.07444 |
| Algeria | 2017 | 1 | 1.73517E+11 | 4.93 | 54.2 | 56.52 | 2.30 | 40.78134 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Algeria | 2018 | 1 | 1.756E+11 | 5.2 | 57.3 | 72.60 | 2.34 | 40.2643 |
| Algeria | 2019 | 1 | 1.77356E+11 | 5.32 | 59.0 | 64.21 | 2.38 | 38.38158 |
| Algeria | 2020 | 1 | 1.6831E+11 | 5.32 | 59.0 | 41.48 | 2.35 | 38.43664 |
| Algeria | 2021 | 1 | 1.74033E+11 | 5.32 | 59.0 | 70.91 | 2.38 | 34.85844 |
| Morocco | 2000 | 2 | 56160912156 | 3.63 | 14.7 | 42.31 | 1.55 | 24.36438 |
| Morocco | 2001 | 2 | 60497559621 | 3.58 | 15.7 | 35.29 | 1.57 | 23.27573 |
| Morocco | 2002 | 2 | 62754238002 | 3.53 | 15.9 | 35.56 | 1.59 | 23.62154 |
| Morocco | 2003 | 2 | 66626866132 | 3.32 | 15.7 | 40.06 | 1.61 | 23.26216 |
| Morocco | 2004 | 2 | 69672633475 | 3.75 | 17.7 | 51.79 | 1.64 | 24.61435 |
| Morocco | 2005 | 2 | 71896757929 | 3.84 | 19.0 | 71.37 | 1.66 | 25.79361 |
| Morocco | 2006 | 2 | 77498104933 | 3.64 | 19.2 | 82.61 | 1.68 | 26.38507 |
| Morocco | 2007 | 2 | 80164867241 | 3.62 | 18.8 | 89.26 | 1.70 | 29.23125 |
| Morocco | 2008 | 2 | 84721870675 | 3.55 | 20.5 | 115.48 | 1.72 | 31.26829 |
| Morocco | 2009 | 2 | 87895356583 | 3.43 | 19.7 | 73.49 | 1.73 | 29.07736 |
| Morocco | 2010 | 2 | 90971304769 | 3.47 | 21.6 | 93.20 | 1.75 | 28.3317 |
| Morocco | 2011 | 2 | 95997146622 | 3.55 | 22.4 | 126.45 | 1.77 | 29.00324 |
| Morocco | 2012 | 2 | 98936909179 | 3.5 | 22.4 | 124.35 | 1.79 | 29.95437 |
| Morocco | 2013 | 2 | 1.03015E+11 | 3.36 | 22.7 | 119.25 | 1.81 | 28.42132 |
| Morocco | 2014 | 2 | 1.05817E+11 | 3.32 | 22.7 | 106.85 | 1.83 | 27.01592 |
| Morocco | 2015 | 2 | 1.10414E+11 | 3.25 | 22.8 | 56.51 | 1.85 | 25.86978 |
| Morocco | 2016 | 2 | 1.10989E+11 | 3.23 | 22.7 | 46.59 | 1.87 | 28.6836 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Morocco | 2017 | 2 | 1.16603E+11 | 3.24 | 23.5 | 56.52 | 1.89 | 28.13547 |
| Morocco | 2018 | 2 | 1.20178E+11 | 3.18 | 24.0 | 72.60 | 1.91 | 27.85858 |
| Morocco | 2019 | 2 | 1.23652E+11 | 3.33 | 26.0 | 64.21 | 1.94 | 27.19271 |
| Morocco | 2020 | 2 | 1.14776E+11 | 3.36 | 26.0 | 41.48 | 1.95 | 26.22569 |
| Morocco | 2021 | 2 | 1.23982E+11 | 3.36 | 26.0 | 70.91 | 1.97 | 26.32877 |
| Egypt | 2000 | 3 | 1.79683E+11 | 3.27 | 29.6 | 42.31 | 1.97 | 18.94996 |
| Egypt | 2001 | 3 | 1.86035E+11 | 3.59 | 30.6 | 35.29 | 2.00 | 17.72562 |
| Egypt | 2002 | 3 | 1.90482E+11 | 3.59 | 30.5 | 35.56 | 2.04 | 17.81473 |
| Egypt | 2003 | 3 | 1.96565E+11 | 3.62 | 31.7 | 40.06 | 2.08 | 16.31138 |
| Egypt | 2004 | 3 | 2.04609E+11 | 3.79 | 32.6 | 51.79 | 2.11 | 16.40223 |
| Egypt | 2005 | 3 | 2.13758E+11 | 4.17 | 33.6 | 71.37 | 2.15 | 17.92015 |
| Egypt | 2006 | 3 | 2.28387E+11 | 4.12 | 34.6 | 82.61 | 2.19 | 18.73078 |
| Egypt | 2007 | 3 | 2.44575E+11 | 4.11 | 36.0 | 89.26 | 2.23 | 20.85124 |
| Egypt | 2008 | 3 | 2.62078E+11 | 3.97 | 37.7 | 115.48 | 2.27 | 22.27806 |
| Egypt | 2009 | 3 | 2.74326E+11 | 3.88 | 38.5 | 73.49 | 2.31 | 18.91192 |
| Egypt | 2010 | 3 | 2.88446E+11 | 3.66 | 39.7 | 93.20 | 2.36 | 19.21101 |
| Egypt | 2011 | 3 | 2.93536E+11 | 3.77 | 39.4 | 126.45 | 2.40 | 16.70921 |
| Egypt | 2012 | 3 | 3.00071E+11 | 3.8 | 40.5 | 124.35 | 2.44 | 14.69517 |
| Egypt | 2013 | 3 | 3.06629E+11 | 3.62 | 39.3 | 119.25 | 2.48 | 12.98645 |
| Egypt | 2014 | 3 | 3.1557E+11 | 3.63 | 38.4 | 106.85 | 2.52 | 12.44601 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Egypt | 2015 | 3 | 3.29367E+11 | 3.45 | 38.4 | 56.51 | 2.56 | 13.6544 |
| Egypt | 2016 | 3 | 3.43683E+11 | 3.64 | 39.6 | 46.59 | 2.59 | 14.46815 |
| Egypt | 2017 | 3 | 3.58053E+11 | 3.66 | 39.9 | 56.52 | 2.62 | 14.72414 |
| Egypt | 2018 | 3 | 3.77141E+11 | 3.44 | 39.8 | 72.60 | 2.65 | 16.49308 |
| Egypt | 2019 | 3 | 3.98081E+11 | 3.26 | 38.7 | 64.21 | 2.68 | 18.17191 |
| Egypt | 2020 | 3 | 4.12213E+11 | 3 | 38.7 | 41.48 | 2.74 | 14.13549 |
| Egypt | 2021 | 3 | 4.25778E+11 | 3 | 38.7 | 70.91 | 2.78 | 13.24459 |
| Saudi Arabia | 2000 | 4 | 3.66707E+11 | 5.16 | 232.6 | 42.31 | 2.23 | 17.35294 |
| Saudi Arabia | 2001 | 4 | 3.62267E+11 | 5.38 | 241.5 | 35.29 | 2.26 | 18.26102 |
| Saudi Arabia | 2002 | 4 | 3.52054E+11 | 6.25 | 244.6 | 35.56 | 2.29 | 18.01153 |
| Saudi Arabia | 2003 | 4 | 3.91632E+11 | 5.63 | 251.6 | 40.06 | 2.31 | 18.29998 |
| Saudi Arabia | 2004 | 4 | 4.228E+11 | 5.11 | 264.9 | 51.79 | 2.34 | 19.15651 |
| Saudi Arabia | 2005 | 4 | 4.46366E+11 | 5.11 | 274.3 | 71.37 | 2.37 | 19.31236 |
| Saudi Arabia | 2006 | 4 | 4.58812E+11 | 5.36 | 276.8 | 82.61 | 2.40 | 20.45216 |
| Saudi Arabia | 2007 | 4 | 4.67287E+11 | 5.55 | 281.0 | 89.26 | 2.42 | 23.65158 |
| Saudi Arabia | 2008 | 4 | 4.96492E+11 | 5.75 | 298.1 | 115.48 | 2.45 | 22.80375 |
| Saudi Arabia | 2009 | 4 | 4.86268E+11 | 6.35 | 305.4 | 73.49 | 2.48 | 25.7565 |
| Saudi Arabia | 2010 | 4 | 5.10773E+11 | 6.73 | 325.2 | 93.20 | 2.51 | 24.43086 |
| Saudi Arabia | 2011 | 4 | 5.66926E+11 | 6.38 | 325.6 | 126.45 | 2.53 | 22.41794 |
| Saudi Arabia | 2012 | 4 | 5.97696E+11 | 6.27 | 334.7 | 124.35 | 2.56 | 22.11319 |

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|---|---|---|---|---|---|---|---|---|
| Saudi Arabia | 2013 | 4 | 6.14732E+11 | 6.03 | 326.0 | 119.25 | 2.58 | 23.46715 |
| Saudi Arabia | 2014 | 4 | 6.39491E+11 | 6.44 | 339.7 | 106.85 | 2.60 | 24.92722 |
| Saudi Arabia | 2015 | 4 | 6.69484E+11 | 6.32 | 341.6 | 56.51 | 2.62 | 29.35602 |
| Saudi Arabia | 2016 | 4 | 6.85305E+11 | 6.26 | 338.3 | 46.59 | 2.65 | 25.60772 |
| Saudi Arabia | 2017 | 4 | 6.84827E+11 | 6.42 | 332.5 | 56.52 | 2.67 | 23.94783 |
| Saudi Arabia | 2018 | 4 | 7.03744E+11 | 6.05 | 323.7 | 72.60 | 2.69 | 20.72098 |
| Saudi Arabia | 2019 | 4 | 7.09601E+11 | 6.03 | 322.0 | 64.21 | 2.71 | 22.38601 |
| Saudi Arabia | 2020 | 4 | 6.78794E+11 | 6.23 | 322.0 | 41.48 | 2.75 | 24.09812 |
| Saudi Arabia | 2021 | 4 | 7.0816E+11 | 6.23 | 322.0 | 70.91 | 2.78 | 24.29783 |
| Iraq | 2000 | 5 | 1.01919E+11 | 5.16 | 46.0 | 42.31 | 1.90 | 2.918028 |
| Iraq | 2001 | 5 | 1.03714E+11 | 5.68 | 50.2 | 35.29 | 1.93 | 6.127233 |
| Iraq | 2002 | 5 | 95211152165 | 5.89 | 46.1 | 35.56 | 1.96 | 5.360612 |
| Iraq | 2003 | 5 | 60308502640 | 8.24 | 41.5 | 40.06 | 1.99 | 10.65096 |
| Iraq | 2004 | 5 | 92502263396 | 5.77 | 43.1 | 51.79 | 2.03 | 5.368255 |
| Iraq | 2005 | 5 | 94048799140 | 5.66 | 40.4 | 71.37 | 2.06 | 13.84722 |
| Iraq | 2006 | 5 | 99359074413 | 5.21 | 40.5 | 82.61 | 2.08 | 17.69172 |
| Iraq | 2007 | 5 | 1.01233E+11 | 5.03 | 42.2 | 89.26 | 2.10 | 6.756403 |
| Iraq | 2008 | 5 | 1.09562E+11 | 5.02 | 43.0 | 115.48 | 2.13 | 14.80043 |
| Iraq | 2009 | 5 | 1.13265E+11 | 5.21 | 47.1 | 73.49 | 2.15 | 10.31148 |
| Iraq | 2010 | 5 | 1.20516E+11 | 5.41 | 48.9 | 93.20 | 2.17 | 16.19896 |

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| Iraq | 2011 | 5 | 1.29611E+11 | 5.51 | 50.0 | 126.45 | 2.19 | 17.14249 |
| Iraq | 2012 | 5 | 1.47674E+11 | 5.35 | 51.2 | 124.35 | 2.20 | 15.00238 |
| Iraq | 2013 | 5 | 1.5894E+11 | 5.15 | 53.1 | 119.25 | 2.21 | 20.11666 |
| Iraq | 2014 | 5 | 1.59253E+11 | 4.9 | 48.9 | 106.85 | 2.22 | 20.96529 |
| Iraq | 2015 | 5 | 1.66774E+11 | 4.44 | 47.2 | 56.51 | 2.24 | 26.01722 |
| Iraq | 2016 | 5 | 1.89768E+11 | 4.19 | 53.0 | 46.59 | 2.25 | 14.57577 |
| Iraq | 2017 | 5 | 1.86315E+11 | 4.94 | 50.9 | 56.52 | 2.26 | 14.58515 |
| Iraq | 2018 | 5 | 1.91222E+11 | 5.45 | 52.2 | 72.60 | 2.28 | 14.17051 |
| Iraq | 2019 | 5 | 2.01765E+11 | 5.51 | 56.6 | 64.21 | 2.29 | 19.76406 |
| Iraq | 2020 | 5 | 1.77479E+11 | 5.04 | 56.6 | 41.48 | 2.34 | 7.769075 |
| Iraq | 2021 | 5 | 1.8029E+11 | 5.04 | 56.6 | 70.91 | 2.36 | 8.243429 |
| Iran | 2000 | 6 | 2.57439E+11 | 7.13 | 78.5 | 42.31 | 1.71 | 31.30545 |
| Iran | 2001 | 6 | 2.63598E+11 | 7.55 | 81.7 | 35.29 | 1.74 | 35.7994 |
| Iran | 2002 | 6 | 2.84893E+11 | 7.23 | 87.8 | 35.56 | 1.78 | 33.24578 |
| Iran | 2003 | 6 | 3.09506E+11 | 6.87 | 88.6 | 40.06 | 1.82 | 32.65808 |
| Iran | 2004 | 6 | 3.22928E+11 | 7.19 | 96.0 | 51.79 | 1.86 | 31.23818 |
| Iran | 2005 | 6 | 3.33229E+11 | 7.73 | 101.7 | 71.37 | 1.90 | 28.55717 |
| Iran | 2006 | 6 | 3.4989E+11 | 7.69 | 109.9 | 82.61 | 1.94 | 27.2471 |
| Iran | 2007 | 6 | 3.78426E+11 | 7.53 | 116.3 | 89.26 | 1.99 | 28.34212 |
| Iran | 2008 | 6 | 3.79375E+11 | 8.05 | 119.5 | 115.48 | 2.03 | 31.92269 |
| Iran | 2009 | 6 | 3.83197E+11 | 7.95 | 122.1 | 73.49 | 2.08 | 30.8549 |

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| Iran | 2010 | 6 | 4.05415E+11 | 7.52 | 121.1 | 93.20 | 2.12 | 27.35283 |
| Iran | 2011 | 6 | 4.16141E+11 | 7.47 | 125.1 | 126.45 | 2.16 | 29.05373 |
| Iran | 2012 | 6 | 4.00547E+11 | 8.1 | 124.6 | 124.35 | 2.20 | 30.05397 |
| Iran | 2013 | 6 | 3.94451E+11 | 8.39 | 128.8 | 119.25 | 2.25 | 27.44561 |
| Iran | 2014 | 6 | 4.14114E+11 | 8.57 | 132.7 | 106.85 | 2.29 | 28.57081 |
| Iran | 2015 | 6 | 4.08213E+11 | 8.68 | 130.2 | 56.51 | 2.33 | 25.36501 |
| Iran | 2016 | 6 | 4.44197E+11 | 8.24 | 135.7 | 46.59 | 2.38 | 22.12071 |
| Iran | 2017 | 6 | 4.5645E+11 | 8.73 | 140.1 | 56.52 | 2.42 | 22.0058 |
| Iran | 2018 | 6 | 4.48061E+11 | 9.14 | 144.6 | 72.60 | 2.47 | 22.62917 |
| Iran | 2019 | 6 | 4.34303E+11 | 9.12 | 148.9 | 64.21 | 2.52 | 23.21473 |
| Iran | 2020 | 6 | 4.48766E+11 | 8.78 | 148.9 | 41.48 | 2.55 | 28.4739 |
| Iran | 2021 | 6 | 4.69947E+11 | 7.98 | 148.9 | 70.91 | 2.59 | 26.84291 |
| United Arab Emirates | 2000 | 7 | 2.0041E+11 | 4.08 | 619.0 | 42.31 | 2.61 | 20.9781 |
| United Arab Emirates | 2001 | 7 | 2.03214E+11 | 5.6 | 593.9 | 35.29 | 2.63 | 20.9781 |
| United Arab Emirates | 2002 | 7 | 2.08159E+11 | 5.4 | 616.1 | 35.56 | 2.65 | 21.07142 |
| United Arab Emirates | 2003 | 7 | 2.26479E+11 | 4.88 | 615.7 | 40.06 | 2.66 | 20.79148 |
| United Arab Emirates | 2004 | 7 | 2.48144E+11 | 4.4 | 600.7 | 51.79 | 2.68 | 18.68412 |
| United Arab Emirates | 2005 | 7 | 2.60192E+11 | 4.47 | 555.7 | 71.37 | 2.70 | 18.37913 |

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| United Arab Emirates | 2006 | 7 | 2.85788E+11 | 4.23 | 506.1 | 82.61 | 2.70 | 17.57821 |
| United Arab Emirates | 2007 | 7 | 2.94889E+11 | 4.45 | 479.6 | 89.26 | 2.71 | 23.57303 |
| United Arab Emirates | 2008 | 7 | 3.04301E+11 | 5.1 | 478.3 | 115.48 | 2.71 | 22.3739 |
| United Arab Emirates | 2009 | 7 | 2.88347E+11 | 5.76 | 422.8 | 73.49 | 2.71 | 28.913 |
| United Arab Emirates | 2010 | 7 | 2.92969E+11 | 5.48 | 410.3 | 93.20 | 2.72 | 23.90251 |
| United Arab Emirates | 2011 | 7 | 3.1118E+11 | 5.07 | 413.5 | 126.45 | 2.72 | 20.83183 |
| United Arab Emirates | 2012 | 7 | 3.16857E+11 | 5.11 | 425.0 | 124.35 | 2.72 | 20.27032 |
| United Arab Emirates | 2013 | 7 | 3.32876E+11 | 5.15 | 445.2 | 119.25 | 2.73 | 17.75343 |
| United Arab Emirates | 2014 | 7 | 3.46743E+11 | 5.6 | 442.4 | 106.85 | 2.73 | 19.06036 |
| United Arab Emirates | 2015 | 7 | 3.70275E+11 | 5.88 | 484.2 | 56.51 | 2.73 | 22.61156 |
| United Arab Emirates | 2016 | 7 | 3.90868E+11 | 6.07 | 497.6 | 46.59 | 2.74 | 23.64431 |
| United Arab Emirates | 2017 | 7 | 3.93741E+11 | 4.97 | 497.1 | 56.52 | 2.74 | 18.73815 |
| United Arab Emirates | 2018 | 7 | 3.98915E+11 | 5.04 | 498.5 | 72.60 | 2.74 | 17.1283 |
| United Arab Emirates | 2019 | 7 | 4.03336E+11 | 5.22 | 494.4 | 64.21 | 2.75 | 18.3695 |

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| United Arab Emirates | 2020 | 7 | 3.83343E+11 | 5.5 | 494.4 | 41.48 | 2.77 | 20.20557 |
| United Arab Emirates | 2021 | 7 | 4.00036E+11 | 5.5 | 494.4 | 70.91 | 2.77 | 20.20557 |