Renewable and Non-Renewable Energy Nexus for Sustainable Development of the MENA Region

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ABSTRACT

The world is growing at a rapid rate and so is the negative effect of man-made effort in increasing economic growth. As a country looks forward to increase her level of growth, the same level of enthusiasm should be applied to make it sustainable. To analyze this, Adjusted Net Savings is empirically modelled by utilizing Renewable Energy Consumption, Energy Use and control variables (Trade and GDP) using data from 9 developed countries and 9 developing countries in the MENA region between 2000 and 2017. The Granger causality test between adjusted net savings and energy use showed a one-way causality relationship while having a bi-directional relationship with renewable energy consumption. To measure the turning point between both sources of energy analyzed, we employ the quadratic regression function to find the turning point from the nonlinear model specification. The minimum level of sustainability is higher in developed countries compared to developing countries hence, developing countries still heavily dependent on conventional sources of energy will need higher levels of adjusted net savings to cater for the externalities of their energy choices.

Keywords: Adjusted Net Savings, Renewable Energy Consumption, Energy Use, Sustainable Development. Dynamic Common Correlated Effects Estimator

ÖZ

Dünya hızlı bir şekilde büyüyor ve insanoğlunun ekonomik büyümeyi artırma çabalarının olumsuz etkisi de öyle. Bir ülke büyüme düzeyini arttırmayı dört gözle beklerken, sürdürülebilir kılmak için aynı seviyede bir coşku uygulanmalıdır. Bunu analiz etmek için, Düzeltilmiş Net Tasarruf, 2000-2017 yılları arasında MENA bölgesindeki 9 gelişmiş ülke ve 9 gelişmekte olan ülkeden alınan veriler kullanılarak Yenilenebilir Enerji Tüketimi, Enerji Kullanımı ve kontrol değişkenleri (Ticaret ve GSYİH) kullanılarak ampirik olarak modellenmiştir. Granger nedensellik testi düzeltilmiş net tasarruf ve enerji kullanımı, yenilenebilir enerji tüketimi ile iki yönlü bir ilişki kurarken tek yönlü bir nedensellik ilişkisi göstermiştir. Analiz edilen her iki enerji kaynağı arasındaki dönüm noktasını ölçmek için, doğrusal olmayan model spesifikasyonundan dönüm noktasını bulmak için ikinci dereceden regresyon fonksiyonunu kullanıyoruz. Minimum sürdürülebilirlik düzeyi gelişmiş ülkelerde gelişmekte olan ülkelere göre daha yüksektir, bu nedenle hala geleneksel enerji kaynaklarına bağımlı olan gelişmekte olan ülkeler, enerji seçimlerinin dışsallıklarını karşılamak için daha yüksek seviyelerde ayarlanmış net tasarruflara ihtiyaç duyacaktır**.**

Anahtar Kelimeler: Düzeltilmiş Net Tasarruf, Yenilenebilir Enerji Tüketimi, Enerji Kullanımı, Sürdürülebilir Kalkınma. Dinamik Ortak İlişkili Etkiler Tahmincisi

This research work is dedicated to my parents who saw me through this phase, friends and family who inspired me and to further research on energy and sustainability.

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AN_tS	Adjusted Net Savings
ENU	Energy Use
EKC	Environmental Kuznet Curve
GDP	Gross Development Product
GHG	Green House Gas
IEA	International Energy Administration
MENA	Middle East and North Africa
OECD	Organization for Economic Co-operation and Development
REN	Renewable Energy Consumption
SD	Sustainable Development
WCED	World Commission on Environment and Development

Chapter 1

INTRODUCTION

1.1 Background of the Study

The long- term availability of energy sources that are affordable, accessible, and environmentally friendly all go a long way to play in sustainable development of any region's economy. The Middle East and North Africa (MENA) region has 57% proven oil reserve and 41% natural oil reserve making it the world's richest in oil resources and proven to be increasing year after year.

According to the world bank, economic growth in this region is expected to increase from 1.4% in 2017 to about 3.5% in 2020 driven mostly by the rise in oil prices but on the flip side, it remains the largest threatening factor to humans and the ecosystem because of the carbon dioxide emissions which constitute 81% of greenhouse gas emissions (World bank, 2018).

	Middle East		North Africa		MENA	
	2003	2030	2003	2030	2003	2030
Power sector	383	800	98	200	481	1000
Industry	232	459	54	90	286	549
Transport	239	507	66	163	305	670
Other*	248	425	77	151	325	576
Total	1 102	2 191	295	604	1 397	2 795

Figure 1: Mena Energy-Related Co2 Emissions (Million Tonnes)

Since 1995, many environmental and energy experts gather every year in Paris to renegotiate the Kyoto Protocol to establish the binding agreement that countries should reduce their greenhouse gas emission and the recent meeting in 2015 affirmed that Renewable Energy (RE hereafter) is important in boosting environmental quality and reducing the hazards from emitting GHGs. GHG here refers to greenhouse gases that trap heat in the atmosphere, increasing global temperature making it globally unconducive for habitation.

The potential for renewables in the MENA region is enormous due to the levels of sunshine and wind reaching the area but this remains largely untapped as it only accounted for 2.5% of total regional energy production in 2015 (IRENA, 2017). Nevertheless, the dynamics of the world today show the RE scene is growing at a rapid state with significant economic development in view. In 2016, the Arab region showed a 9% increase in investments in RE compared to numbers from 2008. The region acknowledges the benefits of RE translating into an opportunity for diversification in technology, new value-chain activities and technology transfer (IRENA, 2018).

It is imperative to know that renewable energy cannot fully provide for the entire regions energy demand even with the overall decline in cost and increased performance. This leaves great percentage on the use of unconventional and conventional source as shown in evidence from other publications. To achieve sustainable development, it would require a matter of urgency to limit the use of GHG emitting sources to a certain threshold that renewable sources can offset the harm it causes.

This research studies an improved method at a measurement of sustainability and the optimal mix of energy sources that aid sustainable development of the region. In order to achieve this target, the world bank indicator: Adjusted Net Savings (AN_tS hereafter), a not yet explored study as an indicator to ascertain the level that signals the region's sustainable development.

AN_tS measures the true level of savings set aside for sustainability in an economy taking into account its investments in human capital, depletion of natural resources and damages caused by pollution. Based on the concepts of extended national accounts proposed by (Pearce and Atkinson 1993; Hamilton and Clemens 1999; World Bank, 2011), it looks at the overall view of an economy's sustainability level.

In calculating the optimal mix of power source resulting from the consciousness of climate change and more focus on the environment, the turning point is analyzed for renewable and non-renewable energy sources to measure the level of savings the country should set aside for sustainability control matters before it negatively starts to impact the country.

On this note, it is imperative to highlight that economic growth and sustainable development are two different terms and although their indictors are similar, they both have different meaning and calculated differently.

1.2 Statement of Problem

In the measurement for sustainable development, scholars have used indicators like GNI, Per capita Income, GDP as measurement which all failed to account for other characteristics of the term that caters to the majority of the sustainability development goals. Sustainable development takes into account social, economic and environmental pattern of behavior and consumption. Increased use of renewables would allow the world to implement these behavioral changes but where does the balance come in between the use of RE and traditional methods to achieve and maintain the sustainable development goals?

While developed countries have shown no more than a small increase in energy consumption, traditional energy use in developing countries has been growing at high rates leading to high prices, cutting into the socio-economic growth and widening the distortion between those who can afford electricity and those who cannot as seen from the graph below showing the energy demand projections of the region.

An estimated 28 million people electricity deficient especially in rural areas, and almost 8 million depend on local biomass for all energy needs. Oil prices are not stable, cost recovery in electricity is low, carbon intensity is on average higher than in industrialized countries, and the potential for renewable energy is under-explored. (Word bank, 2018). This dependency on non-renewable sources affects the overall sustainability of the region because of its side effect. In respect to these highlighted problems, this research study seeks to answer the following:

- The balance between the use of non-renewable source of energy and renewable energy and how it affects the region's existing energy industry
- Proper economic measurement of sustainable development for the purpose of economic analysis.
- The correlation between AN_tS and other growth factors to assure its use in sustainable development.

1.3 Objective of the Study

The principal objective of this research study is to examine the energy trends in the middle east and North Africa region to explore the potential of renewables, conventional and unconventional sources of energy that yields the most sustainable development benefit while answering questions to:

- The optimum turning point for renewable energy before it starts to decline.
- The optimum turning point for non-renewables before it starts to decline
- An economic variable that takes into consideration the correct measurement of sustainable development.

1.4 Significance of the Study

The growing increase in environmental hazards caused by the use of non-renewable sources of energy and the interchangeable use of economic growth as a measure for sustainable development prompts this investigation. Seeing that increase in innovation and economic development is tailing more towards the use of renewables, it is imperative that the region is in line with these changes and not thrown off the bus when this developmental transition occur.

This study therefore essentially extends on the existing literature on sustainable development using AN_tS, contributing to the measurement of the term. It goes further to measure the optimal input of both sources of energy highlighted to yield sustainable development. To further expand it on this investigation, it will include top developed countries in the world into the analysis to see how the variables interact with adjusted net savings and the difference in result between the two worlds.

1.5 Research Methodology and Hypothesis Testing

Research of the study is subject to data availability for the duration of 2000 - 2017 (17 years) for 9 developing countries in the MENA comprising of Azerbaijan, Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Tunisia, Saudi Arabia and 9 developed countries; Australia, Germany, Netherland, Norway, Singapore, Sweden, Switzerland, Denmark and Finland all gotten from the world bank repository. Data includes; Adjusted Net Savings (dependent variable), GDP, energy use, renewable consumption, Trade openness, CO2 emissions are independent variables.

Second generation panel testing shall be carried out estimating panel unit root test, cross sectional dependence test and Augmented mean group. To measure the optimal input of both sources of energy, the environmental kuznet curve shall be employed against the dependent variable. Using the figures from the world bank repository highlighted above, the following hypothesis will be tested:

$\mathbf{H_0}$: AN_tS is a preferable measurement of sustainability development

$\mathbf{H_1}$: AN_tS is not a preferable measurement of sustainability development

$\mathbf{H_0}$: The optimality is determined for Renewable and Non-renewable energy

$\mathbf{H_1}$: The optimality is not determined for Renewable and Non-renewable energy

1.6 Scope of the Study

This study is divided into 5 chapters and organized as follows; Chapter 1 shows an overview of the research study, containing the research problem, study objective, significance and scope of the study. The next chapter covers theoretical and empirical literature review of previous study on economic growth, determinant of sustainable development. Chapter 3 looks at the aspect of methodology, model specification, data collection, econometrics techniques employed in the analysis of the data. Chapter 4 considers data analysis and interpretation of result. chapter 5 summarizes aforementioned chapters, lastly offering recommendations based on the research findings.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This literature has been framed to review previous publications on the correlation existing between energy use and economic growth, paying adept attention to the indicators of growth. The outcome yielded different estimation results and causality directions affected by region, economic growth stage, estimation model and varying time duration explained by (Yu and Choi 1985; Ferguson, Wilkinson and Hill 2000) who given a constraint of 100 developing countries, found a correlation between wealth creation and electricity use (Toman and Jemelkova 2003). Nearing the end, the concept of sustainable development will be introduced its relationship with energy and improved research on the term.

2.2 Energy Consumption and Economic Growth

Up until now, increasing publications are being made on the interconnection between energy and economic growth since the work of (Kraft and Kraft, 1978) who tested energy consumption growth nexus of US using data for the period 1947–1974. Their research confirmed a one-way causality running from economic growth to energy consumption (Paul and Bhattacharya, 2004).

This is known as the conservation hypothesis which asserts that employing energy conservation policies in order to reduce energy consumption does not adversely affect economic growth. (Cheng and Lai, 1997) added that energy is an important factor for the economic development of developing countries because increasing output in production operations such as, construction, manufacturing and transportation demands huge amount of energy thus influencing energy consumption. Jumbe (2004), for Malawi, (Oxley and Scrimgeour, 2004) for New Zealand, (Aqeel and Butt, 2001) for Pakistan, Zamani (2007) for Iran and Binh (2011) for Vietnam established confirmation of the conservation hypothesis.

(Yu and Choi, 1985), (Lee and Chang, 2005) proposed a one-way causality from energy consumption to economic growth in Philippines and Taiwan indicating that the countries are energy dependent. In other words, energy plays a significant role in economic growth indirectly and directly most especially for developing countries where increase in production, manufacturing demands increased influx of energy.

Energy preservation policies which reduce consumption of energy may unfavorably affect the growth of the economy. Other research that also found result of this growth hypothesis include; Masih and Masih (1998) for Sri Lanka, Asafu-Adjaye (2000) for India and Indonesia and Soytas and Sari (2003) for Japan, Germany, Korea, Italy, France and Turkey.

Valeria Costantini and Chiara Martini (2009) collated information on 71 countries, dividing them into two groups; 26 OECD and 45 non-OECD regions with respect to their development and policy settings for the period 1960–2005. Results showed a uni-directional causality form energy consumption to GDP for the non-OECD countries and a unidirectional causality from GDP to energy consumption for the OECD countries. In summary this meant that energy consumption was widely affected by economic growth for the non-OECD countries and the conservation hypothesis is the OECD countries.

Bi-directional causality also known as the feedback hypothesis exist when the correlation runs in both direction; form energy consumption to economic growth and from economic growth to energy consumption, simultaneously serving as complements. Evidence that showed presence of this causality include (Soytas and Sari, 2003) for Argentina, (Fatai et al., 2004) for Thailand and Philippines and (Oh and Lee, 2004) for South Korea. In terms of policy recommendations, experts should look out for the interference between energy consumption and GDP to implement policies to reduce energy use. Implementation of energy efficient methods should also be initiated to improve productivity.

The neutral hypothesis asserts that no causality exist between energy consumption and economic growth. In other words, conservative or expansive growth policy recommendation on energy consumption have no effect on economic growth supported by (Yu and Jin,1992), Cheng (1995) (Wolde and Rufael, 2006), Ozturk (2010). Some results yielded more than one causality like the Sarwat Razzaqi and Saadia Sherbaz study for period 1980-2007 in 8 developing countries showing both one-way directional relationship (i.e energy consumption→ GDP) and a feedback in the case of (GDP↔ energy consumption) for Malaysia, Iran, Pakistan Bangladesh, Indonesia, Turkey, Nigeria and Egypt. Evidence form the study showed a long-run and short-run causality for most of the countries excluding Indonesia.

Although other research argued that the possible use of energy in an economy is dependent on the development stage of the economy concerned as earlier stated (Ghali and Sakka, 2004), Mehrara (2007).

2.3 Economic Growth and Environmental Quality

As mentioned in the introduction, fossil fuel caused greenhouse gas emissions are gradually intensifying, putting global warming on the list of the most search topics in ecology. The only way to reduce its effect is to limit the use but it's important to view its effect on economic growth seeing the aforementioned causality between economic growth and energy. This section reviews the literature on the relationship between energy, economic growth and environmental quality.

In his study on economic growth and income inequality in I955, Simon Kuznets defined economic growth as a sustained increase in per capita or per worker product mostly accompanied by increase in population and structural changes with a view to understanding changes in income inequality with economic growth. He studied data for Germany, United Kingdom and United states which give rise to the hypothesis of the pattern of income inequality in developing countries called the Environmental Kuznets curve.

The EKC assumes that environmental degradation first increases as per capita income increases then falls when income reaches a certain threshold called the turning point and finally decreases to depict improvement in environment forming an inverted U shape Grossman and Krueger (1991), Shafik and Bandyopadhyay (1992), Selden and Song (1994), Wyckoff and Roop (1994), Rothman and de Bruyn (1998), Heil and Selden (1999), Coondoo and Dinda (2006).

While many empirical results supported the literature, some results were in the opposite. Take the research done by Vincent 1997 for Malaysia on air and water pollutant whose result concluded that EKC relationship does not exist as higher income is only associated with higher levels of pollution. The hypothesis was criticized for insufficient interference from environmental pollutants to economic output economic growth is assumed to be an exogenous variable Arrow et al (1995), Stern (2004), Hung and Shaw (2002).

Motivated by the world's largest energy consumer and emitter, Xing-Ping Zhang and Xiao-Mei Cheng (2009) examined the relationship between economic growth, energy consumption and environmental pollution in China for the period 1980-2007. With an average increase in GDP at 9%, primary energy consumption in the region constituted a 340% increase, 352% for carbon dioxide constituting 70% of Coal.

The empirical result showed long run one-way relationship from GDP to energy consumption inferring that the government of China can implement energy conservative policies without causing any long run negative effect on the country's economic growth. Energy consumption reduction, mostly the consumption of coal, would greatly impact a reduction in carbon emissions. To that effect, China set a goal to achieve its development plan for renewable energy starting at a ratio of 10% of renewable energy to 15% of total primary energy consumption.

Economic growth in summary explained an increase in a country's wealth with a potential to reducing poverty and in some cases followed by human development. With this growth comes greater inequality, higher unemployment, adverse environmental risk or overconsumption of natural resources needed by future generations (World bank, 2000).

While previous studies have explored the relationship and causality direction between energy consumption, environment and economic growth, this present study aims to explore the optimal mix of energy source to yield sustainable development and in order to fully understand the synergy between economic growth, social and environmental issues, academic experts agree growth is inevitably not long run hence the term sustainable development which characterizes a behavioral change that can be forever.

2.4 The Concept of Sustainable Development

In recent studies, sustainability is being looked at from three points of view and recently United Nations championed the support of these interdependent and mutually reinforcing indicators; economic development, social responsibility and environmental protection which economic growth failed to account for. Economic development can be defined almost as economic growth but it needs to make adjustment for long term growth without jeopardizing the future generations. Environmental protection simply encompasses the existence of the Kyoto protocol targeting the reduction of harmful fuels that cause GHG emissions and social responsibility ensuring that the poor benefit, women incomes are looked after, human rights for all and children's rights are taken into consideration.

Several economists have tried to come up with various interpretation of sustainable development; sustainable development is explained as development that allows for the present generation to work without compromising the ability of future generations (WCED, 1987). Sustainability requires non-decreasing levels of capital stock over time, or, at the level of the individual, non-decreasing per capita capital stock (Hicks, 1946). Thus the term “development” is a process that creates growth and positive change, it was bound to have an objective and a means to achievement.

Sustainable development (SD) can also be called unbiased; continuous development should take into consideration of varying interests of people. This can span within and among generations, incorporating the three features of SD making sure there is fairness in social, economic, and environmental objectives.

In economic terms, equating development with increased utility translates to sustainable development which has come to be equated with a development path that ensures no declining per capita utility over some time horizon (David, Giles, 1998). Within another literature, SD is seen as an indicator of human well-being which does not decline over time (Pezzey, Pearce et al., 1989) of which well-being is closely estimated based on per capita national income.

Previous research used different indicators ranging from GDP, GNI, Per capita Income to measure sustainable development which were all deficient in accounting for the other features of the term. Thus, this study seeks to fill the corresponding research gap in the existing literature by using AN_tS as a measure of sustainable development because it takes care of the deficiencies of previous determinants, giving holistic and simple indicator of all the features of sustainability and also showing how environmentally sustainable the country’s investments are.

2.5 Adjusted Net Savings (AN_tS): An Indicator of Sustainable Development

The topic of development is deemed questionable when researchers opt to use GDP or other economic variables as indicators. Nearly all research use Gross Domestic Product bearing in mind its pitfalls in representing human development. GDP is accepted as an ideal indicator of market activity but clearly fails to represent well-being (Stiglitz et al., 2009).

Taking into account the future damages of environmental deterioration, caused by CO2 emissions, an alternative measure that takes generations to come into account is therefore be better suited. AN_tS is an indicator that considers the wealth of a country (physical, human and natural capital) nit leaving out future generations so as to have a wider measure of development. It emerged as an indicator in the system of environmental economic accounting (SEEA) of the United Nations organizations sourcing.

Adjusted Net Savings (AN_tS) formerly called genuine savings was conceived by (Pearce and Atkinson,1993, Hamilton 1994), (Pearce and Atkinson,1997), (Hamilton and Clemens, 1999) and later improved by the World Bank, (2011). It is measured as gross national savings deducted by depreciation of produced capital, depletion of subsoil assets and timber resources, the cost of air pollution damage to human health, addition of credit for education expenditures World Bank, (2018). It measures the savings a country sets aside for matters that concern sustainability indicators of a country. Positive adjusted net savings imply that total wealth is appreciating and negative adjusted net savings imply that total wealth is in decline which puts policies in check because policies that lead to negative genuine savings are unsustainable.

Physical capital which measures the market prices of buildings, machinery, urban infrastructure. Human capital which comprises of the value of skills, knowledge and experience by the working population over their lifetimes distributed into gender and employment status. Natural capital made up of agricultural life, forest, mineral, energy all measured by the sum of rent discounted over the life of the asset. Stock of knowledge and Social capital looks at the networks of relationships among people who live and work in a particular society all valued in monetary terms.

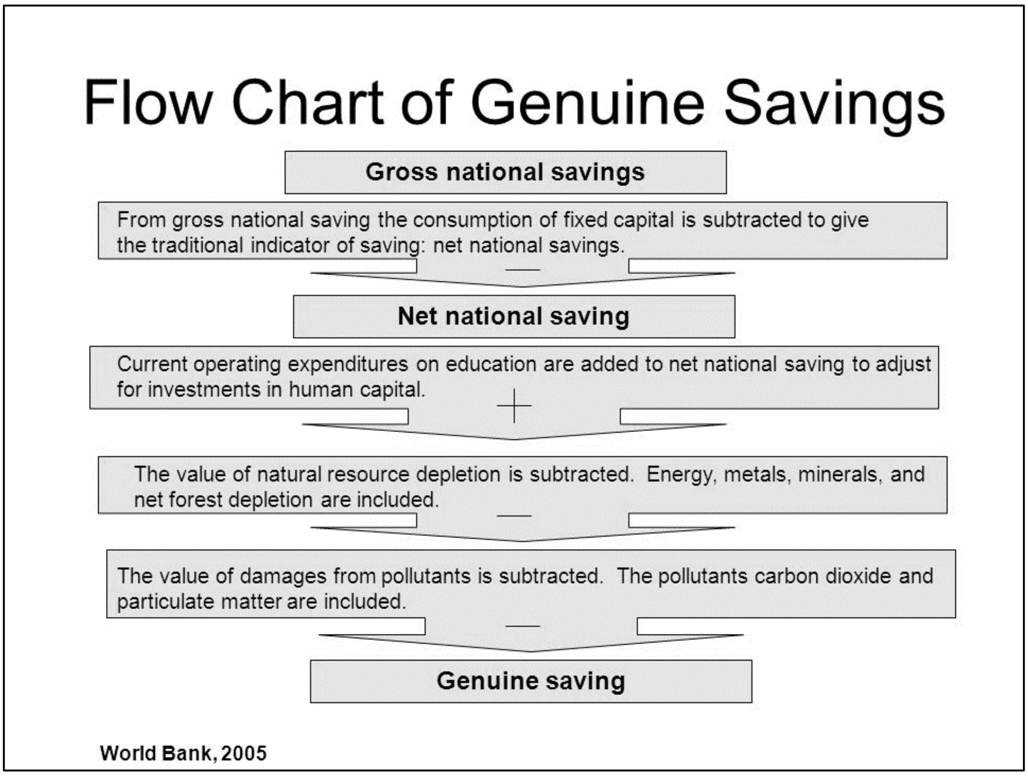

Figure 2: Flow Chart of Genuine Savings

In calculating these estimates, adjustments for pollution, depletion of forest life and all other negative that might arise in estimation. The figure for damages caused from carbon dioxide is valued at marginal global damages of US$20 (1995 prices) per metric ton of carbon emitted (Fankhauser 1994). AN_tS including Particulate emission damage which is the dependent variable in this study is calculated as the willingness to pay to reduce the risk of mortality attributed to airborne particles. (Pandey et al., 2005).

In 1999, the world bank started including them as indicators with its first estimates produced by (Pearce and Atkinson, 1993) for 18 countries, now having more than 150 countries in 2003. As pointed out in the introduction, one of the strongest ally for the use of AN_tS is that it cancels out all other traditional measurement of sustainability although some researchers expressed their shortcoming in its accounting like the error measurement included in the estimation of physical capital which assumes that all investments are productive and that the depreciation rate is constant over time sighted by Pritchett (2000) who critiqued the depreciation allowance derived from UN's capital consumption.

(Dietz and Neumayer, 2004) highlighted that the world bank omitted many other types of pollutant in its accounting for environmental pollution resulting in wrong assumptions. Some of these pollutant include air pollutant like Sulphur Oxide, water pollutant like faecal coliforms. Hamilton and Atkinson's (1996) in his policy recommendations done with the UK in a research suggested air pollution damage make up 5% and 3% of GDP during the 1980s which was enough to push the UK's GS below zero in the early 1980s.

Seeing this is a newly developed indicator, it is not exempted from criticism by experts. For instance, (Dietz and Neumayer 2004) argues that structure rests on the assumption of inter-temporally efficient country which describes how present decisions affect what options are available in the future. Throughout this study, adjusted net savings has been focused on overall wealth while holding population constant which might not be tenable for developing countries in the short-run as pointed out by Dasgupta (2001) which then brought attention to measuring AN_tS on a per capita basis.

In accounting for natural capital stock, (Thiry & Cassiers, 2010) stressed that its calculation only estimated for polluting countries and not environmentally damaged countries resulting from poor consumption. He also added that due to unavailability of data, estimation of air and water pollution, fisheries, was not taken into consideration.

Lastly, countries with high levels of GDP have a high chance of having increased investment in physical and human capital while having low levels in natural capital (Everett and Wilks, 1999). The short comings on the methodology of the variable sparks up a continuing step in the research for an encompassing measurement that takes into account almost all factors that impacts sustainability thereby enhancing its potential influence on the coordination at the international level of sustainability policies.

2.6 Adjusted Net Savings, Energy Use and EKC Relationship

In the EKC concept, per capita GDP is used as an explanatory variable hypothesizing that environmental degradation first increase at low levels of economic development then gradually decreases once a certain threshold is reached.

Having mentioned above the connection between economic growth, environmental quality and energy consumption, introducing the environmental kuznet curve and AN_tS into the mix further strengthens the study as it helps understanding the roles each of these variables play and how they translate into decision making. Within this framework, this is the first study in the MENA region to explore the Adjusted net savings - energy consumption - renewable energy consumption nexus.

AN_tS reflects the evolution of a country's global wealth wit negative figures representing a nation on a path of unsustainability and positive figures representing a country on a path to sustainability. This measure depends on the assumption of replacement between physical, human and natural capital assets. Used as the dependent variable, it is plotted against energy use and renewable energy consumption to find the turning point. This level shows the level of savings the countries need to set aside to cater to matters that involves their sustainable development.

The study of the link between GHG emission and economic growth has been mostly supported by the Environmental kuznet curve which has shifted its reason from the depletion of natural resources to issues on how economic growth to can overcome environmental deterioration and pollution. The first empirical research was done by (Grossman and Krueger, 1991), (Shafik and Bandyopadhyay,1992) explaining that environmental indicators deteriorate in earlier stages of development, then starts to decrease once a certain income level has been reached known as the turning point depicted in an inverted U-shaped curve similar to the curve proposed by Kuznets (1955) regarding the relationship between economic growth and income inequality.

Energy use accounts for one of the most important determinants of the sustainability of any nation picking its root from CO2 emissions which is strongly correlated with environmental degradation and income also called the PIR Lieb (2003). This came about after the oil crises in the 1970s giving rise to discussions on energy transition and conservation policies.

Previous studies by Richmond and Kauffmann (2006) Luzzati and Orsini (2009) analyzed the EKC relationship between energy, CO2 emissions, and economic growth. Their research revealed a positive correlation which ultimately meant that energy facilitates economic growth. For an economy to improve on its development, there has to be a direct increase in the use of its energy which can either be in its consumption or production and on the other hand, the aim of reducing CO2 emissions by reducing energy consumption will have a negative effect on economic growth. Marrero (2010) Chontanawat et al (2008) further facilitates analyzing the correlation between energy consumption and AN_tS.

In (M, Neve & B Hamide, 2017) research on the tradeoff between environment and development where he analyzed 28 countries according to their 2010 GDP benchmark, grouping them into high income, middle income and low income countries. Before using AN_tS in place of per capita Gross Domestic Product, AN_tS was converted to per capita to make up for estimating it alongside per capita GDP. His analysis concluded that as a country develops, taking into consideration the welfare of future generations, Co2 emissions increases as this development takes place then gradually decreases once an AN_tS threshold has been reached. Nonetheless, these high levels of AN_tS may be quite unattainable for developing countries.

Chapter 3

EMPIRIRCAL METHODOLOGY

3.1 Introduction

For the investigation of the optimal energy source for sustainable development, annual frequency panel series data was collected from the world bank development indicators for period 2000 – 2017 for 9 developing countries of Azerbaijan, Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Tunisia, Saudi Arabia and 9 developed countries; Australia, Germany, Netherland, Norway, Singapore, Sweden, Switzerland.

The choice of sampled countries is based on oil rich developing countries that also have potential for renewable energy utilization having little already in utilization and 10 developed countries to allow us observe the effect of savings (AN_tS) on the two sources of energy generation analysed. Variables estimated include; dependent variable -Adjusted net savings (AN_tS). Independent variable includes; Trade Openness (TR), GDP, Energy use (ENU). Renewable energy consumption (REN).

AN_tS which includes particulate emission damage measured in current US dollar prices for this estimation serves as the independent variable. It measures the savings and investment in a country after pollution damages, depreciation and depletion of physical and natural capital have been deducted. Trade openness (% of GDP) constitute the addition of goods and services imported and exported as a proportion of GDP.

Renewable energy consumption is the percentage share of renewable energy in total final energy consumption. measures the share of renewable energy use in the country. Energy use employed as a proxy to represent the effect of non-renewable use of energy on environment because it determines CO2 emission which appears to be the major contributor to global warming through the combustion of fossil fuels. According to a report from world bank (2007), C02 emissions contributed 58.8% of GHG emissions making it top priority in environmental degradation indicators. GDP which stands for Gross domestic product measured at constant US prices. Data used in this research is retrieved from the world bank development indicators and will be used to employ several analyses using stata application.

3.2 Model Specification

To verify the long run relationship between AN_tS, energy use, renewable energy consumption, GDP and Trade openness, we opt for the methodology implemented by Apergis and Payne (2009a, 2010) then empirically examine the model below:

$$AN_tS_{it} = \beta_{it} + \delta_{1i}ENU_{it} + \delta_{2i}ENU_{it}^2 + \delta_{3i}REC_{it} + \delta_{4i}REC_{it}^2 + \delta_{5i}TR_{it} + \delta_{6i}GDP_{it} + \varepsilon_{it}$$

Where:

i = 1,2,3…N represents each country in the panel data arrangement

t = 1,2, 3…N represents the time period

AN_tS represents Adjusted net savings put aside by the country

ENU represents energy use which accounts for fossil fuel consumption

ENU^2 represents the square root of energy use

REC represents renewable energy consumption

REC^2 represents the square of renewable energy consumption

TR represents Trade openness

GDP represents the gross domestic product

The expected signs for the coefficient of GDP δ_{6i} is positive and expected sign for trade δ_{5i} could be positive or negative. For ENU and REC, expected signs for the quadratic signs could be negative or positive for δ_{2i} and δ_{4i}. If it is negative, there is an inverse U-shaped curve. If it is U-shaped, it is a positive relationship.

3.3 Testing for Cross Sectional Dependence

In deciding which unit root test is befitting for this study, it is first important to carry out a cross sectional dependence test which could arise due to spatial or spillover effects or unobserved (or unobservable) common factors. The first generation panel unit root proposed by Maddala and Wu (1999), Hadri (2000), and Choi (2001) which assumed cross sectional independence all have shortcomings which could lead to insignificant size distortions in the presence of neglected cross-section dependence.

Knowing that the size of the data set influences the results of the test (T >N), it is imperative to propose the Lagrange multiplier (LM) test, developed by Breusch and Pagan (1980), improved by Pesaran and Chudik (2015), favorable to second generation, and the proposed method of analysis for this study because it takes into consideration if the unobserved element that create interdependencies across cross sections are correlated with the included regressors. Its statistics is given as:

$$\breve{\mathrm{PN}} = \frac{2}{\mathrm{N}(\mathrm{N}-1)} \sum_{\mathrm{i}=1}^{\mathrm{N}-1} \sum_{\mathrm{j}=\mathrm{i}+1}^{\mathrm{N}} \breve{\mathrm{P}}\,\mathrm{ij}$$

Where:

$\mathrm{H}_0\colon \mathrm{P}_{\mathrm{ij}} = 0 \text{ for } \mathrm{i} \neq \mathrm{j}$

$\mathrm{H}_1\colon \mathrm{P}_{\mathrm{ij}} \neq 0 \text{ for } \mathrm{i} \neq \mathrm{j}$

3.4 Panel Unit Root Test

Over a decade now, model testing has been done with the use of panel unit root designed to test the null hypothesis of a unit root for each series in a panel. The alternative hypothesis on the other hand, depends on assumptions made about the nature of the homogeneity of the panel.

(Levin and Chu test 2002), (Pesaran and Shin test, 2003) and Fisher -type tests was applied to datasets where the time series dimension and the cross-section dimension were of the same order. The empirical analysis explained the constraint of assumption of cross-sectional dependence amongst variables.

In recent years, the second generation panel unit root test that takes into consideration cross sectional dependency proposed and adopted by Bai and Ng (2004), Chang (2002), Choi (2002), Phillips and Sul (2003), Moon and Perron (2004). For the sake of this study, we employed Panicca (2015) panel unit root test because of its ability to capture cross-sectional dependency.

3.5 Granger Causality Test

The Granger causality test is the most important test when estimating macroeconomic variables because it examines the causal relationship and direction that exist between economic variables being observed. To carry out this test, we employ the Granger causality test of Dumitrescu & Hurlin (2012) because the causal behavior of the EKC variables has been a subject of controversy. The test is deemed worthy when the cross-sectional dimension (N) varies while the time lag dimension (T) is fixed, and when T is greater than N. The test is structured in (VAR) framework with the notion of cross-sectional dependency. Therefore, the estimates of the test are robust in the existence of cross sectional dependence.

3.6 Co-Integration

The concept of co-integration allows us to examine the presence of a long term steady relationship between non-stationary variables but having a stationary linear combination. It resembles the long-run systematic movement among two or more variables. For this study, the co-integration analysis used is (Westerlund and Edgerton, 2008) because orthodox tests for co-integration can be very imprecise unless the length of the time series is substantial.

(Westerlund and Edgerton, 2008) is favorable because it takes into account the cross-section dependence among the countries and proposed four co-integration estimators to give more reliable estimation. The first two tests statistics (Ga and Gt) checks that the alternative hypothesis of the whole panel is co-integrated. The other two statistics (Pa and Pt) are used to check the substitute hypothesis of at least one unit of the panel is co-integrated. The justification of this method is to analyse the null of no co-integration and the notion that the Error Correction Term (ECT) in a conditional panel is equal to zero.

3.7 Regression: Dynamic Common Correlated Effect Mean Group

The regression of DCCE was developed by (Pesaran and Chudik, 2015) is employed for the estimation of the EKC model to analyze the relationship between the variables because it allows for cross sectional dependency and controls for endogenous regressors, corrects small sample biasness and supports both balanced and unbalanced panels Ditzen (2016).

3.8 Quadratic Regression Model

Quadratic regression functions are the simplest and most widely used method to ascertain the precision of the turning point in the sustainability-energy relationship. This is based on the exact distribution of the turning point estimator of quadratic regression functions, which is based on the assumption that the errors are (asymptotically) normally distributed.

Assuming relationship between the variables β and η is estimated with the quadratic equation $\beta = \alpha + \delta_1\eta + \delta_2\eta_{it}^2 + \varepsilon_{it}$ and the turning point Ţ for the equation is:

Ţ = ${}^{\delta_1}/_{(-2\delta_2)}$

Chapter 4

DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

Following through with the introduction of the empirical methods needed for this study highlighted in chapter 3, this section goes further to employ these methods to see how the variables interact with each other. As aforementioned, empirical analysis that includes differing choice of econometric methods; second generation unit root tests, cross sectional dependency test, causality, EKC, co-integration, and regression will be tested to critically arrive at a logical conclusion to measure the optimal use of energy use and renewable energy consumption in regards to sustainable development of developing and developed countries.

4.2 Descriptive Statistics

The descriptive statistics shows an overall information of all variable examined for this study. It gives further insight on the average, variation minimum and maximum between countries.

Table 1: Descriptive Table

	Variable	Mean	Std. Dev.	Min	Max
AN_tS	overall	6.38e+10	9.31e+10	-9.00e+09	5.33e+11
	between		8.67e+10	-3.86e+09	3.75e+11
	within		3.94e+10	-1.49e+11	2.21e+11
ENU	overall	3047.73	2227.211	0	8438.49
	between		1912.954	498.4259	6130.703
	within		1222.16	-2790.937	6381.402
REC	overall	929.7318	6832.555	0	70471.44
	between		1377.854	.0075618	3932.357
	within		6699.646	-3002.625	67468.81
Trade	overall	96.23671	1.38e+11	.5351017	437.3267
	between		1.27e+11	39.82619	347.5078
	within		6.20e+10	-250.736	186.0556
GDP	overall	6.81e+10	1.32e+11	39.27118	7.60e+11
	between		1.22e+11	39729.21	4.75e+11
	within		5.85e+10	-2.27e+11	3.53e+11

N=288, n=18, T=18

The data set for estimation of the econometric analysis in Table 1 consists of an observation of 18 countries estimated for a duration of 18 years, showing an overview of results from ranges within, between and the countries in total. Trade openness highlighted 96.2% of GDP, average renewable energy consumption at 929.7. The standard deviation shows the significant changes within, between and the overall country which is pretty large justifying the need to study the dynamics that exist between them.

Observation of the descriptive statistics shows that Saudi Arabia has the minimum consumption of renewable energy while Switzerland has the highest renewable energy consumption. Morocco on the other hand, has the minimum amount contributing to energy use while Saudi Arabia has the highest value contributing to energy use. Saudi Arabia here has the lowest contribution to renewable energy and the highest in terms of energy use. In the following pages, I discuss and analyze how the variables interact with the different economic analysis.

4.3 Cross Sectional Dependency-Test

In analyzing panel data, the first step taken into consideration is to test for cross sectional dependency because previous statistical estimations have found that many macroeconomic applications are simultaneously correlated by country or data which could arise due to spatial spillover effect, common factors, etc. Using the methods of Pesaran and Chudik (2015), the following estimations were done.

Table 2: Result of Cross Sectional Dependency Test

Variable	CD-statistics	P-value
AN_tS	33.717	0
Energy Use	6.435	0
Ren Energy Con	12.161	0
Trade	51.267	0
GDP	50.128	0

Significant at 5%

H_0: There is no cross sectional dependency between the variables.

H_1: There is presence of cross sectional dependency between the variables.

The findings of Pesaran and Chudik (2015) cross sectional dependency test sets out to verify the presence of a common factor affecting the estimated variables in cross sections resulting in a spillover effect. In recent times, most economic variables are all estimated to have cross sectional dependence supporting the use of second generation panel test. This method is employed because it takes care of that bias by basing its assumption on cross sectional dependence between variables before analyzing.

The result of the cross sectional dependency test from table 1, shows that the CD statistics are highly significant at 5% therefore we fail to accept the null hypothesis because there is cross sectional dependence.

4.4 Panel Unit Root Test

The panel analysis of non-stationarity in idiosyncratic and common components of (Bai and Ng, 2004) are among the popular approaches for cross section correlated panels but for this study, I employed the recent PANICCA method which combined the strengths of cross section average of Pesaran and PANIC of (Bai and Ng, 2004).

Table 3: Result of Panel Unit Root Test

Variable	Common factor statistics	Pa	Pb	PMSB
AN_tS	-1.49***	-2.169(.015)	-1.328(.092)	-1.048(.1472)
ENU	-4.24***	-.214(.4152)	-.142(.4436)	-.798(.2123)
REC	-4.24***	.243(.5961)	.08(.5317)	-1.57(.0583)
Trade	-4.16***	-1.297(.0973)	-1.035(.1503)	-.539(.2951)
GDP	-.896***	-1.016(.1548)	-.707(.2397)	-.673(.2504)

p-values are all in parenthesis, significant at 5%

H_0: There is unit root; not stationary between the variables.

H_1: There is no unit root; there is presence of stationarity between the variables.

From the estimation in table 2, the p-values of the idiosyncratic components are not stationary at 5% level of significance thus, we do not reject the null hypothesis (H_0) negating the decision of the common factor. The common factor statistics rejects the null hypothesis signifying the presence of stationarity between the variables. Thus, this explains that the non-stationarity of the variables are due to the peculiar characteristics of each country.

4.5 Co-Integration Test

One of the main objectives underpinning this research study is to define the existence of long run interaction between the variables. The cross sectional dependence estimation sets the foundation for the bootstrap panel co-integration test proposed by Westerlund.

Table 4: Result of Co-Integration Test

Statistics	Value	Z-value	P-value
Gt	-6.746	-19.665	0.000
Ga	-18.041	-4.869	0.000
Pt	-32.912	-20.564	0.000
Pa	-19.256	-7.626	0.000

significant at 5%

H_0: There is no co-integration between the variables.

H_1: There is co-integration among the variables.

In table 4, Basing our decision on the result of the p-values, this empirical finding shows that there is co-integration thus proving the presence of a long run relationship between Adjusted Net Savings, Renewable Energy Consumption, GDP, Energy Use, and Trade thereby statistically failing to accept the null hypothesis of no co-integration. The long run relationship explains the sustainability concept that today's development should not compromise the ability of future generations to meet their own needs.

4.6 Granger Causality

The (Dumitrescu & Hurlin, 2012) Granger causality approach is proposed for this study because it takes into account the cross sectional dependence and reduces the bias in stationarity test when examining the direction of dynamic causality relationships among the variables. Two variables are usually tested together yielding either of these results:

- No Causality
- Uni-directional causality
- Bi-directional causality

Table 5: Result of Granger Causality Test

Hypothesis	Z-bar-statistics	Z-bar tilde
Energy use does not Granger-cause AN_tS	-0.0293(0.9766)	-0.3979(0.6907)
AN_tS does not Granger-cause Energy use	1.9895(0.0466)	1.1197(0.2628)
AN_tS does not Granger-cause REC	2.1796(0.0293)	1.2627(0.2067)
REC does not Granger-cause AN_tS	3.3335(0.0009)	2.1301(0.0332)
AN_tS does not Granger-cause Trade	2.1595(0.0308)	1.2475(0.2122)
Trade does not Granger-cause AN_tS	-0.9680(0.3331)	-1.1036(0.2698)
GDP does not Granger-cause AN_tS	4.6367(0.0000)	1.4523(0.1464)
AN_tS does not Granger-cause GDP	4.4066(0.0000)	1.3373(0.1811)

p-value are all in parenthesis, significant at 5%

H_0: There is no Granger causality from one variable to the other.

H_1: There is Granger causality running from one variable to the other.

The estimation of the p-values of the Z-bar-statistics and Z-bar tilde at 5% level of significance establishes uni-directional relationship between energy use and adjusted net savings thus we do not accept the null hypothesis; There is granger causality between energy use and adjusted net savings.

A bi-directional causality is evident in Adjusted Net Savings to Renewable Energy Consumption and Adjusted net savings to GDP. Finally, the evidence of uni-directional causality is also found between trade and adjusted net savings. Thus, trade Granger-causes AN_tS.

4.7 Regression: Dynamic Common Correlated Effects Estimator - Pooled Mean Group

Panel Regression analysis aims to analyze the impact of the dependent variable (Adjusted net savings) on the independent variables (Energy Use, Renewable Energy consumption, Trade, GDP) and vice versa taking into consideration the sign, size, and significance of the estimates.

The estimation for this section is grouped into the two sample data; Energy Use and Renewable energy consumption each showing the results for developing, developed and cumulative data analysed to account for robustness of the study. Lastly, we estimate the points at which the quadratic regression is maximum or minimum referred to as the turning point.

Table 6: Energy Use (Adjusted Net Savings and developing countries)

AN_tS	Coef	Std. Err.	z	P>z	[95% Conf.	Interval]
Pooled:						
_cons	3.35e+10	6.02e+10	0.56	0.578	-8.44e+10	1.51e+11
Mean Group:						
ENU	-6.86e+07	1.68e+07	-4.08	0.000	-1.01e+08	-3.57e+07
ENU2	38891.36	14218.9	2.74	0.006	11022.83	66759.9
GDP	.0595723	.0421302	1.41	0.157	-.0230014	.142146
TRADE	2.15e+07	1.34e+08	0.16	0.872	-2.41e+08	2.84e+08
Turning Point	88194.4					

Significance level of 10%

From the estimation of the p-values above, the empirical findings show a significant relationship between energy use and adjusted net savings for developing countries. The coefficients of energy use and its square shows a U shaped curve for the region explaining that a continuous use in non- renewable sources of energy which could result from economic growth factors like increase in factors of production, industrialization will cause a reduction in adjusted net savings. Trade is found to be insignificant which could mean that favorable and unfavorable effect cancels each other.

The turning point calculated as 88194.4 shows the minimum level at which net savings gets to while energy use is being utilized before the region either turns to cleaner sources or increase their level of savings.

Table 7: Energy Use (Adjusted Net Savings and developed countries)

AN_tS	Coef	Std. Err.	z	P>z	[95% Conf.	Interval]
Pooled trend:	-3.24e+08	9.15e+08	-0.35	0.724	-2.12e+09	1.47e+09
_cons	-9.86e+10	2.26e+11	-0.44	0.663	-5.42e+11	3.45e+11
Mean Group:						
ENU	4.55e+07	1.68e+07	2.71	0.007	1.26e+07	7.83e+07
ENU2	-7727.806	3478.03	-2.22	0.026	-14544.62	-910.9932
GDP	1128362	582297.6	1.94	0.053	-12920.73	2269644
TRADE	2.78e+07	2.18e+08	0.13	0.898	-3.99e+08	4.55e+08
Turning point	294391.4					

Significance level of 10%

From the estimation in table 4.2, a significant relationship exists between adjusted net savings and energy use for developed countries. Compared to developing countries, the coefficients depict an inverse U-shaped relationship. GDP has a significant effect on Adjusted net savings. Trade is found to be insignificant in developed countries.

The turning point for developed countries is a higher level than that of developing countries with a difference of (206197) which is makes perfect economic sense seeing the region is on a higher level of development compared to that of developing countries.

Table 8: Energy Use (Adjusted net savings and Cumulative)

AN_tS	Coef	Std. Err.	z	P>z	[95% Conf.	Interval]
Pooled						
_cons	-8.20e+10	1.14e+11	-0.72	0.472	-3.05e+11	1.42e+11
Mean Group:						
ENU	9.90e+07	2.35e+07	4.22	0.000	5.30e+07	1.45e+08
ENU2	-52030.72	21980.23	-2.37	0.018	-95111.18	-8950.267
GDP	-221037.8	813766	-0.27	0.786	-1815990	1373914
TRADE	6.20e+08	4.77e+08	1.30	0.194	-3.15e+08	1.55e+09

Significance level of 10%

Cumulatively, both developing countries and developed countries for the data set analyzed are significantly correlated with adjusted net savings. The difference in values of turning point between developing and developed countries supports my argument that developed countries have reached a reasonable level of sustainability because the point to which funds should be directed to AN_tS to cater for the negative impacts of energy consumption is much higher for developed countries compared to developing countries.

Table 9: Renewable energy consumption (Adjusted Net Savings and developing countries)

AN_tS	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Mean Group:						
REC	1.15e+10	6.87e+09	1.67	0.095	-1.99e+09	2.49e+10
REC2	-5.69e+09	4.73e+09	-1.20	0.229	-1.50e+10	3.59e+09
GDP	.2017833	.0727149	2.77	0.006	.0592648	.3443018
TRADE	9.38e+07	3.41e+07	2.75	0.006	2.70e+07	1.61e+08
trend	1.18e+08	2.87e+08	0.41	0.682	-4.44e+08	6.80e+08
_cons	-2.79e+10	2.07e+10	-1.35	0.178	-6.85e+10	1.27e+10

Significance level of 10%

From the estimation in table 4.4, renewable energy consumption and adjusted net savings relationship is shows a positive significance while depicting an inverted U shaped curve for the developing countries of the MENA region. All variables analysed shows a significant relationship with adjusted net savings supporting the concept of sustainable development.

Table 10: Renewable energy consumption (Adjusted Net Savings and developed countries)

AN_tS	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Mean Group						
REC	9.49e+09	1.92e+09	4.93	0.000	5.72e+09	1.33e+10
REC2	-1.43e+08	3.21e+07	-4.46	0.000	-2.06e+08	-8.02e+07
Log of GDP	-1.82e+11	3.80e+10	-4.79	0.000	-2.56e+11	-1.08e+11
TRADE	-9612379	7.06e+07	-0.14	0.892	-1.48e+08	1.29e+08
trend	-3.77e+10	3.90e+09	-9.67	0.000	-4.54e+10	-3.01e+10
_cons	3.50e+12	1.96e+12	1.79	0.074	-3.42e+11	7.34e+12

Significance level of 10%

As seen in the case of the MENA region estimated, variables estimated for developed countries also show a significant correlation with adjusted net savings. Although, the coefficients of trade and GDP are negative.

Table 11: Renewable energy consumption (Adjusted Net Savings and cumulative)

AN_tS	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
Mean Group:						
REC	1.38e+09	7.77e+08	1.77	0.076	-1.46e+08	2.90e+09
REC2	-2.82e+07	1.23e+07	-2.29	0.022	-5.24e+07	-4070357
Log of GDP	5.90e+09	1.85e+09	3.18	0.001	2.27e+09	9.53e+09
TRADE	-2.58e+08	2.43e+07	-10.60	0.000	-3.06e+08	-2.10e+08
trend	-9.10e+09	1.15e+09	-7.89	0.000	-1.14e+10	-6.84e+09
__cons	1.64e+10	4.02e+10	0.41	0.682	-6.23e+10	9.52e+10

Significance level of 10%

In summary, estimation from developing, developed and the cumulative analysed shows that renewable energy consumption has a significant relationship with sustainability although GDP had a positive relationship in one and negative in the other.

Chapter 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

The goal of this research study was to add more insight to the definition and measurement of sustainable development paying special attention to the optimal mix of Renewable and Non-Renewable energy for sustainable development of the MENA region using a new measurement for sustainable development. To determine the optimal mix, I employed the use of quadratic regression to estimate the minimum levels of adjusted net savings-energy use relationship. For further understanding, a causal relationship between Adjusted net savings, Renewable-energy consumption, Trade, Energy use and GDP was examined to reveal the direction to which each variable influenced each other.

The literature review examined different definitions of sustainable development, highlighting the misconceptions behind the definition of sustainable development and economic growth. Economic growth as a proxy for sustainable development specifically accounts for the GDP in the economy most of the time failing to take into consideration other determinants of sustainable development as defined by the world bank hence the use of AN_tS.

Quite a number of literatures reviewed the use of AN_tS as the best measurement for sustainable development because it encompasses majority of the characteristics of sustainable development. This section analyses the results on the use of Adjusted net savings on other macroeconomic variables to determine of it is a proper measurement for sustainable development.

Cross sectional dependency test rejects the null hypothesis at a significance level of 5% meaning that the data sample analyzed are highly interconnected. In cases like this where the number of observation is not dependent of each other, it creates a bias in other statistical analyzed. To treat such contingencies, the panel unit root model that takes into attention cross sectional dependence is engaged.

The result from the unit root test fails to reject the null hypothesis of non-stationarity of the variables among the idiosyncratic components although the common factor estimates show evidence of stationarity among the variables. Interpreting this would mean that the non-stationarity of the variables is due to the peculiar characteristics of each country.

Using the selected significance level of 5%, the result for the Dumitrescu & Hurlin (2012) Granger non-causality test showed no causal relationship between adjusted net savings and energy use meaning that an increase in energy consumption which could be as a result of production has no direct increase in the savings the country sets aside for sustainable development and vice versa which is in line with the world energy outlook (2004) .The opposite seems to be the case for renewable energy consumption.

The result for co-integration found AN_tS, Energy use, Renewable energy consumption GDP and trade are all co-integrated in the long run which supported the concept of sustainability that caters to long run relationship between current and future generations. With this estimation, next step is to determine what kind of relationship exist between them hence causality test.

The existence of bi-directional causality from adjusted net savings to renewable energy consumption in the Granger causality estimation explains that an increased use of renewable energy consumption positively impacts the savings in the country which can genuinely reduce the impact of the emissions of GHGs validating all advancement towards the use of clean energy as championed by the sustainable development goal 7. This could also mean that when countries realize they have to save too much towards sustainability for the negative impacts of Energy use, they start to shift to Renewable energy consumption. GDP granger causes AN_tS and vice versa which supports most growth hypothesis that an increase in the market value of goods and services increases the value set aside for savings in the economy.

Both renewable energy consumption and energy use showed significant relationship with AN_tS. The coefficient of energy use was U-shaped for developing countries and inverted U-shaped for developed while it was inverted U-shaped for both developing and developed for renewable energy consumption estimates. Conventional sources of energy might be able to kick start development but in the long run it is not sustainable and that the more a country switches to cleaner sources of energy the less it contributes funds towards Adjusted Net Savings.

Form the quadratic regression analyzed, it is observed that the minimum level of sustainability is higher in developed countries compared to developing countries hence, developing countries still heavily dependent on conventional sources of energy will need higher levels of adjusted net savings to cater for the externalities of their energy choices. I recommend developing countries set aside funds early enough to caters to their sustainability which will definitely decline as they improve in the process.

In conclusion, as all countries are becoming industrialized although at a slower pace, production increases, pollution increases, more energy is used resulting in GHG emissions and other harmful by-product. Setting funds aside to cater for sustainability is imperative and calculating the optimality using quadratic regression methods as used by (Plassmann, F., & Khanna, N. 2007) to ascertain the respective levels countries need to attain to effect the lifestyle becomes irresistible.

Expectedly, this research confirms the importance and quick actions international organizations have borne upon themselves to reduce GHG emissions. It would be beneficial for developing nations to enact policies to guide their citizens toward a more sustainable path. Finally, a gradual move from non-renewable energy sources to renewable sources makes any country sufficiently sustainable, causing a decline AN_tS evident in the regression analysis. This then goes to say that AN_tS can be used as a measurement of sustainable development.

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