QATAR UNIVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

ESTIMATING ECONOMIC GROWTH THROUGH COBB-DOUGLAS PRODUCTION FUNCTION, STATISTICAL, AND GOAL PROGRAMMING MODELS

BY

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ABSTRACT

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Title: Estimating Economic Growth through Cobb-Douglas Production Function, Statistical, and Goal Programming Models

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Several studies have linked economic growth to renewable energy sources utilization. The Cobb-Douglas production function model is widely applied to estimate the contribution of economic variables to the Gross Domestic Product (GDP) for countries. The aim of this research is to utilize Goal Programming and Regression models in estimating the contribution of some independent variables in explaining the growth of GDP for countries. The two models were applied to Egypt and Morocco. The results of this study show that both models are quite similar; however, the Goal Programming model provides more flexibility in allowing the Policy-Makers to integrate explicitly their preferences and incorporating additional constraints related to the decision-making context.

DEDICATION

This thesis is dedicated to my mother and beloved wife. Without their love and encouragement, I would never have been able to complete this study. I love you and appreciate everything you did and are doing.

ACKNOWLEDGMENTS

I would like to thank Professor Belaid Aouni for all his support during the study and his patience with me. He also helped me to choose the topic and models to use. I am truly grateful. Thanks

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Chapter 1: Renewable Energy And Economic Growth

Abstract

In the chapter I have presented the debate about utilizing the renewable energy sources, the most common types, and the world outlook of energy. Moreover, I have indicated how the world's consumption of energy is growing and the renewables represent the biggest share of supplying this demand. Furthermore, I have introduced how renewable energy sources use can contribute to economic growth, Growth Domestic Product GDP.

Introduction

In the past few decades more, attention was devoted to the field of energy economics specifically renewable energy consumption and its economic implications, where the United Nation designated the decade 2014–2024 as the decade of Sustainable Energy (UN website editors, 2012). Due to factors such as: a) the oil crisis in the 1970's, b) the reduction of the accessible energy resources, c) and the environmental problems caused by the expansion in non-renewable energy consumption, especially fossil fuels, energy economics has emerged as a new field of study, dedicated towards resolving such problems; where recently several studies have been conducted mainly focusing upon renewable energy consumption and its effect on economic growth since it is considered to be the cleanest, safe and inexhaustible source of energy.

After reviewing several studies in this field, most of which were concerned with determining the relationship between renewable energy consumption and its implications on the economy, I have perceived that the findings are not supporting the fact that there is a positive relationship, but either no relationship or it exists in negative. Hence, based upon those studies my main focus is to investigate the relationship between renewable energy consumption REC and economic growth.

In this research, I will research to conduct a comparison between Egypt and Morocco regarding renewable energy consumption and its effect on economic growth. The reason behind this can be attributed to several factors, first of which is that Morocco is one of the leading counties that have recently made a breakthrough in the field of renewable energy, wherein 2008 the Moroccan authorities launched a national renewable energy and efficiency plan to promote energy efficiency and to meet a target of more than 40% of green energy production by 2020 (RCREE, 2018). Furthermore, Egypt possesses an abundance of renewable energy sources and as a result, it started to take steps towards exploiting it where there is an intention to supply 20% of generated electricity from renewable sources by 2022. Moreover, the reason behind choosing these two countries particularly as a comparative case study is because Morocco faces similar conditions to that of Egypt, however it succeeded to efficiently utilize its available renewable energy resources and not only oust Egypt in this field, but it managed to exceed other developed counties in the field of renewable energy application.

Accordingly, this paper is a comparative time-series analysis examining the effect of renewable energy consumption on economic growth in Morocco and Egypt over the period [1991-2014]. This will be conducted by using the quantitative approach where a Cobb-Douglas production function will be utilized for this purpose. Moreover, the model in this paper is analyzed through the Vector Autoregressive model, through a statistical software package which is Microsoft Excel statistical analysis plugin and SPSS from IBM. In addition, another technique will be utilized to demonstrate its effectiveness of estimation technique against regression model which is Goal Programming; that is one of the multi-objective programming techniques.

Before I get into the analytical part, I will introduce the global energy outlook as a demand which urges to find sustainable, clean, and cheaper sources of energy. Then, I will present basic information about the RES the paves the way to understand a few famous debates about it.

World Energy Outlook 2017

Four energy shifts are the symptoms in the 2017 outlook for the global economy (International Energy Agency IEA, 2018);

a) the clean energy technologies are rapidly deployed, and the cost is decreasing,
b) electrification of energy is on the rise,
c) China's economy is becoming more service-oriented with a cleaner mix of energy,
d) and the USA is shifting towards more dependence on shale gas and tight oil.

Moreover, India is leading a group of the country that energy producers and consumers have no defined distinction as used to be earlier.

Consequently, the energy sector is influenced by the above in different ways that I will address below:

1.3.1 Growing Energy Demand

Although the increase of energy consumption globally is slower than earlier, it still expected to rise by 30% until 2040, where the largest demand comes from India and Southern Asia.

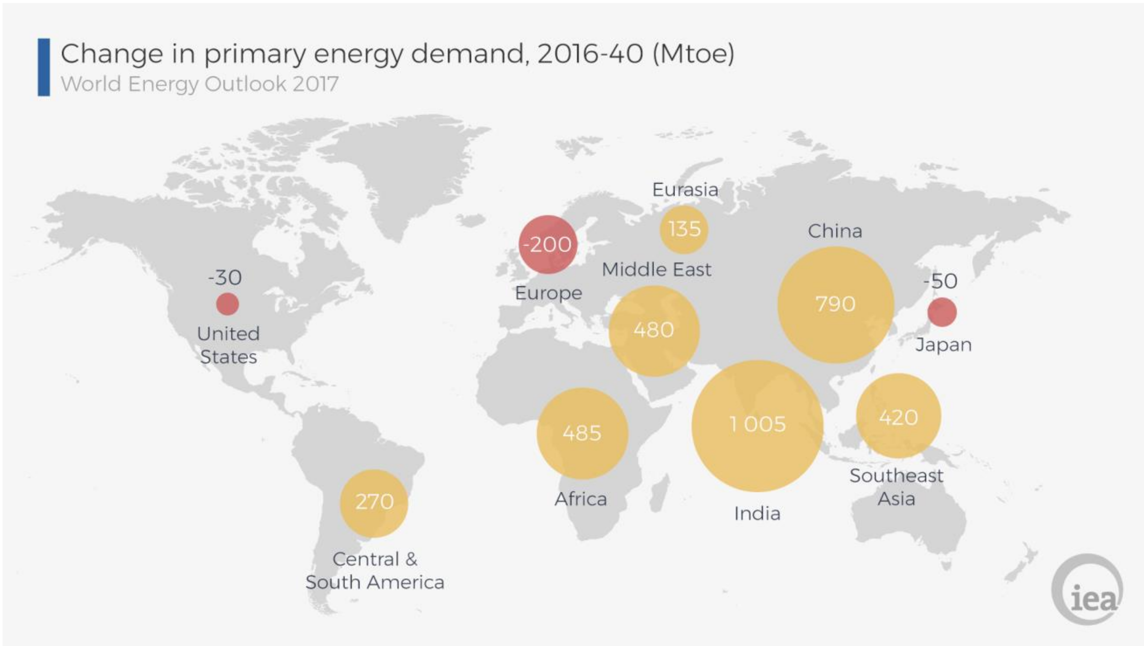

Figure 1. Chane in primary energy demand, 2016 – 20 (Mtoe)

Figure 1. Chane in primary energy demand, 2016 – 20 (Mtoe) is extracted from the World Energy Outlook 2017 (International Energy Agency IEA, 2018) shows the energy global energy growth by million ton of oil equivalent by the year 2040. It is clear that India dominates the growth by 30% which is which its share of the global demand will reach 11% in the year of 2040 (while its population is about 18% of the world population). Moreover, the demand for energy is globally increasing. This is due to the fact the economy is growing with an average of 3.4% per year worldwide and the population is from 7.4 billion to 9 in 2040.

1.3.2 Coal leads and renewable energy is growing

Renewable energy is expected to meet 40% of the increasing energy demand and the efficient utilization of energy dominates the discussion worldwide. The following graph describes the changes as coal flat lines, the gas expands and RES. On the other hand, oil grows at a slower pace.

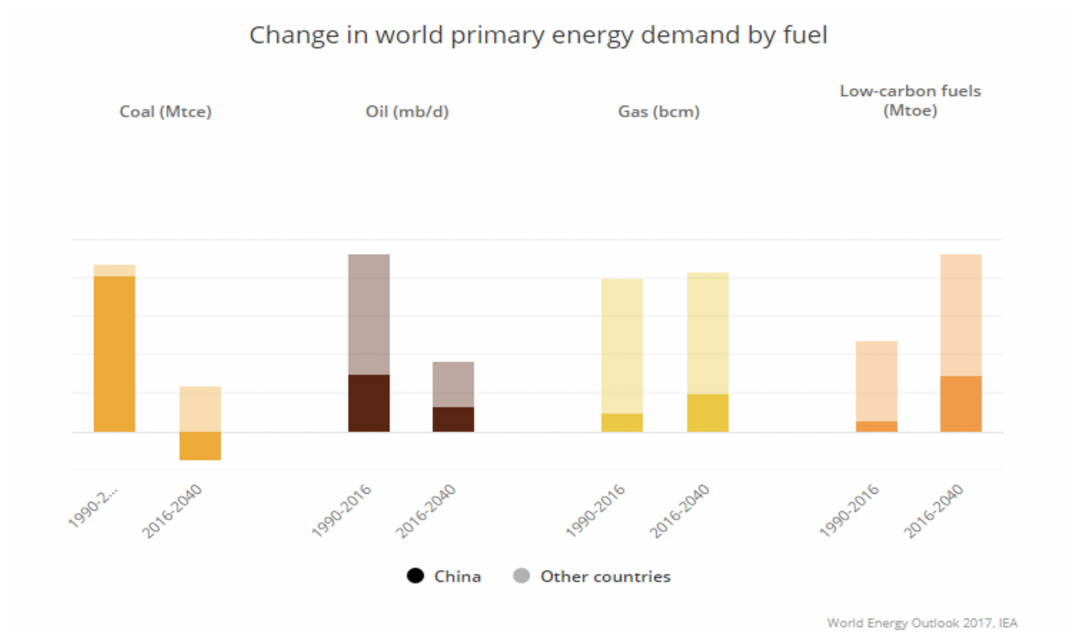

Figure 2. Change in world primary energy demand by fuel

With the new policies scenarios assumed by the report (International Energy Agency IEA, 2018), it can be seen that different from the last twenty-five years, the world will be supplying its demand from energy by the lead of natural gas, renewable energy, and other energy efficient ways.

Figure 2. Change in world primary energy demand by fuel is extracted from the World Energy Outlook 2017 (International Energy Agency IEA, 2018), shows that coal and oil dependence will significantly reduce, gas will continue supply most of the demand and renewables and other low- carbon fuels will form a rise in supplying the demand. For instance, from the year 2000, the coal-fired power plants had expanded by only 900 gig watts (GW), while it is expected to grow by only 400 GW until 2040. Gigawatts (GW) are a unit for measuring electrical power which is equal to 1000 Megawatt (MW) that is enough to supply a medium-sized city. Qatar's installed power capacity was reported as 8.56 GW in 2016 (CEIC data editors, 2017).

1.3.3 The future of renewables is bright

Renewables which is renewable energy sources is referred to as RES. In 2016, the production of electricity using RES grew worldwide by about 6% and formed about 24% of the total generated power (International Energy Agency IEA, 2017). Hydropower continued to be the biggest RES producer by about 70% comes next to the wind by 16%, then biomass and solar was 5%. In the previous year, the RES plants connected to grids were about 153 GW (Gega watt, a form of measuring power) which is about 15 more than the year of 2014. And RES in that year was about 50% of the newly installed power plants.

Moreover, it was expected to grow 36% over the years 2015 to 2021 which is the fastest growth of a source in power generation. Power production by RES is expected to become more than 7650 TWH by 2021 (Terawatt-hour). However, in an effort called 2DS (to limit the global increase of energy to 2-degree Scenario by the year 2100), the power from RES has to expand faster to reach 10300 TWH by 2025.

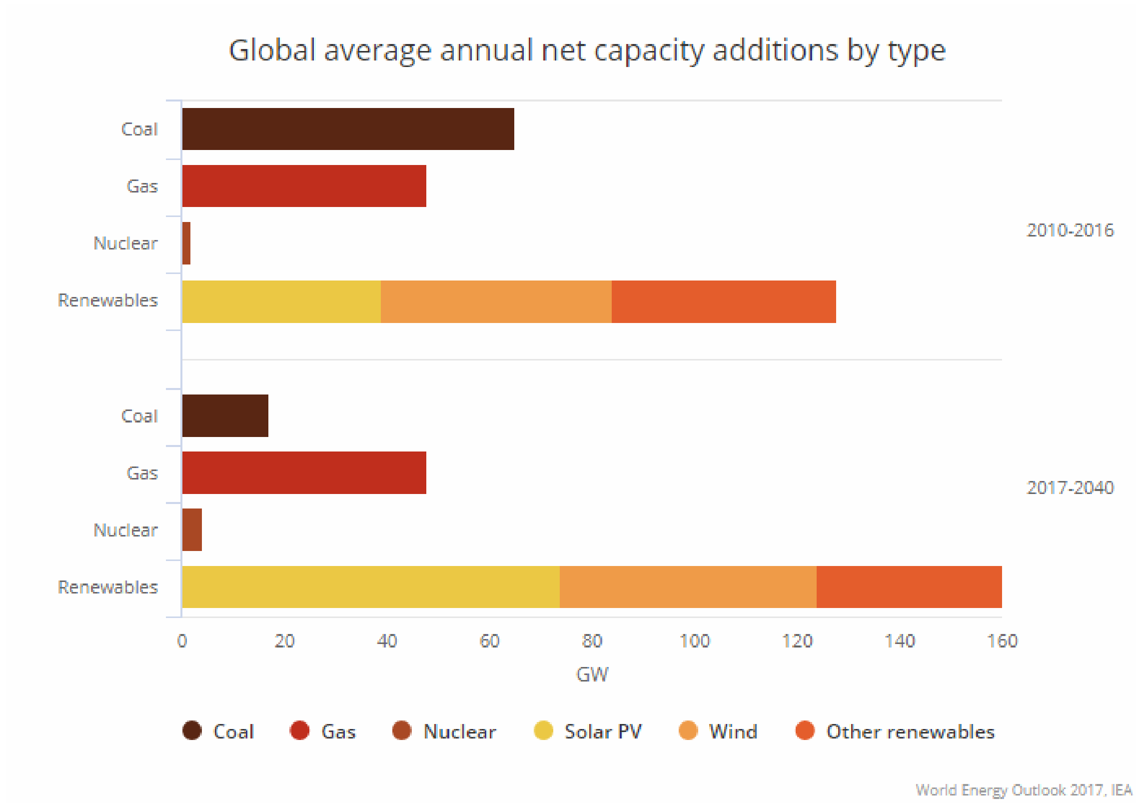

Figure 3. Global average annual net capacity additions by type

Figure 3. Global average annual net capacity additions by type is extracted from the World Energy Outlook 2017 (International Energy Agency IEA, 2018) illustrates the fact that renewables will responds for most of the increasing supply. As shown the addition of RES capacities will increase to 160 GW while it significantly decreases for coal and almost stabilizes for gas. PV is clearly shown that Solar PV dominates the growth led by India and China in development. Soon after 2030, wind energy will be the dominating source of energy. Moreover, the report (International Energy Agency IEA, 2018)

indicates that renewables are not only used in power generation but also as direct use of energy installed in businesses, households, communities.

1.3.4 The future is electrifying

Electricity forms about 40% of the increase in demand for all sources of energy in the globe. In many places of the world, this new trend is taking place, represented in installing new cooling systems and rising into appliances utilization driven by the increase of the incomes. The whole world is electrifying, even shifting into electric cars, not only in developed countries but also in emerging economies such as India and China. Moreover, the increase of digital technology and connectivity increases the need for electrical power.

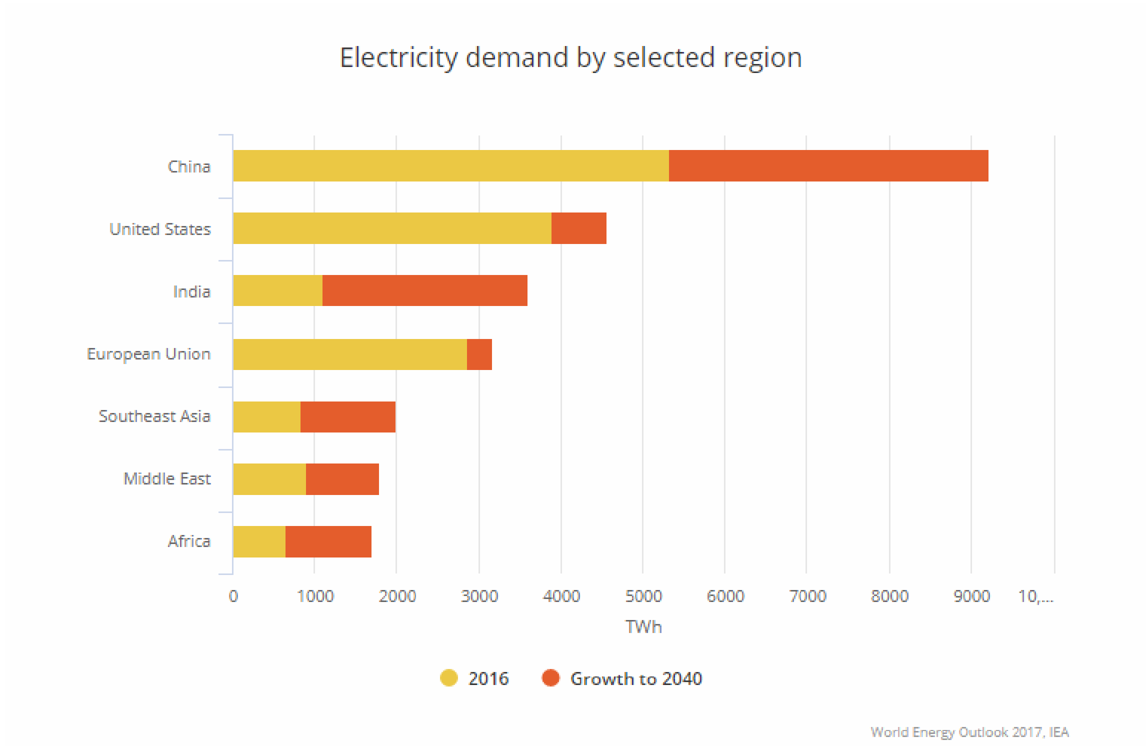

Figure 4. Electricity demand by selected region

Figure 4. Electricity demand by selected region is extracted from the World Energy Outlook 2017 (International Energy Agency IEA, 2018) illustrates how the electrical power in Terawatt (1000 GW) is rapidly increasing which is clear in all locations expect the USA which is the least by the percentage of the position of 2016. Out from the electrical power generation, RES new installations are increasing yearly in a steady base. As cleared earlier, the world energy is steadily increasing on an annual basis. Moreover, the portion generated by RES is increasing too. Representing what was previously stated in the above graphs, one can highlight the magnitude of the RE increase in consumption, where- data is provided from (IRENA's editors, 2018):

Table 1. World Installed Capacity of renewable energy sources

	2014	2015	2016	2017
World Installed MW Capacity of RES	1693695	1851384	2011446	2179426
Increase from the previous year	8.2%	9.3%	8.6%	8.4%

Table 1. World Installed Capacity of renewable energy sources shows a recent increase of 8.2 to 9.3% yearly in the installed capacity of RES worldwide. After clarifying how the world of mix energy is formed and the prediction of demand and supply combinations are made, I will introduce the renewable energy sources. First, the sources of energy are classified into two categories by source: renewable and conventional. The renewables which are referred to as RE or RES (Renewable Energy or Renewable Energy Source) have different forms such as solar; which is the most famous one; wind, geothermal, biomass, hydropower. On the other hand, conventional sources are fossil fuel, gas, oil, and coal and nuclear. In the following section, I will state the types of RES, RES in developing countries, a few challenges for RES development, and an initiative that supports RES.

Renewable energy sources

Renewable energy RE or Renewable energy sources RES can be seen as the energy source that is replaced rapidly by a natural process were following the emergence of the clean energy revolution around the world; renewable energy policy has been the ultimate goal for energy sectors worldwide. And it is defined as the source of energy that is replenished within human' timescale or that does not deplete such as sunlight (Frewin, 2013).

With regard to renewable energy resources, there are four used sources of energy: solar, wind power, hydropower, and biomass. The coming sections will describe the meaning of each.

1.4.1 Solar energy

It is radiant energy emitted by the sun and is used in a range of evolving technologies such as solar home system, solar dryers, solar cookers, thermal power generation, and water heat.

It is considered as the most common by MWH production RES as per the outlook of "Renewable Energy Statistics 2018". It has a few challenges that are addressed as:

1. Low oil prices, however, it is dependent on the country status of either being an importer or exporter of it. As every other RES, the price of oil affects much the investment in such renewable energy as it is a substitution source of energy.
2. Integration with the grid, the power produced by RES normally is unstable in value due to weather and environment conditions such as dust. Therefore, depending on it to supply the user with fixed voltage and frequency (quality) is an issue. Avoiding this costs money and sometimes makes it uneconomical.
3. Environmental impacts of it, such as occupying great areas of land and consuming minerals to produce.
4. Technological constraints and people's expertise.

On the other hand, it has opportunities such as providing heating for industries, off-grid use which avoids integration concerns, and business opportunity that arises from recycling the aged panels of solar cells.

1.4.2 Wind power

It is the use of airflow and is used in power generation, windmills and water pumps. It is famous in two forms, onshore wind, and offshore wind. Of course, the wind offshore can produce more power as wind is faster, however, it costs more to install and maintain. Moreover, not all countries have enough coasts to occupy with a wind turbine, if they even have at all. The integration with the grid is still a difficulty similar to solar. However, with the electrical storage methods developments, it is becoming more visible to integrate it well with electrical networks.

1.4.3 Hydropower

It is the water power which is derived from the energy of falling water or fast running water and is used in power generation. This is considered as the biggest sources of RES globally representing about 70%. It depends on the existence of water paths such as rivers, lakes, and other running currents. The idea is to let the water fall into turbine blades which rotate to generate electricity. The output power is normally huge and free of emissions and fuel consumption which makes it cheap and clean. However, it requires huge installations such as dams and rivers path transformations. And the extended years of installation for such huge projects have much waste of materials and cause some socio-economic changes. This is in the form of creating huge water existence in the area and migrating animal and people. On the other hand, it is easily interchangeable with the grid of the electrical power as it is available during the year due to the existence of the water reservoir. Secondly, it is cheaper than fossil fuel and nuclear, as per hydropower cost analysis of IRENA’s report (International Renewable Energy Agency IRENA, 2012).

1.4.4 Modern biomass

It is energy that is derived from burning wood and other organic matter and is considered renewable because plant stocks can be replaced with new growth and it is used directly in heat generation through combustion.

1.4.5 Renewable Energy in developing countries as an energy field

The world is presently facing a substantial challenge in the energy sector, where the majority of countries rely heavily on non-renewable energy sources. A couple of major concerns emerged as a result of deployment of non-renewable energy sources which are reflected in: the depletion of the most easily accessible energy resources (i.e. oil, gas and coal), as well as global warming caused by the rapidly increasing emissions of greenhouse gases such as carbon dioxide (CO2) and methane.

With the depletion of fossil fuels, the need for using renewable energy sources is becoming more and more urgent. As a result, more attention has been devoted to renewable energy sources since it is considered to be the primary clean, costless and inexhaustible energy sources.

In order to evaluate the relative importance of renewable energy sources in comparison to non-renewable energy sources, we have to realize s few facts about the advantages associated with renewable energy sources. The advantages of renewable energy are reflected in the following factors: its sustainability, it has a low cost of operation as it requires less maintenance where it depends on natural sources of energy, and it has no negative effect on the environment as it does not produce carbon dioxide emissions. However, it has some drawbacks that need to be taken into consideration such as the quantity of electricity supplied by renewable energy sources is lower than that supplied by traditional energy sources, and its dependency upon natural resources may represent a source of vulnerability, because natural resources such as the weather are volatile and can be highly unpredictable; which is called dispatchability that is detailed below. Below is a list of the major challenges of renewable energy sources use:

1.4.6 Dispatchability and dispatchable generation

Electricity should be available for utilization, or otherwise, the loads, electricity users, will get interrupted. This concept raises the need for such a term “dispatchability” which simply means how capable the power generation of becoming used on-demand (Wikipedia, 2019). For instance, solar power can’t be dispatchable as it has its peaks and bottoms. Therefore, classifying the power source according to dispatchability became a necessity. Conventional energy sources are dispatchable; however, not all renewable energy sources are by nature. For instance, biomass, geothermal, and ocean thermal energy are dispatchable without the need to have electrical energy storage (EES). On the other hand, RES -such as solar and wind energy- require a form of energy storage, which creates the requirement to have electrical energy storage. Non-dispatchable RES is also called VRE (Wikipedia, 2019) -Variable Renewable Energy- as they have a variable output of electrical power during a specific period of time.

There are other debatable points like that the renewable energy is costing the world more than other sources regardless any environmental advantages that may bring, as this is another argumentative area of research about the impact of RES. However, due to technological advancements, the capital expenditure CAPEX for installing RE generation plants is significantly reduced. Moreover, the main item that reduces its integration with electricity grids is reduced as well. This is due to the unavailability of the RES throughout the whole year, which requires having storage facilities such as pumped power storage or battery banks, will be presented later in the chapter. Nevertheless, both cases are costly. However, the expected bulk production of batteries -such as Tesla's mega plant- can support in this regard. This is due to the fact that batteries could earlier be exploited in smaller scales like in Kilo Watt Hour KWH, not in Mega MWH. With the range of MWH efficient storage, cities can be supplied from batteries. While earlier, KWH level was able only to supply a building or less by electricity for a few hours. Additionally, the new batteries have higher efficiency, longer lifetime; which means less waste due to replacement of the battery cells, and less maintenance need. All of this benefits the environment. Furthermore, this all makes more available for electricity storage on a wider scale, efficiently, and less costly.

1.4.7 Cost of power production

As per the International Renewable Energy Agency IRENA report (IRENA, Power Costs 2018, 2018), primarily known as the second most famous source of energy in RE, the prices of RES for wind are $ 4 cent / kWh and in some counties as low as $ 3 /kWh for onshore wind energy as per IRENA's report (IRENA, Power Costs 2018, 2018). Whereas, the fossil fuel can be sold for $5-17 cents/ kWh. This is actually an average of the 150 countries in the IRENA, while the best solar field can deliver it for $3 cent/kWh. Undoubtedly, all of that depends on the site conditions and distance between the load concentration area and generation site. In areas of the world, the debate continues to about if it worth shifting to RES or not. For instance, a study for southeast Asia and Australia (Bogdanov, Breyer, & Gulagi, 2017) with three assumed scenarios had demonstrated that although it is economical to integrate the area of emerging countries and developed ones Australia and NZ, it is sometimes challenging due to the distances of electricity transmission from Australia, which is rich with solar and wind energy, to Asia where more load (area of electricity consumption) concentration is.

Another reason for the dilemma of if the advantages outweigh the disadvantages of RES use is how the conventional energy producers are shifting the price of electricity into the lower end that frightened the users from converting into RES due to the fixed cost of installation and maintenance regardless of the consumption. In addition, the restriction on coal usage in Australia pushed the prices of electricity high to be peaking in developed countries. Entirely, that is demonstrated in (Wild, 2017). In the report, the author suggests withdrawing from the Paris Climate Change Agreement. That is an agreement that supports reducing greenhouse gas effect globally by producing fewer emissions and shifting into cleaner energy generation.

The cost of power production does not only consist of the running variable cost of maintenance but also contains the installation cost which is magnified by the need for energy storage to compensate for the dispatchability issue.

1.4.8 Electricity Storage

It is also, known recently as, E-Storage. Due to the fact that RES reliability improves significantly with electricity storage; a dispatchability solution, e-storage of electrical storage is one of the main associated systems. An example of e-storage: pumping water into a reservoir at height off-peak then free falling to generate hydropower when needed, which denominated the market for decades. Additionally, there is battery storage which is a disrupting technology that is seen in cars, and many other big applications. This opened an avenue for massive battery storage facilities which are better for the economy of scale. A few other technologies are available for such storage.

E-storage comes with environmental challenges such as land use, massive construction waste for dams, ecosystem issues, water use, emissions and leaks from batteries, and decommissioning (World Energy Council WEC, 2016). More socio-economic impacts are associated too. All of this is resulted from building dams and diverting waterways directions.

1.4.9 Environmental Impacts of Hydropower

Hydropower is normally associated with building dams which in turn come with ecological changes. The bigger the dam is, the more impact it makes to the environment. Therefore, it raises concerns if they are truly environmentally beneficial. Of course, dams are used for two common purposes; one is to control the flow of a water path like rivers, and the other is for storing electrical energy EES in a technique called pumped storage. In pumped storage, water is lifted to a higher elevation in the off-peak period, where the installed power generation capacity of the grid may sit idle, making the electricity comparably cheaper than peak period. Later, when electricity is needed, water is let to free fall to generate power through hydro turbines. The need for hydropower is unstoppable especially when two-thirds of the feasible hydro plants are undeveloped. Moreover, it is one vital part of the power generation capacity globally as it supplies 19% of the power in the world and growing. In addition, the movement of Water, Wind, and Solar WWS described later in the chapter, has some motives towards its use (Berga, 2016). On the other hand, socioenvironmental impacts of hydropower are questionable. For instance, most of the dam lakes consume a huge area of land, which changes the nature of the area forever leaving the ecosystem impacted by creating new environments for some creatures and destroying for some. Some other dams impact people's lives as they have to be migrated to other places as the land where life on has to be occupied by the dam and flooded by water of the lake. Most of the dams prevent the land downstream from getting rich fertile soil that used to travel downstream by stopping them by the dam walls. In some countries, there is a no-go river anymore due to the fact that all the rivers paths are occupied by dams that control the flow. Eventually, rivers are in severe danger of change which can significantly affect the habitat life. For instance, in China, there are 46 large dams under construction on the Yangtze River, 27 in Latin America on La Plata, and many other countries are planning a huge installed capacity of electrical power and huge dams (World Wide Fund For Nature WWF, 2007). Rivers are endangered and therefore the associated population and ecosystem. Additionally, hydro turbines kill fish passing through them which is truly harmful. Another point is that methane and cardo dioxide can be produced by the nature of the water reservoir of the dam, which is argued that it is close to fossil fuel harm. Dams take a long time to construct and fill the reservoir which produces a massive construction waste and fuel utilized for the works, that is another issue. The deterioration of water quality of rivers pops to surface when dams are in the picture as the dissolved oxygen reduces leaving fish harmed considerably (George Ledec, 2003). This and others in details are in the mentioned references.

1.4.10 Wind, Water, and Solar integration

In a study by (Mark Z. Jacobson, 2015), a model to effectively use the integration of wind, water, and solar (WWS) systems to supply the energy needed without any other source of energy. The method is led by multiple storage systems that utilize every facility to store and transmit energy such as Underground thermal energy storage UTES, which stores energy for building equipped with air conditioning and heating. The study suggests 6 types of energy storage. Wind, water, and solar WWS sources can be integrated to supply clean and sustainable energy for the world. That is due to the fact that the risk of variability and uncertainty always address the fear of utilizing RES in the supply of electrical power on the grid. In order to minimize this, WWS solutions are introduced as a sustainable, safe, clean, and widely available sources of energy. However, they still are described as uncertain and variable in nature of power generation. On the other hand, grid operators and other utilities have always feared from the probability of endangering the supply of power that can be accompanied with any significant dependence on wind and solar.

Conclusion

RES is presented in four forms of energy, wind, solar, power, and modern biomass. They all have challenges, drawbacks, as well as advantages. Concerns regarding them are highlighted as economic, environmental, grid integration and dispatchability. On the other hand, they benefit the globe in the form of providing clean, sustainable, and in some cases cheaper energy (compared to oil and gas). Since, the demand for energy is increasing daily, especially in the form of electricity, the world has to find more ways to supply it. Technological advancements, additionally, is closing the gap between the conventional and RES. That is by making the second, more available by cost and other aspects. For instance, although storage of electrical power is one of the difficulties in utilizing the RES, technology made it possible to build better schemes such as bigger batteries those last longer and can be used in huge scales. A few models such as the study on WWS integration proofed that RES also can be solely used to supply a country with energy.

In the coming chapter, I will present a few debates about the relationship between economic growth and the utilization of the RES. Then I will apply two estimation methods on the data of the countries I chose to present, Egypt and Morocco for such relationships. The models are regression and goal programming for the developed formula of the production function of Cobb-Douglas.

Chapter 2: Economic Growth And Renewable Energy Sources Utilization

Abstract

Economic growth can be judged through a relationship with Renewable Energy Sources RES that can be a negative or positive relationship. Some studies show a bidirectional relationship. Countries and decision makers need to judge this performance to invest in the right type of energy source, either conventional or RES. The chapter examines the idea of if such a relationship exists or not. Moreover, it indicates which direction it is.

Introduction

In the past few decades more, attention was given to the field of energy economics specifically renewable energy consumption and its economic implications, where the United Nation designated the decade 2014–2024 as the decade of Sustainable Energy. Due to factors such as the oil crisis in the 1970's, the reduction of the accessible energy resources and the environmental problems caused by the expansion in non-renewable energy consumption, especially fossil fuels, energy economics has emerged as a new field of study, dedicated towards resolving such problems; where recently several studies have been conducted mainly focusing upon renewable energy consumption and its effect on economic growth since it is considered to be the cleanest, safe and inexhaustible source of energy.

Having reviewed several studies in this field, most of which were concerned with determining the relationship between renewable energy consumption and its implications on the economy, we have perceived that most of the conclusions turned out to be contradictory such as (Apergis, 2010), (De Arce, 2012), and (Frondel, 2010) which are going to be introduced in this chapter. Hence, based upon those studies our main focus is to investigate the relationship between renewable energy consumption and economic growth.

This study contains separate chapter for different topics that prepares for a presentation of a full picture of understanding about RES relationship with economic growth, RES definition, RES in the areas of study; Egypt and Morocco, introductions about the used models; Cobb-Douglas and Goal Programming and applying the two models for estimation of economic growth using RES consumption.

This chapter explores the relationship between economic growth and RES utilization in a country. Some studies and show a positive effect on economic growth for renewable energy sources utilization. Others have proven that the policies utilized for such models in some counties like Germany caused the relationship to be negative in the sense that the economic growth is reduced by the expansion in RES use. Other studies showed a bidirectional relationship. The economic growth explored here will be in terms of growth in domestic product GDP. And RES has a few components that are sometimes navigated by a study. And in other ways, it has been only RES without sub-areas such as types of RES.

Literature review

The literature review indicates that the impact of renewable energy consumption on economic growth is a research topic for several researchers. In fact, many empirical studies have been made using different tests in this area in order to identify whether there is a relationship between economic growth and renewable energy ; (Apergis, 2010) analyzed the causal dynamics between nuclear energy, emissions, renewable energy and economic growth for a panel of 19 developing and developed countries over the period [1984-2007]. This analysis was conducted using a panel error correction model and it indicated that there is bidirectional causality between renewable energy consumption and economic growth.

Moreover, the researchers added that the expansion of renewable energy not only can reduce the dependence on foreign energy sources for import-dependent economies, but it can minimize the risk associated with volatile oil and natural gas supplies prices which has an impact on the decision-making process in such economics.

In Morocco by using learning curves and in support of this positive relationship, (De Arce, 2012) reached the same conclusion that renewable energy consumption has a positive impact on economic growth. Moreover, (Pao, 2013) analyzed the Brazil's case study from [1980 to 2010] so as to explore the causal relationships between the real GDP and four types of energy consumption: non-hydroelectric renewable energy consumption (NHREC), total renewable energy consumption (TREC), non-renewable energy consumption (NREC), and the total primary energy consumption (TEC). The conventional neo-classical one-sector aggregate production technology treatment was employed in which capital, labor, and energy are treated as separate inputs. The results indicated that a 1% increase in total renewable energy consumption increases real growth in domestic product GDP by 0.20%. Moreover, the study highlighted that the expansion of renewable energy projects would enhance Brazil's economy and improve its competitive situation with more developed nations.

Furthermore, (Sebri, 2013) who applied their study on Brazil, Russia, India and China, BRICs (or BRICS) countries, over the period [1971-2010], argued that the expansion of non-renewable energy consumption especially fossil fuel energy leads to 2 major problems; first is the reduction of the accessible energy resources which is oil. Second is the problem of global warming caused by carbon dioxide emissions. As a result, they claimed that it is preferable to use renewable energy sources as it is considered to be clean, safe and inexhaustible. In this context, Auto-Regressive Distributed Lag (ARDL) bounds testing approach to co-integration and Vector Error Correlation Model (VECM) were used to investigate the impact of renewable energy consumption on economic growth. It was found that renewable energy consumption has a positive impact on economic growth and vice versa and this has been significant in Brazil compared to other countries.

In the same context, (Shahbaz, 2015) aimed to analyze the relationship between the consumption of renewable and economic growth. They conducted their study on Pakistan since it has the abundant potential for renewable energy like solar energy. Moreover, in the past two decades, energy consumption in Pakistan has increased by about 80 %. Therefore, the study was done within the time interval of 1972 Q1 until 2011 Q4 by incorporating the renewable energy factor into the Cobb-Douglas production function (Douglas, 1971). They used Auto-Regressive Distributed Lag (ARDL) bound testing approach to co-integration to test the existence of a long-run relationship between renewable energy consumption and economic growth. Moreover, The VECM Granger causality approach was utilized to examine the direction of the causal relationship between them. Finally, an innovative accounting approach was used to test the robustness of the causality results. The results indicated that renewable energy consumption raises economic growth.

In addition, (Lotz, 2015) and (Fotourehchi, 2017) concluded that energy conservation policies are inefficient and have prohibitive impacts on economic growth and that the government policies that are dedicated toward promoting the use of renewable energy should be adopted; where (Lotz, 2015) studied quantitatively the impact of renewable energy consumption on the economic conditions by employing annual data for OECD countries (Organization for Economic Co-operation and Development is an intergovernmental organization that was formed in 1961 and contains 34 countries) over the period 1990-2010 within a multivariate framework based on the Cobb-Douglas production function. The result of the Pedroni Co-integration test showed that there is a long-run relationship between real GDP and renewable energy consumption where it indicated that a 1% increase in renewable energy consumption will increase real GDP by 0.105 %. While (Fotourehchi, 2017), conducted his study on 42 developing countries over the period [1990-2012] using canning and Pedroni panel causality test where the results showed that growth benefits from substituting renewable energy for non-renewable energy.

However, unlike the previous studies; (Frondel, 2010) who focused on the German experience of applying renewable energy policies argued that the German renewable energy policy has failed to provide the market incentives needed to enhance economic growth. They proved in their study that the renewable energy policy applied in Germany led to high costs with no positive impact on the economy nor employment as the net employment was shown to have a balance of zero or even negative balance in the long run due to the opportunity cost of applying renewable energy technologies. As a result, they regarded the country's experience as “A cautionary tale of massively expensive environmental and energy policy that is devoid of economic and environmental benefits." Similarly, (Awatef, 2015) Examined the causal relationship between Economic growth, Renewable energy consumption, fossil fuel use and labor force for 8 MENA region countries which are Algeria, Egypt, Morocco, Iran, Jordan, Tunisia, Turkey and Israel for the period 1980-2011 using panel tests. They tested this relationship using cross-sectional dependence test, Unit root test, panel co-integration test, and panel causality test. The panel causality test resulted in a positive impact of all variables except labor force on economic growth. However, the impact of renewable energy on Economic growth was shown to be very small compared to fossil fuel energy which had a greater significant effect on economic growth in the selected 8 MENA region countries. In addition, they explained the reason behind this minimal effect which is that the renewable energy in the MENA region is underutilized and still not fully explored and thus more research and development is needed in this area.

On the other hand, other studies reached controversial results where one of these studies was conducted by (Mahmoodi, 2011) who applied their study on 7 Asian developing countries including Bangladesh, India, Iran, Pakistan, Jordan, Sri Lanka, and the Syrian Arab Republic. They tried to investigate the long-run causal relationship between renewable energy consumption and economic growth using ARDL bound test as well as a modified version of the Granger causality test so as to test the causal relationship between them. They reached two conclusions; first, there is unidirectional causality from economic growth to renewable energy consumption in India, Iran, and Pakistan and the Syrian Arab Republic. Second, there is bidirectional causality between economic growth and renewable energy consumption in Bangladesh and Jordan. However, there is no evidence for causality in Sri Lanka.

In the same context, (Farhani, 2015) studied the linkage between economic growth, renewable energy consumption and CO2 emissions for a panel of 12 MENA countries over the period [1975 -2005] using panel unit root, panel co-integration methods and panel Granger causality test. The author found that in the short run there is no causal relationship between the variables except that increasing the consumption of renewable energy leads to decreasing CO2 emissions only but doesn't cause any economic growth. However, in the long run, a causal relationship was shown, where the consumption of renewable energy caused economic growth.

Similarly, (Koçaka, 2016) utilized the traditional production function in order to test the relationship between renewable energy consumption and economic growth. They applied this framework for 9 Balkan and Black Sea countries over the timeframe [1999-2004]. They used three different methods to test this relationship which are panel cointegration, cointegration estimate methods, and heterogeneous panel causality estimation. The results using the panel cointegration test conveyed that a positive, long-term relationship existed between renewable energy consumption and economic growth. Concerning the heterogeneous panel causality technique, even though it supported the growth hypothesis in several countries including Bulgaria, Greece, Macedonia, Russia, and Ukraine, yet this hypothesis did not apply on Turkey as in Turkey the neutrality hypothesis held instead.

Moreover, (Destek, 2017) attempted to determine the impact of renewable and non-renewable energy consumption on emerging economies where they chose 17 countries over the period [1980-2012] and utilized bootstrap panel causality for this purpose. The findings of their study displayed that with respect to renewable energy consumption the results differed from one country to another, where the growth hypothesis, which implies a unidirectional relationship between renewable energy consumption and economic growth, held for only one country which is Peru. As for Colombia and Thailand, the conservation hypothesis is the one that prevailed, where we have a unidirectional relationship from economic growth to renewable energy consumption. Moreover, the feedback hypothesis, representing a two-way relationship between the two variables under study, held for Greece and South Korea. And finally, the neutrality hypothesis held for 12 emerging economies including Egypt.

As reviewed by different studies in literature, we can find that the impact of renewable energy consumption on economic growth remains controversial where some studies indicate that there is a relationship between them while others indicate the opposite. Furthermore, since most of the studies are found to have a lack of explanation for the relationship between both variables in Morocco and Egypt, this paper will tackle the gap in the literature by examining the impact of renewable energy consumption on economic growth in Morocco and Egypt over the period [1991-2014]. Following that, based on the results, a comparison between the two countries will be established concerning renewable energy consumption and its implications and finally convenient policy recommendations will be suggested for Egypt.

Conclusion

In summary, there can be a relationship between the GDP and RES depending on the market and judging policies. Either, positive, negative, or bidirectional it is, it exists.

In the following chapters, I will explore this relationship by applying an econometric model Cobb-Douglas and Goal Programming GP model. Therefore, I will discuss the

Cobb-Dougal and production function model and how it can predict GDP, the GP model compared to it and the enhancements it can introduce into such causality.

Chapter 3: Morocco's Success In The Renewable Energy Sources Field

Abstract

Despite the challenges that countries face to shift to renewable energy sources use especially in developing countries and emerging economies like Morocco, the country is one of the leading in the area. However, the relationship between the GDP and RES is unclear on the short-run. On the other hand, in the long run, the investments in such projects will help to maintain relative growth. The country enacted a few laws to force introducing such sources by providing incentives for research and establishment of plants. The chapter illustrates the leap in renewable energy sources use in Morocco, addressing legal, institutional challenges that the country overcomes to be a leader in the field.

Introduction

Supported by (Fahrani 2015) who studied the linkage between economic growth and renewable energy consumption for a panel of 12 MENA countries including Morocco over the period [1975-2005] using panel unit root, panel co-integration methods and panel Granger causality test where the author found that in the short-run there is no relationship between economic growth and renewable energy consumption . However, in the long-run causal relationship was shown, where the consumption of renewable energy causes economic growth. In the same regard, for Morocco, despite its significant investment in a variety of resources in the field of RES, the short-term relationship does not exist, however, it is predicted that in the long run, it will cause economic growth that is reflected in the GDP. On the other hand, Egypt shows a mild effect on RES utilization on GDP. Moreover, renewable energy is a new field where Morocco has exerted vigorous efforts and has engaged in pursuing projects that permits the effective utilization of renewable energy sources such as Noor project, which is considered to be one of the largest solar energy projects on a global scale.

Consequently, building of the above results where renewable energy consumption in Egypt has a minimal effect on Real GDP, I believe that if Egypt's resources were directed towards accomplishing more dependency upon renewable energy, it is more likely to experience economic growth than Morocco and what supports Egypt as well is that it already possesses great potentials in terms of natural resources which can assist it in excelling in this field. Both countries relationships of GDP and RES utilization will be presented mathematically later in other chapters. In this chapter, I will introduce the current situation of both countries for RES. First, I will describe Morocco's background of energy and renewable energy then I will move to Egypt.

Morocco's success

Initially, Morocco suffered from a lack of energy supply due to its high dependency upon non-renewable sources of energy where a considerable portion of its imports was dedicated towards non-renewable sources of energy. Consequently, this led to a high-energy import bill accompanied by a rapidly rising electricity demand. In its pursuit to transform the situation and take advantage of its abundant renewable energy resources, Morocco gradually shifted towards the utilization of renewable energy resources (Dr. Abdelbari Redouane, 2006). Nowadays, Morocco is regarded as a leading country in the Middle East and North Africa region in the field of renewable energy, where over the past few years Morocco has reached a milestone with regard to this field as it began to search for ways to resolve its energy problems. Thus, in its attempt to encourage renewable energy development within its borders, Morocco eventually emerged as a stable destination for power sector investment. Hence, it is expected that Morocco would reap the fruits associated with its newly established projects somewhere around 2020 and 2040. This could be supported by a research paper claiming that Morocco's investment in renewable energy is expected to impact the range of GDP from 1.21% to 1.99% by the end of the forecasting period of (2040). Accordingly, I can assume that the Moroccan renewable energy investment projects are still in their infancy, but the benefits in the near future seem clear, where I can already perceive that Morocco has undergone some major transformations in the field of renewable energy and managed to become the focal point of large investments in this field. Moving on to the case of Egypt, I, moreover, examined the short run dynamics between real GDP and renewable energy consumption and the results conveyed that the relationship between the two variables was minimum. However, it is clear that Egypt is one of the fortunate countries which enjoy a variety as well as easy access to renewable sources of energy; this gives rise to the question of why Egypt is lagging behind in this field whereas other countries with similar backgrounds such as Morocco managed to achieve an impeccable breakthrough. In this chapter, we aim to provide a logical explanation to this question as well as a solution to this problem, through offering a detailed explanation of the factors contributing to Morocco's success as well as providing an in-depth explanation of the various factors and barriers thwarting Egypt from achieving its energy goals.

To have a better understanding of Morocco's contribution to this field I shed light on the main factors that were conducive to Morocco's adaptation of renewable energy, I will also elaborate on the evidence that supports our view of Morocco as a leading country of study in this field.

Factors Conducive to the development of renewable energy

3.4.1 Strong Legal and Institutional framework

The reason why Morocco made such a dramatic breakthrough in the development and enforcement of renewable energy can be attributed to a variety of factors. To begin with, one of the main factors that supported development within this field is Morocco's strong regulatory structure where several laws were introduced and were successful in maintaining an efficient legal structure. One of the main laws include the renewable energy law number 13-09 (Unknown, 2010) which is responsible for the establishment of the legal framework for renewable energy development and partially opens the electricity market to competition for the production and commercialization of power from renewable energy sources. Moreover, it permits renewable energy generators to develop transmission lines if the existing transmission capacity is insufficient. Accordingly, the kingdom of Morocco can plan ambitiously to rely more on renewables. For instance, in 2015, RES was 34% of the installed power generation plants. The country plans to increase it to 42% in 5 years then to 47% I n2025. That is to reach 52% in 2030. That great plan contains an addition of 10 GW of power by 2040 as 45.6% solar, 42% wind, and 13.3 hydropower (editors, 2018). In addition to the strong legal structure that characterizes Morocco, there are plenty of other laws that contribute to the development of the renewable energy sector through the establishment of institutions and programs. For example, law number 57-09 which created the MASEN that stands for Moroccan Agency for Solar Energy, where it is considered to be the most important actor for the Moroccan solar energy sector. MASEN conducts plenty of activities such as: studying and designing solar program, promotion, investment, financing, implementing projects, contribution to the development of expertise, research and solar industry, managing and monitoring the implementation of the solar program. Another law such as law number16-09 which created the national agency for the promotion of renewable energy and energy conservation which is known as ADEREE, where the ADEREE is primarily active in the Corporate Energy Efficiency Program. Moreover, a number of institutions have been created, among which is “The Office National de l'Electricite et de l'Eau Potable” which can be abbreviated as (ONEE). This entity is responsible for the production, transport, and distribution of electricity. ONEE does not work alone it also works side by side along with three independent power producers (IPPs), it also operates as a single buyer. Another major Institution is known as (Institute for Research in Solar Energy and New Energies) which is also referred to as of the IRESEN.

3.4.2 Renewable energy policies

It is important to note that Morocco follows certain renewable energy policies which involve promoting BOT (Build-Operate-Transfer) ;a form which seeks to award long-term agreements to private sector actors where a private entity builds a facility, operate it for a certain period of time, then transfer it to the government (Moez Cherif, Sameh I. Mobarek, 2018). Moreover, with respect to its policy framework, Morocco implemented a strong foundation supporting its renewable energy sectors, through implementing feed-in-tariff, which is a payment made to households or businesses generating their own electricity through renewable energy sources. BOT is a form of project financing in which the private entity receives a concession from the private or public sector to finance, design construct owns and operate a facility sated in the concession.

3.4.3 Evidence of Morocco’s high performance in the field of renewable

energy

Morocco’s has impeccable achievements where plenty of projects have been established and are considered to be the backbone of Morocco’s success as they managed to achieve a milestone on the country’s path towards pursuing a secure, sustainable, clean, green and affordable energy supply. One of the world’s largest projects adopted by Morocco, in its attempt to increase its utilization of renewable energy sources, was the construction of solar energy plants. This was considered to be one of the most ambitious projects carried out in this field with a total investment amount equivalent to USD 9 billion. It aims at generating 2000 megawatts of solar power by 2020 through building 5 mega-scale solar projects (Mafalda Duarte, 2015).

Furthermore, with respect to wind energy resources, which are the main source of renewable energy for Morocco, plenty of projects were implemented and resulted in unprecedented progress in Morocco. Where several wind farms have been constructed such as a wind farm known as Abdelkhalek Torrès (50.4 MW) which is characterized by being the initial investment within this field in Morocco (Yaneva, 2015). Moreover, other projects were launched in this field such as the Moroccan Integrated Wind Energy Project, where its total investment was equivalent to MAD31.5 billion.

Conclusion

I have highlighted the growing importance of renewable energy globally and provided an introduced about of the short run dynamics that occurred between real GDP and renewable energy consumption in both; Egypt and Morocco. With regard to Morocco, I arrived at the addressed some researcher’s views that the relationship between our variables of interest is almost insignificant in the short term. This could be justified by the fact that most of

Morocco’s projects within the field of renewable energy were designed such that they yield benefits in the long-run, where most of the projects in this field have been recently established and are considered to be new. In the next chapter, I will illustrate the Egyptian development of RES projects, background, challenges, and recommendations.

Chapter 4: Renewable Energy in Egypt

Abstract

Egypt had great opportunities of utilization Renewable Energy Sources RES, whereas its challenges should be addressed on a national level to encourage investors to supply more funds to such projects, the public to adopt such ideas nationally and individually, the grid controller (power transmission companies) to request power generation plants to use alternative energy sources; RES in this case. In this chapter, I defined the types of RES available for the Egyptian use then presented Egypt's challenges to implementing. Afterward, I provided recommendations to turn its energy market into more RES against the current sever use of fossil fuel in the country.

Introduction

Ancient Egyptians were among the pioneers in the utilization of renewable energy such as wind power to sail ships on the Nile River. Following that, 5000 years later, as per (Saleh, 1978) Frank Shauman built the world's first solar thermal power station in Egypt. Moreover, the high dam in Aswan remains a sign of national pride where its hydroelectricity is considered to be fundamental to the country's industrialization. Accordingly, based on its historical performance, Egypt is characterized by having plenty of potentials within the field of renewable energy where it is fortunate to enjoy an environment and location that provide it with a wide variety of energy resources that are not perishable. However, in the time being renewable energy usage and production in Egypt faces several challenges due to many macroeconomic factors. These challenges as per (Ismael, 2018), (MERE, 2018), and (WTO.org, 2009) hinder Egypt from attaining the optimal output level of renewable energy in terms of its consumption and production. Hence, we refer to Morocco as a developing country with similar conditions to those of Egypt, in order to follow its footsteps in achieving progress within this field in Egypt. Furthermore, Egypt is famous for its strategic location which provides it with access to several renewable energy resources. Egypt being ranked the 29^{th} with regards to the index of the forty most attractive states in the RES sector highlights its capabilities and potentials, thus all that Egypt needs to focus on in the meantime is how to harness those abundant resources for its own benefits. Where among Egypt's high potentials in the field of renewable energy are in the coming sections. In the following section, I will define the types that are utilized in Egypt and can be expanded further. Then I will discuss the barriers that make Egypt lag a true development in the field of RES while it is available and more than many places in the world. In the end, I will provide a few recommendations about the stated challenges for decision-makers in Egypt to enhance the future of RES and clean, cheap, and sustainable energy sources.

Wind Energy

Egypt possesses outstanding conditions that support it in harnessing and utilizing wind energy, these conditions prevail within regions characterized by a high, stable and frequent wind speed such as coastal regions. Additionally, the country enjoys spatial deserts which are mostly uninhabited or have low populations; hence they are adequate for the construction of large wind farms. Accordingly, the Egyptian Meteorological Authority (EMA) issued the Egyptian Wind Atlas. It also worked alongside the Danish Riso laboratories in its endeavors to identify different locations with the highest capability of generating wind energy in order to construct new wind farms. Together they arrived at the conclusion that; the Gulf of Suez Area and sides of the Nile River, and some areas in Sinai enjoy the highest potentials for wind energy. Consequently, they decided to build wind farms along the Red Sea to harness the wind energy present in those areas. Danish Riso laboratory for sustainable energy is a scientific research organization that is responsible for a wide range of Research and Development R&D programs and consultative services in the fields of energy, environment, and materials.

Solar Energy

With regards to its solar energy resources, Egypt is recognized as one of the few countries that possess a high capacity for harnessing the power emanating from the sun, and this is conveyed by the fact that it is considered to be one of the Sun Belt countries. Furthermore, Egypt enjoys a long period of sunshine as it lasts somewhere between nine and eleven hours per day (WA, 2019). Hence, Egypt is able to generate 73,656 billion watts per hour on an annual basis as per (World Bank, 2010). Additionally, in support of utilizing the widely abundant renewable energy resources, the Egyptian government as per (IEA, 2008) set up a plan that seeks to achieve a share of 20% from renewable energy sources in the country's national energy balance by the year of 2020 which will result in substantial progress and development in terms of providing more business opportunities in the field of solar energy.

Hydropower

Another renewable energy source that Egypt has is hydropower, which is also referred to as Hydroelectricity, and it plays a major role in generating electricity in Egypt. This is manifested in the existence of a variety of hydroelectric generation stations within the borders of the country, this includes the Aswan low dam, the Esna dam, the Naga Hamady

Barrages and finally the Aswan High Dam. The importance of these dams is conveyed by the considerable amount of energy they generate, where collectively they supply around 5% to 10% of the country's annual energy requirements as per (Wikipedia, 2019) and (CIA, 2019).

However, although Egypt is rich in such resources, there are several economic challenges that have to be overcome for the RES to flourish in the country that supports the development of the economy. This prevents the country from attaining the optimal utilization of renewable energy sources. I will introduce in the following sections the major parts of these challenges.

Barriers Hindering Egypt's progress in the field of Renewable energy

4.6.1 New Investments and economic concerns

Nowadays, the interest rate in Egypt is regarded to be extremely high especially with the newly introduced economic reforms which further contributed to the increase in the interest rate. This skyrocketing interest rate discourages investors from investing in the renewable energy field. To aggravate matters, the interest rate on bank deposits is also high which provides investors incentives to deposit their money in banks rather than invest them in this field. From (Hamdy, 2014) and (IRENA, Renewable Energy Outlook Egypt, 2018) this interest rate is due to a few financial reasons such as the floating of the Egyptian currency which mush devalued it against any foreign currency, the slow economic growth due to a few political issues, and the slowdown of tourism which was one of the biggest incomes to the country.

Secondly, even if the interest rates were not as exaggerated as mentioned earlier, there are plenty of other economic obstacles facing the renewable energy field and prevents its application in Egypt. For instance, the financial context; this is because Egypt suffers from a lack of funds, and renewable energy projects require a large budget for its implementation. Aside from its high costs, renewable energy projects are not exempted from taxation. This resulted in the discouragement of the private sector from participating in this field. Not only is the private sector's role limited, but there is also a shortage in terms of foreign direct investment within this field. In addition to that, there are other exogenous factors that hinder the implementation of renewable energy projects within the country; these factors involve: shifts in energy prices, changes in the number of consumers, any unanticipated economic crisis, changes in the prices of substitute goods such as the price of gas; addressed in (Mondal, 2019).

4.6.2 Technical challenges

Technically, the issues can be summed up in two elements; the production of renewable energy on a large scale and the lack of skilled workers as stated in (RES4MED, 2015). First of all, Egypt has a humongous population; hence, if it is going to adopt renewable energy and apply it within its borders, it needs to do this on a large scale especially if it wants to implement renewable energy usage within urban areas. In addition to that, the renewable energy components and equipment that Egypt utilizes are mostly imported and hence operating these technologies has been quite problematic especially due to the lack of sufficient and adaptive research within this field. Furthermore, as per (Khalil, 2010), this field requires profound efficiency in terms of implementation and extremely advanced technological methods, this is because sources of renewable energy are not lasting, like the sun and wind, they are present for a certain period of time. This requires efficient utilization schemes that are integrated with other energy production and storage systems. Hence, the technology should be tailored such that it could be connected to electricity grids when the need arises and store the energy which an immediate use isn't demanded. This implies an extra cost to integrate with others. In addition, for the second element which is concerning the shortage of skilled workers within this field, this can be attributed to Egypt is a developing country, as well as renewable energy, is a new field of research. This resulted in a lack of courses as well as a deficiency in research within the renewable energy sector which further contributed to the problem of unskilled labor. Therefore, the RES is seen by the public in Egypt as a luxurious item not a necessity in some cases.

4.6.3 Legal Challenges

On the contrary of the situation in Morocco, where laws support the implementation of RES and research in the field, the legal structure within Egypt is not constructed in a way that supports the implementation of such in the country, as addressed in (Khalil, 2010). Hence, the legal challenges are manifested in the wanting number of laws enforced within the renewable energy field, where; there is a deficiency in both; the number of laws that encourage investments in energy projects, as well as laws that stimulate citizens to rely upon renewable energy sources.

4.6.4 Social Challenges

Concerning social challenges, these challenges prevail due to the lack of awareness on the behalf of citizens with regards to renewable energy sources, as highlighted in (RES4MED, 2015). As we have mentioned earlier, Egypt is a developing country and faces a lot of educational challenges, this resulted in a large proportion of the citizens to be ignorant and hence they lack understanding with regards to the importance of renewable energy sources. Accordingly, they prefer utilizing conventional non-renewable sources of energy. Moreover, due to the sever subsidiary of energy prices, which is not only an economic need for Egyptians but also a social requirement, the ordinary citizen does not feel the demand for such source to reduce his cost of energy use. For instance, in many developing countries, some localized utilization of RES such as biomass and solar photovoltaic cells, help people to reduce the grid dependence and hence energy cost. This does not exist in Egypt due to the fact that the real electricity price does is not felt by the public.

4.6.5 Institutional Challenges

As addressed in (Mondal, 2019), the last type of challenges lies within the country's institutional framework. The government did not undertake sufficient nor effective policies with regards to the field of renewable energy. The government neither provided a comprehensive strategy to align economic activities with the field of renewable energy nor did it emphasize the scope and importance of renewable energy.

In the following sections, I will suggest a few solutions to overcome the addressed challenges in the light of the earlier introduced case of Morocco which is an example of a similar emerging economy in the same region with a close situation of natural resources.

Policy recommendations for Egypt

After tackling the major challenges that Egypt encounters with respect to its renewable energy sector, I will provide sound and efficient policies that would help us conquer these challenges and pave the path for the successful adoption of renewable energy methods.

Having reviewed the case of Morocco and witnessed its successful performance and operation within the renewable energy field, I have managed to use it as a leading example and extract what I believe to be highly efficient policies that if implemented efficiently would become a major game changer for the Egyptian energy sector.

4.7.1 The enforcement of a stronger feed-in tariff

This is considered one of the most effective measures that could be implemented in order to enhance the adoption of renewable energy methods, and this has been proven in the case of Morocco. In 2014, a feed-in-tariff scheme, of 14.34 US cents per kWh, was implemented for solar projects in Egypt. However, this scheme proved to be insufficient, accordingly a stronger and more efficient scheme is perceived to be necessary. Thus, in order to implement a stronger scheme, using the feed-in-tariff, the government should be willing to offer guarantees and preferential prices for producers who generate electricity using renewable sources of energy. This should eventually result in attracting private capital as well as international investments in order to contribute to renewable energy projects.

4.7.2 The elimination of energy subsidies

Considered as one of the most radical economic incentives to shift to RES, the user has to feel the necessity to a cheaper source of energy. As the reform to reduce and eventually eliminate the subsidies of electricity (energy) which has already begun to implement, Egypt is expected to have a large positive impact on the economy by such step and this supports indirectly the idea of shifting to RES with the hotter prices from the pocket of the user apart from freeing more money for the country to support the installation of such plants (solar, wind, ..etc.). The omission of energy subsidies will discourage individuals from shifting towards the usage of non-renewable sources of energy as they would be regarded to be more expensive. In other words, reduction in energy subsidies is associated with a number of benefits such as decreasing market distortions, diminishing the country's budget deficit and it also paves the path for the introduction of renewable sources of energy as a more efficient and less expensive substitute.

4.7.3 Seeking technical assistance

For such emerging economy with the lack of technical capabilities, it can be a key solution to overcome the above-mentioned technical challenges is to seek assistance in the field of research, manufacturing, construction of plants, and operations and maintenance. And thus, it would assist in the implementation of efficient renewable energy projects. Egypt has a big potential for success in the sector of RES development if it seeks the aid of international organizations such as the World Bank. This can support is endeavors to adopt renewable energy techniques; this is because such organizations are characterized by having high capacities that could provide economic and developmental benefits. Additionally, the country should pursue the establishment of partnerships with other countries that possess the experience and technology relevant to this field. These countries should provide Egypt with access to advanced courses in this field, which would consequently help in the treatment of the problem of the unavailability of skilled workers.

4.7.4 The construction of giant solar thermal electricity generators

Large scale plants have massive economic benefits of scale and developing the technical capabilities of the country. This could not only help to build strength in the field but also provide a successful example in the country's plan to work towards a cleaner more sustainable energy source. Second, due to the fact that Egypt has a dry weather with long hours and plenty of days of sunshine during the year, not to mention the density of the watt of power that can easily be generated from Egypt's sunny land, solar panels should be a successful project in Egypt where land does not form an issue; as Egyptians occupy less than 5% of the Egyptian soil. This means that Egypt is characterized by having an abundance of solar energy, which makes the construction of a thermal electricity generator both viable and practical. Moreover, the establishment of such a generator would create plenty of jobs in the country, thus creating direct economic benefits along with benefits in the renewable energy sector. Additionally, the solution has proved to be extremely efficient for Morocco, which has launched one of the largest solar energy projects on a global scale and is now a net exporter of renewable energy.

4.7.5 The adoption of a competitive bidding approach

The electricity market in Egypt is actually fully public, except a few recent examples of private forms such as of the BOOT project of Suez Gulf Power Plant which purchases the gas with a submissive price and cells delivers electric on a fixed price too. However, even the BOOT plants are subject to a fixed delivery cost of power and compete in a free market of electricity. This cause the private sector to feel limited in providing any solutions to help the grid to reduce the price by introducing alternatives to the gas operated power plants such as RES. Consequently, it should be undertaken in the electricity sector in Egypt, where the Electricity Transmission Company should issue tenders for private sector companies in order to ask for their assistance in supplying large-scale renewable energy on the basis of a build, own, transfer (BOT) approach, which has been successfully implemented in

Morocco.

4.7.6 Having a firm grasp of the Egyptian market dynamics is considered

It is an integral part to enable the country to attain economic benefits through the adoption of renewable energy methods. In order to establish that, it is important to determine the main players competing within the market and to have a clear understanding of the rules and guidelines that govern the energy market. The Egyptian energy market has many forces that are fixed by the government which makes it rigid and difficult for investors to enter without a clear picture and overview of the government about the long-term future.

Conclusion

The Egyptian nature provides a high source of return from investing in RES such as solar, wind, hydro, however, there are a few challenges that face the decision makers. These are addressed as economic, technical, social, institutional, and legal. In light of the Morocco experiment, I have provided a few suggestions to help Egypt to overcome such barriers.

In the coming chapters, I will address the technique of production function and goal optimization to predict economic growth using RES and other factors. First, I will introduce the production function and specifically the application of Cobb- Douglas then I will apply it on the data taken from the world bank about Egypt and Morocco. Then I will compare it with results generated from Goal Programming that will be introduced as well in the coming chapters.

Chapter 5: Cobb-Douglas Production Function

Abstract

The aim of this chapter is to prepare to utilize of Cobb-Douglas production function has to estimate the GDP for renewable energy utilization. Therefore, I described the productivity, production theory, and the component of Cobb-Douglas' equation. Moreover, I have highlighted the criticism of it and its assumptions.

Introduction

In order to measure GDP in terms of renewable energy use, I have chosen the Cobb-Douglas production function to indicate the relationship between them. In this chapter, I will introduce the Cobb-Douglas production function and its use to estimate the economic welfare of a country. That is used in the form of gross domestic product GDP for Egypt and Morocco. I will first introduce how economists tried to define productivity, the production theory, then its form for Cobb-Douglas. Later I will illustrate how the GDP can be estimated using renewable energy resources consumptions and other independent factors those are illustrated in a study (YipingFang, 2011). He used renewable energy consumption and share of renewable energy consumption of the total energy used in China to find out their influence on GDP. Then I will present the advancement of the Cobb-Douglas production function which introduces logarithm in the equation.

Productivity

Cobb-Douglas Production function is a special form of the production function. Productivity is measuring the output associated with a specific quantifies of input. Countries are compared economically by productivity. For instance, the USA is a strong country as it is productivity, as for the same number of populations, it produces more. That is measured in GDP which will be illustrated later, what GPD means. First, I will illustrate how scientists, measured productivity. Assuming that earnings of individuals can represent the productivity of a person, economists succeeded to explain some of the difference in earnings among humans. This was presented by (Becker G. S., 1977) as economists assumed that the earning difference is due to the difference in their education and time spent at work. However, although this was true, it explained only 30% of the difference in some countries addressed by the study. Therefore, it is not only the gained skills and hours worked but also productivity. Which is much influenced by physical and mental factors such as fatigue. Moreover, there is more factor that is used to enhance production differ from one person to another. For instance, marriage enhances the productivity of males, yet doesn't do so in the case of females. Since this argument started, some assumed that productivity is caused by utilitarianism. In other terms, utilitarianism is a part of the production function. Utilitarianism (Several, 2019) is a philosophical concept that means individuals work towards the benefits of the majority, not themselves. This theory clears an idea that the productivity of an individual can increase when the group of his is aiming to achieve a target. For instance, a producer will do his best through efficiently allocate his resources to reach the attainable optimal level of production subject to the least cost. And the employee will work according to this. This is by putting more efforts that include physical and mental efforts associated with a certain task. Moreover, as stated by (William J. Baumol, 1991) , this can be affected by the pressure of due dates, which affects the degree of elasticity of this particular job. Elasticity here means the sensitivity of the relationship between effort and productivity, which is very similar to efficiency in physics. Consequently, productivity has many factors that influence it those are always supported and argued with theories by economists.

Production Theory

In order to distinguish between different production functions, one should consider two factors: 1) Macro or micro level, and 2) Short- or long-term. There're four types of production functions, namely 1) the ex-ante function at the micro level, 2) the ex-post function at the micro level, 3) the short run function at the micro level, and 4) the long run function at the macro level (Douglas C. W., 1928).

According to (Douglas, 1971), the first production function type is concerned with the possible change in technology accompanied by introducing new device or equipment. Furthermore, the second type attempts to interpret the existing relationship among the factors of production and output ex-post installing equipment. Nevertheless, the third type explains the relation between production inputs and outputs and indicate the contribution of each of the former in the production of the latter. Finally, the fourth type describes the relationship between inputs and outputs assuming hypothetically that the input can be reallocated to their most productive use once any deficiency in allocation is recognized.

The production process of a rational firm is determined by its utility function, which has other determinants rather than the price and scarcity of this product. Also, the relative importance (weight) for each dimension differs from one firm to another. Moreover, I will assume human capital and labor in that will help in my analysis and findings.

The firm takes into account the efforts and time of each employee when it wants to make decisions regarding the number of employed workers and takes into account the depreciation rate, productivity and asset specificity of capital when deploying them in the production process. The labor-to-capital ratio should be taken into consideration when allocating productive resources in their most efficient use, and this is in line with the firm's ultimate objectives in maximizing the profit resulting from its economic activities. As a result of all the discussions about productivity, economists such as Douglas tried always to find ways to correlate between inputs of production and the resulting outputs by constructing and testing functions such as the enhanced Production function which is called Cobb-Douglas Production Function.

Cobb-Douglas Production Function

There was a need to measure the contribution of the firm production in the manufactured output, and hence to determine how a change in the labor-capital ratio can affect the company's output and estimate the relationship between the factors of production. This type of analysis raises the nation of the marginal productivity of each factor of production and its price that can be adjusted by market forces, where a rational producer will choose more from a factor of production rather than another according to its degree of influence or increment in total production and its degree of scarcity that is highly reflected in its price and whether there exists a fixed ratio to produce a certain output or not (Cobb CW, 1928). The Cobb-Douglas production function is used to measure a country's productive capacity and performance. A main underpinning assumption of the function is the fact that labor is held as a constant factor of production at least in the short-run. The actual output cannot be estimated, however, using this model a potential value is estimated. The three factors of production contributing to the Cobb-Douglas model are labor, capital, and total factor productivity. Hence, the production function is a channel to measure the structural policies of the government and it guarantees that the available resources are allocated to their most efficient use subject to the least cost.

Following an economic approach, the Cobb-Douglas is a function widely used to represent the relationship between inputs and output. It was first proposed by Knut Wicksell (1851-1926), and empirically tested by both Charles Cobb and Paul Douglas (1928). They published an empirical study tackling the American economic growth in the time period 1899-1922, and this is through the channel of the production function, where they tested the impact of the amount of labor and capital units used in the production process and their accompanied output. Consequently, it is clear that they held everything constant except for labor and capital.

The two-factor Cobb-Douglas production function with Hicks-neutral technology is represented as follow:

$$Y_t = A_t . {L_t}^{\propto} . {K_t}^{\beta} \quad (5.1)$$

Where:

- Y_t is the real GDP, which represents the total production of a certain level of inputs and is measured in pecuniary terms,
- A_t is Hicks-neutral technology, which is the total factor productivity,
- L_t is the labor value, which is the aggregate number of workers engaged and needed for the production of this aggregate level of output.
- t denotes time, which is the point in time i.e. the year the study is interested to measure the production in.
- K_t is the capital value, which denotes the monetary value of capital with all its

forms needed and used during the production process at a specified point in time. The capital includes equipment, machinery, and plants.

- $\propto$ and β denote output elasticities of labor and capital, given a constant level of technology. The output elasticity measures the degree of responsiveness of the level of output due to an input change in either labor or capital, holding all the other factors constant. For instance, if $\propto$ = 0.25, this means that when the labor changes by 1%, the level of output will increase by 25% on average.

Therefore, the productivity can be estimated using the mentioned above inputs of Cobb-Douglas production function. Moreover, it has a few special cases as follow; return to scale.

Returns to scale

The returns to scale are a technical concept related to production, which focuses on the change that is incurred by the output ex-post a change in all inputs, worth noting that all the inputs should change with an equal level. Returns to scale entail three cases as follow:

1. Increasing Returns to Scale (IRTS): This is the case when the output more than doubles when the input doubles. More generally, when the inputs increase proportionately, the output increases more than proportionately. For instance, increasing the inputs by 20% will increase the output by more than 20%. Symbolically representing IRTS, it will imply that $\propto + \beta$ >1.
2. Constant Returns to Scale (CRTS): This is the case when the output exactly doubles when the inputs double. More generally, when the inputs increase proportionally, the output increases with the same proportionate. For example, increasing the inputs by 20% increases the output by exactly 20%. Symbolically representing CRTS, it

will imply that $\propto + \beta = 1$.

3. Decreasing Returns to Scale (DRTS): This is the case when the output less than doubles when the inputs double. More generally, when the inputs increase proportionally, the output increases with less than this proportionate. For example, increasing the inputs by 20% increases the output by less than 20%. Symbolically representing DRTS, it will imply that $\propto + \beta < 1$.

Any production process is subject to the three types of returns to scale, where it always starts with increasing returns to scale, then constant returns to scale, and ends up with diminishing returns to scale. To elaborate more, at the beginning of the production cycle, increasing the number of factors of production will have a substantial effect on the product output. For instance, if there's only one labor unit in a certain restaurant, he will be responsible for cooking and baking the food, taking the orders, serving them, and calculating the receipts; however, if the total number of labor increased by utmost 4, on average, the marginal productivity of each labor unit will be higher and hence the increment to the total production will be higher on each extra labor unit. This means that they will be able to serve as many customers as possible due to specialization in production. This is until a certain point, whereafter it the total product will increase by the same proportion, and after this point it will increase at a decreasing rate till it reaches its peak, where if the owner of the firms employed more labor or capital, the total product will decrease and eventually the returns to scale will be decreasing. This is due to over-crowding effect, which incurs that the number of labor is much higher than what is needed, which restrains them from using the available capital and hence acts as a barrier against achieving the desired level of output.

Cobb-Douglas Underlying Assumptions

The neoclassical Cobb-Douglas production function is based on several assumptions, mainly:

1. **Labor and Capital as factors of production:** The Cobb-Douglas production function primarily depends on two factors of production; labor and capital.
2. **Marginal product:** It incurs positive and diminishing marginal products of factors of production when they're used to produce a certain output.
3. **Returns to scale:** The production process entails constant returns to scale.
4. **Elasticity:** The elasticity of output ranges between zero and one, where the higher its value the more elastic an output is to any change in inputs.
5. **Homogeneity of labor:** The labor is characterized by homogeneity and
6. **Technological advances:** The technological changes are assumed to be static at a certain point in time.
7. **Marginal product:** In order to estimate the potential contribution of every factor of production in the total output, one can use the partial derivative, which will compute the cost of hiring labor, the cost of purchasing capital, or the cost of investing in technology, worth noting that the cost of labor is the wage (w) and the cost of capital is the rent (r). More prominently, w = $\frac{\partial Y}{\partial L}$ and r =$\frac{\partial Y}{\partial K}$, and hence r$K$ + wL =Y respectively.

Criticism against Cobb-Douglas Function

Several scholars have challenged the accuracy and adequacy of the Cobb-Douglas function, and this is primarily due to its radical assumptions which became later-on questionable (Bhanumurthy, 2002). For instance, they developed a model depending on the assumption of a constant number of factors of production at a specified point in time, which isn't significantly proved to hold true. Moreover, there was not enough literature affirming those assumptions, particularly the constancy of inputs, and there was a relative absence of proof of those assumptions by either Cobb or Douglas per se.

Moreover, Cobb-Douglas function is only used for a limited number of inputs and can't handle a large number respectively. This restricts the accuracy of its results and reduces its usage in real life, especially in the cases where a producer is using advanced factors of production, other than labor and capital.

Nevertheless, the Cobb-Douglas function is inherently based on the assumptions of perfect competition, which are quite difficult to satisfy and unrealistic, due to the presence of opportunistic behavior, information asymmetry, and institutional violations. It also assumes constant returns to scale, which is unrealistic, as every production process is subject to the three types of RTS consecutively, not only one.

Furthermore, the factors of production are subject to the multicollinearity problem, where the labor is implicitly correlated with the capital, and vice versa, implying a relationship among the dependent variables. This brings the results to an unbiased outcome where each factor's coefficient doesn't only reflect the contribution of this specific input in the product, but also part of this contribution is influenced by the other input respectively.

The esteemed function also reflects the productive efficiency only, yet it doesn't take into account the technical efficiency or the level of desired growth per se.

Regardless of its major drawbacks, one wouldn't deny the path-breaking work of Knut

Wicksell followed by Charles Cobb and Paul Douglas, where they managed to initiate the solid ground that enabled the following scholars to reach further results and accomplish more reliable steps and realistic achievements.

Renewable energy utilization effect on GDP

(YipingFang, 2011) assessed the impact of renewable energy consumption and its share on the GDP of China by applying Cobb-Douglas production function. He applied this for the period of 1978 to 2008. The study concluded that the real GPD was raised by 0.120% and GDP per capita 0.162% and annual income of rural household by 0.444% and per capita annual income of urban household by 0.368% for the increase of renewable energy consumption (REC) by 1%. It also showed that the REC impact is significant while the renewable energy consumption share (SREC) is insignificant. Moreover, the share of REC increase impacts the GDP slightly. Now, I am going to elaborate on the variable of the Cobb-Douglas production function in its simple form. One of the utilized forms of Cobb-Douglas production forms is represented the relationship between outputs and inputs which was assumed and used by Knut Wicksell (1851–1926) and verified by Cobb and Douglas in 1928 (Cobb CW, 1928). The form used is:

$$Q = AL^{\alpha}K^{\beta} \quad (5.2)$$

Where Q = total production (the monetary value of all goods produced in a year); L = labor input (the total number of person-hours worked in a year); K = capital input (the monetary worth of all machinery, equipment, and buildings); A = total factor productivity; α, β are the output elasticities of labor and capital, respectively. These values are constants determined by available technology.

A slight advancement for the equation is to omit the technical change which was taken into consideration by (Handsaker ML, 1937) and (Williams J., 1945) to determine the impact of renewable energy consumption on GDP. In order to do so, logarithm and total consumption of renewable energy, the share of renewable energy, and per capita Research and Development R&D expenditure were added. Moreover, the number of employees and per capita R&D expenditure as an indicator for capital, labor and technological progress respectively. Consequently, the new form of a Cobb–Douglas can be written as follow:

$$\ln \mathrm{GDP} = \varphi + \alpha \ln \mathrm{REC} + \beta \ln \mathrm{SREC} + \gamma \ln \mathrm{K} + \delta \ln \mathrm{L} + \lambda \ln \mathrm{T} + \mu \qquad (5.3)$$

Where REC is total renewable energy consumption, SREC is the share of renewable energy consumption, K is the gross capital formation, as an indicator for capital stock, L is the total number of employees which is considered as an indicator for labor variable, T is per capita R&D expenditure, as an indicator for technological progress, it represents a natural logarithm, and $\varphi, \alpha, \beta, \gamma, \delta, and\ \lambda$ are unknown parameters to be estimated, μ is an error term.

In the next chapter, I will utilize the above equation to estimate the GDP for Morocco and Egypt. To get the unknown parameters, I will be using two estimation models: Regression Analysis and Goal Programming (GP). The obtained estimation results will be compared.

Conclusion

In this chapter, I have indicated how production was measured by economists. Then I described the production function in general and indicated a special form of it that is called Cobb-Douglas and its assumptions. Moreover, I highlighted a few debate points about this model. In addition, I have shown how the REC, SREC, and other input parameters of an economy can be used to estimate the GDP of a country in a form that was utilized in a study on China's economy. However, the study mentioned measured a few dependent variables, whereas, I used only one parameter which is the GDP as a dependent variable. In the coming chapters, I will introduce to regression and goal optimization programming to estimate the unknown parameters of the equation (5.3).

Chapter 6: Data collection and Regression analysis for Egypt and Morocco

Abstract

The relationship between the Growth Domestic Product GDP and renewable energy consumption REC in both Egypt and Morocco was found negative using regression analysis for the period of 1990 to 2014; the World Bank data. While the use of None REC NREC has a negative relationship with GDP in Egypt and positive in the case of Morocco.

Introduction

As highlighted in the previous chapters, there is a trend of increase in energy consumption, especially emerging economies. Moreover, the economic growth presented in the form of GDP has a clear relationship with Renewable Energy Sources RES in different ways. Egypt and Morocco, which were chosen for the study, have been presented as cases of challenges and opportunities in the field. After outlining, these elements, I am going to clarify the data collected about Egypt and Morocco. Then show how the data analysis is going to be made. The Cobb-Douglas production function (equation 5.3) in the general form of,

$$\ln \text{GDP} = \varphi + \alpha \ln \text{REC} + \beta \ln \text{SREC} + \gamma \ln \text{K} + \delta \ln \text{L} + \lambda \ln \text{T} + \mu ,$$

will be specified for the purpose of this study to have only 4 independent terms: REC, NREC, L, and GFCF which will be detailed in the chapter. This is similar to the selected form by (Selim Adem Hatirli, 2005) and (Bhattacharya, 2016). Therefore, the equation that will be utilized is:

$$\ln \text{GDP} = \varphi + \alpha \ln \text{REC} + \beta \ln \text{SREC} + \gamma \ln \text{GFCF} + \delta \ln \text{L} \quad (7.1)$$

Eventually, I aim to estimate the relationship between GDP and REC by finding, $\alpha, \beta, \gamma,$ and δ.

Data definitions

In order to use Cobb-Douglas and Goal Programming models, I will be utilizing data this is collected from reliable sources. Therefore, I used the world bank website as a source. The data collected for both Egypt and Morocco were for the following components of the economy:

6.3.1 GDP (Current LCU), GDP

The Growth Domestic Product GDP of a country is considered a good measure for the whole economy output measured monetarily. This helps to compare economies for different countries and the size of a country. There are also many economic measures based on the GDP such as GDP per capita, and per capita at purchasing power parity PPP which can help in comparing nations especially in the standard of living. In this study, I am using the GDP (current Local Currency LCU) in terms of local currency. The mentioned GDP collected is from the world bank website (World_Bank, 2019), and I used it without referring to it as current LCU. In other words, I call GDP (current LCU) GDP for the ease of use. It is used here as the dependent variable in the production equation of Cobb-Douglas, referred earlier in chapter 5. This below will be estimated using the following independent variables of L, GFCF, REC, NREC.

6.3.2 Labor Force Total (L)

The labor total force L measures the number of people over 15 years old, employed and none employed. This is counts for the active part of the citizens in the country who are capable of productivity as indicated by the international labor organization. This presents the variable L in equation 7.1.

6.3.3 Gross Fixed Capital Formation GFCF

It identifies the value of the expenditure in the gross domestic product GDP. It is statistically calculating the value of the new and existing acquisitions of fixed assets for a specific economical organization such as governments, and companies after deducting the disposal of fixed assets. In other terms, it is the net acquisition of fixed assets spent from the GDP. It is called gross as it does not consider the depreciation of the assets over time (Wikipedia, 2014). This represents K in the Cobb-Douglas equation.

6.3.4 Renewable Energy Consumption REC

The term REC represents the renewable energy consumption out of the total energy consumed in the country. In order to calculate it, I had to multiply the share of REC of a country by the value of total energy consumption equivalent in kg of oil. In this case, the total energy consumption in the country is considered to consist of REC and none REC which is called NREC.

6.3.5 Non-Renewable Energy Consumption NREC

From the total energy consumption of the country, quantifying the share of REC, NREC could be easily obtained as the rest of the total. Therefore, REC + NREC = 100% of the total energy consumption of the country. Which results in that NREC = Total energy consumption of the country – NREC. All the three terms were in kg of equivalent oil, from the world bank website (World_Bank, 2019).

After indicating how the data was obtained and defining each variable, Egypt and Morocco data will be presented and described.

Egypt and Morocco's data

The data collected for Egypt and Morocco from the World Bank were for the period from 1990 to 2014. This is due to the fact that they were available and non-interrupted. There were no missing years for all the variables needed in the study. The following sections will describe statistically each country then run into the analysis by both regression and goal optimization programming as indicated in the earlier chapters.

6.4.1 The description of the data of Egypt

Below is the description of each variable in the equation that was introduced earlier.

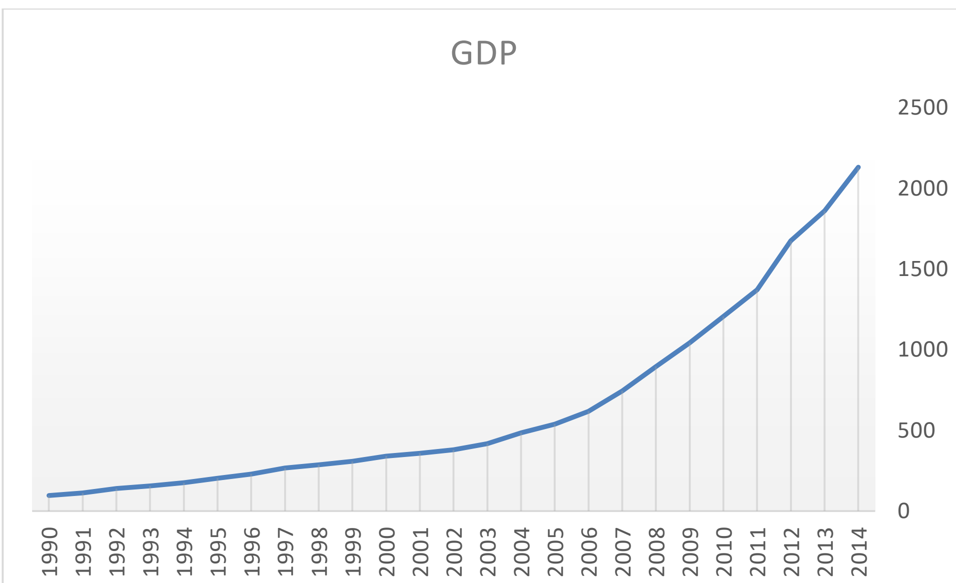

Figure 5. GDP of Egypt in billion Egyptian Pounds

GDP in Egypt was slightly growing from 1990 until around the year 2003 linearly then it started to exponentially grow until 2014. The numbers shown are in billion local currency (Egyptian Pounds).

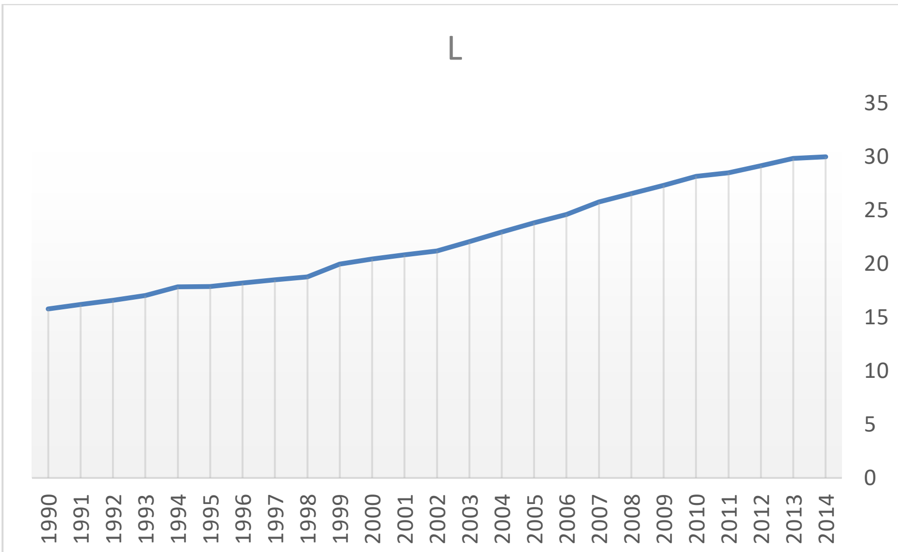

Figure 6. Labor of Egypt in million

Labor L in million is presented in the above graph which was always linearly growing steadily until 2003 then the slope of the increased mildly raised.

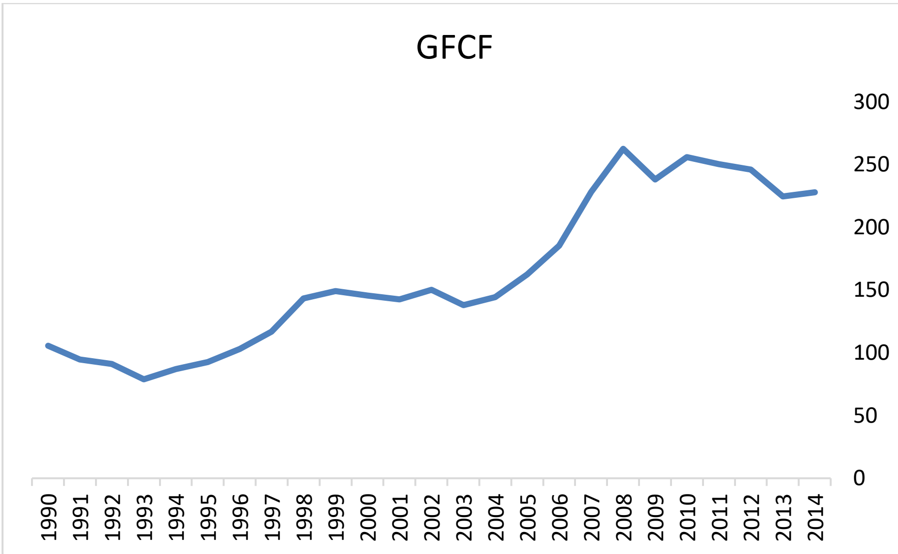

Figure 7. Gross Fixed Capital Formation of Egypt in billion Egyptian Pound

The GFCF is presented in billion local currency as well. The value kept increasing until peaked in 2008 for 262. Then it started to decrease until 2014 to become 227.

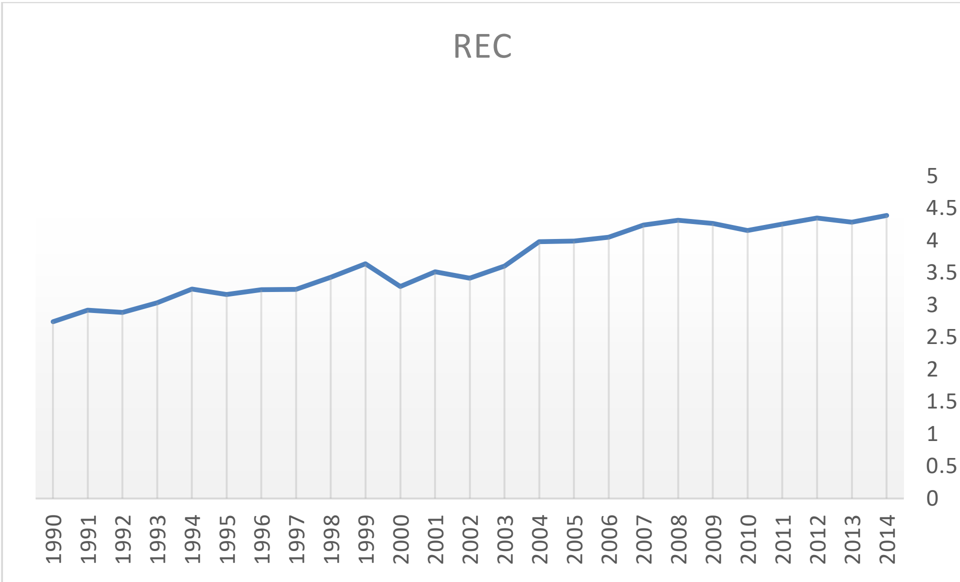

Figure 8. Renewable Energy Consumption of Egypt in billion kg of equivalent oil

The REC in billion kg of equivalent oil of energy in Egypt is shown on the graph which also though continually increasing, it has a few localized ups and downs.

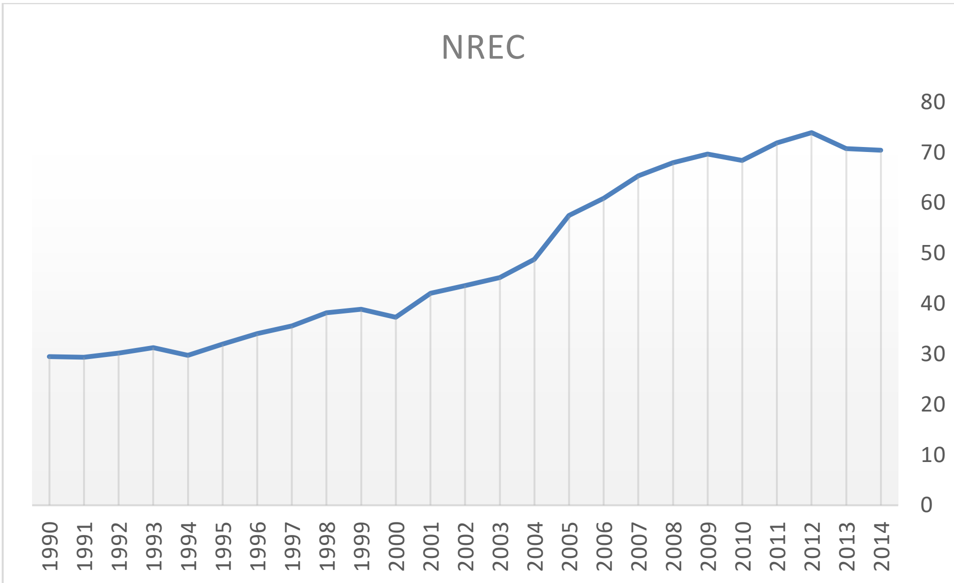

Figure 9. Non-Renewable Energy Consumption of Egypt in billion kg of equivalent oil

Similar to REC, the NREC is in billion kg of equivalent oil. And the graph and number show how significant the NREC is more than the REC. Moreover, the increase in non-renewable energy consumption has heavily increased after the year of 2003. Then it almost flattened in 2010 – 2012 and eventually started to decrease.

Although the above data are the real data, the Cobb-Douglas has a logarithm transformation of the numbers. Secondly, one of the techniques of estimation that I will use is a regression. Which has some assumptions those have to be verified such as multicollinearity. For that, I will present the correlations between them after taking the natural log of each variable (ln). In order to do this, I am going to present the correlations done by SPSS. Regression analysis is used to construct a model for a dependent variable estimation out of independent variables (Tabachnick, 1996). Moreover, it is utilized to find relationships with the independent variables. In such research, causality does not have to be assumed.

6.4.2 Correlation

The following table (table 6.1) has the correlations between the variables of the equation (6.1).

Table 2. Correlation table for Egypt

	LN (GDP)	**LN (L)**	**LN (GFCF)**	**LN (REC)**	**LN (NREC)**
LN (GDP)	1				
LN (L)	.991**	1			
LN (GFCF)	.930**	.946**	1		
LN (REC)	.955**	.970**	.924**	1	
LN (NREC)	.966**	.986**	.961**	.968**	1

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

With the above results about the correlations among the independent variables, multicollinearity can be concluded as follows. The independent variables demonstrate intercorrelation. Therefore, there is an issue of multicollinearity, as the correlation values are above 0.7, which is one of the main assumptions that affect the linear regression model. Moreover, all the variables are significant at the level of 0.01.

6.4.3 Regression summary

Table 3. Regression Summary table for Egypt

R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
.993	0.985	0.982	0.120486695

The R square is truly high as it is 0.985 which means that 98.5% of the GDP (dependent variable) variations in GDP can be explained by the independent variables.

Table 4. Regression Coefficient table for Egypt

	Unstandardize Coefficients		**Standardized Coefficients**	**T**	**Sig.**
	B	Std. Error	Beta		
(Constant)	-45.28	8.117		-5.578	0
LN (L)	5.815	0.743	1.362	7.828	0

	Unstandardize Coefficients		Standardized Coefficients	T	Sig.
LN (GFCF)	0.098	0.231	0.042	0.425	0.675
LN (REC)	-0.165	0.715	-0.027	-0.231	0.82
LN (NREC)	-1.022	0.525	-0.39	-1.945	0.066

As shown in the above table the coefficients of the parameters found from the regression are in the second column. The relationship between the GDP and L and GFCF is positive whereas it is negative for REC and NREC. Therefore, in this case, the hypothesis cannot be proven. I failed to verify that the GDP increases with the REC increases. In other terms, the economic growth in Egypt failed to be justified by the increased utilization of renewable energy sources.

However, I still succeeded to find a relationship between GDP and REC in the country.

In the following section, I will introduce a similar regression analysis for Morocco. Then, I will illustrate the goal optimization as a method to find the equation parameters (coefficients of Cobb-Douglas). Afterward, I will show the advantage and disadvantage of using each methodology.

6.4.4 The description of the data of Morocco

Below is the description of each variable in the equation that was introduced earlier.

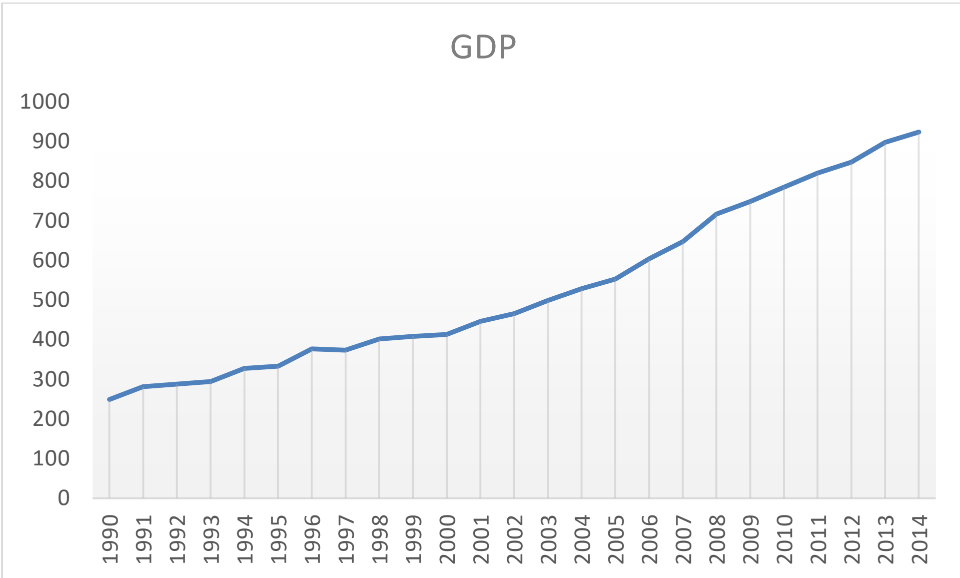

Figure 10. GDP of Morocco in billion in Moroccan Dirham

GDP in Morocco is linearly growing with a fixed slope then it ramped a bit in 2005 and continued to be linear. The numbers shown are in billion local currency (Moroccan dirham).

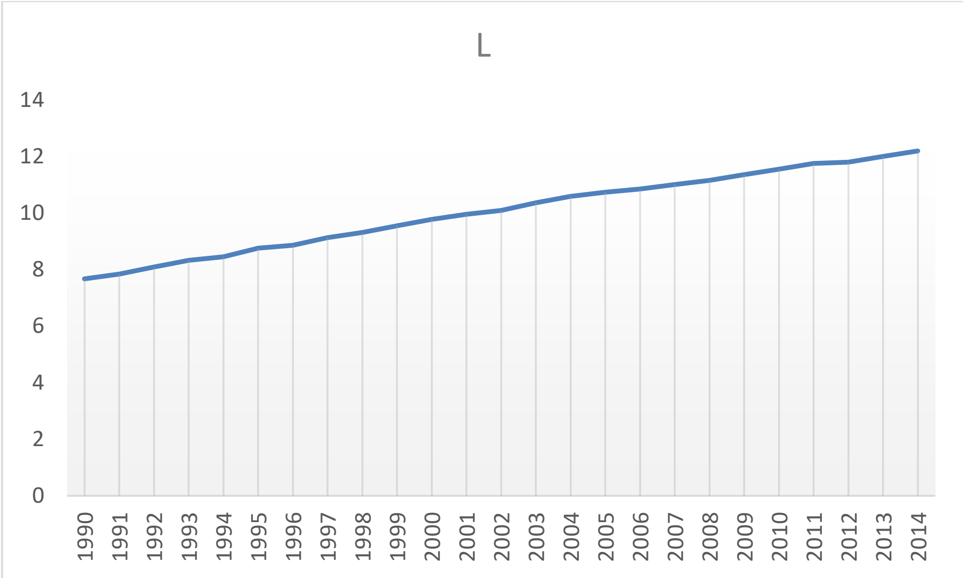

Figure 11. Labor of Morocco in million

Labor L in million is presented in the above graph which was always linearly growing steadily for the entire period from 1990 to 2014.

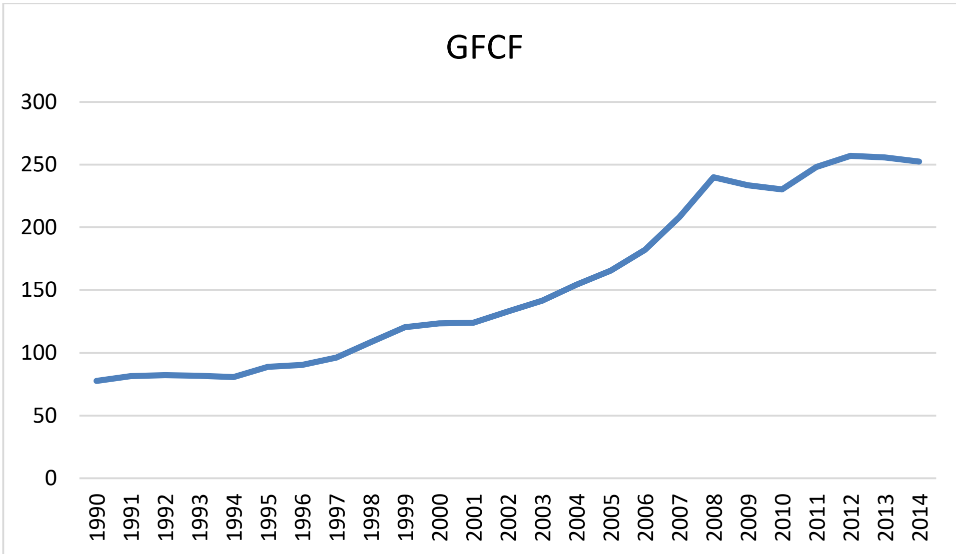

Figure 12. Gross Fixed Capital Formation of Morocco in billion Moroccan Dirham

The GFCF is presented in billion local currency as well. It linearly increased until peaked in 2008 at 238 locally then slightly decreased and continued to increase till 257 and 252 in 2013 and 2014.

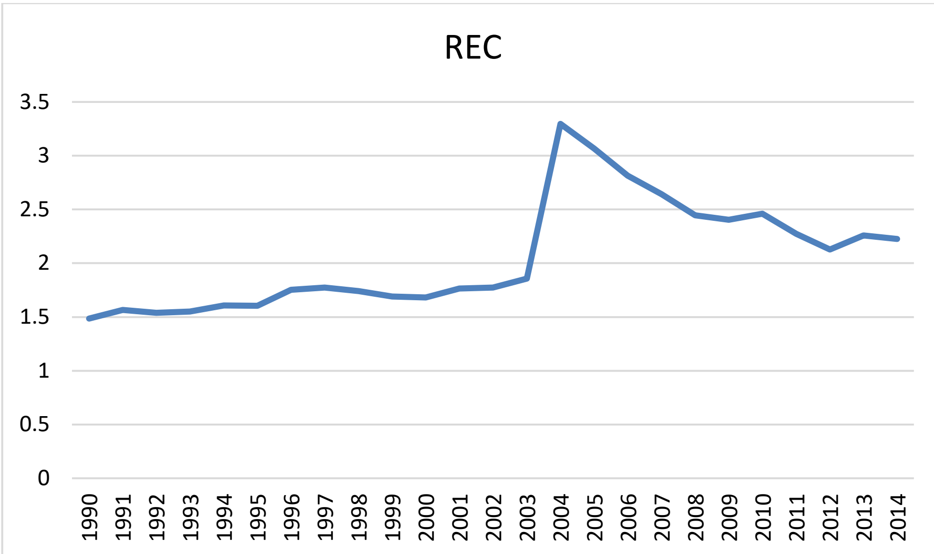

Figure 13. Renewable Energy Consumption of Morocco in billion kg of equivalent oil

The REC in billion kg of equivalent oil of energy in Morocco is shown on the graph which also though continually increasing until 2003 linearly from 1.5 to about 1.9. Then it peaked in 2004 to be about 3.3 then deeply depleted until it reached 2.2 in 2014.

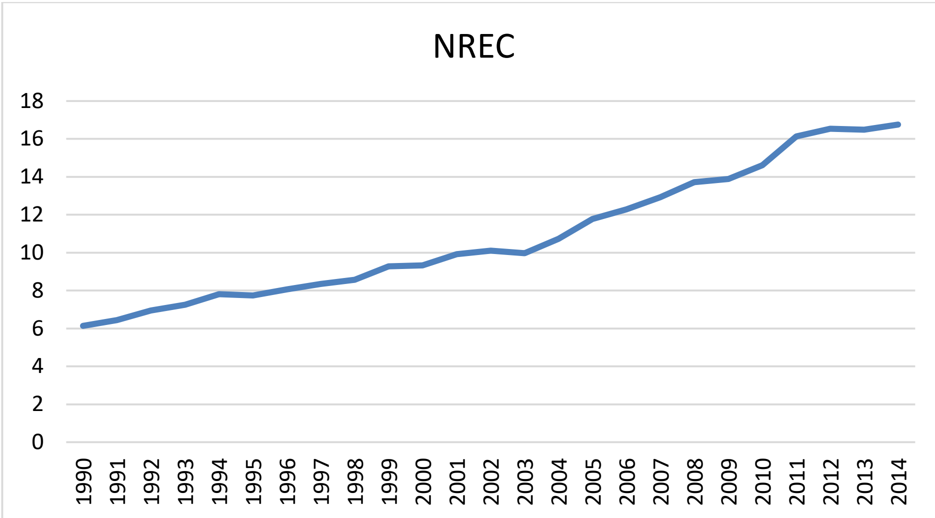

Figure 14. Non-Renewable Energy Consumption of Morocco in billion kg of equivalent oil

Similar to REC, the NREC is in billion kg of equivalent oil. And the graph and number show how significant the NREC is more than the REC. Moreover, the increase in non-renewable energy consumption has steadily and mildly increased for the entire period with a higher slope starting in 2003.

Similar to the data from Egypt, it is real data; however, the Cobb-Douglas has a logarithm transformation of the numbers. Additionally, I will use regression to estimate the relationship between the variables. I will also verify some assumptions such as multicollinearity. For that, I will present the correlations between them after taking the natural log of each variable (ln). In order to do this, I am going to present the correlations done by SPSS. Regression analysis is used to construct a model for a dependent variable.

6.4.5 Correlation

The following table (table 6.2) has the correlations between the variables of the equation (6.1).

Table 5. Correlation table for Morocco

	LN (GDP)	**LN (L)**	**LN (GFCF)**	**LN (REC)**	**LN (NREC)**
LN (GDP)	1				
LN (L)	.984**	1			
LN (GFCF)	.987**	.972**	1		
LN (REC)	.743**	.772**	.761**	1	
LN (NREC)	.996**	.983**	.985**	.734**	1

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

With the above results about the correlations among the independent variables, multicollinearity can be concluded as follows. The independent variables demonstrate intercorrelation. Therefore, there is an issue of multicollinearity, as each correlation values are above 0.7, which is one of the main assumptions that affect the linear regression model.

Moreover, all the variables are significant at the level of 0.01.

6.4.6 Regression summary

Table 6. Regression Summary table for Morocco

R	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
0.997	0.994	0.992	0.03538

The R square is truly high as it is 0.997 which means that 99.7% of the GDP (dependent variable) variations in GDP can be explained by the independent variables.

Table 7. Regression Coefficient table for Morocco

	Unstandardized Coefficients		**Standardized Coefficients**	**t**	**Sig.**
	B	Std. Error	Beta		
(Constant)	-3.443	1.862		-1.849	0.079
LN (L)	0.36	0.3	0.127	1.202	0.243
LN (GFCF)	0.191	0.099	0.209	1.93	0.068
LN (REC)	-0.008	0.052	-0.004	-0.149	0.883

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
LN (NREC)	0.859	0.181	0.668	4.757	0

As shown in the above table the coefficients of the parameters found from the regression are in the second column. The relation between the GDP and L and GFCF is positive whereas it is negative for REC. On the contrary, NREC has a positive relationship with GDP. Therefore, in this case, the hypothesis cannot be proven. I failed to verify that the GDP increases with the REC increases. In other terms, the economic growth in Morocco failed to be justified by the increased utilization of renewable energy sources.

However, I still succeeded to find a relationship between GDP and REC in the country.

Conclusion

Using regression, I estimated the coefficients of the variable for the relationship between the economic welfare of Egypt and Morocco, Growth Domestic Product GDP, and Renewable Energy Consumption REC that was constructed and proven for the two countries using the World Bank data for the years from 1990 to 2014. Both have shown a negative relationship; - 0.165 for Egypt and - 0.008 for Morocco. In other words, GDP is negatively impacted by the expansion in REC. While it shows negative for Egypt and positive relationship for Morocco with Non-Renewable Energy Consumption NREC. In the coming chapter, I will try to estimate the same Cobb-Douglas equation parameters using Goal Programming GP.

Chapter 7: The Goal Programming Model For Estimation

Abstract

The Goal Programming GP is a distance function model that minimizes the deviations between the aspiration and achievement levels. This model has been reformulated by (Aouni B., 1997) and (A¨ida Kharrat, 2007) as an estimation model. In the chapter, I presented the mathematical formulation of the Goal Programming model to estimate the GDP of a country.

Introduction

The parametric estimation models in economics field aim to explain and predicting phenomenon behavior (dependent variable) by a) identifying the factors (independent variables) that explain the economic phenomenon behavior, b) provide the type of the distance function that links the economic phenomenon behavior to the explaining factors, and c) the estimation of the factor's contributions in explaining the economic phenomenon. In fact, these models minimize the distance between the observed phenomenon behavior and the predicted one by the mathematical and statistical models. The response functions of these models are based on a) the least squares method and b) the least absolute value method.

According to (Aouni B., 1997), "the Goal Programming constitutes an interesting alternative to some conventional statistical methods such as that of the least squares". In fact, the Goal Programming model is based on mathematical programming techniques and it represents a special case of the distance function model that minimizes the distance between the estimated and the observed values of the economic phenomenon.

Goal Programming can be utilized for estimation by providing a solution for complicated management problems by applying a GP algorithm. This occurs without jeopardizing the necessity of the management to keep all the variables, and objectives in turn, intact in the equation. This is due to the fact that a manager does not have to be subject to the priori principle which is the basis for many other methodologies. In other terms, the GP helps managers to support their decisions by integrating the number of elements they desire without making it impossible to solve or more favorable to drop one or more. In this chapter, I will present it and how to use it for GDP estimation.

Goal Programming Model

(Aouni J.-M. M., 1990) Introduced the structure of decision-makers' preferences into the GP model. This was to judge the decision-making by reviewing the deviations from aspiration levels. Multiple-criteria decision-making problems have many algorithms that can solve it. Goal- programming GP is considered to be one of them. It is a linear programming methodology with special considerations. With complicated decision - making problems, decision-makers have to have priori (aspiration levels). GP stands as a perfect method for such. (Aouni B. a.-M., 2000) introduced to the GP in the study then presented its first form as:

The GP equation can be written as

$$\min_{x \in X} \sum_{i=1}^{p} \left| \sum_{j=1}^{n} a_{ij} x_j - g_i \right| \qquad (8.1)$$

Subject to

$x \leq c$ (system constraint)

Where g_i = the goal of the objective i

x = $(x_1, x_2, \dots, x_n)$ decision-making n-dimensional vector and X is the feasible set of solutions

a_{ij} = technological constrain

The model in a more explanatory format can be written as:

$$\underset{x \in X}{\text{Minimize}}\, Z = \sum_{i=1}^{p} (\delta_i^+ - \delta_i^-) \quad (8.1.1)$$

Subject to

$$\sum_{j=1}^{n} a_{ij}\, x_j - \delta_i^+ + \delta_i^- = g_i$$

$$x \leq c \text{ (system constraint)}$$

$$x_j, \delta_i^+ \; and \; \delta_i^- \geq 0 \; (j = 1,2, \dots, n); (i = 1,2, \dots, p)$$

(8.1.2)

Where $\delta_i^+ and \; \delta_i^-$ are variables that represent the positive and negative deviations from the aspiration levels g_i. In addition, the model is capable of considering the importance of variables by introducing weight W vector to transform it into, as described in (Belaid Aouni, 2009):

$$\underset{x \in X}{\text{Minimize}}\, Z = \sum_{i=1}^{p} (W_i^+ \delta_i^+ - W_i^- \delta_i^-) \quad (8.2)$$

Where W_i^+ and W_i^- are the positive and negative coefficients of importance, respectively, associated with the deviations from each objective i.

The Goal Programming model for estimation

The Goal Programming model aims to minimize the distance between the observed values and estimation. The aim of this estimation model is to determine the contribution of each independent variable in the dependent variable. Therefore, using equation (8.1.1), we can estimate the GDP. Equation (8.3) is a simplified form of (8.1.1).

$$\min \sum_{i=1}^{n} (\mathcal{Y}_i - \hat{\mathcal{Y}}) \tag{8.3}$$

Where $\mathcal{Y}_\mathrm{i}$ is the observed value of the dependent variable.

And $\hat{\mathcal{Y}}$ is the estimated value of the model.

The linear equivalent formulation of (8.3) is

Minimize $\quad \sum_{i=1}^{m} (\delta_i^+ - \delta_i^-)$

Subject to

$$b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + \cdots \dots\dots + b_m x_m + \delta_i^+ + \delta_i^- = \mathcal{Y}_i \tag{8.4}$$

Where

b_0 : the estimation parameter that is not explained by the model which is called the constant,

b_j : the explanation power of the independent variable j,

δ_i^+: the positive deviation between the aspiration level and the estimation,

δ_i^-: the negative deviation between the aspiration level and the estimation.

The minimization of the distances is obtained by a linear programming algorithm which produces a number of parameters that are associated with the decision variables.

7.5. Estimating the GDP using GP

As mentioned earlier in chapter 7, there are 4 independent variables, L, GFCF, REC, and NREC. In order to find out the coefficients of the equation, I utilized regression once. And now, I am going to use GP to estimate the parameters meant. Therefore, equation 8.4 can be seen in the following form:

$$b0 + b1\, x_1 + b2\, x_2 + b3\, x_3 + b4\, x_4 + \delta_i^+ + \delta_i^- = \mathcal{Y}_i \tag{8.5}$$

Where we have only 5 unknowns: *b0, b1, b2, b3,* and *b4* those should be estimated using the Goal Programming. Moreover, I will use n_i to represent the term δ_i^- and p_i to represent the term δ_i^+ for the ease of programming:

In addition, the equations will be as follow:

b0+16.57b1+25.38b2+21.73b3+24.11b4+*n1*-*p1*=25.29

This is the equation for Egypt's first year of data 1990.

Where

16.57 is the L value for Egypt in 1990 has *b1* coefficient

25.38 is the GFCF value for Egypt in 1990 has *b2* coefficient

21.73 is the REC value for Egypt in 1990 has *b3* coefficient

24.11 is the NREC value for Egypt in 1990 has *b4* coefficient

25.29 is the corresponding value of GDP in 1990.

After writing the corresponding equations for years 1990 to 2014 (25 values 1 to 25), we have to request the GP software tool to find out the values of *b0* to *b5* those minimize the value of *p1* to *p25* and *n1* to *n25*.

As follow is the equation constructed for use in the programming subroutine, using the entire set of data:

7.5.1 Egypt

Min *p1 +p2 +p3 +p4 +p5 +p6 +p7 +p8 +p9 +p10 +p11 +p12 +p13 +p14 +p15 +p16 +p17 +p18 +p19 +p20 +p21 +p22 +p23 +p24 +p25+ n1 +n2 +n3 +n4 +n5 +n6 +n7 +n8 +n9 +n10 +n11 +n12 +n13 +n14 +n15 +n16 +n17 +n18 +n19 +n20 +n21 +n22 +n23 +n24 +n25*

Subject to

$b0+16.57b1+25.38b2+21.73b3+24.11b4+n1-p1=25.29$

$b0+16.6b1+25.27b2+21.8b3+24.1b4+n2-p2=25.43$

$b0+16.62b1+25.23b2+21.78b3+24.13b4+n3-p3=25.66$

$b0+16.65b1+25.09b2+21.83b3+24.17b4+n4-p4=25.77$

$b0+16.7b1+25.19b2+21.9b3+24.12b4+n5-p5=25.89$

$b0+16.7b1+25.25b2+21.87b3+24.19b4+n6-p6=26.04$

$b0+16.72b1+25.36b2+21.9b3+24.25b4+n7-p7=26.16$

$b0+16.73b1+25.48b2+21.9b3+24.3b4+n8-p8=26.31$

$b0+16.75b1+25.69b2+21.96b3+24.37b4+n9-p9=26.38$

$b0+16.81b1+25.73b2+22.02b3+24.38b4+n10-p10=26.45$

$b0+16.83b1+25.7b2+21.91b3+24.34b4+n11-p11=26.55$

$b0+16.85b1+25.68b2+21.98b3+24.46b4+n12-p12=26.61$

$b0+16.87b1+25.74b2+21.95b3+24.5b4+n13-p13=26.66$

$b0+16.91b1+25.65b2+22.01b3+24.53b4+n14-p14=26.76$

$b0+16.95b1+25.7b2+22.1b3+24.61b4+n15-p15=26.91$

$b0+16.99b1+25.81b2+22.11b3+24.77b4+n16-p16=27.01$

$b0+17.02b1+25.95b2+22.12b3+24.83b4+n17-p17=27.15$

$b0+17.07b1+26.15b2+22.17b3+24.9b4+n18-p18=27.34$

$b0+17.09b1+26.29b2+22.19b3+24.94b4+n19-p19=27.52$

$b0+17.12b1+26.2b2+22.17b3+24.97b4+n20-p20=27.67$

$b0+17.15b1+26.27b2+22.15b3+24.95b4+n21-p21=27.82$

$b0+17.17b1+26.25b2+22.17b3+25b4+n22-p22=27.95$

$b0+17.19b1+26.23b2+22.19b3+25.03b4+n23-p23=28.15$

$b0+17.21b1+26.14b2+22.18b3+24.98b4+n24-p24=28.25$

$b0+17.22b1+26.15b2+22.2b3+24.98b4+n25-p25=28.39$

b0, b1, b2, b3, and *b4* are free

n_i and $p_i \geq 0$ (i = 1, 2, 3, ... ,25)

7.5.2 Morocco

Min $p1 +p2 +p3 +p4 +p5 +p6 +p7 +p8 +p9 +p10 +p11 +p12 +p13 +p14 +p15 +p16 +p17 +p18 +p19 +p20 +p21 +p22 +p23 +p24 +p25+ n1 +n2 +n3 +n4 +n5 +n6 +n7 +n8 +n9 +n10 +n11 +n12 +n13 +n14 +n15 +n16 +n17 +n18 +n19 +n20 +n21 +n22 +n23 +n24 +n25$

Subject to

$b0+15.85b1+25.08b2+21.12b3+22.54b4+n1-p1=26.24$

$b0+15.87b1+25.12b2+21.17b3+22.59b4+n2-p2=26.36$

$b0+15.91b1+25.13b2+21.15b3+22.66b4+n3-p3=26.39$

$b0+15.93b1+25.13b2+21.16b3+22.7b4+n4-p4=26.41$

$b0+15.95b1+25.11b2+21.2b3+22.78b4+n5-p5=26.52$

$b0+15.99b1+25.21b2+21.2b3+22.77b4+n6-p6=26.53$

$b0+16b1+25.23b2+21.28b3+22.81b4+n7-p7=26.65$

$b0+16.03b1+25.29b2+21.3b3+22.84b4+n8-p8=26.64$

$b0+16.05b1+25.41b2+21.28b3+22.87b4+n9-p9=26.72$

$b0+16.07b1+25.51b2+21.25b3+22.95b4+n10-p10=26.73$

$b0+16.1b1+25.54b2+21.24b3+22.96b4+n11-p11=26.75$

$b0+16.11b1+25.54b2+21.29b3+23.02b4+n12-p12=26.82$

b0+16.13b1+25.61b2+21.3b3+23.04b4+n13-p13=26.87

b0+16.15b1+25.68b2+21.34b3+23.02b4+n14-p14=26.93

b0+16.18b1+25.76b2+21.92b3+23.1b4+n15-p15=26.99

b0+16.19b1+25.83b2+21.84b3+23.19b4+n16-p16=27.04

b0+16.2b1+25.93b2+21.76b3+23.23b4+n17-p17=27.13

b0+16.21b1+26.06b2+21.69b3+23.28b4+n18-p18=27.2

b0+16.23b1+26.2b2+21.62b3+23.34b4+n19-p19=27.3

b0+16.25b1+26.18b2+21.6b3+23.35b4+n20-p20=27.34

b0+16.26b1+26.16b2+21.62b3+23.41b4+n21-p21=27.39

b0+16.28b1+26.24b2+21.54b3+23.5b4+n22-p22=27.43

b0+16.28b1+26.27b2+21.48b3+23.53b4+n23-p23=27.47

b0+16.3b1+26.27b2+21.54b3+23.53b4+n24-p24=27.52

b0+16.32b1+26.25b2+21.52b3+23.54b4+n25-p25=27.55

b0, b1, b2, b3, and *b4* are free

n_i and $p_i \geq 0$ (i = 1, 2, 3, ... ,25)

7.6. Goal Programming Results

In the following section, I will present the results from Goal Programming for Egypt and Morocco.

7.6.1 Egypt

The coefficients of the Cobb-Douglas found using the Goal Programming are:

Table 8. Goal Programming Coefficients for Egypt

Independent Variable	**Coefficient**	**value**
(Constant)	*b0*	-46.444252
LN (L)	*b1*	6.41207
LN (GFCF)	*b2*	-0.176784
LN (REC)	*b3*	-0.207044
LN (NREC)	*b4*	-1.058809

As shown in table 7.1, both the REC and NREC impact the GDP negatively. This is similar to the results of the Regression model.

7.6.2 Morocco

The coefficients of the Cobb-Douglas found using the Goal Programming are:

Table 9. Goal Programming Coefficients for Morocco

Independent Variable	**Coefficient**	**Value**
(Constant)	*b0*	-5.165181
LN (L)	*b1*	0.476083

Independent Variable	Coefficient	Value
LN (GFCF)	*b2*	0.124634
LN (REC)	*b3*	0.003061
LN (NREC)	*b4*	0.917051

As shown in table 7.1, both the REC and NREC impact the GDP positively. This is similar to the results of the Regression model for NREC. Whereas, it is opposite to Regression in the case of REC.

Conclusion

After finding out *b0* to *b5* for both Egypt and Morocco, I utilized the values to estimate GDP for each year 1990 to 2014. Then I compared estimated values from both models; Regression and Goal Programming, using mean absolute deviation MAD. For Egypt, the MAD is 2.19 for the Regression model while 2.02 for Goal Programming which has a mild difference. Similarly, for Morocco, the MAD is 0.676 for regression while 0.672 for Goal Programming GP. In conclusion, the deviation between the aspiration and estimation levels are similar in the two models with a slight difference in the relationship in terms of direction and the value of the coefficient. However, Goal Programming enhances the decision-making process by providing managers with a tool that gives them flexibility in choosing the model. Moreover, they can value a goal over the other by adding. All of these tools are impossible with Regression model such as “weights, priority levels, thresholds or trade-offs” those are addressed in (Belaid Aouni, 2009).

General Conclusion of the study, Limitation, and Future Research

In this part, I will present the general conclusion of this research where I will discuss the main idea and summarizing the findings of this work and I will highlight also its limitations. Some futures research avenues will be discussed.

7.8.1 General Conclusion of the study

A global trend towards renewable energy sources used has been a hot debate in recent years. That is due to some facts that many countries face such as energy prices are increasing and change drastically due to global changes, the geopolitical situations stress countries’ economics due to the dependence of their economic activities on oil and gas, and the huge technological advancements in the renewable energy field that caused their prices to decrease. This study, therefore, was looking to the effect of the renewable energy sources consumption on the economic growth in Egypt and Morocco.

Through the Cobb-Douglas production function model, I estimated the dynamic relationship of the renewable energy sources, non-renewable energy sources, Labor and Gross Fixed Capital Formation with the Gross Domestic Product (GDP). This is using the data from 1990 to 2014 from the World Bank database. This was done using two linear estimation techniques; Regression which is a statistical method and Goal Programming which is a mathematical programming model.

Using linear Regression, I concluded that GDP for Egypt has a positive relationship with Labor, Gross Fixed Capital Formation and negative relationship with renewable and non-renewable energy consumption. Moreover, for Morocco, GDP has a positive relationship with all the variables except the renewable energy sources consumption which is, in fact, negative.

Furthermore, using Goal Programming, GDP in Egypt has a negative relationship with all the variable except the Labor. However; for Morocco, GDP has a positive relationship with all the variables.

Both models provided a good estimation for the relationship with GDP which can help policymakers to make informed decisions taken into consideration all the influences generated from such combination. Although the relationship is different between the two models, this is a positive finding that shows that different approaches have different meanings and implications. This makes decision-makers alerted about the nature of each variable and gives them flexibility in considering a technique for use. For instance, although both models are linear, GP has a few advantages over the Regression such as providing an option to assign weighs to values of the goal and trade-offs or thresholds. Consequently, decision-makers can add their contribution by leveraging a goal over the other to underweight a year of GDP for instance or increase its importance when needed.

In addition, although the negative relationship with the renewable energy sources is not desired, it can be due to the fact that both countries are still building their capabilities in the field, research and development, manufacturing, and installation. As both countries counties to import most of the technology need for such sector, it will continue to cost them much until they cop up to the level when they can achieve real economic welfare of it; on the long-term.

Encourage investments in the field of renewable energy sources by the private sector in such counties is a challenge to emerging economies. Therefore, policymakers have to evaluate the value of using renewables in the true development of the country. In such, they have to increase the incentives, in research and development, manufacturing, installations, and services such as training and developing human resources. Financially, they have to invest in renewables operators by decreasing taxes and financial implications such as establishment and license fees. On the legal and institutional side, they should encourage a freer marker for energy that prefers renewables over fossil fuel. International organizations such as UN and World Bank should also support such transformations in these countries, as they will still face technical issues such as the unstoppable manpower to install and run them without the need of importing spare parts and technology, which means a higher cost versus return on the medium-term.

7.8.2 Limitations

Firstly, for Egypt and Morocco where I used the data for, it was difficult to find a local governmental website that can provide updated data, as a lot is going after a sever strive for energy in both. Therefore, I used international resources, mentioned in the references. Similarly, the available data was until 2014, and although from 2015 to 2018 both countries were booming in the field of renewable energy and the news was full of new projects and decisions, the World Bank and other websites lack information about both the countries.

Secondly, it was too difficult to take any contribution from policymakers which could have enhanced the study. In other words, policymakers' preferences were not taken into consideration.

Lastly, due to the absence of policymakers' in the process of the study, all the factors were considered deterministic; however, in practice, the stochastic approach could have been more realistic and appropriate. Consequently, the probability distribution of the variables was not taken into account.

7.8.3 Future Research

As indicated in the limitations, the deterministic approach was considered in the study. Therefore, it would be useful to consider the stochastic nature of the variables where the values of the parameters are subject to probability distributions.

Moreover, a similar study can be applied to Qatar’s economic growth in relation to renewable energy sources used.

In addition, involve real policy makers in the study which can help to develop more realistic results. They can, for instance, decide to undervalue one of the observations due to some abnormal factors, such as revolutions or sever political issues. Therefore, some of the data of certain years could have different weights, more or less, in the estimation.

Furthermore, the study can be extended to contain non-linear statistical tools instead of the linear approaches that I followed.

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APPENDIX

Appendix A: Morocco's data from the World Bank

Morocco					
	GDP	**L**	**REC**	**NREC**	**GFCF**
1990	248.7535	7.668712	1.484273	6.1342	77.72808
1991	281.096	7.839376	1.565619	6.44044	81.52713
1992	287.8251	8.090429	1.537924	6.942428	82.07968
1993	294.3642	8.324223	1.552068	7.248546	81.62039
1994	327.6649	8.449848	1.608007	7.816888	80.68876
1995	333.3186	8.75518	1.602786	7.735172	88.84373
1996	376.1909	8.861257	1.751744	8.062174	90.31147
1997	372.9615	9.131262	1.77251	8.343622	96.15209
1998	401.5237	9.310525	1.740082	8.570047	108.4145
1999	408.1771	9.553581	1.688999	9.272737	120.3087
2000	412.8972	9.77512	1.681369	9.33749	123.4618
2001	446.0116	9.952465	1.76576	9.915077	123.9888
2002	465.4922	10.08808	1.773333	10.09945	133.0175
2003	498.4821	10.36455	1.856225	9.964354	141.4579
2004	528.7635	10.58715	3.29633	10.72737	154.4054
2005	552.6709	10.73653	3.066445	11.77771	165.5872

Morocco					
2006	603.7372	10.84445	2.815174	12.28027	182.1345
2007	647.53	11.01105	2.641983	12.92715	208.216
2008	716.959	11.15124	2.444144	13.72187	239.885
2009	748.483	11.35473	2.402746	13.87983	233.5466
2010	784.624	11.55294	2.460959	14.61971	230.1654
2011	820.077	11.75109	2.273269	16.13127	248.106
2012	847.881	11.79598	2.128687	16.53583	257.0818
2013	897.923	12.00322	2.258678	16.48514	255.7554
2014	923.696	12.19802	2.22436	16.75711	252.541

Morocco					
	LN (GDP)	**LN (L)**	**LN (GFCF)**	**LN (REC)**	**LN (NREC)**
1990	26.24	15.85	25.08	21.12	22.54
1991	26.36	15.87	25.12	21.17	22.59
1992	26.39	15.91	25.13	21.15	22.66
1993	26.41	15.93	25.13	21.16	22.7
1994	26.52	15.95	25.11	21.2	22.78
1995	26.53	15.99	25.21	21.2	22.77
1996	26.65	16	25.23	21.28	22.81
1997	26.64	16.03	25.29	21.3	22.84
1998	26.72	16.05	25.41	21.28	22.87

Morocco					
1999	26.73	16.07	25.51	21.25	22.95
2000	26.75	16.1	25.54	21.24	22.96
2001	26.82	16.11	25.54	21.29	23.02
2002	26.87	16.13	25.61	21.3	23.04
2003	26.93	16.15	25.68	21.34	23.02
2004	26.99	16.18	25.76	21.92	23.1
2005	27.04	16.19	25.83	21.84	23.19
2006	27.13	16.2	25.93	21.76	23.23
2007	27.2	16.21	26.06	21.69	23.28
2008	27.3	16.23	26.2	21.62	23.34
2009	27.34	16.25	26.18	21.6	23.35
2010	27.39	16.26	26.16	21.62	23.41
2011	27.43	16.28	26.24	21.54	23.5
2012	27.47	16.28	26.27	21.48	23.53
2013	27.52	16.3	26.27	21.54	23.53
2014	27.55	16.32	26.25	21.52	23.54

MAD Calculation

Morocco

	Goal Optimization Forecast (Goal Optimization)	Error	Absolute Deviation
1990	26.2415	-0.0015	0.00153
1991	26.302	0.05795	0.05795

MAD Calculation

Morocco

	Goal Optimization Forecast (Goal Optimization)	**Error**	**Absolute Deviation**
1992	26.3865	0.00353	0.00353
1993	26.4327	-0.0227	0.0227
1994	26.5132	0.00678	0.00678
1995	26.5356	-0.0056	0.00555
1996	26.5797	0.07027	0.07027
1997	26.6291	0.01093	0.01093
1998	26.681	0.039	0.039
1999	26.7763	-0.0463	0.04625
2000	26.8034	-0.0534	0.05341
2001	26.8634	-0.0434	0.04335
2002	26.9	-0.03	0.02997
2003	26.9	0.03	0.03
2004	26.9994	-0.0094	0.00939
2005	27.0952	-0.0552	0.05516
2006	27.1488	-0.0188	0.01883
2007	27.2154	-0.0154	0.01543
2008	27.2972	0.00279	0.00279
2009	27.3133	0.02666	0.02666
2010	27.3707	0.0193	0.0193
2011	27.4725	-0.0425	0.04248
2012	27.5035	-0.0335	0.03355

MAD Calculation			
Morocco			
	Goal Optimization		
	Forecast (Goal Optimization)	**Error**	**Absolute Deviation**
2013	27.5133	0.00675	0.00675
2014	27.5294	0.02061	0.02061
		MAD	0.67219

Morocco			
	Regression		
	Forecast (Regression)	**Error**	**Absolute Deviation**
1990	26.2648	-0.0248	0.02481
1991	26.3223	0.03766	0.03766
1992	26.3998	-0.0098	0.00983
1993	26.4418	-0.0318	0.03177
1994	26.514	0.00601	0.00601
1995	26.5395	-0.0095	0.00948
1996	26.5806	0.06937	0.06937
1997	26.6289	0.01111	0.01111
1998	26.6846	0.0354	0.0354
1999	26.7795	-0.0495	0.04946
2000	26.8053	-0.0553	0.05534
2001	26.8602	-0.0401	0.04015
2002	26.8979	-0.0279	0.02787

Morocco			
	Regression Forecast (Regression)	Error	Absolute Deviation
2003	26.9012	0.02885	0.02885
2004	26.9914	-0.0014	0.00136
2005	27.0857	-0.0457	0.04574
2006	27.1429	-0.0129	0.01289
2007	27.214	-0.014	0.01403
2008	27.2995	0.00053	0.00053
2009	27.3123	0.02768	0.02768
2010	27.3637	0.02631	0.02631
2011	27.4638	-0.0338	0.03382
2012	27.4955	-0.0255	0.02547
2013	27.5028	0.01719	0.01719
2014	27.5157	0.03434	0.03434
		MAD	0.67647
Error Reduction	0.63%		

Appendix B: Egypt's data from the World Bank

Egypt					
	GDP	**L**	**REC**	**NREC**	**GFCF**
1990	96.1377	15.7859	2.74212	29.5088	105.688
1991	111.244	16.1886	2.921	29.348	94.6501
1992	139.1	16.5772	2.88574	30.2264	91.0184
1993	155.2	17.0249	3.03503	31.3007	78.8494
1994	175	17.8433	3.24674	29.7856	87.0632
1995	204	17.8728	3.16259	31.9655	92.6591
1996	229.4	18.1955	3.23558	34.0489	103.183
1997	265.9	18.4887	3.24037	35.5909	116.928
1998	287.4	18.7739	3.43204	38.176	143.442
1999	307.6	19.9571	3.64107	38.8961	149.114
2000	340.1	20.4492	3.28832	37.2994	145.681
2001	358.7	20.8232	3.5128	42.0683	142.499
2002	378.9	21.2067	3.41342	43.6059	150.339
2003	417.5	22.0743	3.60571	45.206	137.932
2004	485.3	22.9541	3.9803	48.7818	144.471
2005	538.5	23.8252	3.99095	57.4852	162.464
2006	617.7	24.6167	4.04942	60.9079	185.523
2007	744.8	25.7789	4.2394	65.3394	228.354
2008	895.5	26.5608	4.3149	67.9624	262.602
2009	1042.2	27.3339	4.26185	69.6916	238.053
2010	1206.6	28.1629	4.15248	68.3912	256.051
2011	1371.1	28.5016	4.25171	71.8804	250.383

Egypt					
2012	1674.7	29.134	4.34685	73.916	246.068
2013	1860.4	29.8443	4.28222	70.7405	224.606
2014	2130	29.9731	4.38934	70.4368	227.92

Egypt					
	LN (GDP)	**LN (L)**	**LN (GFCF)**	**LN (REC)**	**LN (NREC)**
1990	25.29	16.57	25.38	21.73	24.11
1991	25.43	16.6	25.27	21.8	24.1
1992	25.66	16.62	25.23	21.78	24.13
1993	25.77	16.65	25.09	21.83	24.17
1994	25.89	16.7	25.19	21.9	24.12
1995	26.04	16.7	25.25	21.87	24.19
1996	26.16	16.72	25.36	21.9	24.25
1997	26.31	16.73	25.48	21.9	24.3
1998	26.38	16.75	25.69	21.96	24.37
1999	26.45	16.81	25.73	22.02	24.38
2000	26.55	16.83	25.7	21.91	24.34
2001	26.61	16.85	25.68	21.98	24.46
2002	26.66	16.87	25.74	21.95	24.5
2003	26.76	16.91	25.65	22.01	24.53
2004	26.91	16.95	25.7	22.1	24.61

Egypt					
2005	27.01	16.99	25.81	22.11	24.77
2006	27.15	17.02	25.95	22.12	24.83
2007	27.34	17.07	26.15	22.17	24.9
2008	27.52	17.09	26.29	22.19	24.94
2009	27.67	17.12	26.2	22.17	24.97
2010	27.82	17.15	26.27	22.15	24.95
2011	27.95	17.17	26.25	22.17	25
2012	28.15	17.19	26.23	22.19	25.03
2013	28.25	17.21	26.14	22.18	24.98
2014	28.39	17.22	26.15	22.2	24.98

MAD Calculation

Egypt

	Goal Optimization Forecast (Goal Optimization)	Error	Absolute Deviation
1990	25.29	-2E-05	1.9E-05
1991	25.4979	-0.0679	0.06792
1992	25.6056	0.05439	0.05439
1993	25.77	-2E-05	1.9E-05
1994	26.1114	-0.2214	0.22139
1995	26.0329	0.00712	0.00712
1996	26.0719	0.08807	0.08807

MAD Calculation			
Egypt			
	Goal Optimization		
	Forecast (Goal Optimization)	**Error**	**Absolute Deviation**
1997	26.0619	0.2481	0.2481
1998	26.0665	0.31352	0.31352
1999	26.4211	0.02888	0.02888
2000	26.6198	-0.0698	0.06979
2001	26.61	-2E-05	1.9E-05
2002	26.6915	-0.0315	0.03151
2003	26.9197	-0.1597	0.15972
2004	27.064	-0.154	0.15402
2005	27.1296	-0.1196	0.11958
2006	27.2316	-0.0816	0.08159
2007	27.4324	-0.0924	0.09237
2008	27.4894	0.03063	0.03063
2009	27.67	-2E-05	1.9E-05
2010	27.8753	-0.0553	0.05532
2011	27.95	-2E-05	1.9E-05
2012	28.0459	0.10411	0.10411
2013	28.2451	0.00495	0.00495
2014	28.3033	0.08673	0.08673
		MAD	2.01982

Egypt			
	Regression Forecast Regression	Error	Absolute Deviation
	25.365	-0.075	0.07496
	25.4958	-0.0658	0.0658
	25.6017	0.05826	0.05826
	25.6986	0.07138	0.07138
	26.021	-0.131	0.13095
	25.9688	0.0712	0.0712
	26.0151	0.14488	0.14488
	26.0748	0.23518	0.23518
	26.1027	0.27729	0.27729
	26.4331	0.01694	0.01694
	26.6321	-0.0821	0.08208
	26.6014	0.00856	0.00856
	26.6809	-0.0209	0.02085
	26.8597	-0.0997	0.0997
	26.9974	-0.0874	0.08739
	27.0573	-0.0473	0.04728
	27.1988	-0.0488	0.04882
	27.4081	-0.0681	0.06808
	27.5524	-0.0324	0.03238
	27.686	-0.016	0.01598
	27.8904	-0.0704	0.0704
	27.903	0.04703	0.04703

Egypt		
Regression		
Forecast	Error	Absolute
Regression		Deviation
27.9967	0.15332	0.15332
28.1752	0.07484	0.07484
28.202	0.18803	0.18803
	MAD	2.19157
Error Reduction	7.84%	