NEAR EAST UNIVERSITY
GRADUATE SCHOOL OF SOCIAL SCIENCES
BANKING AND FINANCE PROGRAM

THE GLOBAL DYNAMIC RELEVANCE OF FINANCIAL DEVELOPMENT AND ENERGY CONSUMPTION IN THE GROWTH CHANNELS OF BOTH THE EAST AND WEST POLES COUNTRIES

ALA’ FATHI ASSI

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THESIS SUPERVISOR
Assoc. Prof. Dr. ALİYA ISİKSAL

CO-SUPERVISOR
Assoc. Prof. Dr. TURGUT TURSOY

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2020

ACCEPTANCE/APPROVAL

We as the jury members certify '**the global dynamic relevance of financial development and energy consumption in the growth channels of both the east and west poles countries'** prepared by the **ALA FATHI MHMAD ASSI** defended on **15/10/2020** has been found satisfactory for the award of degree of

JURY MEMBERS

Assoc. Prof. Dr. ALİYA ISİKSAL (Supervisor)
Near East University (NEU)
Faculty of Economics and Administrative Sciences, Department of Banking and Accounting

....

Assoc. Prof. Dr. TURGUT TURSOY (Co-supervisor)
Near East University (NEU)
Faculty of Economics and Administrative Sciences, Department of Banking and Finance

....

Prof. Dr. Hüseyin IŞIKSAL (Head of Jury)
Near East University (NEU)
Faculty of Open and Distance Education, Department of International Relations

....

Prof. Dr. MUSTAFA SAGSAN
Near East University (NEU)
Faculty of Economics and Administrative Sciences, Department of Knowledge Management

....

Asst. Prof.Dr. Veclal Günüz
Bahçeşehir Cyprus university (BAU)
Faculty of economics, administrative and social sciences, Department of Banking and Finance

....

Assoc. Prof. Dr. Derviş KIRIKKALELİ
European University of Lefke (EUL)
Faculty of Economics & Administrative Sciences, Department of Banking and Finance

....

....
Prof. Dr. MUSTAFA SAĞSAN
Graduate School of Social Sciences
Director

DECLARATION

I ALA FATHI ASSI, hereby declare that this dissertation entitled ‘**the global dynamic relevance of financial development and energy consumption in the growth channels of both the east and west poles countries’** has been prepared myself under the guidance and supervision of ‘**Assoc. Prof. Dr. ALİYA ISİKSAL** and the co-supervisor of **Assoc. Prof. Dr. TURGUT TURSOY**’ in partial fulfilment of the Near East University, Graduate School of Social Sciences regulations and does not to the best of my knowledge breach and Law of Copyrights and has been tested for plagiarism and a copy of the result can be found in the Thesis.

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DEDICATION

This thesis is dedicated to my dear country, Palestine, which we hope will be liberated soon. And also to my parents Fathi and Rebhia Assi, and the entirety of the Assi family.

ÖZ

THE GLOBAL DYNAMIC RELEVANCE OF FINANCIAL DEVELOPMENT AND ENERGY CONSUMPTION IN THE GROWTH CHANNELS OF BOTH THE EAST AND WEST POLES COUNTRIES

Bu araştırma çalışması, küresel sürdürülebilir kalkınma için güçlü kamu politikası ve düzenleyici müdahalelerin serbest bırakılması görüşü çerçevesinde Avrupa Ekonomik Alanı [AEA] ile Güneydoğu Asya ülkeleri ve Üç [Asya+3] birlik üyesi arasındaki finansal gelişme, ekonomik özgürlük, çevre kirliliği, teknolojik yenilik ve enerji tüketimi [yenilenebilir ve yakıt] arasındaki küresel dinamik bağlantıları incelemeyi amaçlamaktadır. Bu çalışmada, 1998 ile 2018 yılları arasındaki süre boyunca AEA'nın da yer alan 24 grup üyesinin ekonomilerine ait küresel verileri ve Asya+3 grubunda yer alan 9 grup üyesinin ekonomilerine ait küresel veriler kullanılmıştır. Ayrıca, bu ekonomilere ilişkin finansal gelişme, çevre kirliliği, ekonomik özgürlük, teknolojik yenilik, yenilenebilir enerji için enerji tüketimi ve yakıt endekslerinin tümü, Temel Bileşen Analizi (PCA) kullanılarak geliştirilmiştir. Belirlenen dönemde değişkenleri analiz etmek için Dumitrescu ve Hurlin nedensellik ile dinamik panel ARDL yaklaşımı ve CS-ARDL testleri kullanılmıştır.

Sonuçlar kısa ve uzun vadede, seçilen değişkenlerin Asya+3 ve Avrupa Ekonomik Alanı ekonomilerindeki ekonomik sürdürülebilirliği destekleyerek Keynesyen hipotezini koruduğunu doğrulamıştır. Kısa ve uzun vadede, Avrupa Ekonomik Alanı ekonomileri ve Asya+3 ekonomileri ile ilgili sonuçlar, finansal gelişmenin yenilenebilir enerji tüketimini desteklediğini ve fosil yakıt enerji tüketimini desteklemekten kaçındığını ortaya koymuştur. Ayrıca, yenilenebilir enerji tüketimi, karbondioksit emisyonlarının azaltılması açısından genel çevreye faydalı olduğu için Avrupa Ekonomik Alanı ülkeleri ve Asya+3 ekonomilerinde çevre kirliliğinin azaltılmasına da fayda sağlamıştır. Aksine, fosil yakıt enerji tüketimi, karbondioksit emisyonlarına zarar verdiği ve çevreyi sürdürülemez hale getiren artan karbondioksit emisyonları açısından da çevreye zarar verdiği bulgulanmıştır. Sonuçlar kısa ve uzun vadede teknolojik inovasyonun Avrupa Ekonomik Alanı ve Asya+3 ekonomilerinde, yenilenebilir enerji tüketim endeksini artırarak ekonomik sürdürülebilirliği desteklediğini ve fosil yakıt enerji tüketimini desteklemediğini doğrulamıştır. Dahası, ekonomik özgürlüğün her iki tüketim göstergesini de (yenilenebilir enerji ve yakıt) desteklediğine dikkat çekilerek, Avrupa Ekonomik Alanı ve Asya+3 ekonomilerinde ekonomik özgürlüğün belirsiz sonuçları ortaya çıkmıştır. Bu basitçe, Avrupa Ekonomik Alanındaki ekonomik özgürlük seviyesinin her iki ekonomik enerji yapısını desteklediği anlamına gelmektedir. Son olarak, Keynesyen hipotez AEA ekonomileri ile Asya+3 kişi başına reel GSYİH ekonomisi arasında olduğu, ve her ikisinin de yenilenebilir enerji ve enerji tüketimi için tüketim göstergeleri olduğu saptanmıştır. Kişi başına düşen reel GSYİH büyüdükçe tüketimin arttığına dikkat çekilmiştir.

Bu çalışmadaki uzun vadeli bulgular, hem ekonomik hem de çevresel sürdürülebilirliğin mümkün olduğunu, ancak bunun kamu politikasının kalitesine ve her iki grubun ekonomilerindeki yetkililer tarafından yapılan düzenleyici müdahalelere bağlı olacağı ortaya konmuştur. Önerilerimiz, politika önerileri bölümünde sunulmuştur.

Anahtar Kelimeler: Finansal Kalkınma, Enerji tüketimi, Ekonomik özgürlük, Teknolojik İnovasyon, Çevre kirliliği, NARDL yaklaşımı, Keynesyen teori.

ملخص الدراسة

THE GLOBAL DYNAMIC RELEVANCE OF FINANCIAL DEVELOPMENT AND ENERGY CONSUMPTION IN THE GROWTH CHANNELS OF BOTH THE EAST AND WEST POLES COUNTRIES

تتجلى أهمية هذه الدراسة البحثية في فحص الروابط الديناميكية العالمية بين التنمية المالية، والحرية الاقتصادية، والتلوث البيئي، والابتكار التكنولوجي، واستهلاك الطاقة [الطاقة المتجددة والوقود الأحفوري] لكل من المنطقة الاقتصادية الأوروبية [EEA group] ورابطة دول جنوب شرق آسيا [ASEAN+3 group] بهدف إطلاق سياسة عامة قوية وتدخلات تنظيمية من أجل تنمية اقتصادية وبيئية عالمية. استخدمت هذه الدراسة بيانات لأربعة وعشرين اقتصادا عضواً في مجموعة المنطقة الاقتصادية الأوروبية، وبيانات لتسع دول أعضاء في رابطة جنوب شرق آسيا خلال فترة تراوحت بين 1998 إلى 2018 ، علاوة على ذلك ، تم إنشاء كل من المتغيرات التالية: التنمية المالية، والتلوث البيئي، والحرية الاقتصادية، والابتكار التكنولوجي، واستهلاك الطاقة لمؤشرات الطاقة المتجددة والوقود الأحفوري كمتغيرات وكيلة باستخدام تحليل المكونات الرئيسة (PCA). ثم إن هذه الدراسة قد استخدمت نهج لوحة PARDL مع سببية Dumitrescu Hurlin واختبارات CS-ARDL لتحليل المتغيرات المختارة لتلك الفترة

.حصلت الدراسة على نتائج توافق النظرية الكنزية مع ما تم تطبيقه من متغيرات مختارة في عينتي الدراسة .حيث أكدت النتائج على المدى القصير والطويل دعمها للإستدامة الإقتصادية والبيئية، فقد كشفت النتائج أن التنمية المالية تدعم استهلاك الطاقة المتجددة مقابل استهلاك طاقة الوقود الأحفوري. إلى جانب ذلك، أثبت أن إستهلاك الطاقة المتجددة مفيد في الحد من التلوث البيئي في دول المنطقة الاقتصادية الأوروبية ورابطة جنوب شرق آسيا من حيث إنخفاض إنبعاثات ثاني أكسيد الكربون، وعلى العكس من ذلك، فإن استهلاك طاقة الوقود الأحفوري تسبب في إلحاق الدمار للبيئة نتيجة لتصاعد إنبعاثات ثاني أكسيد الكربون. كما أكدت نتائج الدراسة أن الابتكار التكنولوجي دعم الاستدامة الاقتصادية والبيئية في المنطقة الاقتصادية الأوروبية ورابطة جنوب شرق آسيا من خلال زيادة الطلب على الطاقة المتجددة في تلك الفترة. أظهرت نتائج الدراسة عن نتائج غير واضحة لمؤشر الحرية الاقتصادية في المنطقة الاقتصادية الأوروبية ورابطة جنوب شرق آسيا ، حيث اشارت النتائج إلى أن مؤشر الحرية الاقتصادية يعزز استهلاك الطاقة المتجددة وكذلك الوقود الأحفوري. أخيرًا، أشارت النتائج أن زيادة الناتج المحلي الاجمالي الحقيقي للفرد يحفز استهلاك المزيد من الطاقة المتجددة والوقود الأحفوري على المدى الطويل. النتائج طويلة المدى في هذه الدراسة أكدت وبقوة سعي هذه الدول نحو الاستدامة الاقتصادية والبيئية.

قدمت هذه الدراسة اقتراحات حول جودة السياسات العامة والتداخلات التنظيمية للفاعلين والمؤثرين في هذه الدول من أجل تصور مستقبلي للحفاظ على إستدامة إقتصادية وبيئية، حيث تم عرض إقتراحاتنا في القسم الخاص بالتوصيات.

الكلمات المفتاحية: التنمية المالية/ استهلاك الطاقة/ الحرية الاقتصادية/ الابتكار التكنولوجي/ التلوث البيئي/ نهج PARDL/ النظرية الكينزية.

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ABBREVATIONS

ADF	Augmented Dickey-Fuller
AIH	Absolute-Income Hypothesis
APC	Average Propensity to Consume
ARDL:	Autoregressive-Distributed Lag
ASEAN:	Association of Southeast Asian Nations
ASEAN+3	Association of Southeast Asian Nations Plus Three
CADF	Cross-Sectional Augmented Dickey-Fuller
CBRED	Capacity Building to Remove Barriers to Renewable Energy
CD	Cross-Sectional Dependency
CEE:	Central and Eastern Europe
CIS:	Commonwealth of Independent States
CO2	Carbon Dioxide Emissions
CS-ARDL	Cross-Sectional Autoregressive-Distributed lags
CS-ARDL:	Cross sectional Autoregressive-Distributed Lag
CSD	Cross Sectional Dependency
DEA:	Data Envelopment Analysis
DFE	Dynamic Fixed Effect
DH	Dumitrescu-Hurlin Non-Causality Test
DOLS:	Dynamic ordinary least squares
EC	Energy Consumption
ECM	Error Correction Model
EEA	European Economic Area
EF:	Economic Freedom
EFSI	European Strategic Investment Fund
EKC	Kuznets Environmental Curve
EPOL:	Environmental Pollution
EU	Europe Union
FD:	Financial Development
FDI	Foreign Direct Investment
FFEC:	Fuel Energy Consumption

FMOLS:	Panel-Based Fully-Modified Ordinary Least Squares
G20:	Group of Twenty
G-7:	Group of Seven
GCC:	Gulf Cooperation Council
GDP	Gross Demotic Product
GEC	Global Energy Crisis
GGF	Green-Growth Funds
GHG	Greenhouse Gas Emissions
GMM:	Generalized Method of Moments
IEF	Indicators of Economic Freedom
IEPOL	Indicators of Environmental Pollution
IMF	International Monetary Fund
IPS	Im Pesaran and Shin Test
IREC	Indicators of Renewable Energy Consumption
ITIN	Indicators of Technological Innovation
KMO	Kaiser-Meyer-Olkin
LACC:	Latin America & Caribbean Countries
LCH	Life-Cycle Hypothesis
LLC	Levin, Lin and Chu Test
LSDV:	Least Square Dummy Variable
MENA:	Middle East and North Africa Countries
MG	Mean Group
MLE	Maximum Likelihood Estimation
MPC	Marginal Propensity to Consume
NAFTA:	North American Free Trade Agreement
NARDL:	Non-Linear ARDL
OECD:	Organization for Economic Cooperation and Development
OLS:	Ordinary Last Secure
PCA:	Principal Component Analysis
PIH	Permanent-Income Hypothesis
PMG	Pooled Mean Group
PTR:	Panel Threshold Regression

PVAR:	Panel Vector Autoregression
REC :	Renewable Energy Consumption
RGDP	Real Gross Demotic Product
RIH	Relative-Income Hypothesis
RVCF:	Restricted Variable Cost Function
SAARC:	South Asian Association for Regional Cooperation
SDGs	Sustainable Development Goals
SEMs:	Simultaneous Equation Modelling
SSA:	Sub-Saharan African Countries
SSAC:	Sub Saharan African Countries
STIRPAT:	Stochastic Impacts by Regression on Population, Affluence and Technology
SUR:	Seemingly Unrelated Regressions
TINN:	Technological Innovation
UK	United Kingdom
UN	United Nations
UNE	United Nation Emirate
US	United State
VAR:	Vector Autoregression
VECM:	Vector Error Correction Model
WD	World Bank
WDI	World Bank Indicator
WEC	Wave Energy Converter

INTRODUCTION

Introduction

The republic of global sustainability is concerned with analysis of economies around the globe without regard to their differences in terms of development, geographical location, regional groupings etc. The term 'economic sustainability' is understood from a variety of perspectives, however, in this thesis the term was restricted to the application of both economic models and econometric techniques in providing practical solutions to the economic and environmental sustainability issues. This was done with economical lenses on financial development, economic freedom, environmental pollution, technological innovation, per capita GDP and the consumption of energy in a way that will unleash robust public policy and regulatory responses for global sustainability.

Background

The global economy was tormented by a plethora of economic crises like the 2008-2009 global financial crisis, 2010-2012 European debt crisis, Global Energy Crisis (GEC) of (1970s, 1990s, and 2000s) and also the 2014-2016 global commodities realignment era. The end of these crises have ushered in new life to the global economy which was forced to its death bed by these avenging crises and this gave impetus for public policies to be realigned in lieu with social, economic and environmental aspects of sustainability (UN, 2019). The UN also noted that in 2017, the European Economic Area (EEA) and Association of Southeast Asian Nations plus three (Asean+3) posted 2.4% and 6.1% of growth, in 2016 it stood at 2.0% and 6.1% in that order. Further growth in 2018 and 2019 was envisioned. The growth of the European Economic Area (EEA) and the Association of Southeast Asian Nations plus three (Asean+3) economics in the past few years was linked to strengthening growth in each members of the group. However, in some parts of the two groups, economies are yet to realize sustainable growth as inequalities are visible on different countries and regions. A strong global macro-economic outlook breeds favorable conditions for investment due to reduced volatilities on financial assets, reduced weakness of the banking systems and recovery of the commodities sectors of the both groups. On the contrary, renewable energy consumption strengthened for the year 2018 and 2019 amid strong demand from European Economic Area (EEA) and the Association of Southeast Asian Nations plus three (Asean+3) due to conducive public policy interventions in this region and improvements in technological innovation in both groups due to stable investment conditions. Economic freedom forms great certainty on renewable energy trade and spread within countries and promoting technological innovation in light of maintaining the environmental quality. Energy sustainability needs to be addressed as an urgent phenomenon because rapid economic growth is normally plagued with a multiplicity of oil energy costs in the form of energy shortages. The shift towards sustainable energy is progressing at a gradual pace globally, with Asean+3 being the “big brother” investor in renewable energy; while energy shortages are common in some regions in world.

Statement of the problem

Economic and environmental sustainability became a global issue and have drawn the attention of development partners, governments, policy makers, investors and academia; although the shocks from the Global Financial Crisis (GFC) of 2008-2009 and Global Energy Crisis (GEC) of 1970s, 1990s, and 2000s) are still seemingly dormant, there is a ‘time bomb’ of uncertainties lumbering on the horizon; European Economic Area (EEA) and the Association of Southeast Asian Nations plus three (Asean+3) Members are on a dilemma of missing one of the important Sustainable Development Goals (SDGs) , a target to achieve economic sustainability through a GDP growth of a minimum of 7% in a not too distant future and achieving environmentally sustainability on the same time and only a handful of the economic groups will be able to meet the economic sustainability target.

Aim and objectives of the study

This research study was aimed at unmasking dynamic links of economic and environmental sustainability through studying the relationships between financial development, economic freedom, environmental pollution, technological innovation, GDP per capita and energy consumption with respect to the East and West poles [European Economic Area (EEA) and the Association of Southeast Asian Nations plus three (Asean+3)] with a view to unleashing robust public policy and regulatory interventions for sustainable development. Other specific objectives include to:

A. Make an investigation on the relationship with respect to the dynamics of financial developments and the consumption of energy in East and West poles [EEA and Asean+3 groups].
B. Empirically examine the relationship with respect to technological innovation and the consumption of energy in the East and West poles [EEA and Asean+3 groups].
C. Explore the environment-energy nexus in the East and West poles [EEA and Asean+3 groups].
D. Investigate the effect of economic freedoms on supporting the growth of the economy and development in the East and West poles [EEA and Asean+3 groups] economies.
E. Reveal the nature of causalities which exist between financial development, economic freedom, environmental pollution, technological innovation, per capita GDP and the consumption of energy in East and West poles [EEA and Asean+3 groups] so as to develop robust public policy and regulatory interventions.

Significances of the study

This research study broadened the scope for public policy reorientation in the East and West poles [European Economic Area (EEA) and the Association of Southeast Asian Nations plus three (Asean+3)] across the domains of financial development, economic freedom, environmental pollution, technological innovation, GDP per capita and energy consumption. The major contributions of this study were examining the dynamics of both groups' economies in the Keynesian hypothesis context, specifically the energy consumption indexes, in the process considering the Sustainable

Development Goal target. The study considered renewable energy consumption indicators and fossil fuel energy consumption indicators in the East and West poles [EEA and Asean+3 groups] in the Keynesian hypothesis analysis and these indicators were put together in an index form. To the best of the researchers' knowledge, this was a unique contribution of this work since there was no available study which employed these factors together as indexes calculated using principal component analysis (PCA), especially in the Keynesian hypothesis context.

Research study questions

The research study sought answers to the questions:

1. Does the Keynesian hypothesis hold in the East and West poles [EEA and Asean+3 groups]?
2. Do we have any relationships with respect to financial developments and the consumption of energy in East and West poles [EEA and Asean+3 groups]?
3. What is the relationship with respect to environmental pollutants and the consumption of energy in context of East and West poles [EEA and Asean+3 groups]?
4. Is technological innovations in the East and West poles [EEA and Asean+3 groups] strong enough to support Sustainable Development Goals?
5. Are there any causality relationships between financial development, economic freedom, environmental pollution, technological innovation, per capita GDP and the consumption of energy in East and West poles [EEA and Asean+3 groups]?

Study Hypothesis

The study will test three alternative hypotheses given below:

- **Hypothesis [1]**: The Keynesian hypothesis is significant in the East and West poles [EEA and Asean+3 groups].
- **Hypothesis [2]**: There are significant dynamic relationships between financial development, economic freedom, environmental pollution,

technological innovation, per capita GDP and the consumption of energy in the East and West poles [EEA and Asean+3 groups].

- **Hypothesis [3]**: The causality relations between financial development, economic freedom, environmental pollution, technological innovation, per capita GDP and the consumption of energy are significant.

Limitations and Delimitations

The research study only considered the nexus that exist on financial development, economic freedom, environmental pollution, technological innovation, per capita GDP and the consumption of energy in East and West poles [European Economic Area (EEA) and the Association of Southeast Asian Nations plus three (Asean+3)]. The study considered data from the year 1998 up to 2018. However, since the study considered all economies which are members of both economic groups, some countries had no relevant data for our selected variables. Such countries were eliminated from our selected sample and only 24 and 9 countries composed our sample respectively, therefore the researchers included only economies which had the data availability for a reasonable period of time. In the same vein, generalization of the findings of this study may be jeopardized by too many missing values in some countries but the researchers considered a multiplicity of interventions on a case by case basis, including interpolations and extrapolations in order to deal with missing values. This was done in a way that could not make the study lose its traction of appealing to the two economic groups' audience. Another issue was on obtaining data for recent years, though the various data series was somewhat balanced, there was no recent update of data for the period 2019 on the World Development Indicator series, however this could not jeopardize our findings since the variables have a long series dating back to the year 1998.

Summary

The researcher in this section presented the background of the research study, statement of problem, aims and objectives of study, significance of study, research questions, hypothesis and limitations as well as delimitations of the research study. Chapter 1 reviews literature relating to financial development, economic freedom, environmental pollution, technological innovation, per capita GDP and the consumption of energy consumption in East and West poles [European Economic Area (EEA) and Association of Southeast Asian Nations plus three (Asean+3)].

CHAPTER 1

REVIEW OF RELATED LITERATURE

Introduction

This chapter provides related literature for financial development, technological innovation, environmental pollution, economic freedom, real GDP per capita and two forms of energy consumption, these include renewable energy and fossil-fuel energy. The first part will provide overview of the consumption of energy.

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1.1. Overview of Energy Consumption

The main types of energy used in economic activities are renewable and fuel energy. Both of these forms of energy are very crucial for economic growth and economic sustainability. This section will give a brief explanation of all forms of energy, their sources and consumption trends.

1.2. Type of Energy Consumption

1.2.1. Renewable Energy Consumption

Renewable energy is a word which is employed when referring to forms of energy which are naturally obtained from the environment and can be obtained from sources replenishing naturally, often referred to as clean energy. These include solar energy, wind energy, geothermal energy, hydro-power, and biomass. They use renewable energy sources to produce electricity, home heating and cooling, hot water and even cooking. Environmental and economic benefits of using renewable energy include; the less maintenance cost because the majority of sources require very few or no moving parts, hence having little mechanical problems. These are economic and may ensure cutting of costs on fossil-fuel energy. They release very little and/or no wastes onto the environment and renewable energy sources are not depleting, hence, they ensure a good prospect for the future.

This part of the thesis will demonstrate the role of some of the influencing factors in renewable energy consumption, which include: financial development, environmental pollution, innovation and real GDP. It will also provide relevant previous studies explaining direction of relationships with respect to these factors and renewable-energy consumption.

1.2.1.1. Renewable Energy Sources and Consumption Trends

Renewable energy emanates from natural processes that can produce cheap energy reliably with less impact to the environment and the mainly popular renewable energy sources include, Figure (1.1) presents the type of this energy:

1. **Hydropower:**

Hydroelectricity is the type of electricity which is extracted from hydropower. In 2015, hydropower contributed 16.6% of global total electricity and 70% of all renewable electricity. It was envisioned to rise by approximately 3.1% every year in the coming 25 years. Hydropower is generated in 150 nations, with Asia-Pacific region producing 33 percent of global hydropower by 2013. In the year 2013 China was the biggest hydroelectricity producer, with the production of (920 TWh) indicating 16.9% of domestic electricity usage. The hydroelectricity costs are relatively lower hence, enabling it to be a cheaper source of renewable electricity (WCD, 2000). Global hydroelectricity power consumption reached 4193.10 terawatt-hours (TWh) per year in 2018 with a growth rate of 3% (BP.Statistical, 2019).

2. **Solar Energy**:

Solar energy come from radiant light and heat collected from the sun which is harnessed by employing a multiplicity of ever-evolving techniques including solar-heating, photovoltaic, solar thermal energy, solar-architecture, molten-salt power plants and also artificial photosynthesis. Solar energy an important renewable energy source and its technology is greatly viewed as either passive-solar or active-solar based on how they absorb and generate solar energy or convert it into solar power. Active-solar technologies involve the use of photovoltaic systems, concentrated-solar power and solar-water heating to generate energy. Passive-solar technologies involve directing a building to the sun, selecting materials with favorable thermal weight or light dispersing characteristics, and creating spaces which make it easy for air to naturally circulate (Wald et al., 2003). Global solar power consumption reached 58 463 terawatt-hours (TWh) per year in 2018 with a growth rate of 29% (BP.Statistical, 2019).

3. Wind Power

Wind energy have been in use for more than 3500 years ago. Wind-power or wind energy involve the usage of wind to generate mechanical power through wind turbines to move electric generators and traditionally to perform some other work, such as milling or pumping. Wind-power is a form of sustainable and also a form of renewable energy, with very little environmental impact as compared to the burning of fossil fuels. Wind is a temporary source of energy , and cannot be used to make electricity or be transmitted on demand (Holttinen et al., 2006). Global wind power consumption reached 126 995 terawatt hours per year in 2018 with a growth rate of 15% (BP.Statistical, 2019).

4. Bio Fuel Power

Bio fuel is generated from contemporary processes from biomass, contrary fossil fuel which is generated from very slow geological processes responsible for the formation of fossil fuels, for example oil. Two major forms of bio fuel include bio-ethanol and bio-diesel. Bio-ethanol is alcohol made through fermentation, while biodiesel is extracted from oils or fats using trans-esterification.

5. Geothermal Power

Geothermal power is produced through geothermal energy by employing techniques like dry steam-power stations, flash-steam power stations and also binary-cycle power stations. Geothermal electricity production is currently employed in 26 nations, whereas geothermal heating is being employed in 70 nations (Holm et al., 2010).

6. Wave Power

Wave-power is captured from wind waves to perform important work – such as, generation of electricity, desalination of water, or water pumping by employing machines which exploits wave power known as wave energy converter (WEC). (Nelson et al., 2008).

7. Tidal Power

Tidal-power or tidal-energy is a special form of hydropower transforms energy produced from tides into important forms of power, especially electricity. Tidal energy has the potential for future electricity generation although not yet widely employed. Tides are very predictable as compared to both wind and the sun (Spain, 2002). Other renewables refer to renewables including geothermal energy, biomass, waste, waves, and tides. Globally, others renewable energy sources of consumption reached 584.98 terawatt-hours (TWh) per year in 2017 with a growth rate of 5% (BP.Statistical, 2019). The energy usage of energy globally is expected to increase steadily through 2030 in the referenced scenario. Globally, the demand for primary energy was envisioned to increase about 1.7% annually ever since 2000 to 2030, approaching a yearly level of 15.3 billion tons of oil equivalent (btoe). These increases will be equivalent to two-thirds of demand in current terms. The expected growth is however slower than realized growth in the past 30 years which was around 2.1% annually (Bilgen et al., 2004).

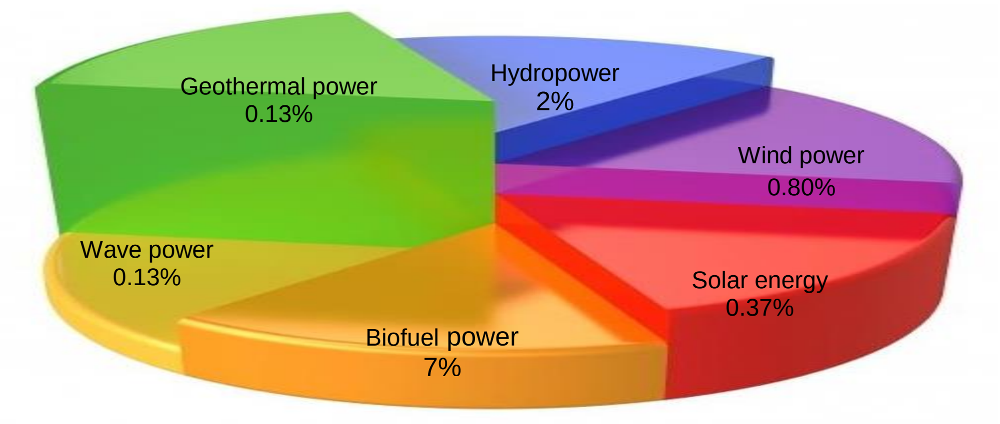


Figure 1 1: Renewable Energy sources and global consumption

Source: Researchers' Design

1.2.2. Fossil Fuel Energy Consumption

Given the increasing importance of fossil fuel energy used in economic activities, where fossil fuels will keep on being the main source of energy, and satisfy more than 90% of increases in demand. With the demand in global oil expected to rise by 1.6% annually, from about 75 million barrels per day in 2000 to about 120 million barrels daily by 2030, transportation sector come in about three quarters of increases in demand. Oil will remain the preferred fossil fuel in the land, sea and air transport (IEA, 2002). Given this importance, this part of the work illustrates the role of some of the factors affecting fossil fuel energy consumption, which include: financial development, environmental pollution, innovation, economic freedom, and real GDP. It will also provide relevant previous studies explaining the direction of the relationship between these factors and fuel energy consumption.

1.2.2.1. Fossil Fuel Energy Sources and Consumption Trends

Sources of fossil fuels (non-renewable fossil) burn coal and/or hydrocarbons fuel, which are remains of degradation of plant and animal matter. The three major forms of fossil fuels include coal, oil, and natural gas see Figure (1.2). The usage of fossil fuels by the eighteenth and nineteenth centuries paved way for the industrial revolution. From that period fossil fuel energy became the primary energy for all economic activities.

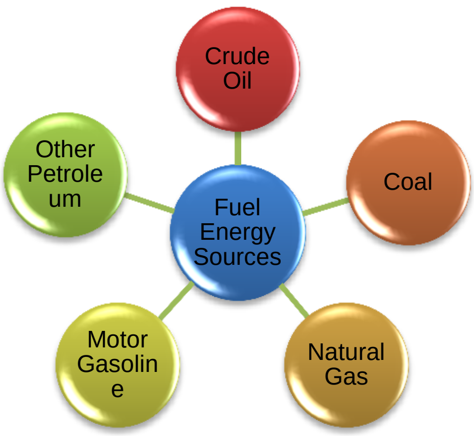


Figure 1. 2: Fuel Energy Sources

Source: Researchers' Design

1.3. Determining the Relationship between Energy Consumption and Other Selected Variables.

This section will present a brief determination of relationship with respect to the consumption of energy and the variables chosen, and also theories that emphasized the relationship, and some relevant studies results are presented.

1.3.1. Energy Consumption and Financial Development

For close to a century, there has been a debate among economists on the impact of a financial sector in economic development. According to Ref. [9], the financial developments stage could affect the consumption of energy through three ways that is direct effect, business effect, and wealth effect. In a direct effect, it pertains clients who in the context of efficient financial intermediation, get resources in an easily way and can purchase products that are durable, which result in an increase in the demand for energy. In the case of business effect, it is promoted by the increase in the trend of financial developments, which provides companies with improved access to financial capital. In the same vein, financial developments allows for access to low cost financial capital to firms, so as to expand business activity or to set up a new business venture, which normally increases the demand for energy. Trust firms created the wealth-effect and households contributed have in the developed stock market. Figure [1.3] shows all the indicators available, selected in this work that fall under the financial development umbrella in influencing energy consumption. Initially, theories of financial development that cause economic growth as a result of increased energy consumption are presented, then relevant literature that focuses on experimental work presented from different places and time periods is presented.

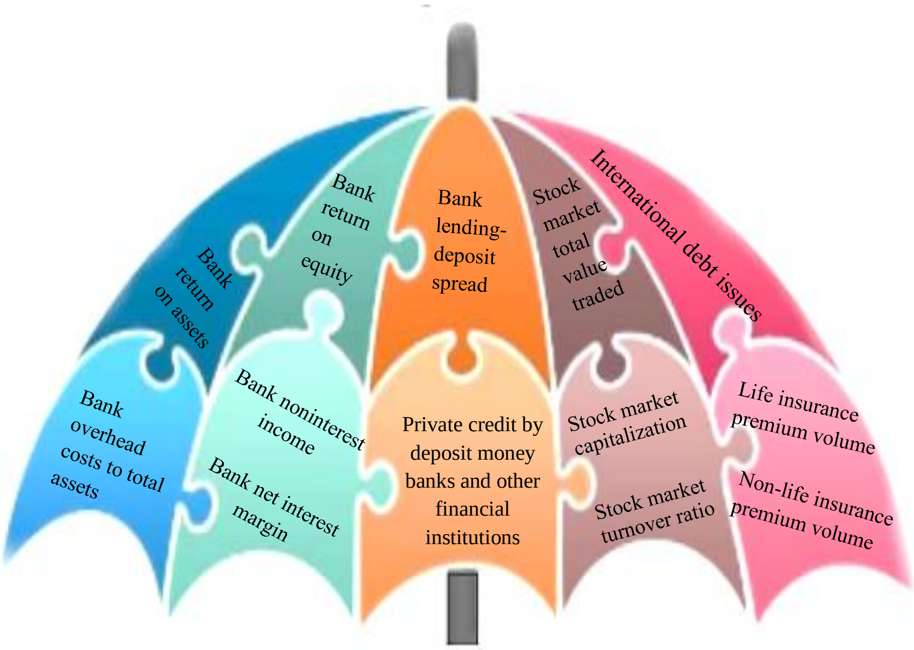


Figure 1. 3: Financial Development Indicators

Source: Researchers' Design

Initially, theories of financial development that cause economic growth as a result of increasing energy consumption are presented, then presenting relevant literature that focuses on experimental work presented from different places and times.

1.3.1.1. Theories of Financial Development

In traditional models, McKinnon (1973) and Shaw (1973) stressed the importance of a financial sector in growing volumes of the savings through creating attractive incentives, so as to achieve higher savings and investments rates. The duo then made recommendation for governments to put an end to ceilings of interest rates and encouraged them to stop raising seignorage through inflationary monetary policies. This resulted in real-interest rates rising to market clearing level, thus increasing savings. One of the crucial features of the McKinnon and Shaw models was that they give details only intermittently higher economic growth rates. Most governments in economies on the rise accepted this policy advice and attained noteworthy accelerations in their economic growth rates, however, sometimes also exceptionally higher and unpredictable real-interest rates. Therefore in traditional models (McKinnon/Shaw); financial liberalization => financial deepening (or saving) => investment => output (development) (Syed Hamid Ali Shah, 2011). New growth theories explain that the economic intermediation escalates production of capital and growth over time, but some government's intervention in the financial system hinder growth. Pagano (1990) demonstrated that financial developments affect growth through: private saving rate, and the proportion of savings channeled to productive investments. The well-known "AK" model indicated this; Yt=AKt (Pagano, 1993). That representation makes an assumption that manufacturing of a single type of good (Y) with a single type of input such as capital (K), and "A" in this case referring to factor productivity. K relies on the savings rate, where a portion (f) of savings (S) was invested. In such a simple model, a secure economic growth equation is obtained, thus: g = A f S – d, where, "d" represents depreciation speed. The equation suggests that financial developments may have an effect on economic growth through capital production or economic system efficiency; in some other terms through reduction of loss of resources, and savings rates (Eschenbach, 2004). Greenwood and Jovanovic, (1990) developed some model where financial intermediations and increase in economic activities (growth) were both internal variables. They suppose the existence of a positive two-way contributory relationship with respect to financial developments and economic growth. The duo alluded that selecting to assign funds to the most capable firms and mangers can produce more competent allocation of funds and faster growth, and have the potential to encourage the technological innovation rate by providing help in form of loans to entrepreneurs.

Empirics of finance and growth have a broad consensus in literature that a well-built and strong positive connection between financial development, measured by a variety of indicators, and financial growth, or the level of financial development; more finance lead to more growth. While some authors argue that the link is causal that is it is possible that the positive relationship reflects reverse causality more growth leads to more finance (Durusu-Ciftci et al., 2017). Potential causal effects are thus:

1. **Finance-led Growth**

This is also known as 'supply-lending" hypothesis (Patrick, 1966), it leads to the increase in the supply of financial services leading to real economic growth.

2. **Growth-driven Finance**

It is also known as 'demand following' hypothesis (Patrick, 1966). Demands on fiscal services and products by financial intermediaries are extremely reliant on the increase in real output, commercialization, and modernization of agricultural products and other surviving economic sectors. Further, elevated growth, the greater demand of financial services required by entrepreneurs for building investments.

3. **Bi-directional Causal Relationship**

In this relationship, it involves an amalgamation of the supply-leading and the demand-following hypotheses that proposes that two variables are linked together via feedback (Schumpeter, 1934). A nation which have a well-established financial sector can endorse a higher economic increase through technological change, products and service innovations. In addition, it then generate a higher demand on the economic resources and also services (Robinson, 1952).

4. **Interdependence Between Finance And Growth**

Stern (1989) have disregarded the part played by financial developments in the finance-growth process. Lucas (1988) on the other hand, proposes that financial economists emphasize the responsibility played by the economic markets. In Figure (1.4) it is summarized.

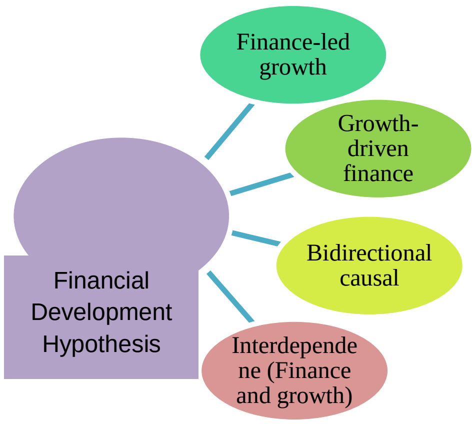


Figure 1. 4: Financial Development Hypothesis
Source: Researchers' Design

1.3.1.2. Relevant Related Literature

Increasing the financial services supply leads to real economic growth by affecting renewable energy consumption. In this regard, the studies supporting this theory includes: Ji and Zhang, (2019) who argues that foreign investment and capital market promote the consumption of renewable energy in China over the duration 1992-2013 by employing Vector Autoregression (VAR) model. However, Paramati et al., (2017a) explored the role of domestic capital (stock market) and foreign capital (foreign direct investments flows) in influencing clean energy uses throughout the European Union (EU), the Group of Twenty (G20), and the OECD, which extends over period 1993-2012. The results showed that both foreign direct investment and supply markets have a crucial role in the promotion of clean-energy use in all three-country groups. Further, Riti et al. (2017) noted that renewable energy consumption is increasing with financial developments, their study used STIRPAT technology on data from ninety countries. In the same vein Kim and Park, (2016) came to a conclusion that that financial development enhance investments in renewable energy by dropping financing costs, which increases the share of renewable energy uses in thirty countries in which this work was applied, during the period from 2000 to 2013 and using the ordinary least squares method (OLS). As mooted by Mazzucato and Semieniuk,(2018) public and private funding of renewable energy projects In Spain ,China, Kenya and the United States,, from 2004 to 2014, played unprogressively more important role in developing of renewable energy technologies. This constituted a reason for the increased renewable energy demand. Koengkan et al., (2020) argued that economic openness and general government capital-stock per person had a constructive impact on renewable energy investments in Latin American economies for the period 1980 to 2014, by using PVAR model. This indicates an increased portion of renewable energy demand in the above economies. Anton and Elena (2020) analyses the role of bank sector, capital market and bond market, via financial developments in influencing the consumption of renewable energy using panel data from twenty eight economies in the European Union between the years 1990-2015 and it was revealed that it have an affirmative impact on the share of the consumption of renewable energy. Wu and Broadstock (2015) exposed the constructive impact on financial developments and institutional quality on the use of renewable energy. As if that is not enough, using data from 22 emerging economies from 1990-2010. Kutan et al. (2018) explored role of foreign unswerving investment inflows and stock market growth in promoting renewable energy consumption through a committee from , China, India ,Brazil and South Africa from 1990-2012. In the same vein, Brunnschweiler (2009) noticed that there is a constructive impact of financial developments on clean energy consumption in 119 countries outside the Organization for Economic Cooperation and Development (OECD). Public investment supported clean energy projects, which show an increase in renewable energy demand, (Rodríguez et al., 2014). While, Lee, (2013) finds convincing evidence that foreign direct investment was linked with renewable energy use in the G20 countries in 1971 to 2009 by applying panel integration method. Further, Zhang et al. (2011) argued that supply market level magnification is the reason for increasing energy use in China over period 1992-2005 period and using regression models.

Additionally, some researchers established the causal association between financial developments and renewable energy utilization as in (Kutan et al., 2018). Their results confirmed that both FDI inflows and supply market expansion cause renewable energy consumption (unidirectional causation). Moreover, Al-Mulali and Sab, (2012a) reported a bidirectional causality connection between financial developments and renewable energy consumption in thirty countries in the Sub-Saharan Africa countries between the duration 1980 - 2008. Similar results were provided by Paramati et al., (2016) which revealed evidence from emerging economies in the period 1991-2012. The development of FDI inflows and supply market (investment in the uncontaminated energy projects to acquire capital (availability) and allows investors to obtain higher risk- adjusted returns (efficiency)) can lead to the use of advanced technologies in clean energy production. It was confirmed that there is a unidirectional causality extending from financial development to the use of renewable energy. On another hand, the study of

Sbia et al., (2014) found the impact of financial developments on renewable power consumption in the UAE between 1975 and 2011 and the outcome indicate that financial development (enhancing public and private capital shares, and lower financing costs) stimulates economic activity which had a bidirectional causality to renewable energy consumption. Furthermore, (Burakov and Freidin, 2017) used data gathered from 1990 to 2014, and employed the Granger causality test and established that renewable energy utilization is not caused by financial developments in Russia. There are other studies which looked into the link between FDI and on renewable-and non-renewable energy consumption for 74 countries from the period 1985-2012. Doytch, N., & Narayan, (2016) employed a Blundell-Bond dynamic panel estimator, and the outcome indicated that financial developments promotes the consumption of renewable energy.

Other preceding studies examined the connection amid financial developments and fossil fuel energy utilization for example;(Dasgupta et al., 2001) emphasized that the role of financial development increases the energy consumption of fossil fuel in a financial system. Sbia et al., (2014) established that the impact of foreign unswerving investments and trade openness increases energy demand in the UAE. Researchers (Omri and Kahouli, 2014) have discovered a positive link between financial developments and energy use. Using the data from 1970-2012 and ARDL bounds method, Rafindadi and Ozturk [2016] gave evidence from Japan that financial development increases the consumption of renewable energy . As Sadorsky [2010] noted, the development of bank deposits was associated with increased energy consumption. Frankel and Romer [1999] lamented that financial developments can catch the attention of more foreign direct investment, which appears to be the main motive r of economic growth in China and increased power demand. Another evidence that financial developments positively affects financial growth in MENA region, and thus increased energy use through the Boulila and Trabelsi [2004]study. A research study by Çoban and Topcu [2013] gathered that more financial developments [stock exchange or banking] could lead escalation in energy consumption. According to Sadorsky (2011)there is evidence of increased power consumption as a result of overall financial developments. Added that financial development certainly and appreciably influences energy consumption in the studies of (Komal and Abbas, 2015). In the (Zeren and Koc, 2014) study, mixed results were presented by three indicators represented as a fluctuation of financial development, and as an outcome of this study on the seven new developed countries straddling from 1971 up to 2010. The results exposed both optimistic and pessimistic shocks for both Malaysia and Mexico while for the Philippines it was negative shocks. By applying ARDL model on Malaysia and Japan, the results were similar and fossil fuel energy consumption promoted by financial development according to Islam et al. (2013) and (Javid and Sharif, 2016)studies, respectively. While by co-integration test, Aslan et al. (2014)show that inclusive financial development increased energy demand.

Many researches have revealed the causal correlation between financial developments and fossil fuel energy utilization, few studies found the bidirectional causality as in a study of (Shahbaz and Lean, 2012) for six individual indicators of financial developments in Tunisia from 1971 to 2008. And, (Mudakkar et al., 2013)for South Asian Association for Regional Cooperation (SAARC) countries over 1975–201, the results confirmed the feedback hypothesis. Similar results were confirmed by Shahbaz et al. (2013) when they applied VECM approach on China during the 1971-2011. Further, Ahmed et al., (2015) supported the feedback hypothesis in their results through the period 1980-2013 in Pakistan. Even though, other studies ensure that unidirectional causality expand from financial developments to the utilization of fossil fuel energy as Bekhet and Othman, (2011) who used the time series data from Malaysia were used for these variables from 1971 to 2009 period, and the l VECM model was employed. These results confirmed the existence of causation running from financial developments to fossil fuel energy utilization. Furthermore, a bi directional causality expanding from financial developments and fossil fuel energy use was evident, Abdouli and Hammami [2017]. Additionally, Chang [2015] considered the non-linear effects of financial developments on energy use , and recognized that energy use increases financial developments, while private and domestic credits are taken as financial developments indicator. On the other hand, when supply value and supply market turnover were used as financial developments indicator, energy use declines faintly with financial developments in advanced finances but increase in higher revenue rising and developing economies, and the results confirmed the subsistence of a unidirectional causality running from financial developments, while few studies found no causality relationship among both variables as (Dan and Lijun, 2009). More so, Hao et al [2018] establish that financial developments could not Granger cause GDP in 29 Chinese provinces for the period from 1995 to 2014.

Other research studies revealed a negative correlation among financial development and fuel energy consumption (Mielnik and Goldemberg, 2002) and they concluded that a unconstructive connection between financial developments via the share of foreign direct investment (FDI) in the gross domestic investment (GDI) and energy intensity was there. In addition, Tamazian and Bhaskara Rao. (2010) found a negative correlation between financial developments and the consumption of energy in 24 transition economies from 1993-2004. Further, financial development plays a negative role for fossil fuel energy consumption as noted by Ouyang and Li. (2018). Even a research study by, Farhani and Solarin [2017]discovered that, in the long haul, an increase in financial developments decreased energy demand in the US using a time series data set over 1973-2014 and the application of ARDL co integration approach. Moreover, Rafindadi [2015] found further evidence that greater financial development in Germany reduces energy demand using time series data during 1970-2013 by applying the ARDL bounds method and the VECM model. Furthermore, Jalil and Feridun [2011] studied the impact of financial developments and the use of energy per person on ecological pollution in China during the period 1953 to 2006 using the ARDL Bound approach. The practical guide to the examination represents a unconstructive sign for the financial development factor, which indicates that China's financial developments protect the environment from pollution by helping to reduce energy use that causes environmental pollution.

1.3.2. Consumption of Energy and Environmental Pollution

The association between environmental pollution and power utilization is a synthesis of the environmental Kuznets curve (EKC) under different economic growth levels. The EKC hypothesis postulates that as income increases which requires more consumption of energy, emissions raise also until some entry level of revenue is reached after which emissions start to fall. In this sense, income growth may serve as a solution to environmental degradation rather than the source of the problem through the type of economic structure the country is to follow. Two decades ago, many researches have shown that high power consumption from fossil fuels drives environmental degradation across industrialized and rising nations around the world. As a result, different governments and policymakers have realized the significance of reducing environmental degradation. As a result, various studies have come in place to investigate the dynamics of power consumption and environmental pollution. This increasing environmental degradation has changed economic structure in some countries, which have shifted attention to the search for clean energy sources in order to reduce pollution. Furthermore, various variables were used as pollution indicators, such as Nitrous oxide emissions, Methane emissions, and CO2 emissions, which employs three indicators that cover air, earth and sea categories can see in Figure (1.5):

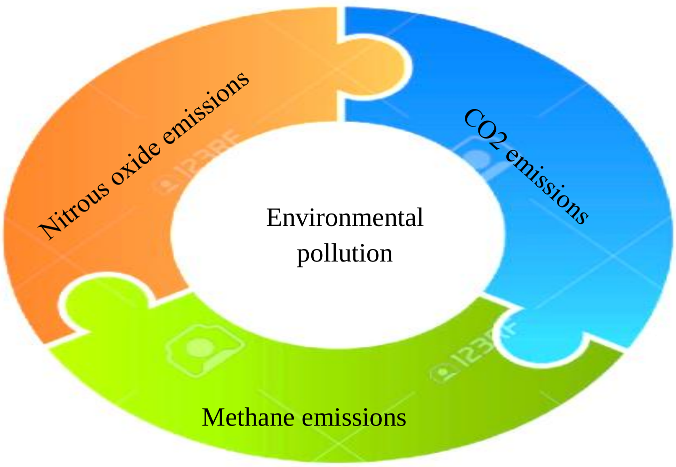


Figure 1. 5: Environmental Pollution Indicators

Source: Researchers' Design

1.3.2.1. Theory Environmental Pollution and Energy Consumption

Environmental pollution in a country necessarily depend on its stage of financial growth and the form of power utilization used in it. Assuming the Kuznets Environmental Curve (EKC) helps understand the relationship between pollution and economic growth. The EKC assumption clarifies that through the early phases of financial development, the raise in income will amplify pollution until it reaches some point where the association between the two variables is negative. This occurrence occurs when the country experience improvements in power efficiency, clean energy, and environmental consciousness which aid in forming an inverted U-shape connection between income and toxic waste. As a result, the raise in the role of renewable energy utilization can help to decrease the contamination levels. Furthermore, the government effort in the promotion of renewable energy and power efficiency might help to launch the environmental Kuznets curve (EKC) association between contamination and economic growth (Figure (1.6).

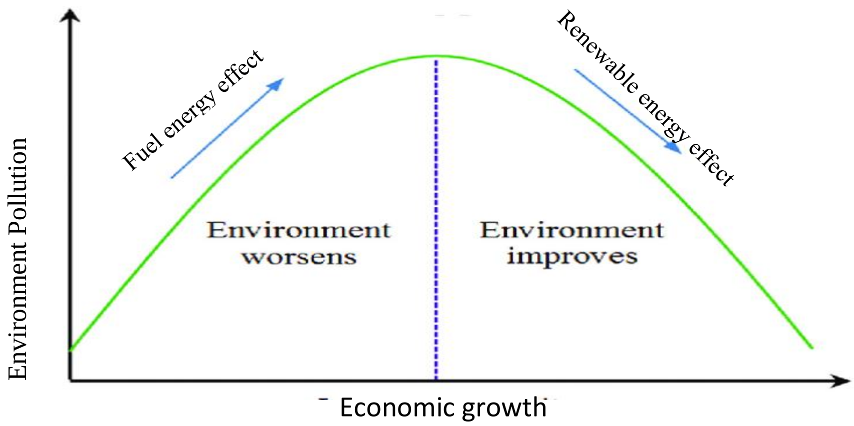


Figure 1. 6: Environmental Kuznets curve

Source: Researchers' Design

1.3.2.2. Previous Relevant Studies on the Environmental Kuznets Curve

The Environmental Kuznets Curve assumption is becoming a significant focus between scholars who observe environmental and financial policies. A number of studies were carried out examining the Environmental Kuznets Curve hypothesis, to assess how growth can help the environment from increasing pollution levels. Several studies have found that the increase in renewable energy utilization reduces environmental pollution in many different countries, regions and organizations. For instance; the co integration test results indicated that CO2 emission level are unconstructively connected to the use of clean energy in the US during 1960–2007, (Jaforullah and King, 2015). While, (Rafiq et al., 2014) examine the dynamic associations among output, carbon emission and renewable power generation for China and India for the period 1972 to 2011 by a multivariate vector error correction model (VECM). The outcome for India revealed a bidirectional long-range causality among carbon emission and renewable energy generation. Causalities in China gave a rather same scenario, with a long run bidirectional causality found between carbon dioxide emissions and renewable energy generation. There was also, (Al-Mulali et al., 2015) who provided evidence from twenty three chosen European countries in the period 1990–2013, that the Pedroni co-integration results indicated that renewable energy generated from (hydroelectricity ,flammable renewables and waste, , and nuclear power) has a negative impact on carbon dioxide emissions. Through investigations of the environmental Kuznets curve (EKC) assumption in Kenya by the time period of 1980–2012, the ARDL approach was utilized. The outcome of (Al-Mulali et al., 2016)research study revealed that the utilization of renewable energy mitigate air contamination in the long time and the short time. Another important study by (Bloch et al., 2015)presented different results from examining the connection linking Chinese aggregate production and utilization of three major energy commodities such as oil, coal and renewable energy using yearly data from 1977- 2013 and 1965 - 2011 for the supply-side and demand-side analyses, in that order. Both autoregressive distributed lag (ARDL) and vector error correction modelling (VECM) revealed that coal consumption causes pollution, while renewable energy consumption reduces emissions, while no significant causation on emissions was found for oil. Therefore, attention to the fastest developing economies policy makers of the world has of late shifted towards the encouragement of renewable power cohort and use across financial activities to make sure there is low carbon economy. Additionally, Paramati et al. (2017b) employed a number of robust panel econometric models by means of annual data from 1990 -- 2012. Pragmatic findings confirmed a downbeat and significant long-run association among renewable power use and CO2 emissions. Moreover, (Liu et al., 2020) presented the ability generate power from renewable generation sources to satisfy the heat demand for 63% in a year with no emissions of carbon dioxide emissions in the UK. A research study by Salim and Ra, (2012) analyzed the determinants of clean energy utilization in a panel of six main emerging economies, namely Philippines, China, , Brazil, Indonesia, India and Turkey that are proactively escalating the implementation of clean energy and covering the period 1980 to 2006. By means of fully modified ordinary least square (FMOLS), Dynamic ordinary least square (DOLS), and Granger causality methods, findings suggested that in the long run, renewable energy use is considerably determined by contaminant emission in Brazil, India, China and Indonesia. Causal linkages between renewable energy and contaminant emissions were discovered to be bidirectional. However, few studies which were examined using co-integration and Granger causality tests showed that the association between environmental pollution and renewable power utilization such as in a cluster of nineteen industrial and rising countries from 1984 to 2007 by Apergis et al. (2010). The long haul estimates indicate that there is a statistically important constructive connection with reverence to renewable energy consumption and emissions, whereas Granger causality test results confirmed that clean energy consumption does not contribute to reductions in emissions. Similar results were found by Menyah and Wolde-rufael, (2010) and they confirmed that the use of renewable energy is not yet on a stage where it can make an important input to emissions reduction in the US for the period 1960–2007. A long-haul, non-linear co-integrated association exists linking renewable energy use and carbon dioxide emissions coefficients positive and statistically significant in the panel of seven Central American countries over the period 1980 to 2010, (Apergis and Payne, 2014) study's. Whereas, Jensen, (1996) revealed that the existence of well-developed economic sector facilitate the attraction of foreign direct investments and may promote financial growth, and then, enhance industrial contamination and reduce ecological quality. However, environmental degradation has increased in economies dependent on fossil fuel energy activities, and financial development has boosted these activities. Additionally, Chiu and Chang, (2009) argued that the pragmatic panel data encompass all thirty member countries of the OECD and cover a period of nearly ten years from 1996 - 2005 and practical outcome provide unambiguous verification that renewable energy mitigates CO2 emissions. While, results of (Bölük and Mert, 2014) is that renewable energy use contribute about half less per unit of power used than fossil power utilization in terms of greenhouse gas emissions (GHG) in the European Union countries over 1990 to 2008. (Shafiei and Salim, (2014) pointed that experimental results suggests that the use of renewable energy reduces CO2 emissions by using STIRPAT model and data from 1980 - 2011 for OECD countries. Additional data was collected for 27 European Union countries during the period 1996-2010, however, Menyah and Wolde-rufael, (2010) argued that the econometric verification seem to propose that nuclear energy use can aid to alleviate CO2 emissions, but so far, renewable energy use is not yet at a level a l where it can make an important contribution to emissions reduction in US for the period 1960–2007. Under the sustainable power policies that ought to be promoted in order to encourage financial increase and environmental safety in a global context, the European Union aimed to achieve plummeting greenhouse gas emissions so as to contribute to climate change by raising the allocation of European Union energy use formed from renewable resources during the period 1996-2010, as alluded by López-Menéndez et al. (2014).

In the past twenty years, many researches have published that high consumption of fossil fuel power lead to high levels of environmental degradation in the world. Therefore, various studies have raised to investigate the dynamics of fossil fuel power use and environmental pollution for example (M. Shahbaz et al., 2013) explored the effects of coal consumption on ecological performance by means of ARDL bounds approach from 1965–2008 in South Africa. Findings form that study revealed that the consumption of coal has an important input to weaken the environment. A research study on the impact of economic development through power utilization on environmental contamination in China from 1953 to 2006 by Jalil and Feridun, (2011) using the autoregressive distributed lag

(ARDL) bounds testing procedure concluded that carbon dioxide release are mostly determined by power use in the long haul. Through studying the influence of energy consumption on environmental degradation in the US by using the wavelet technique from the 1973 to 2015, (Raza et al., 2019) revealed that in the long haul, power consumption has a constructive influence on carbon dioxide release and also causality test results confirmed a unidirectional causality running from energy consumption to carbon dioxide emissions. Furthermore, the ARDL results also provided by Sehrawat et al. (2015) confirmed that environmental dilapidation is increasing with fossil fuel energy consumption in India for the period 1971-2011. While, some research studies employed causality tests to examine causal relationships among both variables, for instance (M Shahbaz et al., 2013) used VECM causality approach for a long haul association involving fossil fuel power use and pollution, the outcome indicated the existence of a feedback assumption between power use and CO2 emissions over the period of 1975–2011 in the case of Indonesia. Similar results were found using Granger causality analysis by (Shahbaz et al., 2013) when they used annual time series data for Malaysia over the period 1971-2008, which results validated the presence of a bidirectional causality among energy consumption and CO2 emissions for the long run. Carbon dioxide emissions in Tunisia increased due to fossil fuel energy usage which increased over the period 1990–2015, and (Mbarek et al., 2018) found a bidirectional causal relationship between energy use and CO2 emissions when Granger causality test was applied. Additionally, in Pakistan using time series data from 1980–2013 to examine the linkages among economic growth, energy consumption, and environmental pollution, a bidirectional causal effect was detected between economic growth, energy consumption and pollution through applying VECM–Granger causality test by (Ahmed et al., 2015). Other studies which investigated the growth-energy consumption-CO2 emissions nexus, (Al-mulali and Sab, 2012) found that fossil fuel power consumption makes it possible for these countries to attain high monetary and financial developments. Though, the high expansion that these countries have attained in the past thirty years augmented the CO2 emission in these 19 countries for the period 1980 to 2008 and using panel data model. Similar issues were investigated by (Al-Mulali and Sab, 2012b) where the duo considered thirty of Sub Saharan African nations and a panel data model was used from 1980- 2008, The outcome showed that fossil fuel power use played an significant role to enhance both economic development and financial developments in the economies investigated but with the result of high pollution. Many studies using bounds F-test for co-integration tests to examine the relationship between energy expenditure and carbon emissions for example in Turkey from 1960–2007 indicated in the outcome provided by (Ozturk and Acaravci, 2013) that a boost in GDP ratio through increasing fossil fuel power demand results a rise in carbon dioxide emissions, thus sustaining the validity of the EKC hypothesis in the Turkish economy. Through applying the Environmental Kuznets Curve (EKC) using the case of Malaysia during 1980–2009 and employing the methodology of Autoregressive Distributed Lag (ARDL), (Saboori and Sulaiman, 2013) results indicated that increasing power consumption such as gas, electricity , coal and oil appear to be an ineffective way to control CO2 emissions, and the long-haul Granger causality tests revealed that there is bidirectional causality between these types of fossil fuel energy and CO2 emissions. Further studies discussed the issue that, in order to guarantee the sustainable growth of a financial system, environmental dilapidation should decrease and at least remain stable (Alam and Fatima, 2007). Their results indicated that a 1% raise in GDP expansion leads to 0.84% raise in the increase rate of carbon dioxide emissions, and an raise of 1% in the energy intensity expansion pace causes almost a 0.24% increases in increase rate of CO2 emissions, while financial growth Granger cause power expenditure and energy consumption causes CO2 emissions in the long-run in Malaysia over the period of 1980-2008. On the other side of financial developments, (Katircioğlu and Taşpinar, 2017) investigated the function of financial developments in a conventional environmental Kuznets curve (EKC) by using two separate models in Turkey as a case study over the period 1960 to 2010 and it was revealed that financial developments moderate optimistically the result of real output on carbon dioxide emissions in the longer time.

1.3.3. Energy Consumption and Technological Innovations

Financial growth is mainly calculated using change in the entire value of goods and services made by a country's financial system or what is known as Gross Domestic Product (GDP). financial growth depends on a multiplicity of factors and these factors are a technological change, country's rate of savings, and increases in the stock of productive inputs, , while innovation give rise to technological transformation, therefore making it a key determinant of financial growth and development. Creating monetary value by ensuring the introduction of new products in the market, reconfiguring organizational practices is essential for firms, redesigning production processes, industries and countries. According to the OECD (2003; 2005a), long haul financial growth is based on the creation and nurturing of surroundings that stimulate innovation and function of new technologies. Generating improvement, creating new technologies, and promoting the implementation of these new technologies cause higher financial growth rates. This work uses several variables as a proxy to innovation to measure the stock of knowledge in influencing energy consumption as shown in (Figure 1.7).

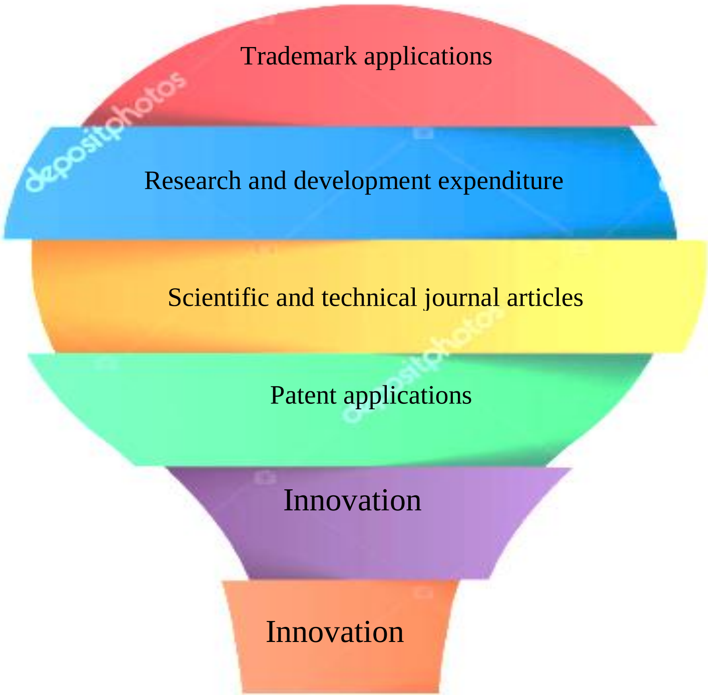


Figure 1. 7: Technological Innovations Indicators

Source: Researchers' Design

1.3.3.1. Theory of Technological Innovation and Economic Growth

The two dominant approaches that have an effect on energy consumption amount in the economy are radical innovations and incremental innovations as shown in Figure (1.8) Figure (1.7). Geels et al., (2018) neoclassical economics also provide an underlying principle for sustaining new power efficient technology at diverse stages of the 'innovation chain', but offer only limited insights into both innovation process or the mainly effective means of policy support. In the framework of the energy sector in common, the most radical advance innovations are linked with mastering new fuels, new energy conversion or energy transfer technologies, new sources of energy. It is essential that innovations of this type are to a certain extent processes than a one-time advance, as heat pumps bio fuel cars, , electric or fuel cell vehicles, , whole house retrofit, district heating system, led lights, bio-methane use in gas grids. While, incremental innovation is 'localized' alteration within a technical regime and its linked trajectory of innovation comprises of enhancement of existing technologies, also with respect to performance attribute or input characteristics (such as more economical use of materials), but it does not essentially modify the core distinctiveness of the existing technology. Such innovation consists of enhancement to pre-existing products. As insulation (double glazing, lofts, walls, fuel-efficient conventional cars and also energy-efficient household appliances such as washing machines, fridges, boilers.

Previous suggestions before Schumpeter (1937; 1942) were fewer compared to studies Schumpeter, wherein the hypothetical association linking innovation and financial growth began to be thoroughly discussed. According to Schumpeter (1937; 1942), financial growth is generated by the endogenous introduction of product and/or process innovations. Furthermore, there are three propositions in Romer (1990)'s model. The first being that technical change drives expansion. Secondly, citizens who react to market incentive take premeditated actions and this causes technical change. Lastly, they propose that designs for making new products are non-rival that is they can be imitated with no extra costs. This model has are three sectors: research and development sector, intermediate goods sector and final output sector. Technological innovation is formed by following a line of investigation and development sector and this sector employs human beings and the accessible knowledge stock. The merchandise of research and development sector is used in the manufacture of final goods and then expansion rate of output will boost everlastingly. At the same time, in the Grossman-Helpman (1991) the model assume that increase rate of the financial system is equivalent to the collective rate of innovation. There are a lot of goods in this financial system and so the model can be seen as a model of 'patent races'. In recent times, Howitt (1999) have come to the defence of innovation-oriented endogenous growth theory, where in his model by taking part in both horizontal and vertical research and growth activities, which guaranteed the innovation- based endogenous growth models. In this regard, tentatively, the innovation-based growth theory proposes that there is a constructive link between innovation and financial growth. Basing on this theory , research and development plays a major role in innovation, raising productivity and escalating economic growth (ÇETİN, 2013)**.**

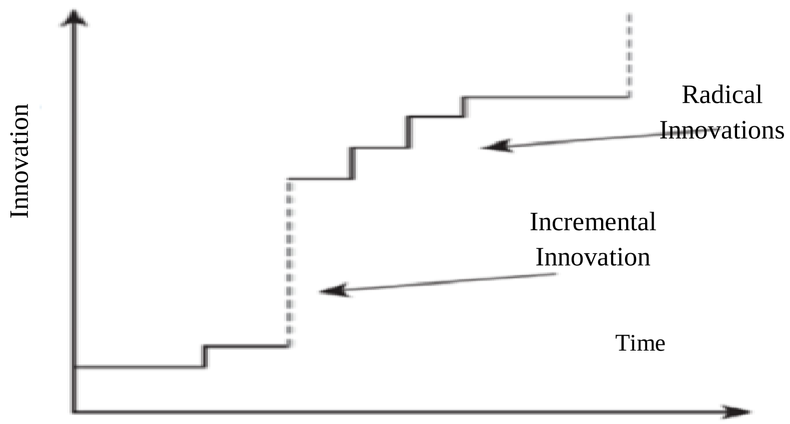


Figure 1. 8: Innovation and growth curve

Source: Researchers' Design

1.3.3.2. Relevant Previous Studies on Technological Innovation and Economic Growth

In this section, the researchers will present the results of previous researches that examined the function of technological innovation indicators on power consumption in both renewable energy and fuel fuels. Initially, previous studies were directly related to technology innovation and renewable energy consumption, where radical innovations through the role of research and development, technology introduction and patents in the energy field contributed to the increases of renewable energy consumption. Kocsis and Kiss (2015) argued that the possible link between the proportion of clean energy utilization and research and development expenditures was studied in the European Union countries throughout the period 2004-2012. A positive relationship have been identified between research and development spending and renewable energy consumption, which means lower fuel energy consumption in these economies. Further, (Chien and Hu, 2007) analyzed the connection among clean energy and technological effectiveness of OECD economies and non-OECD economies during the 2001–2002 period. The results indicated that improving an economy's technical efficiency increases the utilizing of renewable energy in OECD finances conversely in non-OECD economies. In recent years, there have been evidence of a decline in energy intensity worldwide. The main aim of Chakraborty and Mazzanti, (2020) analysis is to enhance the understanding of how green energy innovative activities are entangled with energy intensity in the OECD through models that take into account heterogeneity and serial correlation. The analysis found the existence of both immediate and long-standing relation-ships between power strength and green energy innovative activities, though this relationship loses its significance over time. A fresh standpoint in reserve economics text by investigating improvement (measured by research and development expenditures), FDI (measured by country to country knowledge transfer), and power for 24 r OECD economies from 1993 to 2014. Through using ARDL model (Alam and Murad, 2020) investigated the short-term and long-term impacts of technical development on renewable power use in organization for economic co-operation and development (OECD) countries for the period from 1970 - 2012. Empirical fallout revealed that technological progress significantly influence renewable energy use over the long-term. When the non-linear model was used by (Ahmad et al., 2020), the results revealed that innovation was encouraged to use renewable energy in the European Union economies from 1990 to 2012.

In spite of the fact that preceding studies have comprehensively investigated the clean e energy-innovation-growth link, the study of (Irandoust, 2016) offered important recommendation for OECD countries, that is technological innovation plays an successful function in the renewable energy-growth relationship through the unidirectional causality operating from technical innovation to clean energy within the data analysis covering the period 1975-2012. Otherwise, the drivers of technical transformation are differentiated by their exogenous or endogenous to the financial system and be assessed with high opinion to their input to equally the conception and the dispersion of innovation, Sam et al. (2016) applied this standpoint to study innovation in the renewable energy (RE) industry in fifteen European Union countries during the period 1990 to 2012. They found that technology-push is a stronger driver of renewable energy consumption diffusion. A study by Feia et al. (2014) has an perception of the consequence of innovation on renewable energy and carbon dioxide emissions in New Zealand and Norway from 1971 - 2010. The outcome of the ARDL model indicated that there is long-haul balance among renewable energy, financial growth, carbon dioxide emissions and technical innovation for all countries, therefore in order to optimize the advantages of clean energy use, New Zealand and Norway must take into consideration their research and development processes. However, Nemet and Kammen, (2007) pointed that patenting activity expose prevalent decline in inventive activities that are connected with research and development (R&D) investment particularly in the wind and solar energy area, affects it on clean energy production thus on its usage in the United States of America through the period 1994-2003. Additionally, Wong et al. (2013) argued that energy research and development increases the demand for renewable energy in 20 OECD countries during the period 1980-2010. Paramati et al. (2016) discussed that developing the stock market and foreign direct investment could lead emerging economies to employ advanced technologies in producing clean energy, leading to a higher share of the use of clean energy. During the period 1991-2012 in 20 emerging market economies, Mazzucato and Semieniuk, (2018) noted that finance by open investors carried an important role in developing renewable energy technologies in China, Spain, the United States, and Kenya, from 2004 to

2014. By using Granger causality test, the Tang and Tan, (2013) investigated the contributory relationships between electrical energy expenditure and technology improvement in Malaysia over the period 1970–2009. The results indicated that technology innovation Granger-cause electricity consumption also encouraging technological modernization to minimize the handling of fossil fuels.

On the other side, technological innovation in fossil fuel energy in the field of energy efficiency improvement can boost or hinder energy use. Technological innovation progress is a "local" change within the technology system and the associated path of innovation, consisting of improvements to current technology, both with regard to participation or contribution distinctiveness (such as the most inexpensive use of materials), except it does not necessarily modify the basic uniqueness of current technology. This improvement comprises of improvements to pre-existing products. As insulation (walls, lofts, double glazing, conventional fuel-saving cars, energy-saving household appliances (washers, refrigerators, boilers). thus technological innovation progress will affect energy intensity, demand on it, and its expansion. The effect of improving energy technology on fossil fuel use has been revealed in results of several studies that indicated that advances in incremental innovation technologies have boosted fuel energy consumption, such as: (Dasgupta and Roy, 2015) who presented on a all-inclusive analysis of the power demand behavior of 7 energy power-intensive industry and the overall manufacturing sector in India from 1973 to 2012. They focused on two most important drivers of power demand that is technological progress and the price of energy. The results indicated that the bias in providing fuel energy used for technological progress has prevailed in recent years. Similar results were found by (Fisher-Vanden et al., 2006) which confirmed that study and progress expenditures and shifts in the business structure are the key drivers of China's dilapidated power strength and use from 1997–1999 by using seemingly unrelated regressions model. Further, (Popp, 2001) using data from 1958-1991 in 13 industries in the United States found results showed that the decrease in fossil fuel energy consumption comes from innovation in (Teng, 2012). The introduction of technology through increased energy research and development leads to lower energy intensity in 31 industries in China for the period 1998-2006. As if that is not enough (Tamazian et al., 2009) emphasized that a well-established monetary system promotes technological innovation, then adopts new technology in economic activities, and thus reduces fossil fuel energy demand. Based on the data on the Chinese industrial sector from 2009 to 2015, (Huang, 2019) empirically analyses the effect of technological innovation through study and development (R&D) subsidy on energy consumption, where the research results revealed that research and development subsidy greatly suppressed energy consumption and promoted the optimization of the energy structure in the short term. More so, the same author confirmed the same findings above in another study on China's 30 provinces for the period 2000–2013. (Huang et al., 2018) investigated the roles of home-grown and overseas innovations in the development of technology spill overs originating from foreign direct investments, exports and imports on the energy intensity through Driscoll-Kraay standard error model, and the results indicated that indigenous innovations play a more important role on energy intensity than foreign innovations. However, (Sohag et al., 2015) argued that technological innovation expands power effectiveness and, in the same way, decreases power use at a certain stage of financial production by using an ARDL (autoregressive distributed lag) bounds testing approach for the period 1985-to 2012 in Malaysia, since diverse countries might take action in a different way to energy consumption and energy research and development, (Wong et al., 2013). The purpose of the study was to give light on the aid of power use and energy research and development on financial increase in OECD countries who have oil reserves and those who do not have over the period of 1980–2010. The results showed that the function of energy investigations and development should not be taken for granted and fossil fuel research and development was found to be driving economic growth more than fossil fuel energy consumption, and renewable energy promote actual output, particularly in the countries who do not have oil reserves. While (Herrerías et al., 2016) analyzed the part played by mutually foreign and indigenous innovation on power strength as well as the likely connections among them across thirty Chinese regions over the years 2006–2010. The outcome suggested that both foreign and domestic advancement efforts play a major role in improving power efficiency thus decreasing fossil fuel energy demand through employing a unique set of panel data for approximately 2500 of China's most energy intensive large and medium-sized industrial enterprises during 1997–1999. (Fisher-Vanden et al. (2004), confirmed that falling coal consumption comes from increasing research and development expenditures which is a driver of declining energy intensity and use. A research study by Zheng et al. (2011) found that the chief determinant of power intensity is participation in technical innovations of China's twenty manufacturing sub-sectors from 1999–2007. Also, Wilson et al., (2012)found that efficient end-use technologies contributed large potential emission reductions. According to Ahmad et al., (2020), using simultaneous equation modelling (SEMs) innovation was the primary source of carbon dioxide, indicating that innovation promoted fossil fuel energy demand for 24 OECD economies from 1993 to 2014.

However, energy consumption has an effect on the value of the surroundings, as many previous studies have confirmed that the level of pollution and climate change occurs with the increase in energy use in economic activities. Some studies have shown that technological innovation plays an effective role in plummeting carbon dioxide release such as; (Hoffert et al., 2002) emphasized that research and development is making energy efficiency improvements to be carbon emission -free in both the clean and non-renewable energy sectors to stabilize the climate. (Riahi and Grubler (2007) argued that technology options help to reduce emissions, and climate change mitigation can also make a big difference in the economy of products and services versus environmentally friendly products and services. (Huesemann and Northwest, (2006) alluded that carbon dioxide alleviation approaches for example energy effectiveness improvement, carbon appropriation, and the expansion of carbon-free energy sources are adequate to bring about the necessary decrease in carbon emissions without causing unforeseen negative impacts in another place. (Myhrvold and Caldeira, 2012)low-greenhouse-gas-emission energy technologies boost to mitigate climate change in the long term.

1.3.4. Energy Consumption and Economic Freedom

Economic freedom plays an essential role in influencing incentives, productive efforts and the resource use effectiveness, and economists and economic historians have focused on this issue. Indeed, De Haan and Sturm (2000) discussed that financial freedom is a crucial factor which explains stagnation and growth of the countries; countries grow or stagnate through two paths. In the first path, technological improvement is an essential growth determinant, a way to new designs, and the development of new technologies. The role of laws (freedom from corruption,) is to protect the assets rights of individuals and institutions. The extent of market openness and investment in a country in various sectors of the economy is also a critical determinant of growth. The sub-indices (foreign direct investment, trade, open market, etc) stimulate productive activities while energy is required to support these productive and manufacturing activities.

In recent years , there has been an escalation of financial independence operations in the majority countries of the world, (Bergh and Nilsson, 2010). This actuality was accompanied by an boost in succeeding study on this topic and its effect on a country's economics (Gurgul and Lach, 2014) and (Gurgul and Lach, 2011). Even though there is a universal opinion that financial freedom has many rewards for the economy of countries, (Miller and Kim, 2016) stated that financial liberty is basically "an individual's natural right to own the value of what he or she creates". With reference to the procedure of financial freedom, the leading existing idea that an cost-effectively free society is essential to a country's financial performance is not open for of discussion, and even though the majority of studies propose to a positive result of financial freedom on economic growth (Hall and Lawson, 2014) ; (Doucouliagos and Ulubasoglu, 2006), unconstructive effects of such a progression can as well be found in the text available(Bergh and Nilsson, 2010); (Carter, 2007). Financial freedom has constantly led to financial growth, all the way through the rise of trade and investment opportunity and by plummeting revenue inequality and deficiency levels. Nevertheless, this liberal revelation is not agreed among economists, because a number of them have shown that these reforms did not bring into being the expected positive results. Several studies have been formed with the rationale of analyzing the associations between financial freedom and fiscal growth. Though the outcome of the majority studies pointed out to the optimistic effects that this process seem to have on expansion, these results are far from being consensual. In order to measure the effect of this process on economic growth, this work covered all ten indicators shown in Figure (1.9). Sometimes, this disagreement can be the complicated in defining and measuring this process. This complexity has led to the use of proxy as trade openness, and foreign direct investment, in the middle of others.

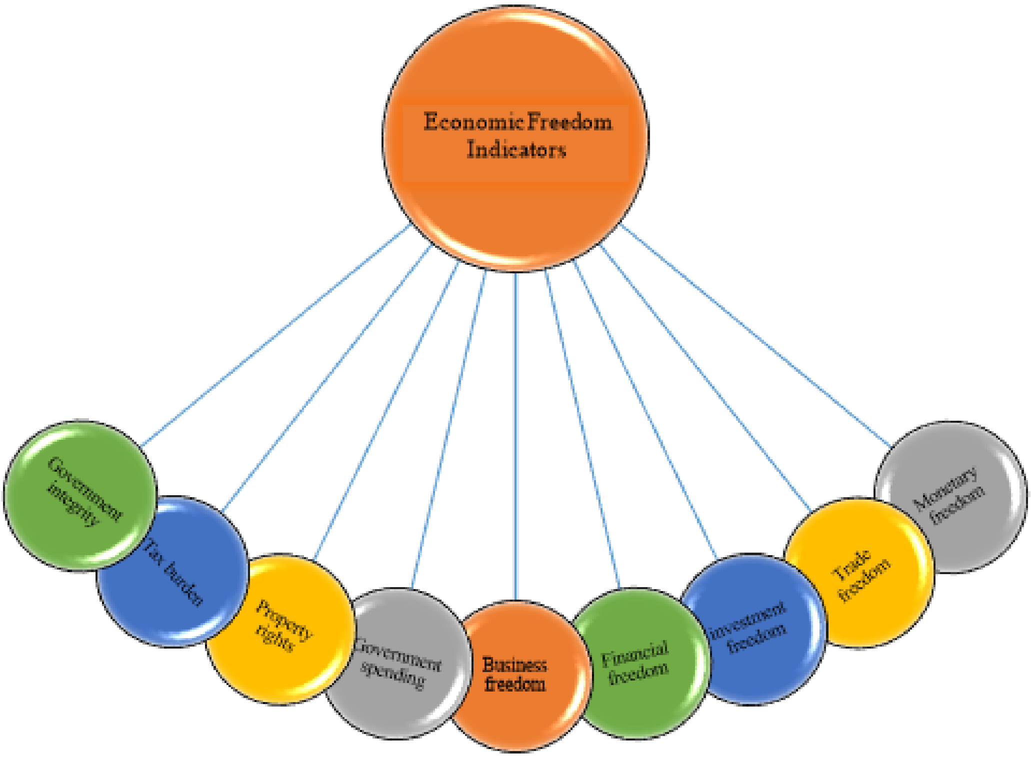


Figure 1. 9: Renewable Energy Indicator

Source: Researchers' Design

1.3.4.1. Relevant Previous Studies on Economic Freedom and Energy Consumption

Past research shows that economic freedom creates an enhancement in the rate of financial growth and economic freedom is also a key factor that promotes the consumption of renewable energy. Since no previous study have explored the connection between financial freedom and energy consumption directly, the relationship between economic freedom and financial growth is discussed in this research study. Firstly, the research study demonstrated the positive relationship between the two variables from previous studies. For example; the article review the arguments which are for and in opposition to the proposition that democratic system enhance property rights protection, and afterward conduct practical tests. Knutsen (2011) study outcome, based on data from 1984- 2004 for over one hundred and twenty countries, show that democracy enhances property rights protection. Although, Martin et al (2005) argued that democracy is a catalyst for technical progress by the protection of propriety rights, it makes it achievable for fresh enterprises to go into the market and it is helpful to the improvement of human capital, thus increased economic growth and increased energy demand. Another research study by (Paldam, 2003), discussed the controversy surrounding successes which were achieved in the Asian tigers countries and the paper surveys use the financial freedom index from 1970 to 1999 to tackle this argument, as the results indicated the positive role played by economic freedom. While, Wulandari (2015) pointed that purpose of the research study was to find the connection amid financial freedom and financial growth in Indonesia in 2004-2014. The results indicated that financial freedom leads to economic growth by institutional reforms, market liberalization, and very powerful engine of innovations. However, it experienced the interaction between economic freedom and financial growth by means of panel data analysis for a sample of 18 Latin American countries for 1970 to 1999. Bengoa and Sanchez-Robles (2003) found that economic freedom in the host country is a positive determinant of growth. The research study results also suggested that foreign direct investment is absolutely correlated with financial growth in the host countries, even when there is application of meta-analytic techniques to the literature on the impact of financial freedom on economic growth. Doucouliagos and Ulubasoglu (2006) found an overall positive direct connection between economic freedom and financial growth in 82 countries for the period 1970–1999. Similar previous results have also been presented by (Doucouliagos, 2005), which was an another evidence of the positive economic freedom-economic growth effects. Additionally, (Pattanaik and Nayak, 2014) provided an evidence that economic freedom has fostered economic growth through three individual dimensions of economic freedom that is government size, strong rule of law, and regulations governing credit must be flexible, in a study involving twenty Indian states covering three time periods 2004 to 2005, 2006 to 2007 and 2009 to 2010. Moreover, (Hussain and Mahfuzul Haque, 2016) showed that the sub-indicators of financial freedom which is the index of commercial freedom, financial freedom, freedom of work, and the index of commercial and financial freedom revealed a positive effect on the expansion rate of a group of 186 countries during the period 2004-2014. While another study discussed the effect of economic freedom levels on growth as (Gwartney et al., 1999), examines the significance of financial freedom by means of an index that measures financial freedom in 4 central areas- which are money and inflation, economic structure, taking and discriminatory taxation, and international trade. The practical results demonstrate that financial freedom level is a momentous determinant of financial growth. Modern pragmatic work has shown that together escalating the degree of economic freedom and a advanced stability of policies are encouraging for economic growth in the past 25 years various countries followed as in an (Pitlik, 2002) and (Weede and Kämpf, 2002) study's. Another study using the co integration test confirmed that the positive connection between financial freedom and growth in 28 nations covered the period 1975-1990, provided by Ayal and Karras (1998). Further, other studies revealed that the positive impact of the increase in the financial freedom on fiscal growth.(Wu, 2011), (Ali and Crain, 2001); (Ali and Crain, 2002); (Gwartney et al., 1999); (Pitlik, 2002); (Weede and Kämpf, 2002)

This piece of writing address the concern of causality in the connection between economic freedom and financial growth in evolution countries. The analysis was conducted for twenty five post-socialist countries during 1990–2008 using a set of indicators of financial freedom and Granger causality tests by Piatek, Szarzec, & Pilc (2013), and the results show that financial freedom has a unidirectional impact to financial growth in evolution countries. The tests also suggest the average level of freedom in a nation, as well as many of the specific underlying components of freedom, causes growth in 147 countries in the world during the period 1994 to 1997 by (Heckelman, 2000). Similar results found by (Kheng et al., 2017), revealed that the openness and foreign direct investment are running to growth in 55 developing countries over the 1980–2011 period. Also, the fundamental links amid improvement in economic freedom and changes in GDP per person of new European Union members in change during 2000-2009.(Gurgul and Lach, 2012) indicated a unidirectional causality running from economic freedom to expansion. Moreover, they found support that improvement in financial freedom is one of the key factors inspiring the union of these economies towards rich EU members. By considering reducing taxes in OECD countries during the 1970-1995 period, causality test results indicated that the being of a unidirectional causality extends from reducing taxes to growth by Kneller et al. (1999).

Secondly, it demonstrates the negative relationship between the two variables from previous studies. For instance, Santhirasegaram. (2007)stated that economic freedom was correlated with a downturn in economic growth in 70 developing countries. Moreover, through examining the impacts of financial freedom on the financial growth of a group of 21 developing nations from Latin America and the Caribbean over the years 1995 to 2015. Considering Santiago et al. (2018)results conclude that economic freedom has a negative impact on the economic growth. Even (Carlsson and Lundström, 2002) concluded that a solitary measure of financial freedom do not reveal the compound financial environment and a highly aggregate index makes it hard to draw policy conclusion. From in 74 countries and within the period 1975–1995, the outcome show that financial freedom matters for growth. This do not connote that rising financial freedom, defined in wide-ranging terms, is good for financial growth since several categories in the index are insignificant and various of the significant variables have negative effects. Further, few studies found that economic freedom had a negative relationship to economic growth as (Doucouliagos, 2005), (Pitlik, 2002)(Bergh and Nilsson, 2010), (Carter, 2007) and (De Haan J, 2003).

1.3.5. Energy Consumption and Real GDP Per Capita

Searching for the association between power demand and financial growth will render important evidence to design appropriate national environmental and energy policies in long run. Based, national policy-makers can develop successful development strategies, which produce a harmony among energy, environment and economy. Therefore, we aimed at analyzing the linkages between energy use and economic growth. All countries are greatly reliant on the energy sector in their advancement processes, and the world's requirement for energy is increasing daily. Despite its rising importance and usage level, renewable energy still does not hold a large share in the world's power portfolio compared to non-renewable sources. Maintaining economic and environmental sustainability with high level of economic growth will be an essential issue to explain the connection among real GDP per capita effects on energy consumption.

1.3.5.1. Theory of Energy Consumption and Economic Growth

The relation between power consumption and financial growth is very important to environmental and power policies. In the literature, the association connecting energy consumption and financial growth has been discussed in several studies. Directions of the connection between power consumption and financial growth must be categorized into four assumptions, each of which has important implications for energy policy (Figure 1.10). The growth hypothesis suggest that unidirectional causality run from power utilization to financial growth. It implies that boost in power use have a positive impact on financial growth. Consequently, energy utilization has a very important role in financial growth in the production process. If there is a unidirectional causality from financial growth to power consumption, it is called conservation hypothesis. This assumption promotes that the decrease in energy use will have little/ no effect on financial growth. Also, it is supported that an increase in real GDP causes a rise in energy consumption. The feedback hypothesis argues bidirectional causality among energy use and financial growth. This association implies that there is a combined effect linking energy use and financial growth. In other terms, energy preservation has a negative effect on economic growth, and decrease in GDP has a negative impact on energy use. No causality between energy use and financial growth is referred to as neutrality hypothesis. Under the neutrality hypothesis, energy use is not linked with GDP, which means that the increase or decrease in power consumption does not have an impact economic growth and vice versa.

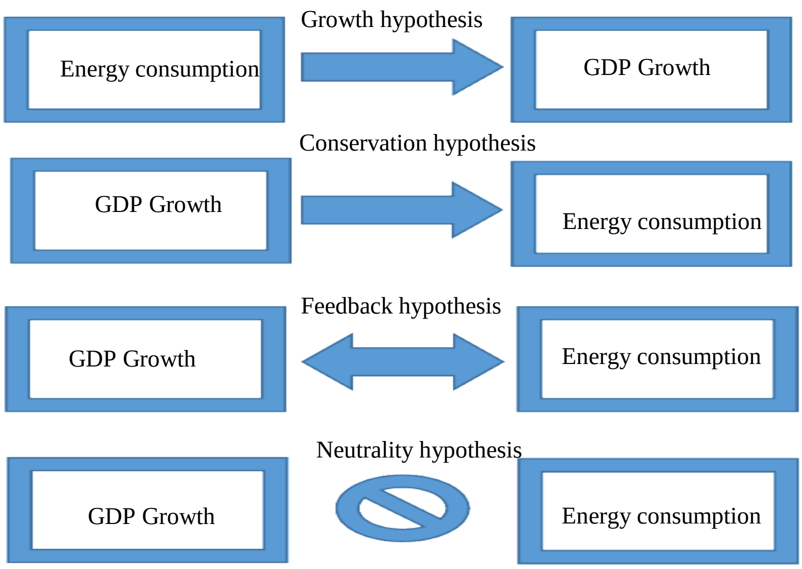


Figure 1. 10: Theory of economic growth

Source: Researchers' Design

1.3.5.2. Relevant Previous Studies on Energy Consumption and Economic Growth

A number of studies examine the association among financial growth and power consumption by applying diverse growth hypotheses. In respect of studies that confirmed a conservation hypothesis, this vital role of economic growth in the production process represents an increase in economic activities that depend on energy and thus constitute a need to increase the energy demand.(Apergis and Payne, 2009a) found the bidirectional causality connecting energy use and real output in 6 Central American nations over the period 1971–2004. (Kula(2014) promoted the (conservation hypothesis) through revealing unidirectional causality from a GDP to renewable electricity consumption for 19 OECD countries over the timeframe 1980–2008. While, ARDL bounds testing approach was applied in the case of UAE covering the period of1975–2011 by (Sbia et al., 2014). The results of the VECM Granger causal approach include a unidirectional causality that extends from GDP to energy consumption. (Kakar et al. (2011) argue that financial growth and the demand for clean energy have a positive relationship. Another study by Sadorsky [2009] found economic growth boosted the use of clean energy in developing. Apergis and Payne[2010] provided evidence from twenty OECD countries that a cooperative causal relationship between renewable powers use and economic growth in the temporary and long lasting term. Apergis and Payne (2012) also proved bidirectional causality among economic growth and clean-energy demand. Moreover, Narayan and Doytch. [2017] found a positive and statistically significant relationship between renewable production and growth. Similarly, (Pao and Fu, 2013) found a strong relationship between GDP and renewable energy consumption. By applying ARDL method in the United States during the period 2001-2009, it was found that industrial output has a positive impact on hydropower, waste and wind energy consumption (Ramazan Sari et al., 2008). Added,(Payne, 2011)found that the unidirectional causation triggered by the biomass energy consumption to economic growth in the United States for the period 1949-2007, using Toda-Yamamoto causality tests. (Sadorsky, 2009b)turned out that in the long run, the increase in per capita real GDP was found behind the renewable energy consumption per capita in the G7 countries. Further, Shahbaz et al [2017] and Menyah and Wolde-rufael(2010) explore the causal relationship among renewable energy consumption and economic growth for the USA over the period of 1960–2007. Also, Atems and Hotaling [2018] found a positive and statistically significant relationship between renewable energy and growth, which indicates low fuel energy demand. On the other hand, the conservation hypothesis supported fuel energy consumption through many of previous studies results as (Ghosh, 2010)was applied in India using ARDL bounds testing approach for time span 1971–2006. Also (Ghosh, 2002)applied the Granger causality in India which was used during the period 1950 to 1996. Also, the study by (Mozumder and Marathe, 2007) that was applied in Bangladesh using co integration and vector error correction model in Taiwan and during 1980–2007, using co integration and error-correction models, found similar results (Pao, 2009). Moreover, , the study of (Narayan and Smyth, 2005)was applied in Australia within a co integration and causality framework. Yoo (2006) had a study which also applied in the Association of South East Asian Nations (ASEAN) 4 members, using modern time-series techniques for the period 1971–2002.

In addition, many studies have shown that it supports feedback hypothesis as the study of (Koengkan et al., 2020) using PVAR model pointed out to the positive impact of per capita economic growth on renewable energy investments. The Panel Granger causality revealed the existence of bidirectional causality when applied to ten Latin American countries from 1980 to 2014.(N. Apergis and Payne, 2010a) support the feedback hypothesis for a panel of twenty OECD countries over the period of 1985–2005. Also, (Apergis et al., 2010)found that bidirectional causality between renewable energy consumption and economic growth, (Apergis and Payne, 2011). In the short and the long-run, the results suggest feedback hypothesis. (Pao and Fu, 2013)empirical results suggest feedback hypothesis for the relationship between GDP and renewable energy consumption. Lin and Moubarak [2014] empirical evidence shows that a bi-directional causal relationship between renewable energy consumption and economic growth. (Apergis and Payne, 2013) reveal bidirectional causality from economic growth to renewable electricity consumption in the long-run for 16 emerging market economies over the period 1990–2007. Another study by (N. Apergis and Payne, 2010b)indicated bidirectional causality between renewable energy consumption and economic growth in both the short-run and long-run in 13 countries within Eurasia over the period 1992–2007, (Apergis and Payne, 2012). The results reveal bidirectional causality between renewable energy consumption and economic growth in both the short-run and long-run for 80 countries within a multivariate panel framework over the period 1990–2007. (Sadorsky, 2009a)verified the feedback hypothesis in the long-run for 18 emerging economies. On the other hand, the feedback hypothesis supported fuel energy consumption through many of previous studies results as Abdouli and Hammami [2017] .Empirical evidence indicated the existence of a bidirectional causal relationship between energy consumption and economic growth. Lin and Moubarak [2014]showed a bidirectional causal relationship between renewable energy consumption and economic growth. Apergis and Payne [2010] found a bio-directional causal relationship between renewable energy consumption and economic growth in the short and long term. Apergis and Payne [2012] found a bi directional causality among economic growth and energy demand. The study by Yoo [2006] shows that the empirical evidence found that a bidirectional causal relationship between fossil energy consumption and economic growth. Another study by Yoo [2006] also points out that the empirical evidence found that a bidirectional causal relationship between fossil energy consumption and economic growth. (Coers and Sanders, 2013) found results also show a strong unidirectional causality running from GDP to energy usage in a panel of 30 OECD countries over 1960-2000.

Other works have supported the neutrality hypothesis, such as; (Yildirim et al., 2012). There is no causal relationship between real GDP and other renewable energy. (Menegaki, 2011) Empirical test results suggest no causality between renewable energy consumption and GDP. (Bowden and Payne(2010) talks of the neutrality hypothesis for commercial and industrial renewable energy consumption and real GDP nexus. Payne (2009) pointed that the results of Toda–Yamamoto causality tests show no causality between renewable energy consumption and economic growth for the period of 1949–2006. (Sadorsky, 2009a) verified the neutrality hypothesis in the short-run. However, (Yildirim et al., 2012) stated that only one causal relationship from biomass-waste-derived energy consumption to real GDP, while there is no causal relationship between real GDP and other renewable energy kinds (geothermal energy consumption, hydroelectric energy consumption, etc.).

While another study confirms the hypothesis of growth, such as: Shahbaz et al [2017] found that higher economic growth leads to increased energy demand. Pesaran [2006] found that for all the countries involved, a positive relationship existed between economic growth and energy consumption in the long run. While, (Bowden and Payne, 2010) found a unidirectional causality running from renewable energy consumption to GDP. Apergis and Payne, (2009b). Based on Granger causality test the results showed a long-run causality from energy consumption to economic growth which supports the growth hypothesis in six Central American countries over the period 1980–2004. While, (Costantini and Martini, 2010)found that possible existence of mutual causal relationships between economic and energy variable in OECD within 1960+2005. Table (1.1) is presented the summarized of previous studies.

Table 1. 1: Summary of Literature Review

Financial development and energy consumption nexus				
Author	**Country**	**Period**	**Model**	**Result**
(Farhani and Solarin, 2017)	United States	1973-2014	ARDL	FD decline FEC
(Jalil and Feridun, 2011)	China	1953-2006	ARDL	FD decline FEC
(Rafindadi, 2015)	Germany	1970-2013	ARDL	FD decline FEC
(Islam et al., 2013)	Malaysia	1971-2009	ARDL	FD increase FEC
(Farhani et al., 2014)	Tunisia	1971-2008	ARDL	FD↔FEC
(Shahbaz and Lean, 2012)	Tunisia	1971-2008	ARDL, GC	FD↔FEC
(Sbia et al., 2014)	United Arab Emirates	1975-2011	ARDL, VECM	FD decline FEC FD↔FEC, REC
(Rafindadi and Ozturk, 2016)	Japan	1970-2012	ARDL, VECM	FD increase FEC FD↔ FEC
(Kutan et al., 2018)	Brazil, China, India ,etc.	1990-2012	ARDL, VECM	FD increase REC
(Ahmed et al., 2015)	Pakistan	1980-2013	ARDL, VECM	FD↔FEC
(Bekhet et al., 2017)	Gulf Cooperation Council	1980-2011	ARDL,UECM	FD increase FEC
(Javid and Sharif, 2016)	Pakistan	1972-2013	ARDL,VECM	FD increase FEC
(Zeren and Koc, 2014)	Industrial countries	1971-2010	Causality test	Mix
(Aslan et al., 2014)	Middle Eastern	1980-2011	Cointegration test	FD increase FEC

(Doytch, N., & Narayan, 2016)	74 Countries	1985-2012	disaggregated approach	FD increase REC
(Anton and Elena, 2020)	Europe Union	1990-2015	Econometric model	FD increase REC
(Mazzucato and Semieniuk, 2018)	China, Spain, Kenya, US	2004-2014	Econometric model	FD increase REC
(Paramati et al., 2017a)	UE, G20,OECD	1993-2012	Econometric model	FD increase REC
(Rodríguez et al., 2014)	87 countries	2000-2011	Econometric model	FD increase REC
(Wu and Broadstock, 2015)	22 emerging economies	1990-2010	Econometric model	FD increase REC
(Brunnschweiler, 2009)	non-OECD	1980-2006	Generalized least squares	FD increase REC
(Tamazian and Rao, 2010)	24 transition economies	1993-2004	GMM	FD decline FEC
(Ouyang and Li, 2018)	30 china	1996-2015	GMM	FD decline FEC
(Çoban and Topcu, 2013)	Europe Union	1990-2011	GMM	FD increase FEC
(Komal and Abbas, 2015)	Pakistan	1972-2012	GMM	FD increase FEC
(Omri and Kahouli, 2014)	65 countries	1990-2011	GMM	FD increase FEC
(Rashid and Yousaf, 2015)	Pakistan	1972-2012	GMM	FD increase FEC
(Sadorsky, 2010)	22 emerging countries	1990-2006	GMM	FD increase FEC
(Sadorsky, 2011)	Central & Eastern Europe	1996-2006	GMM	FD increase FEC
(Abdouli and Hammami, 2017)	17 countries	1990-2012	GMM	FD→FEC

(Boulila and Trabelsi, 2004b)	MENA	1960-2002	Granger causality	FD increase FEC
(Hao et al., 2018)	29 Chinese	1995-2014	Granger causality	FD≠FEC
(Dan and Lijun, 2009)	china	1985-2006	Granger causality	FD≠FEC
(Al-Mulali and Sab, 2012a)	SSA	1980-2008	Granger causality	FD→ REC
(Burakov and Freidin, 2017)	Russia	1990-2014	Granger causality	FD≠ REC
(Mudakkar et al., 2013)	SAARC	1975-2011	Granger causality	FD↔FEC
(Shahbaz et al., 2016)	Pakistan	1985-2014	NARDL	FD increase FEC
(Chang, 2015)	53 countries	1999-2008	NARDL	FD→FEC
(Kim and Park, 2016)	30 countries	2000-2013	OLS	FD increase REC
(Paramati et al., 2016)	Emerging country	1991-2012	PCA, HPCT	FD increase REC FD→REC
(Koengkan et al., 2020)	Latin American countries	1980-2014	PVAR	FD increase REC
(Mielnik and Goldemberg, 2002)	developing countries	1987-1998	Regression model	FD decline FEC
(Zhang et al., 2011)	China	1992-2009	Regression model	FD increase REC
(Lee, 2013)	G20	1971-2009	Regression model	FD increase REC FD→REC
(Riti et al., 2017)	90 countries	1980-2014	STIRPAT	FD increase REC
(Ji and Zhang, 2019)	China	1992-2013	VAR	FD increase REC

(Bekhet and Othman, 2011)	Malaysia	1971-2009	VECM	FD→FEC
(M. Shahbaz et al., 2013)	China	1971-2011	VECM	FD↔FEC
Technological Innovation and energy consumption nexus				
Author	**Country**	**period**	**Model**	**Result**
(Tang and Tan, 2013)	Malaysia	1970-2009	Granger Causality	INN →REC
(Fisher-Vanden et al., 2004)	China’s industrial	1997-1999	Division decomposition	INN decline FEC
(Zheng et al., 2011)	China	1999-2007	Regression model	INN decline FEC
(Herrerías et al., 2016)	China	2006-2010	panel-corrected standard errors	INN decline FEC
(Huang, 2019)	China’s industrial	2009-2015	Regression model	INN decline FEC
(Dasgupta and Roy, 2015)	India	1973-2012	Regression model	INN decline FEC
(Popp, 2001)	United State	1958-1991	RVCF	INN decline FEC
(Fisher-Vanden et al., 2006)	China's industrial	1997-1999	SUR	INN decline FEC
(Sohag et al., 2015)	Malaysia	1985-2012	ARDL	INN decline FEC
(Huang et al., 2018)	China's countries	2000-2013	Driscoll–Kraay	INN decline FEC
(Teng, 2012)	China's industrial	1998-2006	Regression model	INN decline FEC
(Tamazian et al., 2009)	China	2009-2015	Regression model	INN increase FEC

(Ahmad et al., 2020)	OECD	1993-2014	SEMs	INN increase FEC
(Wong et al., 2013)	OECD	1980-2010	FMOLS & DOLS	INN increase FEC, REC
(Alam and Murad, 2020)	OECD	1970-2012	ARDL	INN increase REC
(Feia et al., 2014)	Norway & New Zealand	1971-2010	ARDL	INN increase REC
(Chakraborty and Mazzanti, 2020)	OECD	1975-2014	CS-ARDL	INN increase REC
(Sam et al., 2016)	Europe Union	1990-2012	Econometric techniques	INN increase REC
(Mazzucato and Semieniuk, 2018)	China, Spain, US, and Kenya	2004-2014	Econometric techniques	INN increase REC
(Paramati et al., 2016)	Emerging economies	1991-2012	Econometric techniques	INN increase REC
(Ahmad et al., 2020)	Europe Union	1990-2012	Non-linear Model	INN increase REC
(Chien and Hu, 2007)	OECD	2001-2002	Regression model	INN increase REC
(Kocsis and Kiss, 2015)	EU	2004-2012	Regression model	INN increase REC
(Nemet and Kammen, 2007)	US	1994-2003	Regression model	INN increase REC
(Irandoust, 2016)	OECD	1975-2012	VAR	INN increase REC
(Tang and Tan, 2013)	Malaysia	1970-2009	Granger causality	INN →REC
(Huang, 2019)	China's industries	2009-2015	Regression model	INN decline FEC
(Popp, 2001)	United state industries	1958-1991	RVCF	INN decline FEC

(Dasgupta and Roy, 2015)	India	1973-2012	Regression model	INN decline FEC
(Fisher-Vanden et al., 2004)	China's industries	1997-1999	Division decomposition	INN decline FEC
(Fisher-Vanden et al., 2006)	China's industries	1997-1999	SUR	INN decline FEC
(Zheng et al., 2011)	China	1999-2007	Regression model	INN decline FEC
(Teng, 2012)	China's industries	1998-2006	Regression model	INN decline FEC
(Huang et al., 2018)	China's countries	2000-2013	Driscoll–Kraay	INN decline FEC
(Sohag et al., 2015)	Malaysia	1985-2012	ARDL	INN decline FEC
(Tamazian et al., 2009)	China	2009-2015	Regression model	INN increase FEC
(Wong et al., 2013)	20 OECD	1980-2010	FMOLS & DOLS	INN increase GDP
(Irandoust, 2016)	OECD	1975-2012	VAR	INN increase REC
(Alam and Murad, 2020)	OECD	1970-2012	ARDL	INN increase REC
(Chakraborty and Mazzanti, 2020)	OECD	1975-2014	CS-ARDL	INN increase REC
(Mazzucato and Semieniuk, 2018)	China, Spain, the United States, and Kenya	2004-2014	Econometric techniques	INN increase REC
(Paramati et al., 2016)	Emerging economies	1991-2012	Econometric techniques	INN increase REC
(Chien and Hu, 2007)	OECD	2001-2002	Regression model	INN increase REC
(Feia et al., 2014)	Norway and New Zealand	1971-2010	ARDL	INN increase REC

(Kocsis and Kiss, 2015)	Europe Union	2004-2012	Regression model	INN increase REC
(Sam et al., 2016)	Europe Union	1990-2012	Different panel data estimators	INN increase REC
(Nemet and Kammen, 2007)	United State	1994-2003	Regression model	INN increase REC
Economic freedom and Energy consumption nexus				
Author	**Country**	**period**	**Model**	**Result**
(Kheng et al., 2017)	Europe Union	1980-2011	Causality test	EF → GDP
(Kneller et al., 1999)	OECD	1970-1995	Causality test	EF → GDP
(Heckelman, 2000)	147 countries	1994-1997	Granger Causality	EF → GDP
(Piatek et al., 2013)	Transition countries	1990-2008	Granger Causality	EF → GDP
(Ekanayake and Vogel, 2003)	Developing countries	1960-2001	Granger Causality	EF → GDP
(R. Santiago et al., 2018)	LACC	1995-2015	ARDL	EF decline GDP
(Carlsson and Lundström, 2001)	77 countries	1975-1996	Cointegration model	EF decline GDP
(Santhirasegaram, 2007)	Developing countries	2000-2004	LSDV	EF decline GDP
(Knutsen, 2011)	120 countries	1984-2004	Cointegration model	EF increase GDP
(Ayal and Karras, 1998)	28 countries	1975-1990	Cointegration model	EF increase GDP
(Paldam, 2003)	Asian tigers	1970-1990	Cointegration model	EF increase GDP

(Alfaro et al., 2004)	Developing countries	1975-1995	Cointegration model	EF increase GDP
(Chortareas et al., 2013)	Europe Union	2001-2009	DEA	EF increase GDP
(Pattanaik and Nayak, 2014)	India	different period	Econometric model	EF increase GDP
(Wulandari, 2015)	Indonesia	2004-2014	Econometric model	EF increase GDP
(Hussain and Mahfuzul Haque, 2016)	57 countries	2004-2014	Extended Model	EF increase GDP
(Kacprzyk, 2016)	Europe Union	1985-2009	GMM	EF increase GDP
(Bengoa and Sanchez-Robles, 2003)	Latin American	1970-1999	LSDV	EF increase GDP
(Doucouliagos and Ulubasoglu, 2006)	82 countries	1970-1999	meta-analytic techniques	EF increase GDP
(Gurgul and Lach, 2014)	CEE	1990-2009	Regression model +GC	EF increase GDP EF → GDP
(Wu, 2011)	China	1995-2008	Regression model	EF increase GDP
(Ayal and Karras, 1998)	OECD	1975-1995	Regression model	EF increase GDP
Environmental pollution and Energy consumption nexus				
Author	**Country**	**period**	**Model**	**Result**
(Jalil and Feridun, 2011)	China	1953-2006	ARDL	FEC increase EPOL
(Sehrawat et al., 2015)	India	1971-2011	ARDL	FEC increase EPOL
(Bloch et al., 2015)	Developing countries	1965-2013	ARDL	REC decline EPOL

(Al-Mulali et al., 2016)	Kenya	1980-2012	ARDL	REC decline EPOL
(Shahbaz et al., 2013)	South Africa	1965-2008	ARDL, ECM	FEC increase EPOL
(Alam and Fatima, 2007)	Malaysia	1980-2008	ARDL+GC	FEC increase EPOL FEC → EPOL
(Ozturk and Acaravci, 2013)	Turkey	1960-2007	Cointegration model	FEC increase EPOL
(Jaforullah and King, 2015)	United State	1960-2007	Cointegration model	REC decline EPOL
(López-Menéndez et al., 2014)	Europe Union	1996-2010	Cointegration model	REC decline EPOL
(Bölük and Mert, 2014)	Europe Union	1990-2008	Cointegration model	REC decline EPOL
(Al-Mulali and Sab, 2012a)	SSAC	1980-2008	Cointegration model	FEC increase EPOL
(Katircioğlu and Taşpinar, 2017)	Turkey	1960-2010	Econometric model	FEC increase EPOL
(Salim and Ra, 2012)	Emerging economies	1980-2006	FMOLS	REC decline EPOL
(Paramati et al., 2017b)	Next 11 countries	1990-2012	FMOLS	REC decline EPOL
(Shahbaz et al., 2013)	Malaysia	1971-2008	Granger Causality	FEC↔ EPOL
(Mbarek et al., 2018)	Tunisia	1990-2015	Granger Causality	FEC↔ EPOL
(Apergis et al., 2010)	Develop and developing	1984-2007	Granger Causality	REC≠EPOL
(Menyah and Wolde-Rufael, 2010)	United State	1960-2007	Granger Causality	REC≠EPOL
(Apergis and Payne, 2014)	United State	1980-2010	non-linear cointegration	REC increase EPOL

(Al-Mulali et al., 2015)	Europe Union	1990-2013	Pedroni cointegration	REC decline EPOL
(Chiu and Chang, 2009)	OECD	1996-2005	PTR	REC decline EPOL
(Shafiei and Salim, 2014)	OECD	1980-2011	STIRPAT	REC increase EPOL
(Ahmed et al., 2015)	Pakistan	1980-2013	VECM	EC → poll
(M Shahbaz et al., 2013)	Indonesia	1975-2011	VECM	FEC↔ EPOL
(Raza et al., 2019)	China, India	1972-2011	VECM	REC≠EPOL
(Assi et al., 2020)	28 Countries	1996-2018	PARDL	FEC increase EPOL FEC → EPOL
Real GDP per capita and Energy consumption nexus				
Author	**Author**	**Author**	**Author**	**Author**
(Bowden and Payne, 2010)	United State	1949-2006	Granger Causality	GDP → FEC
(Apergis and Payne, 2009a)	American state	1971-2004	Causality Model	GDP → FEC
(Costantini and Martini, 2010)	OECD	1960-2005	Causality Model	GDP → FEC
(Abdouli and Hammami, 2017)	17 countries	1990-2012	GMM	GDP → FEC
(Narayan and Smyth, 2008)	G-7	1974-2002	Granger Causality	GDP → FEC
(Mozumder and Marathe, 2007)	Bangladesh	1971-1999	Granger Causality	GDP → FEC
(Narayan and Smyth, 2005)	Australia	1966-1996	Granger Causality	GDP → FEC

(Kakar et al., 2011)	Pakistan	1980-2009	Granger Causality	GDP → FEC
(Kaboudan, 1989)	Zimbabwe	1965-1984	Regression model	GDP → FEC
(Fallahi, 2011)	United state	1960-2005	VAR	GDP → FEC
(Ghosh, 2010)	India	1971-2006	ARDL, ECM	GDP ↔ FEC
(Sbia et al., 2014)	United Arab Emirates	1975-2011	ARDL, ECM	GDP ↔ FEC
(Ghosh, 2002)	India	1950-1996	Granger Causality	GDP ↔ FEC
(Coers and Sanders, 2013)	OECD	1960-2000	Granger Causality	GDP ↔ FEC
(Narayan and Smyth, 2009)	Middle Eastern countries	1974-2002	Granger Causality	GDP ↔ FEC
(Zachariadis, 2007)	G-7	1960-2004	Granger Causality	GDP ↔ FEC
(Yoo and Kim, 2006)	Indonesia	1971–2002	Granger causality	GDP ↔ FEC
(Yoo, 2006)	Korea	1968-2002	Granger causality	GDP ↔ FEC
(Yoo, 2006)	ASEAN	1971–2002	Granger Causality	GDP ↔ FEC
(Miketa and Mulder, 2010)	CIS	1992-2004	VECM	GDP ↔ FEC
(Koengkan et al., 2020)	Latin American countries	1980-2014	PVAR	GDP ↔ REC
(Jakob et al., 2012)	Developing & industrialized	1971-2005	ad-hoc model	GDP increase FEC
(Sari et al., 2008)	USA	2001-2005	ARDL	GDP increase FEC

(Shahbaz et al., 2017)	Pakistan	1972-2011	ARDL, ECM	GDP increase FEC
(Niu et al., 2011)	Asia-Pacific	1971-2005	Causality Model	GDP increase FEC
(Lee and Chang, 2008)	Asian countries	1971-2002	Cointegration model	GDP increase FEC
(Lee et al., 2008)	OECD	1960-2001	Cointegration model	GDP increase FEC
(Richmond and Kaufman, 2006)	OECD	1973-1997	Cointegration model	GDP increase FEC
(Gómez and Rodríguez, 2019)	NAFTA	1971-2015	Cointegration model	GDP increase FEC
(Al-Iriani, 2006)	GCC	1971-2002	Cointegration model	GDP increase FEC
(Fotis et al., 2017)	34 countries	2005-2013	GMM	GDP increase FEC
(Narayan and Doytch., 2017)	89 countries	1971-2011	GMM	GDP increase FEC
(Al-Mulali and Sab, 2012a)	SSAF	1980-2008	Panel model	GDP increase FEC
(Alam and Fatima, 2007)	Pakistan	1971-2005	VAR	GDP increase FEC
(Raza et al., 2019)	United of England	1973-2015	wavelet technique +GC	GDP increase FEC
(Atems and Hotaling, 2018)	174 countries	1980-2012	GMM	GDP increase FEC, REC
(Sadorsky, 2009b)	G-7 countries		Cointegration model	GDP increase REC
(Apergis and Payne, 2014)	Central America	1980-2010	FMOLS	GDP increase REC
(Sadorsky, 2009a)	Emerging economies	1994-2003	FMOLS	GDP increase REC

(Shahbaz et al., 2013)	South Africa	1965-2008	ARDL, ECM	GDP increase FEC
(Al-Mulali et al., 2016)	Kenya	1980-2012	ARDL	GDP increase FEC
(Menegaki, 2011)	Europe	1997-2007	Granger Causality	GDP≠REC
(Yildirim et al., 2012)	United State of America	1949–2010	Toda Yamamoto test	GDP≠REC
(Bloch et al., 2015)	Developing countries	1965-2013	ARDL, ECM	GDP→FEC,REC
(Burakov and Freidin, 2017)	Russia	1990-2014	Granger Causality	GDP→REC
(Kula, 2014)	OECD	1980-2008	Granger Causality	GDP→REC
(N. Apergis and Payne, 2010a)	OECD	1985-2005	Multivariate framework	GDP↔REC
(Apergis and Payne, 2012)	80 countries	1990-2007	Multivariate framework	GDP↔REC
(Pao and Fu, 2013)	Brazil	1980-2010	VECM	GDP↔REC
(Yoo, 2006)	ASEAN	1971–2002	Granger Causality	Mix
(Apergis and Payne, 2013)	South America		Granger Causality	GDP↔REC
(Apergis et al., 2010)	Develop & developing	1984-2007	Granger Causality	GDP↔REC
(Payne, 2009)	United State	1949-2006	Granger causality	REC, EC≠ GDP
(Menyah and Wolde-Rufael, 2010)	United State	1960-2007	Granger causality	REC≠GDP
(Lin and Moubarak, 2014)	China	1977-2011	ARDL,GC	REC↔GDP

(Apergis and Payne, 2011)	Central America	1980-2006	Cointegration model	REC↔GDP
(Apergis and Payne, 2010)	Eurasia	1992-2007	FMOLS	REC↔GDP

Notes; SSAC: Sub Saharan African Countries RVCF: Restricted variable cost function SUR: Seemingly unrelated regressions ARDL: Autoregressive-Distributed Lag CS-ARDL: Cross sectional ARDL SSA :Sub-Saharan African Countries RVCF: Restricted variable cost function DOLS: Dynamic ordinary least squares PVAR: Panel vector autoregression REC : Renewable energy consumption LSDV: Least Square Dummy Variable PCA: principal component analysis SEMs: Simultaneous equation modelling GMM: generalized method of moments	STIRPAT: Stochastic Impacts by Regression on Population, Affluence and Technology OECD: Organization for Economic Cooperation and Development ASEAN: Association of Southeast Asian Nations NAFTA: North American Free Trade Agreement MENA: Middle East and North Africa countries SAARC: South Asian Association for Regional Cooperation CIS: Commonwealth of Independent States FMOLS: Panel-based fully-modified ordinary least squares LACC: Latin America & Caribbean countries VECM: vector error correction model	EF: Economic freedom →: unidirectional causality ↔: bi-directional causality ≠: NO causality VAR: vector autoregression OLS: ordinary last secure G-7: Group of Seven FD: Financial development EPOL: Environmental pollution G20: Group of Twenty NARDL: Non-linear ARDL CEE :Central and Eastern Europe TINN: Technological innovation GCC: Gulf Cooperation Council FEC: Fuel energy consumption DEA: Data Envelopment Analysis

Source: Author compilation based on robust literature reviews

1.4. Chapter Summary`

Chapter 1 delved into the review of related literature to this study, in the process considering an overview of the technological innovation, financial development, economic freedom, and environmental pollution, real gross domestic product per person and power use effects. Economic growth was defined in this chapter and also theories of economic growth, models of economic growth, determinants of economic growth and economic growth dynamics. This chapter was further engrossed into environmental sustainability indicators, in the same vein considering Nitrous oxide emissions, Methane emissions, and CO2 emissions. Literature relating to energy consumption also formed part of our related literature, wherein energy sources and demand, and energy type used as well as regional energy trends were given due attention. As if that was not enough, Chapter 2 also considered literature on economic freedom, where issues relating to global economic freedom level and sub-indicators it covered were the subject matter. It could not be enough without considering financial development, the sub indicators, and the theories of financial development. Before the researchers delved into technological innovation trends where theories were robustly reviewed. The chapter closed with a summary of relevant previous empirical studies. In Chapter 2, the researchers will look at an overview of the economies of ASEAN + 3 and the European Economic Community.

CHAPTER 2

REGIONAL ECONOMICAL PROFILE OF THE TWO SELECTED GROUPS

Introduction

In this chapter researchers introduce regional economical profiles for two groups of countries that is the European Economic Area and Association of Southeast Asian Nations Plus Three [Asean+3]. This will set the stage for both theoretical and public policy implications arising from the research study, later to be presented in the conclusion and policy recommendation chapter. To be specific this chapter will address the how, why, and what questions arising from our research study.

2.1. Association of Southeast Asian Nations Plus Three (Asean+3)

The ASEAN Plus Three, in corporating all ASEAN member countries, China, Japan, and South Korea, was born in 1997. The proposal was meant to neutralize the growing influence the United States of America in Asia-Pacific Economic Cooperation (APEC) and the whole of Asia. Since this co-operation began in 1997, ASEAN Plus Three have given attention to subjects outside finance for example energy security, financial co-operation, trade facilitation, environment and sustainable development, and narrowing the development gap. This section will display the policies that have been implemented regarding the variables employed in the research study..

2.1.1. Regional Energy Integration Strategies

Energy security involves the capacity of a country to ensure the availability of energy resources supply sustainably and in a timely manner at affordable prices which will promote economic activities. There are four major factors of availability, accessibility, affordability and acceptability of energy which have been identified as having the potential of affecting an economy's vulnerability to supply disruptions. Higher and volatile energy prices, especially with respect to oil and gas, rising demand for energy, foreboding depletion of fossil fuel sources, and the threats of climate change disruptions, as well as supply disruptions caused by increasing reliance on imports of energy and political instability in some major suppliers have called for the need to secure energy supply (Cabalu et al., 2010). Therefore, the ASEAN + 3 energy strategies (Secretariat, 2007) have been applied as follows:

1. Promoting energy diversification through exchanging information and research with respect to alternative, new and renewable energy developments including solar, wind, sea tides and waves, hydro, geothermal, clean coal technology, biofuels, biomass, gas and marsh gas, and others, considering each country's specific national circumstances; and those member countries which choose to do so, the use of civilian nuclear energy, while giving careful and due regards to the security, environmental, health and internationally-recognized safety standards of the energy source.
2. Promoting dialogue with Middle East oil and gas producing countries to enhance mutual understanding and cooperation between oil-producing and oil-consuming countries, as well as for diversification of energy transportation routes to enhance energy security.
3. Support for the work of the ASEAN Centre for Energy; and conducting collaborative activities to exchange best practices, share experiences and build capacity on the use of clean and environmentally friendly energy technologies.

2.1.2. Regional Financial Integration Strategies

Following the Asean+3 agreement, the need arose for ASEAN banking institutions to accommodate and expand their services to an intra-ASEAN market. The roadmap for financial integration was the latest regional initiative which aim to strengthen local self-help and support mechanisms (Secretariat, 2007):

Supporting the Asian Bond Markets Initiative (ABMI)'s contribution to the development of local currency bond markets across the region; and promoting the issuance of government and corporate bonds denominated in domestic currencies and strengthening the functions of the Credit Guarantee and Investment Facility (CGIF).

2.1.3. Integration Strategies of Regional Technology Innovation

ASEAN+3 countries launched some successful science and technology cooperation programs (including in the field of energy) among its member states. Particularly in the light of the new “ASEAN Krabi Initiative”, which was a framework for intraregional cooperation on STI3 that was agreed upon in March 2014 by the members of ASEAN in 2012 as part of plans for forming the AEC. In the following sections, several strategies were proposed for promoting science (Secretariat, 2007), technology and innovation at the ASEAN level.

1. Promotion of science through:

   a. Promoting co-operation in the study of energy science, that is energy science courses and programs, aimed at arousing interest and creating better understanding of the subject as well as laying a strong foundation for energy innovation were introduced.

   b. Promoting collaborative scientific research, that is collaboration, both bilateral and multilateral, and both within ASEAN and also with its dialogue partners – in the advancement of energy science is required in order to lay a strong foundation for solving complex, long-term energy problems of common interest to ASEAN members. Examples of such problems include advanced biofuels, photovoltaics, solar-assisted cooling, marine energy, energy storage and CCS. To this end, ASEAN-wide joint scientific research programs are being developed and funded by the ASEAN. Since each member state have specific strengths in different areas, which are often complementary, ASEAN centers of excellence in different areas were established in different countries with ASEAN-level support to act as the focal point of scientific research that would benefit the ASEAN as a whole.

2. Promotion of technology through:

a. Promoting co-operation in technology research and development, that is, energy technology development and innovation at the ASEAN level requires a comprehensive and co-ordinated approach with a clear focus on selected technologies in specific sectors. Policies promoting energy technology development should include the establishment of regular ASEAN-wide energy research programs that are tendered openly and transparently as research projects. Universities and applied research institutions should be encouraged to form consortia of various players and tender for ASEAN support. Furthermore, there is need to promote co-operation in research and development personnel development.

3. Promotion of innovation through:

a. Promoting co-operation in technical human capacity development, that is, ASEAN industry require skilled technicians and engineers who are capable of designing, installing and operating renewable energy technology equipment to the proper industry standards, and implementing energy efficiency measures. Through training programs and know-how transfers from developed countries, some ASEAN members, such as Thailand, have acquired relevant standards and skills such as those for solar thermal systems design and installation. These practices can be shared among ASEAN members.

b. Promoting technology facilitation, that is energy technology facilitation centers, in the form of one-stop clearing houses should be set up in each ASEAN member country and linked as an ASEAN network to facilitate innovation in enterprises, particularly small and medium-sized enterprises. In this regard, services provided by the center should include advice and access to technical and financial information, university talent research facilities, intellectual property, government incentive schemes and consultancy. Such an ASEAN network should facilitate intra-ASEAN technology and know-how transfer between members as well as from outside ASEAN, particularly in the field of renewable energy and energy efficiency.

c. Supporting STI-oriented policy research, that is, in order to support STI policy decision-making at the enterprise, national and regional levels. STI policy research should be encouraged and STI policy research centers/institutes be set up in every country; such centers/institutes should be linked as a network of excellence and co-ordinated by such an entity as the ASEAN Centre for Energy.

d. Supporting industry-targeted translational research, that is energy science research programs and applied research aimed at technological innovation are funded.

2.1.4. Integration Strategies of Regional Environmental Sustainability

The 2000s have witnessed further enhanced ASEAN+3 environmental cooperation and the ASPEN will deepen understanding of ASEAN+3 environmental cooperation mechanisms through the following strategies (Secretariat, 2007):

1. Forging closer cooperation in protecting the environment and promoting sustainable use of natural resources.
2. Forging closer cooperation among ASEAN plus Three countries to mitigate and adapt to climate change.
3. Forging closer cooperation in the areas of: (a) application of advanced and environment-friendly technologies. (b) Multilateral environmental agreements, in particular climate change and chemical and chemical waste related conventions and partnerships.
4. Promoting sustainable development as a means to reduce negative externalities of development on the environment.

2.1.5. Regional Integration Strategies for Economic Freedom

The following regional integration techniques should be employed in the ASEAB plus 3 in order to enhance economic freedom in its member countries:

1. Continuing efforts towards promoting and strengthening economic cooperation in the East Asian region, including an idea of region-wide FTAs.
2. Phasing out tariffs and non-tariff barriers to ensure free flow of goods in ASEAN plus Three countries.

3. Promoting the application of information and communication technology (ICT) in the field of customs clearance for better management and service delivery.
4. Providing regional support to foster an attractive investment climate through sharing best practices, giving mutual encouragement, responding to the requirements of investors, extending technical assistance and exchanging statistical information.
5. Undertaking appropriate measures to strengthen IP systems and promote greater public awareness of IP and IPR issues in the field of education and industries, the commercialization of IP, the utilization of IP information, and technology transfer.
6. Promoting the harmonization of IP laws and systems, where possible, to enhance trade and investment in the region and facilitate intellectual property rights registration.

2.2. The European Economic Area (EEA)

The European Economic Area, abbreviated as EEA, consists of the member states of the European Union (EU) and three countries of the European Free Trade Association (EFTA) (Iceland, Liechtenstein and Norway). The Agreement on the EEA entered into force in 1994. It sought to strengthen trade and economic relations between the contracting parties and is principally concerned with the four fundamental pillars of the internal market, namely: the free movement of goods, people, services and capital.

2.2.1. Regional Energy Integration Strategies

1. Increasing energy production: The Union could reduce the dependency on particular suppliers and fuels by maximizing its use of indigenous sources of energy through increasing energy production in the European Union through increasing the use of renewable energy, nuclear energy, as well as sustainable production of competitive fossil fuels by:
    a) Initiating the Europeanization of renewable energy support systems through improved coordination of national support schemes;

b) Accelerating fuel switching in the heating sector to renewable heating technologies;
c) Ensuring stable national regulatory frameworks for renewables and address administrative barriers;
d) Facilitating access to finance for renewable projects on all levels (large and small scale) (European Commission, 2018).

2. Further developing energy technologies: New technologies are needed to further reduce primary energy demand, diversify and consolidate supply options (both external and indigenous), and to optimize energy network infrastructure to fully benefit from this diversification; where the Horizon 2020 Framework Program for Research and Innovation was implanted.

2.2.2. Regional Financial Integration Strategies

'Sustainable finance' generally relates to the process of taking due account of environmental and social considerations in investment decision-making, leading to increased investments in longer-term and sustainable activities. EEA countries employed Financing Sustainable Growth policy between 2000 up to 2018 (Principles for Responsible Investment (PRI), 2018).

1. Reorienting capital flows towards sustainable investment, in order to achieve sustainable and inclusive growth:
   a) Establishing an EU classification system for sustainability activities.
   b) Creating standards and labels for green financial products.
   c) Fostering investment in sustainable projects.
   d) Incorporating sustainability in providing investment advice.
   e) Developing sustainability benchmarks.
2. Mainstreaming sustainability into risk management by better integrating sustainability in ratings and research, further, clarifying institutional investors and asset managers' duties by incorporating sustainability in prudential requirements.
3. Fostering investment in sustainable projects by employing several strategies such as; strengthening sustainability disclosure and

accounting rule-making. In addition, fostering sustainable corporate governance and attenuating short-termism in capital markets.

4. Technical expert group on sustainable finance (TEG): The Commission set up a technical expert group on sustainable finance to assist it notably in the development of a unified classification system for sustainable economic activities, an EU green bond standard, methodologies for low-carbon indices, and metrics for climate-related disclosures.
5. Platform on sustainable finance: The platform will be an advisory body composed of experts from the private and public sector and this group of experts will advise the Commission on the sustainable finance more broadly. In addition, the platform will monitor and report on capital flows towards sustainable investments.
6. International platform on sustainable finance: The ultimate objective of the IPSF was to assist scaling up the mobilization of private capital towards environmentally sustainable investments. The IPSF is a forum to strengthen international cooperation and, where appropriate, coordination on approaches and initiatives for the capital markets (such as taxonomies, disclosures, standards and labels), which are fundamental for private investors to identify and seize environmentally sustainable investment opportunities globally.

2.2.3. Integration Strategies of Regional Technology Innovation

1. Supporting Innovation networks and platforms through fostering networking of enterprises, the development of business associations, and support to setting up innovation platforms of businesses, universities, and research institutions.
2. Innovation support services by supporting innovation intermediaries or promoting the creation of innovation advisory structures, organizations which provides support to enterprises such as advisory services, hands-on trainings and networking events, internationalization.
3. Technology transfer within the support given to establish structures and mechanisms to encourage the transfer of know-how and technology from research to business. This could include funding of

technology transfer offices and other knowledge transfer structures between academia and industry, SME-academia networks and other research commercialization support structures.

4. Financial instruments (loans and guarantees), that is the form of funding such as subsidized loans, guarantees, support to innovations and research and development.
5. The European Institute of Innovation and Technology was created in 2008 with a mandate to stimulating and delivering world-leading innovation through the creation of highly integrated Knowledge and Innovation Communities (KICs). The KICs would bring together higher education, research, business and entrepreneurship in order to produce new innovations and new innovation models that can inspire others to follow suit.

2.2.4. Integration Strategies of Regional Economic Freedom

1. Economic policies promoting enterprises through improving competitiveness among economy enterprises and the activity of economy enterprises. It focuses on easing access to public markets and foreign markets. Furthermore, it also considers measures focused on business functions, such as financing, consultancy/advice, training, employment and human resources management, cooperation and networks, research and development and also innovation, quality, new computing and communication technologies, physical space.
2. Creating a favorable ecosystem for enterprises by putting in place cognitive measures and institutional measures: legal form of economy entities, recognizing them as private players (Avila and Monzon, 2018).

2.2.5. Integration Strategies of Regional Environmental Pollution

Climate policies in the EU have been developing since 1990, introducing common measures in the areas of greenhouse gas emissions, renewable energies and energy efficiency initiatives. An EU-wide climate policy framework has been developed, implemented, and revised over time. In the process of climate policy development three main areas of climate policy were identified and addressed and are still present today, these are reducing greenhouse gases (GHGs), promoting renewable energy sources (RES) and improving energy efficiency (EE) (Dauwe et al., 2018).

1. The European Green Deal was a plan to make the European Union's economies sustainable and this was done by turning climate and environmental challenges into opportunities, and making the transition just and inclusive for all through boosting efficient usage of resources by moving to a clean, circular economy, including:
    a) Investing in environmentally-friendly technologies,
    b) Supporting industry to innovate sustainably,
    c) Rolling out cleaner, cheaper and healthier forms of private and public transport decarbonizing the energy sector,
    d) Ensuring buildings are more energy efficient, and
    e) Working with international partners to improve global environmental standards.

2.3. Summary Chapter

In this chapter, the researchers present a review of the policies that have been implemented over the past years in both groups of countries. Explicit consideration was given to reforms to financial development, technological innovation, economic freedom, the energy sector, and pollution. Chapter three will present the theoretical framework of the research study and it is the next chapter.

CHAPTER 3

THEORETICAL FRAMEWORK

Introduction

This chapter shows that, the researchers presented the 'hypothetical framework' of the research study. The expected relationships among the variables were dealt with and also the justification for the variables used in the study was provided.

3.1. Keynesian consumption function

Theoretically, several well-known theories were put in place by influential economists initially in the 30s. Meynard Keynes in 1936 became the first to formulate a consumption function and created " (AIH) which had a notion that , when there is an income increase , thre will also be consumption increase with proportion though only by a fraction of the first increase in current income. Nevertheless, during the 40s many results from empirical articles have been in contrast with the absolute income hypothesis which created the birth of more theoretical frameworks of patterns of consumption; (Duesenberry (1949) developed the "relative-income" hypothesis (RIH) differing from (Keynes (1936) and Duesenberry (1949) who asserted that contemporary levels levels of consumption are driven futher by the levels of consumption reached in initial periods (Keynes, 1970). The Keynesian consumption function was developed which represents the functional nexus between total expenditure and the real income of the nation; (Modigliani and

Brumberg (1954) then formulated beginnings of the life-cycle hypothesis (LCH). This was the foundation for the contemporary theory explaining collective consumption following a representation of personal behavior behavior, with assumptions of a specification of a many period effectiveness maximization behavior. From this context level of consumption is governed by income, interest rates and also the age of the agent. On the other hand, (Friedman, 1957) came with the permanent income hypothesis (PIH) for them to account for the discrepancies in the data for the mentioned hypotheses. After a while. (Hall, 1978) have combined logical expectations to both the life cycle hypothesis and the permanent income hypothesis (PIH). There are various research articles which were carried out t to explore the consumption function for developed economies such as (Muellbauer and Lattimore, 1995); (Muellbauer, 1994) and (Fagan et al., 2005). Recent research studies have confirmed that consumption depends on income as Koengkan et al., (2020), Rafindadi and Ozturk (2016); Yoo, (2006); Chang (2015) reiterated.

The lessons learnt from the creative writing are that t generalized specification of consumption function should include a function of income that is complex as the main determinant. In this regard, the recent findings overcame the simplistic Keynesian creation of the linear consumption function, which linked current consumption to current income. However in a pragmatic real framework, financial development considered the experimental role of financial development that leads to increased energy consumption as Çoban and Topcu (2013), Yue et al. (2019), Pradhan et al. (2018), Koengkan et al. (2020), Sadorsky, (2010) pointed out. Empirical evidence proposes that financial developments can reduce the consumption of by ensuring increased energy efficiency as shown by Islam et al. (2013), Sbia et al. (2014), Ouyang and Li, (2018). In addition, technology innovation may influence current consumption smoothing decisions as in (Nemet and Kammen, 2007); (Kocsis and Kiss, 2015); (Wong et al., 2013); (Boulila and Trabelsi, 2004). Some studies confirm that technological innovation can change the nature of economic activities that affect energy consumption by increasing energy efficiency and finding renewable sources as indicated by

Dasgupta and Roy, (2015), and Mielnik and Goldemberg, (2002). In addition, consumption decisions are influences by the degree of environmental pollution to control the Kuznets Environmental Curve (EKC) hypothesis, as in Rafiq et al. (2014), Sbia et al. (2014), Farhani and Shahbaz, (2014). Moreover, another economic factor which may affect the consumption function is economic freedom like what was alluded (Gurgul and Lach, 2011); (Kheng et al., 2017); (Coetzee and Kleynhans, 2017); (Piatek et al., 2013).

3.2. The Elasticity of Income of Keynesian Consumption Function

Diacon and Maha (2015) defined the incomes elasticity for consumption of energy as the responsiveness of energy expenditure to changes in income in an economy. Murota and Ono, (2010) and Grossman, (1972) pointed out that the relationship with respect to the consumption and income in an economy evolves in three main stages that is subjective and objective effect. In the case of subjective effects they are internal to the economic systems. Keynes's subjective factors fundamentally bring about and determines the form that is the movement and positioning of the consumption function. These biased factors are psychological descriptions of human nature, institutions and social practices , mainly the behavioral pattern of business concern in respect to wages, retained earnings, dividend payments, , and social arrangements affecting income distribution. There are two driving forces to subjective factors that is individual and business. The objective factors are not endogenous to the economic system. These factors may, then, go through rapid changes and then marked shifts in the consumption utility (i.e., the C curve) as changes in interest rate, volume of wealth, and sales effort of the producers. Thus, structural factors affecting consumption like income distribution. Aslan et al., (2014) and Zeren and Koc, (2014) affirm that financial policies change energy consumption and may increase or decrease income, thereby leading to a reduction of costs and creating more economic activities so as to satisfy the demand for energy.

3.3. Determinants of the Keynesian Consumption Function

The research study presented other factors which were chosen to investigate how income is affected by these factors, which also affect consumption level.

3.3.1. Financial development of Keynesian consumption

The Keynesian consumption function can be well explained by financial development policy as one of the important factors. Financial sector development refers to the improvement in financial activities for instance the increase in banking sector activities, bond market activities and stock market activities.. There is a considerable body of literature that link economic sector development and also economic growth, on the other hand , more recent theoretical and empirical research indicated the importance of financial sector development in the energy-growth nexus (Shahbaz and Lean, 2012), (Shahbaz, 2015), and (Sadorsky, 2011). It can be noted that an efficient financial sector stimulates economic growth, ensuing an amplified venture which in turn increases the requirement for energy. This chain reaction justifies a study on the connection between economic development and the consumption of energy (Kahouli, 2017). However, there are three effective channels namely a business effect direct effect, and a wealth effect through which financial development contributes towards energy consumption (Sadorsky, 2011). Therefore, successful organization of the economic system allows financial resources to be used more productively for energy projects. This in turn creates a socio-economic environment conducive for energy innovation and technological progress, all of which stimulate the development of energy sources. Moreover, an efficient economic sector allows for the distribution of sufficient economic resources in the power sector, and maintaining a good equilibrium between energy supply and utilization. Scientists considered that an advanced financial system can provide funds to institutions at much lower costs, which facilitates the expansion of their production, hence increasing energy consumption. Financial developments also increase consumers ‘access to customer credit, which greatly encourages them to purchase more goods that rely on energy, therefore stimulating the demand for energy. There are several studies which highlighted the need for financial developments to drive financial growth, as well as policy requirements in this regard (Calderón and Liu, 2003), (Dritsakis and Adamopoulos, 2010). The integration of financial development and economic growth further justifies the need for linking financial developments with both energy consumption and economic growth.

3.3.2. Economic Freedom of Keynesian Consumption

The Keynesian consumption function can be well explained by economic freedom policy as one of the most crucial factors. Economic freedom refers to the improvements in financial activities such as increases in transfer capital, foreign investments activities, institution improvements, reforms in property rights and others. In this regard, there are research studies which linked economic freedom and economic growth. Economic freedom plays an important role in influencing incentives, productive efforts and the efficient use of resources in an economy and economists and economic historians alike have strengthened their attention to this issue. Indeed, De Haan and Sturm (2000) argued that decisive factor in explaining why countries grow or stagnate is economic freedom on two tracks. The first track is clear technological progress in its broad sense and this is a critical determinant of growth, access to inventions, new designs, and the development of new technologies through laws (property rights, freedom from corruption). These laws play a fundamental role in protecting technological innovations in the energy field for both individuals and institutions. The extent of market openness, and trade and financial liberalization in a country in various sectors of the economy is also a critical determinant of development, which then affects the energy demand.

3.3.3. Technological innovation of Keynesian Consumption

Most finance experts agree that technological improvement is a main driver of financial growth. In financial terms, innovation describes the growth and appliance of ideas and technology that develop goods and services or make their production more efficient. One of the main advantages of innovation is the contribution to financial growth. Simply put, improvement can lead to higher production, in other words, the same input generates a greater output. As production rises, more goods and services are created – in other words, the economy grows. Innovation has reflective effects on the macroeconomic setting, the policy-maker monitors its expansion and researches the financial and social preconditions that enable and support innovation. Moreover, there are two dominant approaches that effect on economic structure in a nation that is radical innovations and incremental innovation (Geels et al., 2018). In the context of energy sector technological- improvement in broad, most deep-seated innovations are linked with mastering new fuels, new energy sources, and new energy exchange or energy transfer technologies. Incremental innovation on the other hand is 'localized' transformation within a technical regime and it is connected with a trajectory of innovation. It comprises of enhancement of technologies already there, either with respect to performance attribute or input characteristics (such as more cost-effective use of materials), but it does not basically change the core characteristics of the existing technology and such innovations comprises of improvement to pre-existing products. Basing on this, tentatively, the innovation-based increase hypothesis suggest that there is a constructive linkage between innovation and financial growth. According to Keynesian consumption theory, technological innovations play a key role, raising production and escalating financial growth (ÇETİN, 2013)**.**

3.3.4. Environmental Pollution of Keynesian Consumption

In the past few years, there has been rising and falling investigations in energy and environmental economics due to escalating environmental contamination, and carbon emissions. Climate change became one of the most urgent concerns that the entire humanity is facing today. Recent reports have also warned that environmental degradation comes from increased energy uses in financial activities. Environmental pollution in a nation necessarily depend on its level of financial growth and the type of energy consumption used in it. An understanding of the EKC helps understand the connection between contamination and economic growth. The EKC assumption clarifies that throughout the early phases of financial development, the boost in income will increase toxic waste until it reaches a certain point (turning point) where the connection connecting the two variables becomes negative. This occurrence occurs when the country experience improvement in power efficiency, change in economic structure, and environmental consciousness which aids in creating an inverted U-shape connection between revenue and environmental pollution. As a result, the boost in the role of sustainable energy consumption can help to decrease the contamination levels. More so, the Keynesian consumption hypothesis provides a rationale for supporting growth within a country and keeping environmental quality across sectors by focusing on the type of energy used in economic activities.

3.4. Theoretical Model

The research study employed the Keynesian consumption hypothesis in its theoretical modeling process as alluded by (Summerfield et al., 2007). Although existing studies apply different techniques on the Keynesian consumption function, most of them adopt a similar specification of the model. The standard consumption function by being a part of income, directly depends upon income itself, thus the reduced form Keynesian consumption function is thus presented as:

$$C_t = \mathcal{F}[Y_t] \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots.. \quad [1]$$

$$Where, \quad Y_t = \mathcal{F}[FD_t, TIN_t, GDP_t, EF_t, REC_t, FEC_t]$$

Where ($\mathcal{F}$) is a linear homogeneous function and (t) is the time index of Eq. (1).

The linear Keynesian consumption function, which dominated early empirical work, is written as:

$$C_t = a + bY_t \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots.. \quad [2]$$

Where (C) represents total consumption, (a) represents autonomous consumption (marginal propensity to consume (MPC) when income is zero), (b) shows marginal propensity to consume (i.e., consumption increases by b for every dollar increase in income. In equation [2] above, there are two measures of the understanding of consumption to income that is the standard propensity to consume (APC) is the ratio of consumption to income $^{C}/_{Y}$ and the insignificant propensity to consume (MPC), the quantity by which utilization increase as existing non-refundable income rises $^{\Delta C}/_{\Delta Y}$. Both the standard and insignificant propensities are generally alleged to be between zero and one. The Kuznets paradox is an pragmatic perspective that relate to the comparative size of these two measures. Therefore, the study will employ panel data series to investigate the economic growth, environmental pollution, energy (fossil/renewable) consumption, economic freedom and technological innovations. Thus the reduced form Keynesian consumption function is thus presented as:

$$EC_t = \alpha_t + \beta_1 Y_t + \beta_5 X_t + \varepsilon_t \quad \dots\dots\dots\dots\dots\text{..} \; [3]$$

Where EC_t is divided into two models. The REC_t referred to the consumption of renewable energy and FEC_t indicated to fossil fuel energy consumption. The forms are written as:

$$REC_t = \alpha_t + \beta_1 Y_t + \beta_5 X_t + \varepsilon_t \quad \dots\dots\dots\dots\dots.model\ (1)$$

$$FEC_t = \alpha_t + \beta_1 Y_t + \beta_5 X_t + \varepsilon_t \quad \dots\dots\dots\dots\dots.model\ (2)$$

In equation [3] above, (α) represents the constant term, (EC) shows energy consumption indicators, X shows economic growth, X being other factors which affect economic growth, β's being the coefficient estimations for independent variables, (ε) representing the error term or the disturbance across cross sections (i) over the time (t). Based on the theoretical specification presented in equation (3) above, the marriage with respect to growth and energy consumption could be:

1. If$\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$, indicates that no relationship with respect to growth and energy consumption.
2. If $\beta_1 > 0; \beta_1 = \beta_2 = \beta_3 = \beta_5 = 0$, when there is the existence of a positive-monotonic relationship with respect to growth and energy consumption.
3. If $\beta_1 < 0; \beta_1 = \beta_2 = \beta_3 = \beta_5 = 0$, when there is the existence of a negative-monotonic connection with respect to growth and power consumption.
4. If $\beta_2 = \beta_1 = 0$, indicates that there is no association with respect to other factors and power consumption.

5. If $\beta_2 > 0; \beta_1 = 0$, when there is the existence of a positive-monotonic association with respect to other factors and power consumption.
6. If $\beta_2 < 0\ ; \beta_1 = 0$, when there is the existence of a negative-monotonic relationship with respect to other factors and energy consumption.

Therefore, the Keynesian consumption hypothesis becomes valid when, $\beta_1 > 0;\ \beta_2 > 0$ resulting in positive relation, and when $\beta_1 < 0;\ \beta_2 < 0$ resulting in negative relation.

3.5. Chapter Summary

In this chapter the researchers gave a hypothetical framework for the research study, in which the income elasticity of energy consumption was explained. There was also consideration for scales, compositions and techniques effect as major factors that explain the Keynesian consumption function in an economy. The role of financial development, technological innovation, economic freedom, and environmental pollution have been considered explicitly in the context of the Keynesian consumption and the theoretical model thereof in this chapter. Chapter three will present the methodology of the research study and it is the next chapter.

CHAPTER 4

Methodology

Introduction

The main aim of this chapter is to explicitly give an explanation of the design of the research and the methodology thereof. In this part the research study will first restate the research hypotheses so as to vigorously elucidate what the researchers intended to achieve. It is also appropriate to venture into the targeted population, size of the main sample as well as sub-samples, sample designing, data collection and data analysis etc.

4.1. Research Hypotheses

The research study seeks to investigate the validity of following hypotheses:

1. Keynesian consumption theory helps to create more energy consumption under economic growth umbrella.
2. The financial system in the two economic groups is strong enough to support sustainable development goals.
3. Economic freedom is inversely proportional to energy consumption.
4. Financial development, technological innovation, environmental pollution, and real GDP boost energy consumption.
5. Financial development, environmental pollutants, technological innovations, economic freedom, and real GDP have a causal relationship with energy consumption in both economics groups.

4.2. Research Design

Mouton (2007) lamented that research designs provide some paste to clutch the research project collectively and shows main parts of a research study, that is samples, groups, programs and also techniques employed and demonstrate how they work together so as to provide solutions to research questions. Rowley (2003) added that research designs logically marry data to be gathered and findings expected to the research questions of the study. The research study will employ a case study design technique. As mooted by O'Leary (2010), a case study is a technique to study some social elements using detailed descriptions as well as an analysis of one situation or case, for example, robust study of individuals, settings, groups, episodes or events. As such, case study research designs delves into depth since it requires the researcher to dig and dig deeper. Saunders et al. (2015) employed a definition used by Yin (2014) to define a case study as an in-depth investigation of a subject of occurrence in its natural setting. The trio also alluded that a "CASE", in case study research may be persons, groups, organizations, associations, change processes, events etc. The trio also mentioned Flyvbjerg (2011)who lamented that selecting the case to investigate and crafting demarcations for the study is important for case study research. As such a case study seeks an understanding of some dynamics inherent in a topic within a certain setup and/or situation, (Eisenhardt, 1989), (Eisenhardt and Graebner, 2007). Saunders et al. (2015)further alluded that understanding some dynamics of a topic relates to some relationships between subjects in a case and its context. According to O'Leary (2010), there is a propensity to delve into details, dig into contexts and really get a handle on sound experience of the individuals, events, communities, groups and/or organizations you are exploring. This has an objective to go deeper into what is generally practicable with other techniques such as large scale survey research. Further, case study may make it possible for researchers to burst into both quantitative and/or qualitative territories, O'Leary (2010). Yin (2014) in Saunders et al. (2015)also voiced and made a distinction between four case study research techniques basing on two major categories such as single-case versus multiple-cases and holistic-case versus embedded-case. In regard to this, a single-case research study is appropriate in situation which seeks to consider a critical case or else a unique case. Saunders et al. (2015)also pointed that a single case may be chosen deliberately because of its appropriateness or due to its ability to provide a chance to observe a situation which a few have considered before. Notwithstanding all this, what is important is for a researcher to decide an actual case. A multiple case study is also another dimension available for consideration by researchers, the rationale being to observe the replicability of findings across cases. According to Saunders et al. (2015), cases will be selected with care with similar results being predicted from each case and according to Yin (2014), in Saunders et al. (2015), it is called, “literal replication”. In other sets of cases, they are selected when factor specific context is different and some effect of this difference is of expected results made by the researcher. This according to Yin (2014) is called theoretical replication. Saunders et al. (2015) alluded that Yin’s holistic versus embedded cases is a unit of analysis. In this case the researcher chooses a single organization as a case, then when a research study is focused on the organization as a whole, it afterward becomes a holistic-case study. On the contrary, when researchers choose an organization and then decide to consider a multiplicity of logical subunits within the same entity, for example departments and work groups, this will demand multiple units of analysis, hence making the research study an embedded case study. Based on the above, it is clear that our study of the global dynamic linkages between financial development, economic freedom, environmental pollution, technological innovation, real GDP and energy consumption will qualify as a multiple case study. This is because the study will take into account 33 economies around the world. These global nations are divided into two groups: ASEAN+3 and EEA. This will effectively make our case the world case, the East Pole issue led by Association of Southeast Asian Nations Plus Three (Asia + 3) and the Western Pole issue led by the European Economic Area (EEA).

4.3. Research Philosophy

Saunders et al. (2015) alluded that a research philosophy is used in relation to a myriad of assumptions and beliefs about knowledge development.

Burrell and G. (1979), in Saunders et al. (2015)alluded that a researcher makes a multiplicity of these types of assumptions whether consciously or unconsciously throughout the research study. Such assumptions incorporate epistemological assumption, ontological assumption and axiological assumption. Burrell and Morgan (1979) alluded to epistemological assumptions as concerns about knowledge that is what makes valid, legitimate and acceptable gnostic and how it could be communicated to others. Axiology on the other hand relates to the importance of ethics and values throughout the research study process. Crotty(1998) mooted in Saunders et al. (2015)that the above assumptions mold the understanding of research questions, methods to be employed and the interpretation of results. This study will therefore be informed by positivism approach. According to Delanty (2005), positivism considers that scientific knowledge can be verified positively as opposed to dogmatism, speculations and superstitions; thus positivistic knowledge is rooted in sure and certain foundations. Saunders et al. (2015)alluded to positivism as being a philosophical position of natural scientists and involves employing observable social realties so as to be able to make generalizations which are law-like. According to the trio, positivism leads to unambiguous and accurate knowledge and is credited to Francis Bacon, Auguste Comte and the Vienna Circle. Denicolo and Becker (2012) lamented that in a positivist technique, one should incorporate in its design some predetermined measurable variables in which some will be independent while the effect on some dependent variables will be observable. To this end, this is exactly what this research study seeks to achieve. The study will investigate the Keynesian consumption function by collecting data on energy consumption variables as well as economic variables and then manipulate it in a positivistic way. This approach will be considered the gold standard in examining the global dynamic linkages between financial development, economic freedom, environmental pollution, technological improvement and power consumption in the growth channels in the East and West poles.

4.4. Research Population

The study considered the huge economies around the globe, however only 33 qualified to be part of the research study due to the availability of data for our intended variables so as to be able to provide practical solutions to our research questions. These 33 global economies further subdivided into two their various regional groupings such as European Economic Area Group (EEA) which contains twenty-four countries are [Germany, Belgium, Bulgaria, Croatia, Slovenia, Republic of Cyprus, Portugal, Czech Republic, Austria, Denmark, Estonia, Finland, France, , Greece, Hungary, Italy, Latvia, Lithuania, Poland, , Romania, Slovakia, , Spain, and Sweden, and United Kingdom], and Association of Southeast Asian Nations Plus Three Group (Asean +3) includes are [, Malaysia, Philippines, Indonesia, Thailand ,Singapore, , Vietnam) +3 the China, Japan, and Korea]. These economies underwent reforms in their economic and financial policies, as the reforms were different in the mechanisms and methods of implementation in the context of strong economic competition between the East and West poles, which caused these economies to enjoy a high level of economic freedom. The two groups were established during roughly the same period, indicating a strong competition between them to reach the first level in influencing global economic power. Also, the two groups have ratified the Kyoto Protocol which created a struggle for energy sustainability and environmental protection. The reason for choosing country groups as above was to contextualize the study on the global dynamic links between financial development, economic freedom, environmental pollution, technological modernization and power consumption in the growth channels of East and West poles. This was done in a way that could enhance robust practical policy recommendations for specific groups of countries due to regional specific macroeconomic and financial dynamics. In this vein it was also made possible to identify the how financial development sustains sustainable growth, and the source of energy that environmental damage in the global economy.

4.5. Data Collection and sorting techniques

In this section the research study presents data collection, data sources, and the techniques used to process it. Further, the research study employed several indicators so as to make it possible to examine the impact of financial developments variables on power consumption variables in order to obtain more accurate and objective results, and avoid multi co-linearity problem between the variables. In this regard, principal component analysis [PCA] was employed to create a proxy indicator, since it is significant to determine the factorability of the unprocessed information to confirm the suitability of indicators. In order to deal with these issues, the research study utilized Bartlett's Test (Bartlett, 1950) and the Kaiser-Meyer-Olkin [KMO] (Kaiser, 1970) measure of sampling adequacy, which investigates the appropriateness of the sample size for the construction of PCA. Both tests are important in identifying their usefulness for accepting the sample adequacy. The normal range of KMO lies between 0 and 1. The value of KMO must be bigger than 0.60 in order to be suitable for principal component analysis [Kaiser, 1970]. Moreover, the Bartlett's Test Chi2 value is calculated where the corresponding p-value must be less than 0.05 so as to confirm the suitability of the principal components.

4.5.1. Financial development indicator data collection and sorting techniques

The research study employed data retrieved from the world development indicators (WDI) of the World Bank (2019) for the global economies. The collection of data was done for financial developments (IFD) indicators such as bank overhead expenses to total assets, bank non-interest income to total income, stock market total value traded to gross domestic product , life cover premium volume to GDP, personal credit by deposit money banks and other economic institutions to GDP, international debt issues to GDP, supply market capitalization to GDP, bank return on equity, supply market earnings ratio, bank lending to deposit spread, bank net interest margin, non-life cover first-class capacity to gross domestic product (GDP), bank return on property. In the research study, financial developments is stated as the rate of growth in loans, savings, stock market capitalization and other securities within one year. By employing these thirteen indicators, the research study developed a financial developments index by using PCA. In figures [4.1] and Figure [4.2] below the research study presents principal component analysis (PCA) proportions for financial development indicators for both samples, that is Asean+3 and EEA groups. In addition, the KMO results presented in Appendix [4.1] of the Asean + 3 and EEA groups, it was revealed that financial development indices are 0.674 and 0.723, respectively. Such a result further highlights that the correlation between the variables is strong enough and suggest the appropriateness of PCA as the value of KMO lies above 0.60. Moreover, the Bartlett's Test reinforces the decision of KMO as it is highly statistically significant at 1%, thus rejecting the null hypothesis implying that the correlation matrix is the identity matrix. Therefore, this means financial developments components are crucial in this study to aid the construction of principal components.

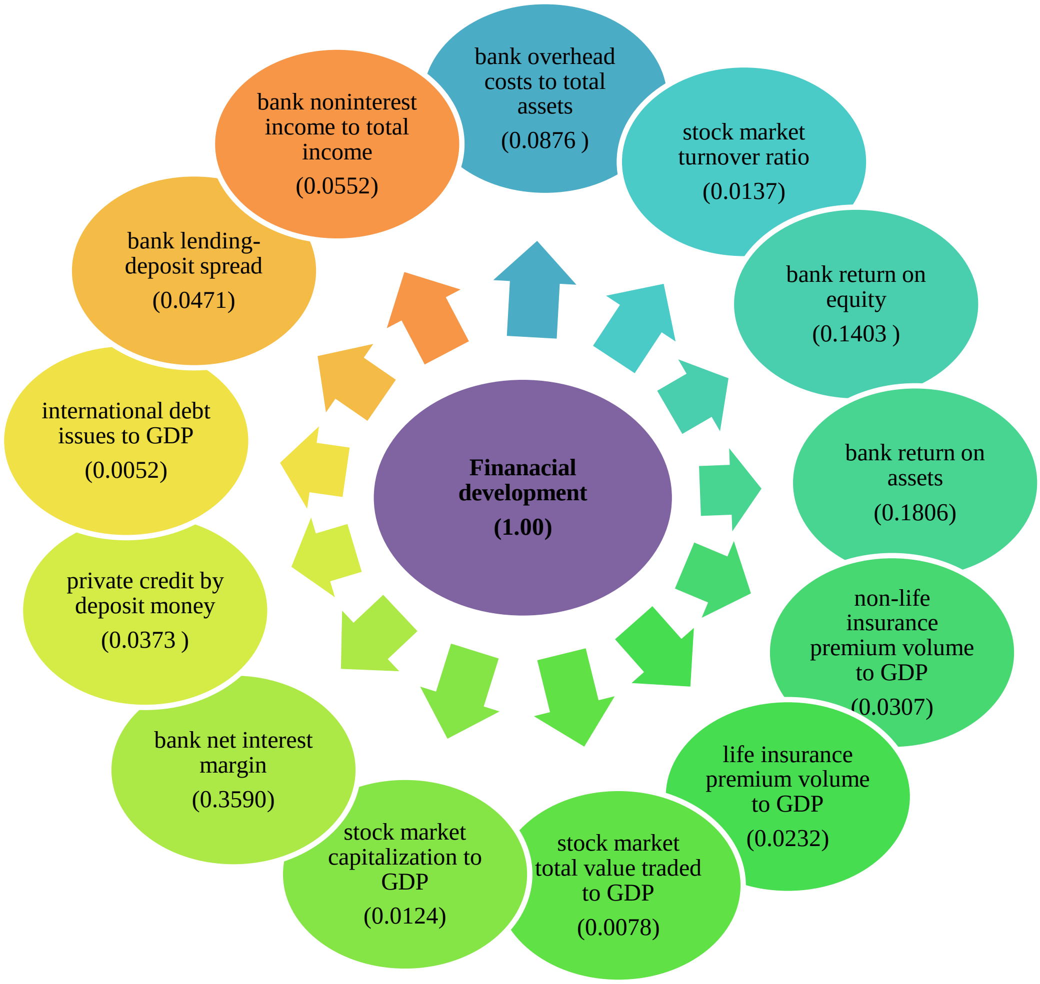


Figure 4. 1: Proportions of financial development index for Asean+3 group

Source: Researchers' Design

Figure 4. 2: Proportions of financial development index for EEA group

Source: Researchers' Design

4.5.2. Economic freedom indicators data collection and sorting techniques

The research study used data retrieved from the Heritage Foundation (2019)for the global economies. The collection of data was done for economic freedom (IEF) indicators such a assets rights, government honor, tax weight, government spending, business independence, monetary liberty, trade freedom, investment liberty, and financial liberty. Economic freedom is defined as the rate of growth in the fundamental rights of every country (and its citizens) to control work and property within a period of one year. These nine indicators were developed into an economic freedom index by using principal component analysis (PCA). In figures [4.3] and Figure [4.4] below we show the principal component analysis (PCA) proportions of economic freedom indicators for both samples [Asean+3 and EEA groups]. Furthermore, the KMO results shown in Appendix [4.1] of the Asean + 3 and EEA groups' economic freedom indices are [0.792] and [0.757], respectively. Therefore, economic freedom components can be used in this research study to construct principal components.

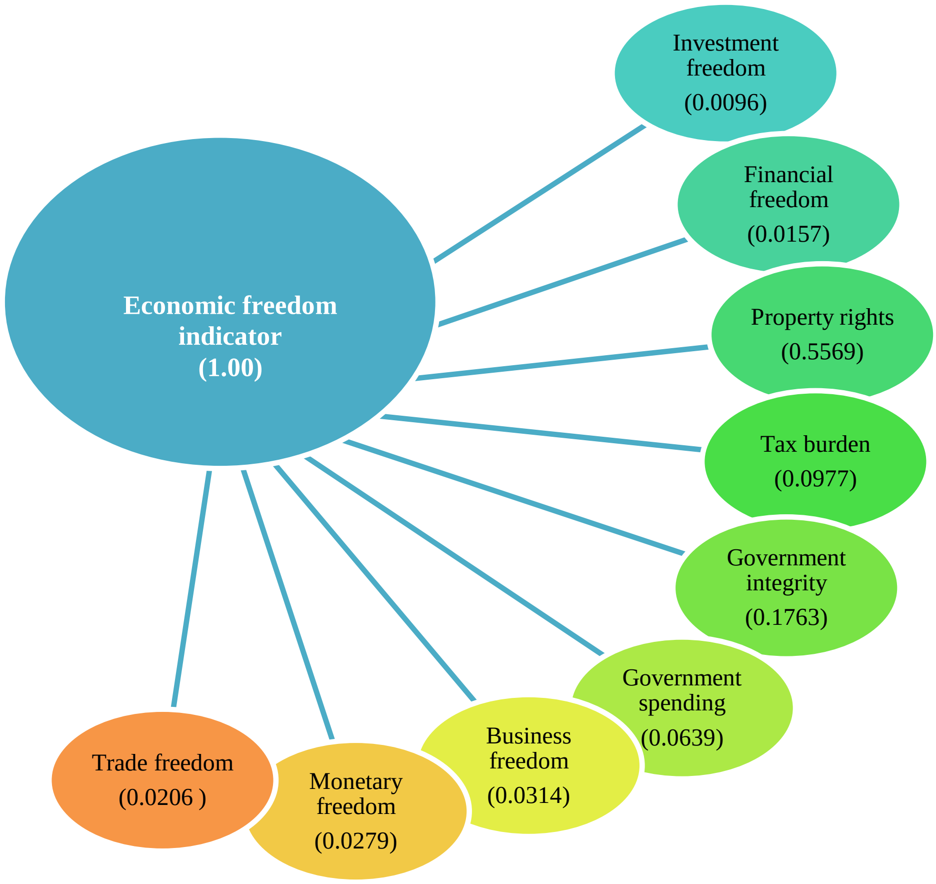


Figure 4. 3: Proportions of economic freedom index for Asean+3 group

Source: Researchers' Design

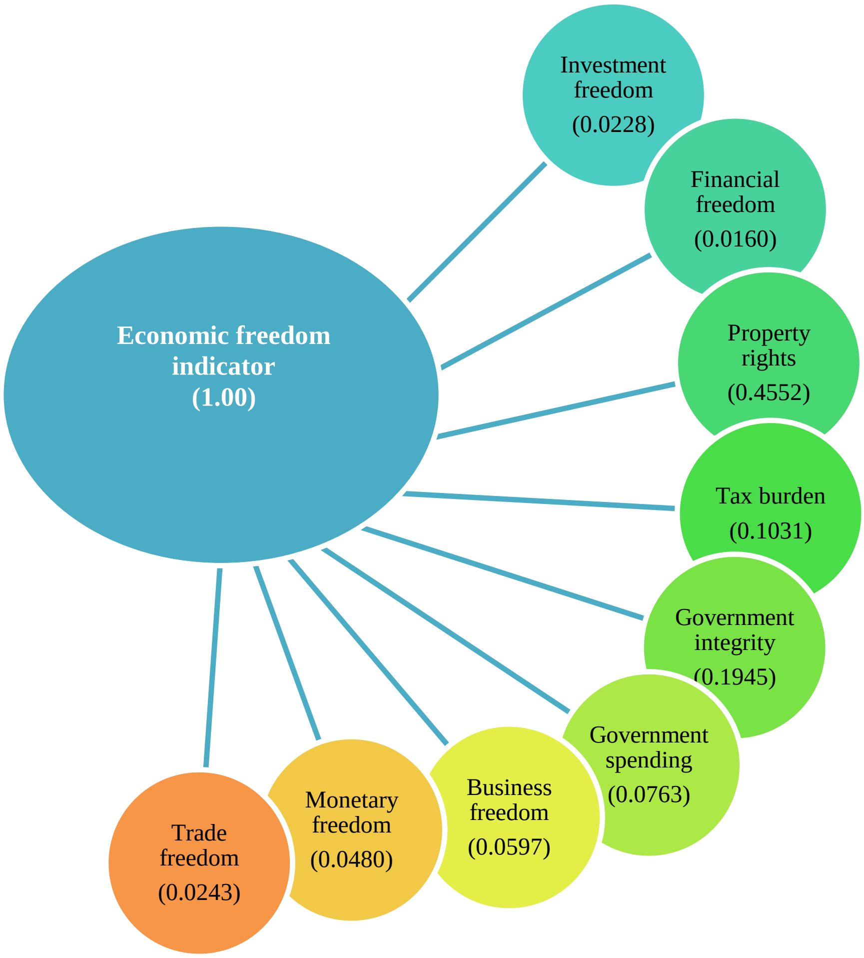


Figure 4. 4: Proportions of economic freedom index for EEA group

Source: Researchers' Design

4.5.3. Environmental pollution indicators data collection and sorting techniques

The research study used data retrieved from world development indicators (WDI) of the World Bank (2019). Collection of facts was done for environmental pollutants (IEPOL) such as nitrous oxide emissions, methane emissions, and Carbon dioxide emissions. Environmental pollution is by definition referred as the rate of carbon dioxide emissions that affect environmental factors within one year. Using these three indicators, the research study developed an environmental pollution index by using principal component analysis (PCA). In figures [4.5] and Figure [4.6] below, the research study indicate principal component analysis (PCA) proportions for environmental pollution indicators for both samples [Asean+3 and EEA groups]. Furthermore, the KMO results shown in Appendix [4.1] of the Asean

+ 3 and EEA Groups environmental pollution Index are [0.672] and [0.690] respectively. Therefore, environmental pollution components can be used in this study to construct PCA.

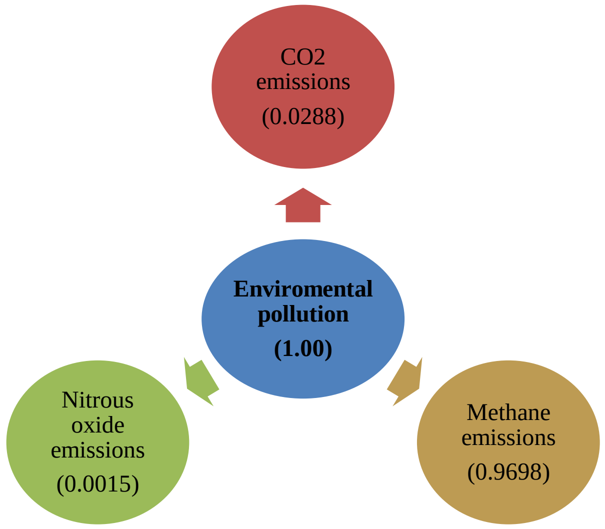


Figure 4. 5: Proportions of environmental pollution index for Asean+3 group

Source: Researchers' Design

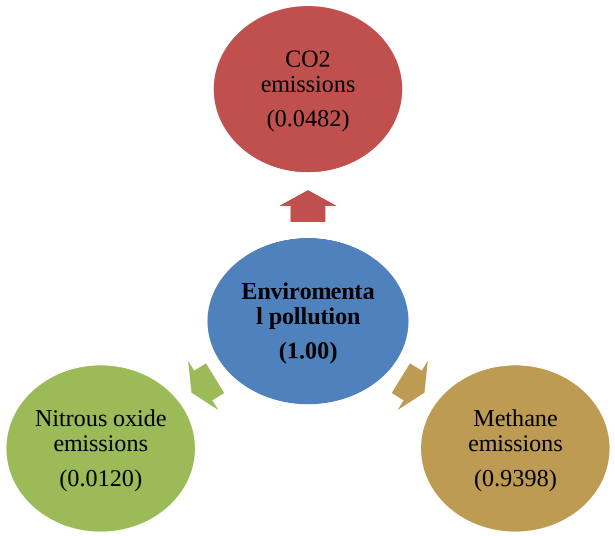


Figure 4. 6: Proportions of environmental pollution index for EEA group

Source: Researchers' Design

4.5.5. Technological innovation indicators data collection and sorting techniques

The research study employed data retrieved from World Development Indicators (WDI) of the World Bank (2019). The collection of data was done for technological innovation (ITIN) indicators such as trademark applications, fixed broadband subscriptions, and rights applications by inhabitants, rights applications by nonresidents, study and growth expenses to gross domestic product GDP, and scientific and technical journal articles. Technological innovation is measured by some activities such as number of patents and research & development within one year. Using these six indicators, the research study developed a technological innovation index using principal component analysis (PCA). In figures [4.7] and Figure [4.8] below we indicate principal component analysis (PCA) proportions for technological innovation indicators for both samples [Asean+3 and EEA groups]. Furthermore, the KMO results shown in Appendix [4.1] of the Asean + 3 and EEA group's technological innovation indices are [0.764] and [0.779] respectively. Therefore, technological innovation components were used in this research study to construct principal components.

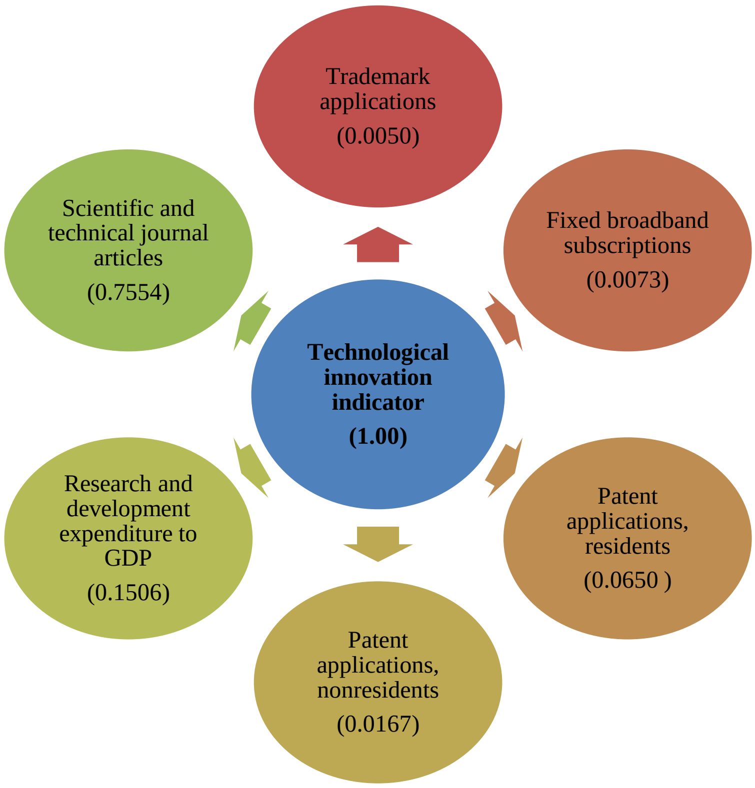


Figure 4. 7: Proportions of technological innovations index for Asean+3 group

Source: Researchers' Design

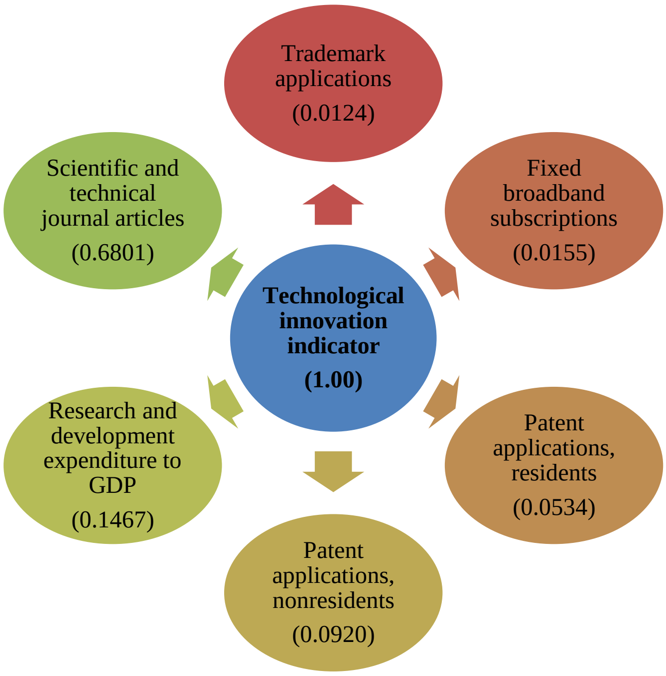


Figure 4. 8: Proportions of technological innovations index for EEA group

Source: Researchers' Design

4.5.6. Renewable energy consumption indicators data collection and sorting techniques

The research study used data retrieved from statistical review of world energy indicators of the PB (2019). Collection of data was done for renewable energy consumption (IREC) indicators such as hydropower, solar power, wind power, other renewables (geothermal, wave, biomass, waste, etc. Renewable power utilization was defined as the distribution of clean energy consumption in full closing energy consumption (billion Kwh). Using these four indicators the research study developed a renewable energy consumption index by using principal component analysis (PCA). In figures [4.9] and Figure [4.10] below we show principal component analysis (PCA) proportions for renewable energy consumption indicators for both samples [Asean+3 and EEA groups]. Furthermore, the KMO results shown in Appendix [4.1] of the Asean + 3 and EEA group's clean energy consumption indices be [0.698] and [0.761] correspondingly. Therefore, renewable energy consumption components were -used in this study to construct principal components.

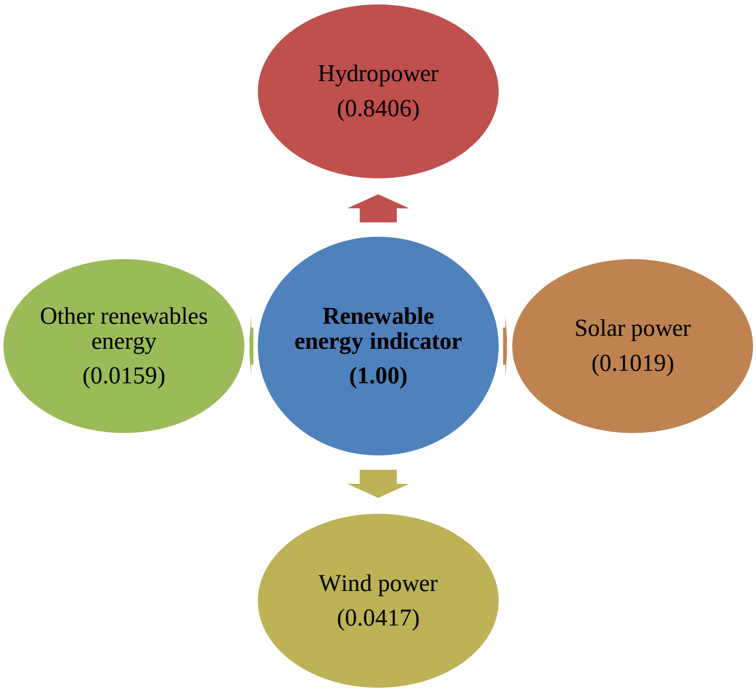


Figure 4. 9: Proportions of renewable energy consumption index for Asean+3 group

Source: Researchers' Design

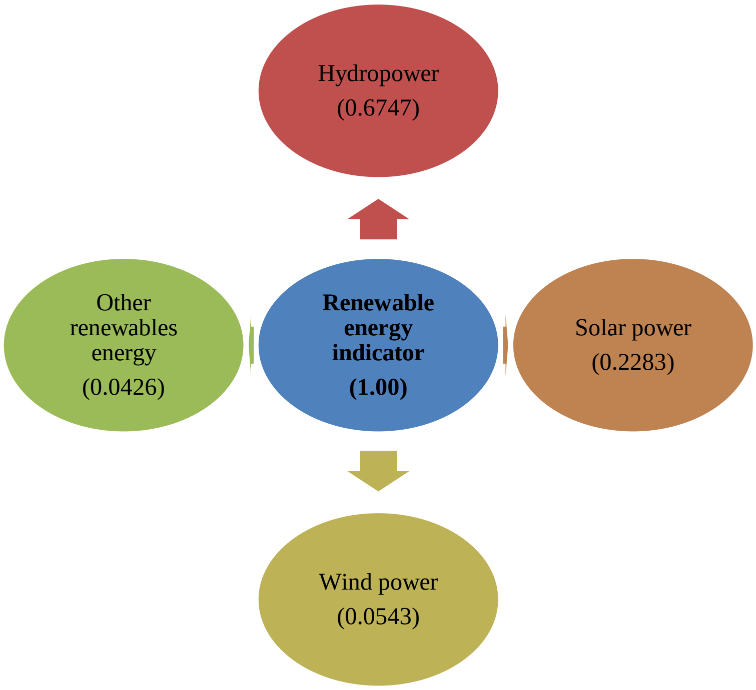


Figure 4. 10: Proportions of renewable energy consumption index for EEA group

Source: Researchers' Design

4.5.7. Fossil fuel energy consumption indicators data collection and sorting techniques

The research study used data retrieved from energy indicators of the Index Mundi (2019). The collection of data was done for fossil fuel energy consumption (IFEC) indicators such as natural gas, crude oil, motor gasoline, consumption of coal and other petroleum products. Fossil fuel energy consumption was explained as the allocation of fuel power consumption in entire final energy consumption (thousand barrels per year). Using these five indicators, the research study developed a fossil fuel power consumption index by using principal component analysis (PCA). Figure [4.11] and Figure [4.12] below we show the principal component analysis (PCA) proportions for fossil fuel energy consumption indicators for both samples [Asean+3 and EEA groups]. Furthermore, the KMO results shown in Appendix [4.1] of the Asean + 3 and EEA group's fossil fuel power utilization index are [0.816] and [0.763] respectively. Therefore, fossil fuel power consumption components were used in this research study to construct principal components.

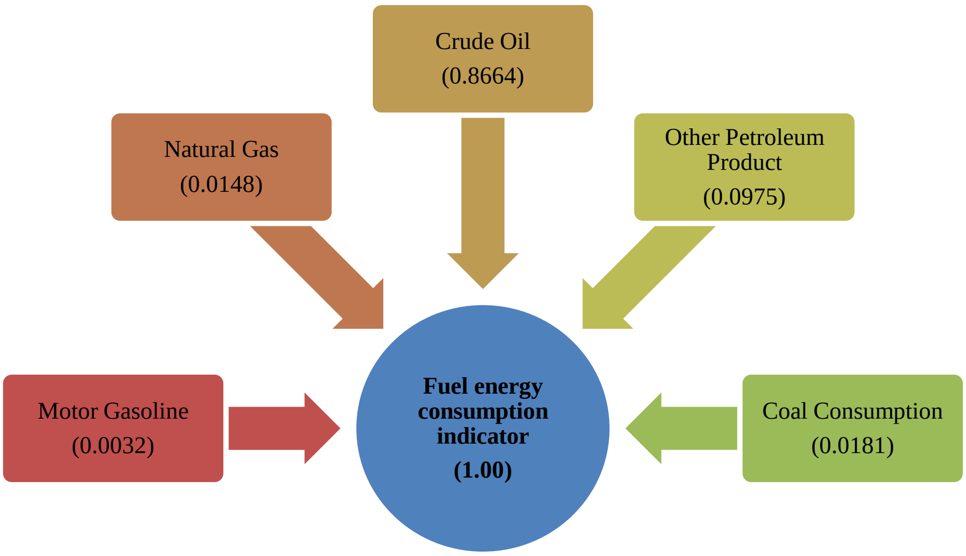


Figure 4. 11: Proportions of fuel energy consumption index for Asean+3 group

Source: Researchers' Design

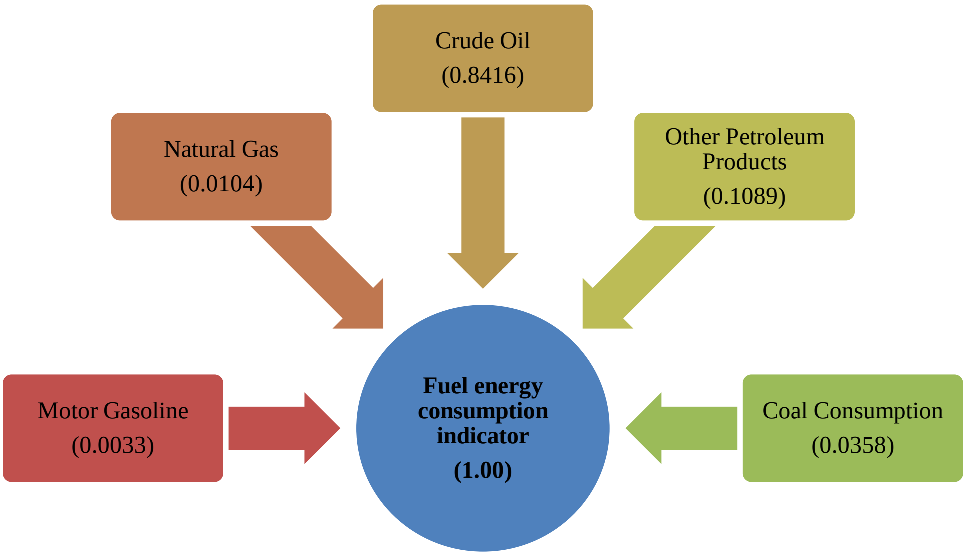


Figure 4. 12: Proportions of fuel energy consumption index for EEA group

Source: Researchers' Design

Further, the research study obtained gross domestic product per-capita (constant 2010 US$) (RGDP) facts from world development indicators (WDI) of the World Bank (2019). The framework in this research study which was used to explore the relationships with respect to the variables was presented as follows:

$$\text{IREC} = \mathcal{F}[\text{IFD}, \text{IEPOL}, \text{ITIN}, \text{IEF}, \text{RGDP}] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..[1]$$

$$\text{IFEC} = \mathcal{F}[\text{IFD}, \text{IEPOL}, \text{ITIN}, \text{IEF}, \text{RGDP}] \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..[2]$$

In equation [1] above, IREC denotes the dependent variable which represents an index of renewable energy consumption, while the independent variables were IFD that denotes the index of financial development, IEF denoting the index of economic freedom, IEPOL representing the index of environment pollution, ITIN represents the index of technological innovation, and RGDP being real gross demotic product. Furthermore, equation [2] indicate the relationships with respect to the variables defined above, with fossil fuel energy consumption (IFEC) which represented the dependent variable. The variables $[\text{IFEC}, \text{IREC}, \text{IFD}, \text{IEPOL}, \text{ITIN}, \text{IEF}]$ were transformed into natural logs in order to remove any possible non-homoscedasticity. Therefore, empirical equations which show variables in their natural logarithms were thus:

$$\mathrm{LIREC} = \beta_0 + \beta_1\mathrm{LIFD} + \beta_2\mathrm{LIEPOL} + \beta_2\mathrm{LITIN} + \beta_3\mathrm{LIEF} + \beta_4\mathrm{LRGDP} + \mu \quad .\ldots[3]$$

$$\mathrm{LIFEC} = \beta_0 + \beta_1\mathrm{LIFD} + \beta_2\mathrm{LIEPOL} + \beta_2\mathrm{LITIN} + \beta_3\mathrm{LIEF} + \beta_4\mathrm{LRGDP} + \mu \quad \ldots.[4]$$

Wherein, $\mathrm{LIFEC}, \mathrm{LIREC}, \mathrm{LIFD}, \mathrm{LIEPOL}, \mathrm{LITIN}, \mathrm{LIEF}, \mathrm{LRGDP}$ represented the natural logarithm of fossil fuel energy consumption, natural logarithm of renewable power consumption index, normal logarithm of financial development index, natural logarithm of environment pollution index, natural logarithm of technological innovation index, natural logarithm economic freedom index, and natural logarithm of real GDP index respectively.

4.5.8. Real GDP per capita indicator data collection and sorting techniques

4.6. Descriptive statistics

The expressive statistics for the full balanced panel data set with nine countries in Asean+3 group and twenty-four of EEA group were presented in Table [4.1] and Table [4.2] below. Cross-group variation in energy consumption [renewable and fuel energy] was extremely constant over the period between 1998 and 2018. The normal deviation of LIREC is [0.82 and 1.12] respectively, and LIFEC is [0.88 and 0.81] respectively, demonstrating how different our sample is with respect to power consumption. The maximum value was observed with respect to renewable power consumption in the ASEAN + 3 group.

Table 4. 1: Description of Asean + 3 group variables

Variables	Obs	Mean	Standard Deviation.	Minimum	Maximum
LIREC	189	-5.123633	0.822049	-5.880355	-1.861706
LIFD	189	-3.117596	0.585052	-5.978233	-2.458529
LIFEC	189	-5.336148	0.8853452	-5.663272	-2.277433
LIEPLO	189	-5.099696	0.5178231	-5.494029	-2.459785
LITIN	189	-5.245233	0.73596	-5.970429	-2.151491
LIEF	189	-2.889463	0.4066531	-5.439124	-2.248798
LRGDP	189	8.84907	1.277479	6.550533	10.97246

Source: Researchers' computations

Table 4. 2: Description of EEA group variables

Variables	**Obs**	**Mean**	**Standard Deviation.**	**Minimum**	**Maximum**
LIREC	504	-5.328489	1.129683	-6.813892	-2.008821
LIFD	504	-2.446601	0.3110414	-6.055803	-1.868851
LIFEC	504	-5.291973	0.816074	-5.329362	-2.337427
LIEPLO	504	-5.185814	0.6955715	-5.104224	-2.602347
LITIN	504	-0.328265	0.7440562	-14388635	1.686306
LIEF	504	-2.712488	0.3588671	-5.706949	-2.183922
LRGDP	504	10.0211	0.658874	8.2313	11.06466

Source: Researchers' computations

4.7. Empirical Model

The research study employed two main empirical techniques in a way which provided robust results and allow for sound public policy recommendations. The first estimation technique was a dynamic system since it incorporated the panel ARDL approach. The second technique was adopted to verify the robustness of the results for use in crafting robust public policy recommendations. Therefore in order to make efficient and consistent estimates, the Mean Group (MG), Pooled Mean Group (PMG), and Dynamic Fixed Effect (DFE) under the Maximum Likelihood Estimation (MLE) was created by Pesaran, Shin, and Smith (Pesaran et al., 1999). Furthermore, robust tests were done by employing the (Dumitrescu and Hurlin, 2012)technique which was employed for causality analysis with a view to unleash sound public policy and regulatory interventions, and CS-ARDL technique by Chudik and Pesaran (2015) due to the non-stationary and CD in the specified variables.

4.7.1. Panel Unit Root Tests

The research study employed a macro time series data set, where the researcher first scrutinize the unit root tests for each cycle, which usually contain unit root characteristics. The first generation Panel nit root tests which were employed in this research study include the LLC[1] and IPS[2](Levin et al., 2002), (Im et al., 2003). This test depend on the ADF technique which was developed by Dickey-Fuller (Im et al., 2003). According to (Im et al., 2003), the IPS Panel Unit Root technique is a perfect technique for determining the existence of unit roots in panel data. An efficient testing technique is needed for the first- invention unit root, as it is easy to determine the order of combination of a variable in the ARDL methodology, which applicable when the variables are mixed I (0) and I (1) order of integration, as in the (Pesaran et al., 1999), (Pesaran and Smith, 1995)studies. Therefore, these checks were employed to ensure that none of the series had an integration order of 1(2).

4.7.2. Pedroni panel cointegration test technique

The study also examine whether a long- run relationship between the variables exists. Therefore, the panel cointegration test was implemented. This study used the (Pedroni, 1999) and (Pedroni, 2004) cointegration test

[1] LLC: Levin Lin-Chu
[2] IPS: Im-Pesaran-Shin

which is based on the Engle and Granger, (1987) cointegration test that explain whether the residual of each variable is stationary at level which means that the variables are cointegrated, or I(1) which indicates that the variables are not cointegrated. The Pedroni cointegration procedure contains several statistical tests between and within dimension to examine whether the null hypothesis of no cointegration can be rejected. The Pedroni cointegration test works under the following regression:

$$Y_{it} = \sigma_{it} + \sphericalangle_{it} + \mathcal{B}_{1i}X_{1i,t} + \mathcal{B}_{2i}X_{2i,t} + \cdots + \mathcal{B}_{Ni}X_{Nit} + \omega_{i,t} \qquad \text{.........(5)}$$

Where, $[Y]$ and $[X]$ are presumed to be integrated in order (1), $[\sigma_i]$ and $[\sphericalangle_i]$ are the individual and trend effects, while $[\omega]$ represents the residuals. If the residuals in regression (5) were integrated in order (1), the null hypothesis of no cointegration cannot be rejected. To examine the integration of the residual, one of the following regressions is used:

$$\omega_{it} = \vartheta_i \omega_{it-1} + \varepsilon_{it} \qquad \text{............(6)}$$

$$\omega_{it} = \vartheta_i \omega_{it-1} + \sum_{m=1}^{Ni} \Phi_{im} \Delta\omega_{it-m} + \Gamma_{it} \qquad \text{............(7)}$$

Regressions [6] and [7] can be utilized for each cross section. If cointegration is concluded among the variables, the panel-pooled fully modified ordinary least square (FMOLS) will be implemented to analyze the long-run cointegration relationship between the dependent and the independent variables. The pooled FMOLS was proposed by Phillips and Moon (1999). This cointegration regression is more capable of preventing spurious regression generated from the involvement of the $I(1)$ variables which can cause misleading results. The pooled FMOLS estimator is presented below:

$$\widehat{\mathrm{B}}_{PF} + [\sum_{i=1}^{z} \sum_{t=1}^{K} \tilde{X}_{it} \tilde{Y}_{it}]^{-1} \sum_{i=1}^{z} \sum_{t=1}^{K} [\tilde{X}_{it} \tilde{Y}_{it} - \hat{\varphi}_{1\grave{2}}^{+} \qquad \text{..........(8)}$$

Where, $[\tilde{X}_{it} \tilde{Y}_{it}]$ are the corresponding data removed from the individual deterministic trends and $[\hat{\varphi}]$ represents the cointegration regressors. It is fundamental to note that the pooled FMOLS estimator sums across cross sections separately in the numerator and denominator. If cointegration is confirmed among the variables, there might be a causal relationship between the variables, at least in one direction. Therefore, the Granger causality was utilized. If cointegration exists, then the Granger causality based on vector error correction model (VECM) will be used. The VECM Granger causality can capture the short-run causality based on the F-statistic and the long-run causality based on the lagged error correction term. The VECM Granger causality is presented below:

$$\begin{pmatrix} \Delta LIREC_{2it} \\ \Delta LRGDP_{it} \\ \Delta LIEPOL_{it} \\ \Delta LIFEC_{it} \\ \Delta LIFD_{it} \\ \Delta LIEF_{it} \\ \Delta LITIN_{it} \end{pmatrix}$$

$$= \begin{pmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \\ \sigma_4 \\ \sigma_5 \\ \sigma_6 \end{pmatrix} + \sum_{n=-1}^{f} \begin{pmatrix} B_{11,n} & B_{12,n} & B_{13,n} & B_{14,n} & B_{15,n} & B_{16,n} \\ B_{21,n} & B_{22,n} & B_{23,n} & B_{24,n} & B_{25,n} & B_{26,n} \\ B_{31,n} & B_{32,n} & B_{33,n} & B_{34,n} & B_{35,n} & B_{36,n} \\ B_{41,n} & B_{42,n} & B_{43,n} & B_{44,n} & B_{45,n} & B_{46,n} \\ B_{51,n} & B_{52,n} & B_{53,n} & B_{54,n} & B_{55,n} & B_{56,n} \\ B_{61,n} & B_{62,n} & B_{63,n} & B_{64,n} & B_{65,n} & B_{66,n} \end{pmatrix} \begin{pmatrix} \Delta LIREC_{2it-n} \\ \Delta LRGDP_{it-n} \\ \Delta LIEPOL_{it-n} \\ \Delta LIFEC_{it-n} \\ \Delta LIFD_{it-n} \\ \Delta LIEF_{it-n} \\ \Delta LITIN_{it-n} \end{pmatrix}$$

$$+ \begin{pmatrix} \mathscr{b}_1 \\ \mathscr{b}_2 \\ \mathscr{b}_3 \\ \mathscr{b}_4 \\ \mathscr{b}_5 \\ \mathscr{b}_6 \end{pmatrix} ect_{it-1} + \begin{pmatrix} e_{1it} \\ e_{2it} \\ e_{3it} \\ e_{4it} \\ e_{5it} \\ e_{6it} \end{pmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

However, if the variables are not cointegrated, the Granger causality based on vector autoregressive [VAR] model will be used. The VAR Granger causality can only show the long- run causality among the variables. The VAR Granger causality model is presented below:

$$\begin{pmatrix} \Delta LIREC_{2it} \\ \Delta LRGDP_{it} \\ \Delta LIEPOL_{it} \\ \Delta LIFEC_{it} \\ \Delta LIFD_{it} \\ \Delta LIEF_{it} \\ \Delta LITIN_{it} \end{pmatrix} = \begin{pmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \\ \sigma_4 \\ \sigma_5 \\ \sigma_6 \end{pmatrix} + \sum_{n=-1}^{f} \begin{pmatrix} B_{11,n} & B_{12,n} & B_{13,n} & B_{14,n} & B_{15,n} & B_{16,n} \\ B_{21,n} & B_{22,n} & B_{23,n} & B_{24,n} & B_{25,n} & B_{26,n} \\ B_{31,n} & B_{32,n} & B_{33,n} & B_{34,n} & B_{35,n} & B_{36,n} \\ B_{41,n} & B_{42,n} & B_{43,n} & B_{44,n} & B_{45,n} & B_{46,n} \\ B_{51,n} & B_{52,n} & B_{53,n} & B_{54,n} & B_{55,n} & B_{56,n} \\ B_{61,n} & B_{62,n} & B_{63,n} & B_{64,n} & B_{65,n} & B_{66,n} \end{pmatrix} \begin{pmatrix} \Delta LIREC_{2it-n} \\ \Delta LRGDP_{it-n} \\ \Delta LIEPOL_{it-n} \\ \Delta LIFEC_{it-n} \\ \Delta LIFD_{it-n} \\ \Delta LIEF_{it-n} \\ \Delta LITIN_{it-n} \end{pmatrix} + \begin{pmatrix} e_{1it} \\ e_{2it} \\ e_{3it} \\ e_{4it} \\ e_{5it} \\ e_{6it} \end{pmatrix} \quad \dots\dots\dots\dots\dots\dots (10)$$

The [i] represents the cross section (number of countries), [t] denotes the time, $[e_{it}]$ is the error term, and $[ect]$ is the lagged error correction term.

4.7.3. Panel Autoregressive Distributed Lag approach (ARDL)

The impact of financial developments, environmental pollution, innovation, financial freedom, and real GDP on renewable power consumption was investigated using the mean group (MG), pooled mean group (PMG), and dynamic fixed effect (DFE) under the maximum likelihood estimation (MLE) developed by Pesaran, Shin, and Smith (Pesaran et al., 1999). In the PMG model, the dynamic heterogeneous panel regression is combined into an error correction model as follows:

$$\mathcal{Y}_{it} = \mu_i + \sum_{j=1}^{p} \lambda_{ij} \mathcal{X}_{i,t-j} + \sum_{j-0}^{q} \delta'_{ij} X_{i,t-j} + \varepsilon_{it} \quad \dots\dots\dots \; (11)$$

Where, in $[1,2,3..,\mathrm{N}]$ indicates the number of nations selected. $t = 1,2,3 \dots, \mathrm{t}$ denotes annual time frames, (j) is the time lag numbers, (q) denotes the independent variables lag, and (p) is the dependent variable lag, μ_i stands for the fixed effects, the coefficients of the lagged reliant variables asλ_{ij}, and $\delta_i'$is coefficient vectors, X_{it} is the vector of illustrative variables (regressors) for group (i), (X') represents the vector of control variables, while (ε_i) denotes the error term that has fixed effects. Based on Pesaran, Shin, and Smith (Pesaran et al., 1999) equation (11) above can be rearranged by reformulating it as follows:

$$\Delta \mathcal{Y}_{it} = \mu_i + \infty \mathcal{Y}_{i,t-1} + \beta_i' X_{it-1} + \sum_{j=i}^{p-1} \psi_{ij}^* \Delta \mathcal{Y}_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}'^* \Delta X_{i,t-j} + \varepsilon_{it} \quad \dots\dots\dots (12)$$

$$\mathrm{i} = 1,2,\dots,\mathrm{N}, \text{and } \mathrm{t} = 1,2,\dots,\mathrm{T},$$

$$\text{where } \varphi = -1\left[1 - \sum_{j=1}^{p} \psi_{ij}\right],\ \beta_i = \sum_{j=0}^{p} \delta_{ij},$$

$$\psi_{ij}^* = -\sum_{m=j+1}^{p} \psi_{im}, \qquad j = 1,2,\dots,p-1,$$

And

$$\delta_{ij}^* = -\sum_{m=j+1}^{p} \delta_{im}, \quad j = 1,2,\dots,q-1.$$

Equation (12) above can also be written in an error correction formulation by further grouping the variables at their levels.

$$\Delta \mathcal{Y}_{it} = \mu_i + \infty_i\{\mathcal{Y}_{i,t-1} - \partial_i' X_{it-1}\} + \sum_{j=1}^{p-1} \psi_{ij}^* \Delta \mathcal{Y}_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}^* \Delta X_{i,t-j} + \varepsilon_{it} \quad (13)$$

Where, $\partial_i = (\beta_i/\infty_i)$ determines the long-run equilibrium relationship with respect to $[\mathcal{Y}_{it}\ and\ X_{it}]$. In contrast, $\psi_{ij}^*\ and\ \delta_{ij}^{*\prime}$ denotes temporary coefficient linked to past values and other growth factors, such as changes in $X_{\ it}$. Furthermore, ∞_i shows the error correction coefficient that represents the velocity of adjustment of $\mathcal{Y}_{it}$ towards the long-term equilibrium after a change inX_{it}. There are two circumstances which must be met in order to ensure a long-standing relationship: the coefficient should be negative ($\infty_i < 0$) and significant. Therefore, where tϖ_i is important and negative, it reveals support for the existence of co-integration between $\mathcal{Y}_{it}\ and\ X_{it}$. To this end, these estimates are thus calculated as follows:

$$\hat{\partial}_{PMG} = \frac{\sum_{i=1}^{N} \tilde{\partial}_i}{N}, \hat{\beta}_{jPMG} = \frac{\sum_{i=1}^{N} \tilde{\beta}_i}{N};\ \hat{\psi}_{jPMG} = \frac{\sum_{i=1}^{N} \tilde{\psi}_i}{N}, and\ \hat{\gamma}_{jPMG} = \frac{\sum_{i=1}^{N} \tilde{\gamma}_i}{N} \qquad (14)$$

Where, $J = 0, \dots \dots, q-1, \quad \hat{\partial}_{PMG} = \tilde{\partial}$

If there is an adequate relationship in the lag of the reliant and self-regulating variables, serial correlation and endogeneity preconception in the model can be skipped which is an advantage of ARDL panel approach. Specifically, the PMG estimator uses enduring non-heterogeneity while allowing short-range heterogeneity. The second estimator for the panel ARDL approach was the MG estimator, since it is suitably being in use on country-specific foundation for regression. In differentiation, the PMG estimator requires elongated and undersized term diversification and the consistency of this estimator depend on the dimension of the time series data. The DFE estimator is the last estimator of the ARDL method and this is applicable to short-term and long-term homogeneity.

4.7.3.1. Empirical Models for Asean+3 group

Since the research study examined the global dynamic linkages between financial development, economic freedom, environmental pollution, technological improvement and power consumption in the growth channels of East and West poles in the Keynesian consumption hypothesis context, the reduced form of the Pesaran, Shin, and Smith (Pesaran et al., 1999) was shown in the model formulated based on equation (7) above.

$$\Delta\, LIREC_{Asean+3i,t} = \mu_i + \infty_i\big(LIREC_{i,t-1} - \psi_1 LIFD_{i,t-1} - \psi_2 LIEPOL_{i,t-1} - \psi_3 LITIN_{i,t-1} - \psi_4 LIEF_{i,t-1} - \psi_5 LRGDP_{i,t-1}\big) + \sum_{j-1}^{p-1} \gamma_j^i\, \Delta(LIREC_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{1j}^i\, \Delta(LIFD_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{2j}^i\, \Delta(LIEPOL_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{3j}^i\, \Delta(LITIN_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{4j}^i\, \Delta(LIEF_{it})_{t-1} + \sum_{j=0}^{p-1} \delta_{5j}^i\, \Delta(LRGDP_{it})_{t-j} + \delta_{i,t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad [15]$$

$$\Delta\, LIFEC_{Asean+3i-t} = \mu_i + \infty_i\big(LIFEC_{i,t-1} - \psi_1 LIFD_{i,t-1} - \psi_2 LIEPOL_{i,t-1} - \psi_3 LITIN_{i,t-1} - \psi_4 LIEF_{i,t-1} - \psi_5 LRGDP_{i,t-1}\big) + \sum_{j-1}^{p-1} \gamma_j^i\, \Delta(LFREC_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{1j}^i\, \Delta(LIFD_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{2j}^i\, \Delta(LIEPOL_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{3j}^i\, \Delta(LITIN_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{4j}^i\, \Delta(LIEF_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{5j}^i\, \Delta(LRGDP_{it})_{t-j} + \delta_{i,t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. [16]$$

Whereby, $LIREC_{Asean+3i,t}$ is Asean clean energy consumption index, $LIREC_{i,t-1}$ represents the first lag of Asean clean energy consumption index, $\Delta\, LIFEC_{Asean+3i,t}$is Asean fossil fuel energy consumption index, $LIFEC_{i,t-1}$representing the first lag of Asean fossil fuel energy consumption index, $LIFD_{i,t-1}$ represented the financial development index, $LIEPOL_{i,t-1}$ shows environmental pollution index, $LITIN_{i,t-1}$ being technological innovation index, $LIEF_{i,t-1}$ is for economic freedom index, $LRGDP_{i,t-1}$ donates the real gross domestic product. On the other hand ψ_i indicate the vector of long-time coefficients of lag self-regulating variables, ∞_i indicates the pace of the adjustment as it must be downbeat and considerable. If the coefficient of [∞_i] is [0], it will be indicating that there is no long-standing connection and [$\delta_{i,t}$] shows the disturbance or error term, whereas [Δ] represents first difference operator. The same representation in equations above was done below for the EEA group.

4.7.3.2. Empirical Models for EEA group

The reduced form of an improved Pesaran, Shin, and Smith (Pesaran et al., 1999) for EEA is given as shown below:

$$\Delta\, LIREC_{EEAi,t} = \mu_i + \infty_i\big(LIREC_{i,t\text{-}1} - \psi_1 LIFD_{i,t\text{-}1} - \psi_2 LIEPOL_{i,t\text{-}1} - \psi_3 LITIN_{i,t\text{-}1} - \psi_4 LIEF_{i,t\text{-}1} - \psi_5 LRGDP_{i,t\text{-}1}\big) + \sum_{j-1}^{p-1} \gamma_j^i\, \Delta(LIREC_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{1j}^i\, \Delta(LIFD_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{2j}^i\, \Delta(LIEPOL_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{3j}^i\, \Delta(LITIN_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{4j}^i\, \Delta(LIEF_{it})_{t-1} + \sum_{j=0}^{p-1} \delta_{5j}^i\, \Delta(LRGDP_{it})_{t-j} + \delta_{i,t} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad [17]$$

$$\Delta\, LIFEC_{EEAi\text{-}t} = \mu_i + \infty_i\big(LIFEC_{i,t\text{-}1} - \psi_1 LIFD_{i,t\text{-}1} - \psi_2 LIEPOL_{i,t\text{-}1} - \psi_3 LITIN_{i,t\text{-}1} - \psi_4 LIEF_{i,t\text{-}1} - \psi_5 LRGDP_{i,t\text{-}1}\big) + \sum_{j-1}^{p-1} \gamma_j^i\, \Delta(LFREC_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{1j}^i\, \Delta(LIFD_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{2j}^i\, \Delta(LIEPOL_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{3j}^i\, \Delta(LITIN_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{4j}^i\, \Delta(LIEF_{it})_{t-j} + \sum_{j=0}^{p-1} \delta_{5j}^i\, \Delta(LRGDP_{it})_{t-j} + \delta_{i,t} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad [118]$$

Whereby $LIREC_{EEAi,t}$ shows EEA clean energy consumption index, $LIREC_{i,t\text{-}1}$ represents the first lag of EEA clean energy consumption index, $\Delta\, LIFEC_{EEAi,t}$ is for EEA fuel energy consumption index, $LIFEC_{i,t\text{-}1}$represents the first lag of EEA fuel energy consumption index, All other variables remain as explained in equations [3] and [4] above.

4.8. Robustness check

4.8.1. Dumitrescu-Hurlin Non-Causality Test Technique (DH)

This technique was created by Dumitrescu and Hurlin (2012)as a non-causality testing strategy for dissimilar panels. According to (Kutan et al., 2018), two dimensions of heterogeneity are accounted for in this technique, that is that of the causality model used and that for the causal relations. Chakraborty and Mazzanti (2020) further emphasized that the Dumitrescu-Hurlin non-causality technique accounts for the heterogeity of causality relations as well as heterogeneity of the model employed. Further, (Kutan et al., 2018)revealed a multiplicity of benefits associated with this technique. The first benefit the duo noted was that, the Dumitrescu-Hurlin non-causality testing technique is simple to implement; the second benefit supported by results from Monte-Carlo simulation is that the panel statistics increases the robustness of the non-causality tests, including that for small samples with small number of panels and time components. Thirdly, the Dumitrescu and Hurlin non-causality test statistic does not require any specific panel estimations. The fourth benefit as explicated by Dumitrescu and Hurlin (2012)was that the technique is implementable under conditions of both balanced and unbalanced panel data series. The specification for the Dumitrescu and Hurlin (2012)as restated by Chakraborty and Mazzanti (2020)in (Kutan et al., 2018)is provided below as:

$$y_{i,t} = a_i + \sum_{j-1}^{N} \varphi^n{}_i y_{i,t-n} + \sum_{j-1}^{N} \beta^n{}_i x_{i,t-n} + \varepsilon_{i,t} \qquad \dots\dots\dots\dots\dots. \ [19]$$

In equation (19) above, x and y represented observable variables for N countries and T time, $\beta_i = (\beta^1{}_i, \dots.., \beta^N{}_i$' and a_i being assumed fixed all the time. The null hypothesis under this non-causality testing technique is that, no causality with respect to any panels. Alternatively, the null hypothesis assumes at least a single causality exists with respect to the panels and is presented as:

$H_0 = \mathcal{B}_i = 0$ For $\forall_i = 1, \dots, N$

$$H_1 = \begin{bmatrix} \mathcal{B}_{i=0} \forall_i = 1, 2, \ldots\ldots \mathcal{N} \\ \mathcal{B}_{i \neq 0} \forall_i = \mathcal{N}_1 + 1, \mathcal{N}_2 + 2, \ldots\ldots, \mathcal{N} \end{bmatrix}$$

The non-causality test results will be instrumental in crafting robust public policy recommendations for the panel of economies considered in our research study.

4.8.2. Cross-Sectional Autoregressive-Distributed lags approach (CS-ARDL)

Pesaran (2004) developed a cross-sectional dependency test (CD) that was applied in the research study since the countries selected have some common characteristics. A Cross-Sectional Dependence (CD) test technique is shown in equation (20) below:

$$\mathrm{CD} = \left(\frac{\mathrm{T}C(\mathrm{C}-1)}{2}\right)^{1/2} \bar{\bar{\mathrm{P}}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \; [20]$$

Whereas $\bar{\bar{\boldsymbol{P}}} = \left(\frac{\mathbf{2}}{\boldsymbol{C}(\boldsymbol{C}-\mathbf{1})}\right) \sum_{\boldsymbol{i}-\mathbf{1}}^{\boldsymbol{C}-\mathbf{1}} \sum_{\boldsymbol{j}=\boldsymbol{i}+\mathbf{1}\check{\boldsymbol{P}}_{i\,j}}^{\boldsymbol{C}}$.and $\check{P}_{i\,j}$suggests pairwise correlation coefficient of the cross-sectional residuals gathered from the Augmented Dickey Fuller (AD) estimation; C and T denotes cross-sectional dimensions and time respectively. When there is cross-sectional reliance between variables, Second-generation unit root tests ought to be applied to conquer the setback of sectional dependence (Pesaran, 2007) and (Shahbaz et al., 2018). Therefore, following (Pesaran, 2007), the Cross-Sectional Augmented Dickey-Fuller (CADF) is estimated as:

$$\Delta Y_{it} = a_i + B_i Y_{it-1} + \varphi_i \bar{Y}_{t-1} + \Phi_i \Delta \bar{Y}_t + \varepsilon_{it} \qquad \ldots\ldots\ldots\ldots \; [21]$$

Where, $t = 1, \ldots., T, i = 1, \ldots..N, and\ \bar{Y}_t$ denotes the mean of cross sections and is resultant from

$\bar{Y}_t = c^{-1} \sum_{i=1}^{c} Y_{it}$ and considering the mean mitigate the modern correlations amongst Y_{it}. The null hypothesis of equation (20) above is; $\mathrm{H}_0: \beta_i = 0\ for\ all\ i$ and the alternative hypothesis is $\mathrm{H}_1: \beta_i < 0\ for\ some\ i$. Pesaran (2004)developed the cross-sectional augmented panel unit root (CIPS) test, which is presented as follows:

$CIPS(C,T) = C\sum_{i=1}^{C} t_i\,(C,T)$; Where $t_i(C,T)$ denotes the t-statistics for β_i.

The research study also applied the CS-ARDL framework by Chudik and Pesaran (2015)due to the non-stationary and CD in the specified variables. Such a framework consists of lagged dependent variables, where a dynamic behavior is allowed to be captured through weak exogenous regression and developed in error correction framework (ECM). Therefore, this enables solving the problem of cross-sectional reliance bias in both the short-range and long-standing. The research study considered three diverse versions of CS-ARDL and solved cross-sectional bias completely in both the short-term and long-term.

$$LIREC_{Asea+3it} = \mu_i + \varphi_i(LIREC_{it-1} - \beta_i\mathcal{X}_{it-1} - \emptyset_{1i}\overline{LIREC}_{t-1} - \emptyset_{2i}\overline{\mathcal{X}}_{t-1}) + \sum_{j=1}^{p-1}\Psi_{ij}\,\Delta LIREC_{it-j} + \sum_{j=0}^{q-1}\varpi_{ij}\,\Delta\mathcal{X}_{it-j} + \mathfrak{A}_{1i}\Delta\overline{LIREC}_t + \mathfrak{A}_{2i}\Delta\overline{\mathcal{X}}_t + \varepsilon_{it} \quad \ldots\ldots\ldots.\ [22]$$

$$LIFEC_{Asea+3it} = \mu_i + \varphi_i(LIFEC_{it-1} - \beta_i\mathcal{X}_{it-1} - \emptyset_{1i}\overline{LIFEC}_{t-1} - \emptyset_{2i}\overline{\mathcal{X}}_{t-1}) + \sum_{j=1}^{p-1}\Psi_{ij}\,\Delta LIFEC_{it-j} + \sum_{j=0}^{q-1}\varpi_{ij}\,\Delta\mathcal{X}_{it-j} + \mathfrak{A}_{1i}\Delta\overline{LIFEC}_t + \mathfrak{A}_{2i}\Delta\overline{\mathcal{X}}_t + \varepsilon_{it} \quad \ldots\ldots\ldots\ldots.\ [23]$$

where, Asean renewable energy consumption is presented as $LIREC_{Asea+3it}$, $LIFEC_{Asea+3it}$represents the Asean fossil fuel energy consumption, $\mathcal{X}_{it}$indicates all independent variables in the long-term in both formulas, $\overline{LIREC}_{t-1}$ indicates the long-term for the mean Asean renewable energy consumption, $\overline{LIFEC}_{t-1}$ is the lasting for the mean Asean fossil fuel energy consumption, $\overline{\mathcal{X}}_{t-1}$refers to the long-term of mean self-regulating variables for both formula, while $\Delta LIREC_{it-j}$ and $\Delta LIFEC_{it-j}$indicated the reliant variable in the short-range, $\Delta\mathcal{X}_{it-j}$ refers to self-governing variables in the short-term, $\Delta\overline{LIREC}$and $\Delta\overline{LIFEC}_t$ denotes the mean of the reliant variable in the interim, and $\Delta\overline{\mathcal{X}}_t$ suggests the mean of the independent variables during the short-term, and ε_{it} represent the error term. Furthermore, j stands for the cross-sectional dimensions $j = 1 \ldots..J,\ time\ t = 1 \ldots T$, $\beta_j$represented the coefficients of independent variables, Ψ_{ij} shows the interim coefficient of the dependent variable, ϖ_{ij} suggests the short-term coefficient of the independent variables, and $\mathfrak{A}_{1i}$ and $\mathfrak{A}_{2i}$ represents the mean of independent and dependent numbers during the short-time respectively.

The reduced form of an improved CS-ARDL framework by Chudik and Pesaran (2015)for the EEA group is given as shown below:

$$LIREC_{EEAit} = \mu_i + \varphi_i(LIREC_{it-1} - \beta_i \mathcal{X}_{it-1} - \emptyset_{1i}\overline{LIREC}_{t-1} - \emptyset_{2i}\bar{\mathcal{X}}_{t-1}) + \sum_{j=1}^{p-1} \Psi_{ij}\,\Delta LIREC_{it-j} + \sum_{j=0}^{q-1} \varpi_{ij}\,\Delta\mathcal{X}_{it-j} + \mathfrak{A}_{1i}\Delta\overline{LIREC}_t + \mathfrak{A}_{2i}\Delta\bar{\mathcal{X}}_t + \varepsilon_{it} \quad \dots\dots\dots\dots. [24]$$

$$LIFEC_{EEAit} = \mu_i + \varphi_i(LIFEC_{it-1} - \beta_i \mathcal{X}_{it-1} - \emptyset_{1i}\overline{LIFEC}_{t-1} - \emptyset_{2i}\bar{\mathcal{X}}_{t-1}) + \sum_{j=1}^{p-1} \Psi_{ij}\,\Delta LIFEC_{it-j} + \sum_{j=0}^{q-1} \varpi_{ij}\,\Delta\mathcal{X}_{it-j} + \mathfrak{A}_{1i}\Delta\overline{LIFEC}_t + \mathfrak{A}_{2i}\Delta\bar{\mathcal{X}}_t + \varepsilon_{it} \quad \dots\dots\dots\dots. [25]$$

Where, EEA represents clean energy consumption and EEA being fossil fuel energy use are presented as $LIREC_{EEAit}$ and $LIFEC_{EEAit}$ in that order. All other variables remain as explained in equations above.

4.9. Chapter Summary

In the chapter, researchers have delved into, a recap of the research questions, research study design, research study philosophy, research study population, data gathering and sorting, empirical model in which the panel Autoregressive Distributed Lag (ARDL) was considered with special emphasis on the empirical models for both groups. The next chapter will consider empirical results from our data analysis.

CHAPTER 5

RESULTS

Introduction

This chapter is presenting results from this research study on the global dynamic linkages between financial development, economic freedom, environmental pollution, technological innovation and energy consumption between the East and West poles. This chapter is therefore divided into two parts, based on two empirical equations employed herein. To this end, Figure (5.1) includes section 5.1 presents the results of the fuel energy consumption and 5.2 shows the results for renewable energy consumption.

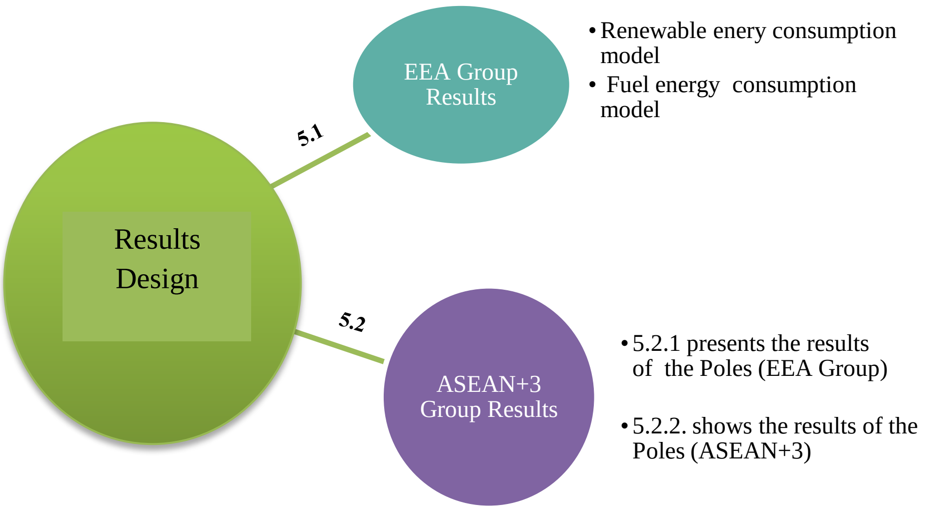


Figure 5. 1: Results Design

Source: Researchers' Design

5.1. European Economic Area Group (EEA) Results

5.1.1. Integration Order

In this subsection the researchers presents the results for the European Economic Area Group (EEA) sample comprising of 24 countries from around the world. The results for unit root test that is (LLC[3]) and (IPS)[4]estimations are presented in Table [5.1] below for all variables. The results gave a different order of implementation under LLC and IPS approach.

Table 5. 1: IPS and LLC unit root results

Parameter	IPS		LLC	
	I(0)	**I(1)**	**I(0)**	**I(1)**
LIREC	8.2069 [1.0000]	-8.7507 [0.0000]*	-1.0066 [0.1571]	-4.8601 [0.0000]*
LIFD	-4.7769 [0.0000]*	-10.486 [0.0000]*	-4.5264 [0.0000]*	-8.9335 [0.0000]*
LIEPOL	1.2539 [0.8951]	-12.030 [0.0000]*	0.6144 [0.7305]	-9.3681 [0.0000]*
LITIN	-1.0756 [0.1410]	-8.0614 [0.0000]*	0.1259 [0.5501]	-6.4442 [0.0000]*
LRGDP	-0.1913 [0.4242]	-6.7433 [0.0000]*	3.4297 [0.9997]	-7.7070 [0.0000]*
LIEF	-0.9879 [0.1616]	-11.495 [0.0000]*	-1.9851 [0.0236]*	-8.6315 [0.0000]*
LIFEC	-2.2469 [0.0123]*	-8.8581 [0.0000]*	-4.4436 [0.0000]*	-9.0311 [0.0000]*

Notes: * refers to statistical significance. The value of the P-value is inside of brackets.

Source: Researchers' computations

5.1.2. Pedroni panel cointegration test technique

Since the variables are stationary at the first difference, the second step is to examine the long-run relationship between the variables for the EEA group models of this study. Therefore, the Pedroni cointegration test was conducted, and its results are reviewed in Table 3. The results reveal that four statistics are significant which, consequently, reject the null hypothesis of

[3] LLC: Levin Lin-Chu
[4] IPS: Im-Pesaran-Shin

no cointegration for both model. Therefore, the long-run relationship between LIFEC, LIREC, LIEF, LIEPOL, LITINN, LRGDP, and LIFD is confirmed. In Table [] shows the aforementioned panel and group mean within dimension statistics for the Pedroni (2004) cointegration test assuming no deterministic intercept or trend. The Schwarz information criteria select the lag length [9]. The results reveal that there is evidence of panel cointegration according to the panel Phillip and Perron (non-parametric) t-statistics and the Augmented Dickey Fuller (ADF) t-statistics at almost the 1% significance level. Similarly, the group Phillip and Perron and ADF between dimension statistics indicate strong evidence of cointegration at the 1% level.

Table 5. 2: Padroni's cointegration tests results

	Statistic	Prob.	Weighted Statistic	Prob.
Panel V-Statistic	2.167432	0.0151*	-5.863675	1.0000
Panel P-Statistic	4.948870	1.0000	7.054463	1.0000
Panel PP-Statistic	-6.904524	0.0000**	-10.81852	0.0000**
Panel ADF-Statistic	6.751905	1.0000	0.251353	0.0092*
Alternative hypothesis: individual AR coefs (between-dimension)				
Group P-Statistic	8.58030	1.0000		
Group PP-Statistic	-13.41550	0.0000**		
Group ADF-Statistic	-28.49245	0.0000**		

Lag length and bandwidth are selected by Schwarz Information Criterion (SIC) and the Bartlett kernel Newey-West estimator. ** Significance at the 1 % level * Significance at 5 % level

Source: Researchers' computations

5.1.3. Panel System ARDL Results (PMG, MG, and DFE)

In this subsection the researchers presents the main results for the EEA group sample which includes 24 countries. The results for panel system ARDL estimations are presented in Table [5.2] below for both clean energy consumption model and fossil fuel energy utilization model. An evaluation of the type and scale of the relationship for models in short-range and long-range through three models PMG, MG, and DFE (Pesaran et al., 1999) was carried out. In order to demonstrate a significant long-term relationship, an error-correction term must be significant and negative. Empirical results confirmed the short-run and long-run relationships with respect to energy consumption for both models through the (ECT) value, indicating a high speed of adjustment for the imbalance correction in the long-term equilibrium in both scenarios. In order for the researchers to observe the efficiency and consistency of all estimators, the research study employed a Hausman test (Hausman, 1978). The validation of the long-term homogeneity constraints was examined for all EEA groups of countries; therefore the efficacy of the PMG estimators on the MG and DFE estimators was examined by way of an Hausman test. The Hausman test results accepted the null hypothesis of the existence of some homogeneity restrictions on long-term regressor, indicating that PMG is more robust as compared to MG and DFE techniques.

The results in Table [5.2] below for EEA clean energy utilization index pointed that the financial developments index has a constructive and important relationship with renewable energy use. A unconstructive and significant relationship exists with respect to the environmental pollution index and renewable energy consumption, and a positive and significant relationship was there giving respect to technological innovation and renewable energy consumption. Financial freedom revealed a negative and non-significant relationship with clean energy consumption, while RGDP per person had a significantly positive connection with respect to renewable energy use. The constant term had a significantly negative impact on clean energy consumption index in a jury of selected nations.

Table 5. 3: ARDL Model Results

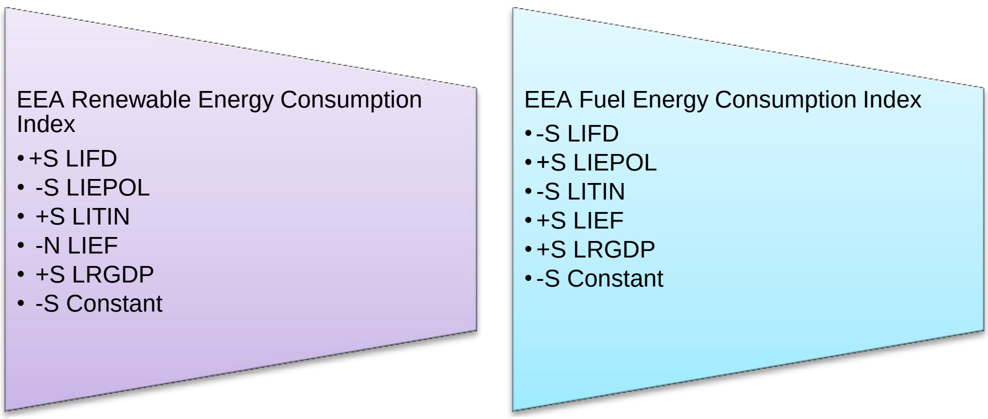
Variable	EEA Renewable energy consumption index						EEA Fuel energy consumption index					
	MG		**PMG**		**DFE**		**MG**		**PMG**		**DFE**	
	Longer -term	**Shorter -term**	**Longer -term**	**Shorter -term**	**Longer -term**	**Shorter -term**	**Longe r-term**	**Shorter -term**	**Longer -term**	**Shorter -term**	**Longer -term**	**Shorter -term**
ECT		-0.9453 [0.000]*		-0.1024 [0.000]*		-0.2044 [0.003]*		-0.9894 [0.007]*		-0.7523 [0.018]*		-0.444 [0.000]*
LFD		-0.0400 [0.864]		0.0100 [0.937]		-0.1046 [0.571]		-0.1970 [0.092]*		0.0004 [0.987]		0.0063 [0.816]
Δ LPOL		-1.7327 [0.028]*		-0.4410 [0.139]		-0.9613 [0.066]*		-0.8069 [0.550]		0.3772 [0.041]*		0.4220 [0.022]*
Δ LITIN		0.17527 [0.634]		0.0156 [0.909]		0.43518 [0.037]*		-0.214 [0.181]		-0.1019 [0.258]		-0.0022 [0.973]
Δ LRGDP		1.18496 [0.000]*		0.3317 [0.063]*		0.61136 [0.023]*		0.3642 [0.004]*		0.3825 [0.000]*		0.3030 [0.013]*
Δ LEF		0.00802 [0.979]		-0.1091 [0.181]		0.45672 [0.051]*		-0.0393 [0.391]		-0.0282 [0.059]*		0.0014 [0.966]
LFD_{t-1}	-2.8752 [0.253]		1.2800 [0.084]*		0.8793 [0.000]*		-0.254 [0.495]		-0.0856 [0.000]*		-0.2140 [0.072]*	
$LPOL_{t-1}$	-36.592 [0.304]		-6.1420 [0.004]*		-0.0204 [0.978]		0.1414 [0.887]		0.8497 [0.000]*		0.6680 [0.011]*	

LITIN $_{t-1}$	1.5576 [0.008]*	1.55923 [0.008]*	2.43449 [0.000]*	-0.409 [0.301]	-0.0267 [0.099]*	-0.004 [0.958]*
LRGDP$_{t-1}$	2.2718 [0.040]*	1.35731 [0.009]*	2.64754 [0.000]*	0.1689 [0.256]	0.0276 [0.084]*	0.1187 [0.121]
LEF$_{t-1}$	3.7896 [0.227]	-0.1124 [0.829]	0.23913 [0.088]*	0.4889 [0.352]	0.0019 [0.096]*	0.0336 [0.663]
Constant	-26.9703 [0.000]*	-4.4215 [0.001]*	-6.25271 [0.0001]*	-31.06 [0.288]	-0.9809 [0.035]*	-1.3882 [0.053]*
Hausman	2.48 [0.7801]		0.79 [0.9779]	0.09 [0.9999]		0.09 [0.9999]
Obs.	456	456	456	456	456	456

Notes: ARDL lag Structure (1, 2, 1, 1, 1). ECT: Error Correction Term. * denote the statistically significant. The value of the P-value between brackets, The value of the coefficient is out of brackets.

Source: Researchers' computations

However, the case of EEA fuel power consumption, long-range elasticity estimates pointed out that financial development has a significant and negative connection with fossil fuel energy consumption index. Furthermore, the results revealed that longer -range elasticity estimates on environmental pollution and economic freedom positively impacts on fossil fuel power utilization index. While the consequences indicate that there is an unconstructive and considerable connection between technological innovation and fuel energy use index, the long-term elasticity estimates in Table [5.2] above indicated that GDP per person has a positive and important relationship with fossil fuel power consumption index. It was also revealed that the constant term has a downbeat and non-significant connection with fossil fuel energy utilization index in the long term. Graphical results for 24 member nations of the European economic area (EEA) are shown in Figure [5.2] below:



Notes: The symbols +S reveal positive and significant, -S indicates negative and significant, +N being positive and non-significant and –N shows negative and non-significant results.

Figure 5. 2: EEA group Panel system ARDL graphical results

Source: Researchers' computations

5.1.3. Robustness Check

5.1.3.1. (CSD) Test and Panel Unit Root Test

In Table [5.3] below, the research study revealed that all variables examined in the research study had a cross-sectional bias. The lowest CD statistic for technological innovation are recorded. The second-generation panel unit roots indicated that the variables were stationary at levels, except for the consumption of clean energy and fuel power, and also technical innovations, but are stationary after taking their first difference.

Table 5. 4: Cross sectional dependency test and panel unit-roots tests.

Variables	CD	Corr	CIPS (I(0))	CIPS (I(1))
LIREC	69.011 [0.000]*	0.91	-1.886	-4.068*
LIFEC	28.998 [0.000]*	0.46	-2.025	-3.806*
LIFD	31.943 [0.000]*	0.51	-2.522*	-4.827*
LIEPOL	26.582 [0.000]*	0.55	-3.130*	-4.655*
LITIN	23.83 [0.000]*	0.51	-1.493	-3.418*
LRGDP	57.452 [0.000]*	0.78	-2.454*	-3.336*
LIEF	32.668 [0.000]*	0.56	-2.235*	-4.626*

Notes: * refer statistical significant. The value of the P-value is inside of brackets.

Source :Researchers' computations

In order to examine the first robustness check, the research study applied the Cross Sectional Autoregressive Distributed Lags approach (CS-ARDL). Given the existence of variables which are not stationary and cross sectional reliance, the Cross Sectional Autoregressive Distributed Lags technique was employed, as shown in Table [5.4] below, where in the CS-ARDL column in both models is important to the interpretation of results, as the cross sectional dependence is eliminated in the short-term and long-term. The results from CS-ARDL are in lieu with results from the PMG estimator.

As for robustness test estimates, the case for EEA's renewable energy consumption index presented in Table [5.4]. The long-run elasticity CD-ARDL's estimates appear that real gross domestic product per person had an insignificant and constructive relationship with renewable energy consumption. The development of bank sectors and other financial institutions have revealed a positive and significant relationship with clean energy consumption in both the short-run and long-run. However, environmental pollution discovered a significant and negative relationship with renewable power consumption. The results further revealed that insignificant and positive relationship holds with respect to technological innovation and clean energy consumption. Financial freedom indicated a constructive and non-significant relationship with clean energy use. The constant term has a significant and negative impact on renewable energy consumption index.

Table 5. 5: CS-ARDL Findings

	EEA renewable energy Consumption Index			**EEA renewable energy consumption Index**		
Long-run						
Variable	**CD _MG**	**CD_PMG**	**CD_ARDL**	**CD _MG**	**CD_PMG**	**CD_ARDL**
LIREC	-1.99065 [0.000]*	-1.37089 [0.000]*	-1.89979 [0.000]*	-------	-------	-------
LIFEC	-------	-------	-------	-1.9482[0.000]*	-1.9083[0.000]*	-1.8189[0.000]*
LIFD	0.06712 [0.377]	0.07310 [0.065]*	0.14253 [0.009]*	-0.0543[0.064]*	-0.0254[0.348]	-0.0908[0.000]*
LITIN	0.07135 [0.507]	-0.04837 [0.768]	0.17103 [0.063]*	-0.0646 [0.079]*	-0.0706[0.053]*	-0.0728[0.000]*
LIEPOL	-1.14498 [0.000]*	-0.47168 [0.509]	-1.07281 [0.002]*	0.4962 [0.005]*	0.3712[0.000]*	0.2039[0.000]*
LIEF	-0.03728 [0.796]	0.07885 [0.629]	0.10903 [0.339]	-1.9482[0.000]*	0.0021[0.931]	-0.0170[0.000]*
LRGDP	0.27564 [0.085]*	-0.10868 [0.681]	0.00425 [0.983]	-0.0416[0.579]	-0.0253[0.711]	0.0269[0.000]*
Short-run						
ECT	-0.99065 [0.000]*	-0.37089 [0.006]*	-0.89979 [0.000]*	-0.9482[0.000]*	-0.9083 [0.000]*	-0.8189[0.000]*
LIFD	0.10301 [0.490]	0.10021 [0.012]*	0.24977 [0.013]*	-0.1283[0.081]*	-0.0668 [0.312]	-0.1567[0.280]

LITIN	0.13748 [0.521]	0.06631 [0.686]	-0.29791 [0.188]	-0.2063[0.093]*	-0.2110[0.067]*	-0.1256[0.428]
LIEPOL	-2.30102 [0.000]*	-0.64662 [0.365]	-1.95587 [0.001]*	1.5604[0.113]	0.8185[0.003]*	0.3518[0.042]*
LIEF	-0.00542 [0.983]	0.10810 [0.508]	0.29454 [0.113]	0.0082[0.904]	0.0313[0.567]	-0.0294[0.541]
LRGDP	0.57714 [0.098]*	0.14900 [0.573]	-0.01245 [0.973]	-0.1316[0.429]	-0.0668[0.312]	0.0464[0.837]
Con_	-2.41768 [0.319]	-3.45512 [0.178]	-0.93585 [0.000]*	3.7145[0.360]	1.6122[0.000]*	-0.8189[0.000]*

Note: * denote the statistically significant. ECT: Error Correction Term, The value of the P-value between brackets, The value of the coefficient is out of brackets.

Source: Researchers' computations

The results for robustness estimates test in respect of EEA fossil fuel energy consumption index in Table [5.4] revealed a negative and significant relationship with financial development, technological innovation, economic freedom and a significantly positive relationship with environmental pollution. The results in the case of real gross domestic product per capita on the other hand exposed a significantly constructive relationship with fuel power consumption index. Further to that, the constant term exposed a significantly positive relationship with respect to fossil fuel energy consumption index. Graphical robustness test results for 24 member countries of the European Economic Area (EEA) are shown in Figure [5.3] below:

EEA Renewable Energy Consumption Index
- +S LIFD
- -S LIEPOL
- +S LITIN
- +N LIEF
- -N LRGDP
- -S Constant

EEA Fossil Fuel Energy Consumption Index
- -S LIFD
- +S LIEPOL
- -S LITIN
- -S LIEF
- +S LRGDP
- -S Constant

Notes: The symbols **+S** reveal positive and significant, **-S** indicates negative and significant, **+N** being positive and non-significant and **–N** shows negative and non-significant results.

Figure 5. 3: EEA group CD-ARDL graphical results

Source: Researchers' computations

5.1.3.2. Dumitrescu-Hurlin Granger Causality Test

The second robustness check involved the application of the Dumitrescu-Hurlin non-causality test, which gives robust and unbiased results for both heterogeneous and deranged panel data. Table [5.5] confirms that the gatherings s from the causality tests are reliable with the results of the estimated panel PMG. The null hypothesis of the Dumitrescu and Hurlin non-causality test indicates that every specific variable (LIPOL, LIFD, LIINN, LIEF, LRGDP) does not Granger cause the consumption of renewable energy or each of them does not Granger cause the consumption of fossil fuel power.

Table [5.5] presents causality test results for renewable energy consumption index for EEA economics, which revealed unidirectional causality operating from financial developments to renewable power consumption index. There was a unidirectional causality extending from environmental pollution to renewable energy consumption index. In addition, causality test results found unidirectional causation driven from financial freedom to clean energy utilization index. While there was a bidirectional causation that extends from technological improvement and real gross domestic product per person to clean energy consumption index. This confirms that the research study's estimates are also strong in terms of internal bias. Further, there is a unidirectional causation that extends from financial development to technological innovation, economic freedom to financial developments, environmental pollution to technological innovation, environmental pollution to financial freedom, and environmental pollution to financial development. Other than that, the causality test results reveal that the bidirectional causality among financial developments and real gross domestic product per person, economic freedom and technological innovation, real gross domestic product per person and environmental pollution, economic freedom and real gross domestic product per person , real gross domestic product per capita and technological innovation.

Table 5. 6: Dumitrescu & Hurlin panel causality results

EEA Renewable Energy Consumption Index				**EEA Fuel Energy Consumption Index**			
Null Hypothesis:	**W-Stat.**	**Zbar-Stat**	**Conclusion**	**Null Hypothesis:**	**W-Stat.**	**Zbar-Stat.**	**Conclusion**
LFD does not similarly y cause LRE	1.5381	1.1153 [0.0264]*	Unidirectional	LFD does not similarly cause LFE	1.7683	1.7495 [0.0802]*	Unidirectional
LRE does not similarly cause LFD	6.8762	1.2676 [0.2049]		LFE does not similarly cause LFD	4.2067	0.6750 [0.4997]	
LINN does not similarly cause LRE	2.2759	3.1484 [0.0016]*	Bidirectional	LINN does not similarly cause LFE	1.2810	0.4070 [0.6840]	No causality
LRE does not similarly cause LINN	3.8687	7.5363 [0.0000]*		LFE does not similarly cause LINN	1.1079	-0.0701 [0.9441]	
LPOL does not similarly cause LRE	3.3019	6.9748 [0.0000]*	Unidirectional	LPOL does not similarly cause LFE	11.5876	1.0694 [0.2849]	Unidirectional
LRE does not similarly cause LPOL	0.7323	-1.1048 [0.2692]		LFE does not similarly cause LPOL	3.4171	1.9230 [0.0545]*	
LEF does not similarly cause LRE	2.1016	2.6677 [0.0076]*	Unidirectional	LEF does not similarly cause LFE	20.2628	3.9204 [0.0001]*	Unidirectional
LRE does not similarly cause LEF	6.6118	1.0503 [0.2936]		LFE does not similarly cause LEF	0.8088	-0.8940 [0.3713]	
LRGDP does not similarly cause LRE	3.2121	1.5593 [0.0118]*	Bidirectional	LRGDP does not similarly cause LFE	1.9198	2.1669 [0.0302]*	Unidirectional
LRE does not similarly cause LRGDP	3.0066	6.1610 [0.0000]*		LFE does not similarly cause LRGDP	9.5112	3.4325 [0.0006]	

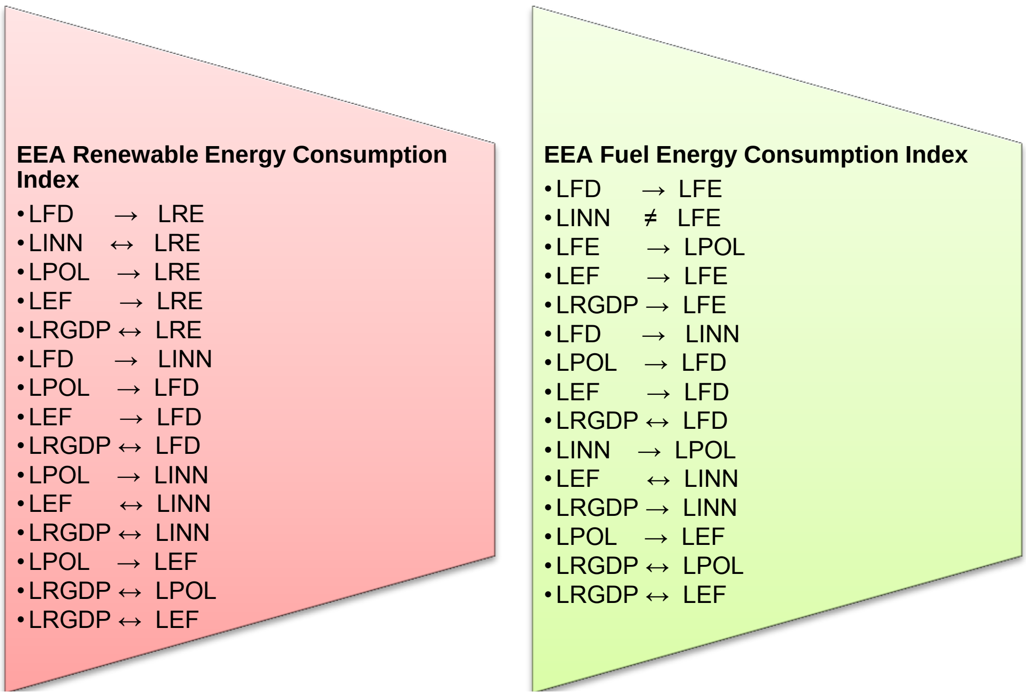
LINN does not similarly cause LFD	3.1820	1.5059 [0.13211]	Unidirectional	LINN does not similarly cause LFD	3.1820	1.5059 [0.1321]	Unidirectional
LFD does not similarly cause LINN	8.9444	21.5206 [0.0000]*		LFD does not similarly cause LINN	8.9444	21.5206 [0.0000]*	
LPOL does not similarly cause LFD	8.5992	0.0874 [0.0304]*	Unidirectional	LPOL does not similarly cause LFD	8.5992	0.0874 [0.0304]*	Unidirectional
LFD does not similarly cause LPOL	1.2345	0.2787 [0.7805]		LFD does not similarly cause LPOL	1.2345	0.2787 [0.7805]	
LEF does not similarly cause LFD	3.5304	2.1241 [0.0337]*	Unidirectional	LEF does not similarly cause LFD	3.5304	2.1241 [0.0337]*	Unidirectional
LFD does not similarly cause LEF	1.3346	0.5545 [0.5792]		LFD does not similarly cause LEF	1.3346	0.5545 [0.5792]	
LRGDP does not similarly cause LFD	2.2997	3.2134 [0.0013]*	Bidirectional	LRGDP does not similarly cause LFD	2.2997	3.2134 [0.0013]*	Bidirectional
LFD does not similarly cause LRGDP	4.6454	9.6763 [0.0000]*		LFD does not similarly cause LRGDP	4.6454	9.6763 [0.0000]*	
LPOL does not similarly cause LINN	6.0814	1.7681 [0.0770]*	Unidirectional	LPOL does not similarly cause LINN	1.5721	1.2090 [0.2267]	Unidirectional
LINN does not similarly cause LPOL	1.5721	1.2090 [0.2267]		LINN does not similarly cause LPOL	6.0814	1.7681 [0.0770]*	
LEF does not similarly cause LINN	2.2420	3.0545 [0.0023]*	Bidirectional	LEF does not similarly cause LINN	2.2420	3.0545 [0.0023]*	Bidirectional
LINN does not similarly cause LEF	2.1004	2.6643 [0.0077]*		LINN does not similarly cause LEF	2.1004	2.6643 [0.0077]*	
LRGDP does not similarly cause LINN	1.9788	2.3295 [0.0198]*	Bidirectional	LRGDP does not similarly cause LINN	1.9788	2.3295 [0.0198]*	Unidirectional

LINN does not similarly cause LRGDP	7.1340	4.3334 [0.0000]*		LINN does not similarly cause LRGDP	7.1340	4.3334 [0.0000]	
LEF does not similarly cause LPOL	1.6648	1.4644 [0.1431]	Unidirectional	LEF does not similarly cause LPOL	1.6648	1.4644 [0.1431]	Unidirectional
LPOL does not similarly cause LEF	1.9094	2.1381 [0.0325]*		LPOL does not similarly cause LEF	1.9094	2.1381 [0.0325]*	
LRGDP does not similarly cause LPOL	2.4922	3.7438 [0.0002]*	Bidirectional	LRGDP does not similarly cause LPOL	2.4922	3.7438 [0.0002]*	Bidirectional
LPOL does not similarly cause LRGDP	2.5155	3.8080 [0.0001]*		LPOL does not similarly cause LRGDP	2.5155	3.8080 [0.0001]*	
LRGDP does not similarly cause LEF	3.3550	6.1209 [0.0000]*	Bidirectional	LRGDP does not similarly cause LEF	3.3550	6.1209 [0.0000]*	Bidirectional
LEF does not similarly cause LRGDP	2.7381	4.4213 [0.0000]*		LEF does not similarly cause LRGDP	2.7381	4.4213 [0.0000]*	

Notes: * refer statistical significant. The value of the P-value between brackets.

Source: Researchers' computations

On the contrary, causality test results confirms that the research study's estimates are also strong in terms of internal bias for the case of fossil fuel energy utilization index in European Economic Area (EEA) economies in Table [5.5] above, which revealed the subsistence of unidirectional causality from financial developments, financial freedom, and realgross domestic product per person with fuel energy expenditure index, while the causal relationship extends from fossil fuel energy consumption to environmental pollution. Although the results indicated that a bidirectional causality relationship was existing with respect to real gross domestic product per person and financial development, economic freedom and technological innovation, real GDP per capita with environmental pollution, and real GDP per capita with economic freedom, the results confirm that there is no causal connection between fossil fuel power consumption and technological innovation. The graphical Dumitrescu & Hurlin causality test results for 24 member countries of the European economic area (EEA) are shown in Figure [5.4] below:



Notes: The symbols → reveal unidirectional causality, ↔ indicates bidirectional causality, ≠ being no causality results.

Figure 5. 4: Dumitrescu & Hurlin causality graphical results

Source: Researchers' computations

5. 2. Asean+3 group Results

5.2.1. Integration Order

In this subsection the researchers presents the results for the Association of Southeast Asian Nations Plus Three Group (Asean +3) sample comprising of nine nations from around the world. The results for unit root test (LLC) and (IPS) estimations are obtainable in Table [5.6] below for all variables. The results gave some different order of implementation under the LLC and IPS approach.

Table 5. 7: IPS and LLC unit root results

Parameter	IPS		LLC	
	Level	1st difference	Level	1st difference
LIREC	7.1314 [0.9901]	-2.8706 [0.0020]*	6.9366 [0.9820]	-3.4882 [0.0002]*
LIFD	-0.9019 [0.1836]	-6.2951 [0.0000]*	-3.1310 [0.0009]*	-3.6718 [0.0001]*
LIEPOL	-1.6281 [0.0518]*	-6.2602 [0.0000]*	1.9272 [0.9730]	-4.9465 [0.0000]*
LITIN	3.0462 [0.9988]	-6.6915 [0.0000]*	-0.0821 [0.4673]	-6.6270 [0.0000]*
LRGDP	2.9590 [0.9985]	-4.2582 [0.0000]*	-1.5775 [0.0573]*	-2.5066 [0.0061]*
LIEF	0.8071 [0.7902]	-7.6307 [0.0000]*	0.8699 [0.8078]	-7.7822 [0.0000]*
LIFEC	0.4860 [0.6865]	-4.7486 [0.0000]*	-0.7118 [0.2383]	-6.8248 [0.0000]*

Notes: * refers to statistical significance

Source: Researchers' computations

5.2.2. Pedroni panel cointegration test technique

Since the variables are stationary at the first difference, the second step is to examine the long-run relationship between the variables for the ASEAN+3 group models of this study. Therefore, the Pedroni cointegration test was conducted, and its results are reviewed in Table [5.8]. The results reveal that four statistics are significant which, consequently, reject the null hypothesis of no cointegration for both model. Therefore, the long-run relationship between

LIFEC, LIREC, LIEF, LIEPOL, LITINN, LRGDP, and LIFD is confirmed. In Table [5.8] shows the aforementioned panel and group mean within dimension statistics for the Pedroni (2004) cointegration test assuming no deterministic intercept or trend. The Schwarz information criteria select the lag length [9]. The results reveal that there is evidence of panel cointegration according to the panel Phillip and Perron (non-parametric) t-statistics and the Augmented Dickey Fuller (ADF) t-statistics at almost the 1% significance level. Similarly, the group Phillip and Perron and ADF between dimension statistics indicate strong evidence of cointegration at the 1% level.

Table 5. 8: Padroni's cointegration tests results

	Statistic	Prob.	Weighted Statistic	Prob.
Panel V-Statistic	-2.927914	0.9999	-4.214873	1.0000
Panel P-Statistic	3.719817	0.9999	4.161489	1.0000
Panel PP-Statistic	-5.099185	0.0000**	-7.551033	0.0000**
Panel ADF-Statistic	1.084780	0.8610	-1.468152	0.0710*
Alternative hypothesis: individual AR coefs (between-dimension)				
Group P-Statistic	5.338872	1.0000		
Group PP-Statistic	-8.362131	0.0000**		
Group ADF-Statistic	-65.60423	0.0000**		
Lag length and bandwidth are selected by Hannan-Quinn Criterion (HQC) and the Parzen – West estimator. ** Significance at the 1 % level * Significance at 10 % level				

Source: Researchers' computations

5.2.3. Panel System ARDL Results (PMG, MG, and DFE)

In this subsection results are presented for Asian+3 group of countries, Asian renewable power utilization and Asian fuel power utilization for nine Asian countries and these results are depicted in Table [5.7] below. The results in Table [5.7] below with respect to Asian renewable energy consumption indicated that real gross domestic product per capita has a constructive and significant relationship with renewable power consumption for both PMG and DFE in models. Financial developments are also optimistically and significantly linked to Asian renewable energy use index, while environmental pollution was significant and negatively related with it in the case of a PMG model. These results further pointed that technological innovation is optimistically and significantly related with clean energy consumption index. In respect of Asian economic freedom level, the relationship was positive and significant with Asian renewable energy utilization index. Moreover, the constant term has a negative and significant relationship with Asean renewable power consumption.

Table 5. 9: Model Results

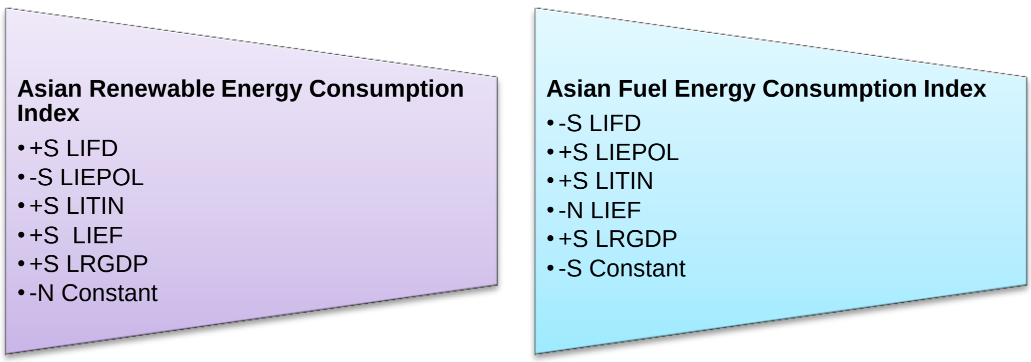
Variable	**Asian Renewable Energy Consumption Index**						**Asian Fuel Energy Consumption Index**					
	MG		**PMG**		**DFE**		**MG**		**PMG**		**DFE**	
	Long-term	Short-term	Longer-term	Short-term	Longer-term	Shorter-term	Longer -term	Shorter-term	Longer-term	Shorter-term	Longer-term	Shorter-term
ECT		-0.488 [0.017]*		-0.164 [0.035]*		-0.110 [0.000]*		-0.696 [0.014]*		-0.437 [0.005]*		-0.246 [0.000]*
Δ LRE		0.943 [0.000]*		0.8424 [0.000]*		0.7945 [0.000]*		-------		-------		-------
Δ LFD		-0.1829 [0.247]		-0.110 [0.341]		-0.0489 [0.011]*		-0.181 [0.267]		-0.1969 [0.151]		-0.035 [0.353]
Δ LPOL		0.0464 [0.933]		0.7768 [0.060]*		-0.076 [0.297]		-0.258 [0.856]		0.1500 [0.859]		-0.142 [0.176
Δ LINN		-0.078 [0.702]		-0.0843 [0.514]		-0.083 [0.407]		0.011 [0.970]		-0.2619 [0.265]		0.0092 [0.960]
Δ LRGDP		0.2686 [0.240]				-0.050 [0.747]		0.609 [0.182]		0.5859 [0.175]		0.3728 [0.093]*
Δ LEF		-0.173 [0.052]*				0.002 [0.959]		0.013 [0.948]		0.0434 [0.798]		0.0695 [0.365]
LFD	-0.879 [0.508]		0.1362 [0.005]*		0.4551 [0.015]*		-0.510 [0.157]		-0.325 [0.000]*		-0.203 [0.125]	
LPOL	-4.925 [0.413]		-2.074 [0.000]*		-0.899 [0.193]		-3.112 [0.632]		1.9104 [0.000]*		1.5368 [0.001]*	

LINN	0.870 [0.847]	0.556 [0.004]*	0.4469 [0.268]	1.218 [0.245]	-0.3661 [0.001]*	-0.455 [0.046]*
LRGDP	1.606 0.614]	0.8676 [0.000]*	0.5430 [0.070]*	-0.375 [0.659]	0.4756 [0.000]*	0.344 [0.089]*
LEF	2.436 [0.020]*	0.2431 [0.000]*	0.316 [0.283]	1.091 [0.331]	-0.080 [0.253]	-0.0988 [0.613]
Constant	-11.772 [0.066]*	-3.992 [0.032]*	-1.5954 [0.004]*	-7.890 [0.369]	-1.518 [0.005]*	-0.968 [0.290]
Hausman	6.34 [0.2747]		0.03 [0.999]	6.32 [0.2760]		0.01 [0.999]
Obs.	171	171	171	171	171	171

Notes: ARDL lag Structure (1, 2, 1, 1, 1). ECT: Error Correction Term., *, Denote statistical significance. The value of the coefficient is out of brackets.

Source: Researchers' computations

The results with respect to financial development have pointed to a downbeat and significant association with fossil fuel energy use in the Asean countries. In addition, Table [5.7] have exposed that real GDP had a positive and significant connection with fossil fuel power consumption in the Asean economies. Table [5.7] it was also revealed that Asean economic freedom level had a non-significant and negative affiliation with fossil fuel power utilization. However, technological innovation in these countries had a positive and important relationship with fossil fuel energy expenditure. Furthermore, results pointed that environmental pollution had a significantly positive connection with fossil fuel energy utilization in the Asean economies and a constant term revealed a negative and significant relationship. The graphical results for the nine Asian+3 countries are provided in figure [5.5] below:



Notes: The symbols **+S** reveal positive and significant, **-S** indicates negative and significant, **+N** being positive and non-significant and **–N** shows negative and non-

Figure 5. 5: Panel system ARDL graphical results for Asean+3

Source: Researchers' computations

5.2.3.1. Cross Sectional Dependency (CSD) test and panel unit root test

In Table [5.8] below, the research study revealed that all variables examined in the Asean group study had some cross-sectional bias. The lowest CD stats for environmental pollution are recorded. The second-generation panel unit roots indicated that the variables were stationary at levels, except for the consumption of clean energy and fossil fuel power, and also technical innovations, however they became stationary after taking their first difference.

Table 5. 10: Cross sectional dependency tests and panel unit-roots test.

Variables	CD	Corr.	CIPS (I(0))	CIPS (I(1))
LIREC	24.00 [0.000]*	0.873	-1.738	-3.560*
LIFEC	10.16 [0.000]*	0.805	-2.042	-4.398*
LIFD	8.64 [0.000]*	0.314	-2.188	-3.514*
LIEPOL	4.68 [0.000]*	0.170	-2.725*	-4.159*
LITIN	21.93 [0.000]*	0.798	-1.638	-3.720*
LRGDP	26.80 [0.000]*	0.975	-2.445*	-3.306
LIEF	22.13 [0.000]*	0.805	-2.548*	-3.995*

Notes: * refer statistical significant. The value of the P-value is inside of brackets.

Source: Researchers' computations

In order to examine the first robustness test for ASEAN countries, a CD-ARDL approach was applied. Given the availability of non-stationary variables and cross sectional dependence, the CS-ARDL technique was employed, as shown in Table [5.8] below. The CS-ARDL column in both models is important to interpreting the results, as the cross sectional dependence was eliminated in the immediate and long-standing. The results from CS-ARDL are in lieu with the results of the PMG estimator.

In the robustness test estimates, the case for the Asean group renewable energy consumption index was presented in Table [5.9] below. Long-run elasticity CD-ARDL's estimates indicated that real GDP per capita had a important and optimistic relationship with renewable power consumption. The development of the financial sector revealed a constructive and considerable relationship with clean energy consumption in the long run. However, environmental pollution revealed an insignificant negative relationship with respect to clean energy utilization. The results further revealed that a significant and positive relationship holds with respect to technological innovation and clean energy consumption. Financial freedom indicated a positive and significant relationship with clean energy consumption. The stable term had an insignificant negative impact on the renewable energy consumption index.

Table 5. 11: CS-ARDL findings

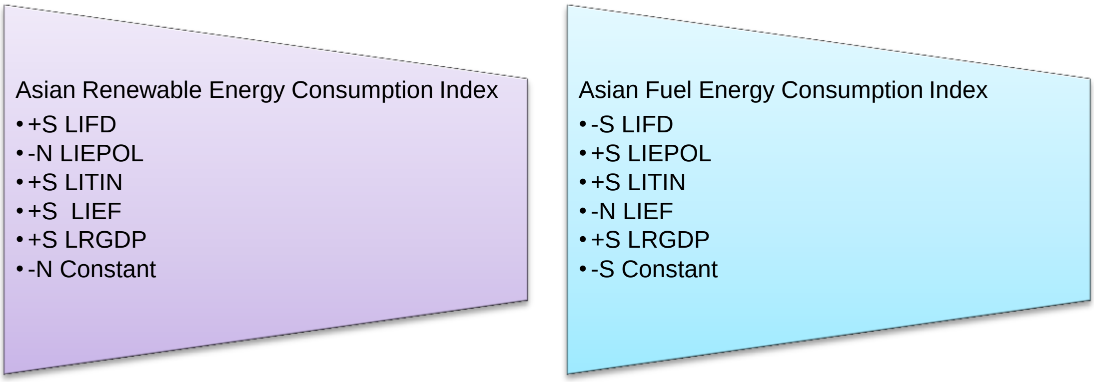
	Asian Renewable Energy Consumption Index			Asian Fuel Energy Consumption Index		
Long-run						
Variable	**CD _MG**	**CD_PMG**	**CD_ARDL**	**CD _MG**	**CD_PMG**	**CD_ARDL**
LIREC	-1.527 [0.000]*	-1.709 [0.000]*	-1.181 [0.000]*	-------	-------	-------
LIFEC	-------	-------	-------	-2.159 [0.000]*	-2.453 [0.000]*	-3.254 [0.000]*
LIFD	-0.061 [0.388]	0.1067 [0.219]	0.013 [0.000]*	-0.022 [0.832]	-0.015 [0.706]	-0.008 [0.000]*
LITIN	0.363 [0.088]*	0.122 [0.612]	0.404 [0.000]*	-0.128 [0.519]	-0.033 [0.700]	-0.051 [0.000]*
LIEPOL	0.421 [0.407]	-0.610 [0.012]*	-0.268 [0.668]	1.487 [0.085]*	0.724 [0.033]*	0.001 [0.000]*
LIEF	-0.103 [0.276]	-0.156 [0.138]	0.019 [0.000]*	-2.159 [0.000]*	0.031 [0.512]	-0.088 [0.000]*
LRGDP	-0.133 [0.743]	0.093 [0.577]	0.235 [0.000]*	0.675[0.368]	0.332 [0.021]*	0.014 [0.000]*
Short-run						
ECT	-0.527 [0.000]*	-0.709 [0.000]*	-0.181[0.011]*	-1.159 [0.000]*	-1.453 [0.000]*	-2.254 [0.000]*
LIFD	-0.064 [0.424]	0.179 [0.230]	0.015 [0.171]	0.017 [0.935]	-0.052 [0.630]	-0.002 [0.988]
LITIN	0.499 [0.077]*	0.201 [0.637]	0.459 [0.024]*	-0.533 [0.323]	-0.072 [0.729]	-0.166 [0.831]
LIEPOL	0.385 [0.572]	-1.030 [0.015]*	0.051 [0.948]	3.175 [0.065]*	1.771 [0.035]*	0.005 [0.999]

LIEF	-0.125 [0.332]	-0.288 [0.127]	0.021 [0.853]	1.6157 [0.097]*	0.086 [0.476]	-0.283 [0.435]
LRGDP	-0.045 [0.923]	0.181 [0.547]	0.267 [0.661]	2.1611 [0.160]	0.786[0.019]*	-0.046 [0.938]
Con_	4.537 [0.475]	-2.869 [0.000]*	-1.80 [0.701]	-16.39 [0.040]*	-3.440 [0.000]*	-3.053 [0.611]

Note: * denote the statistically significant. The value of the P-value between brackets.

Source: Researchers' computations

The results for robustness estimates test with respect to Asean economies fossil fuel energy consumption index in Table [5.9] shows a negative and significant relationship with financial development, technological innovation, economic freedom, a significantly positive relationship with environmental pollution. The results with respect of real GDP per capita however exposed a significantly positive relationship with the fossil fuel energy consumption index. Further, a constant term exposed a significantly negative relationship with fuel energy consumption index. The graphical robustness test results for nine member countries of the Asean plus three group (Asean+3) are shown in Figure [5.6] below:



Notes: The symbols **+S** reveal positive and significant, **-S** indicates negative and significant, **+N** being positive and non-significant and **–N** shows negative and non-

Figure 5. 6: Panel system ARDL graphical results for Asean+3

Source: Researchers' computations

5.2.3.2. Dumitrescu-Hurlin Granger Causality Test

Table [5.10] presents the causality test results for renewable energy consumption index for Asean+3 economics. The unidirectional causality results were running from: financial developments index; environmental pollution; and economic freedom to renewable energy index. Further, a unidirectional causality extended from financial development to technological improvement; environmental pollution to financial development; environmental pollution to technological innovation; environmental pollution to economic freedom; and real GDP per capita and environmental pollution. However, a bidirectional causality results were relevant between:

technological innovation and real GDP per capita with clean energy consumption, also a bidirectional causality was discovered between economic freedom and financial development; real GDP per capita and financial development; real gross domestic product per person and financial development; economic freedom and technological innovation; real GDP per capita and technological innovation; and real gross domestic product per person and economic freed

Table 5. 12: Dumitrescu & Hurlin panel causality results

<u>AseanRenewable Energy Consumption Index</u>				<u>AseanFuel Energy Consumption Index</u>			
Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.	Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
LFD does not homogeneously cause LRE	3.5403	1.3115 [0.0189]*	Unidirectional	LFD does not homogeneously cause LFE	2.3191	2.0005 [0.0454]*	Unidirectional
LRE does not homogeneously cause LFD	0.5213	-1.0327 [0.3018]		LFE does not homogeneously cause LFD	1.2390	0.1782 0.8586]	
LINN does not homogeneously cause LRE	3.0091	3.1648 [0.0016]*	Bidirectional	LINN does not homogeneously cause LFE	0.4614	-1.1336 [0.2570]	Unidirectional
LRE does not homogeneously cause LINN	4.3801	6.4779 [0.000]*		LFE does not homogeneously cause LINN	3.3009	3.6571 [0.0003]*	
LPOL does not homogeneously cause LRE	3.3779	-3.7870 [0.0002]*	Unidirectional	LPOL does not homogeneously cause LFE	7.6232	1.1521 [0.2493]	Unidirectional
LRE does not homogeneously cause LPO	0.6929	-0.7431 [0.4574]		LFE does not homogeneously cause LPO	3.6696	4.2791 [0.0000]*	
LEF does not homogeneously cause LRE	4.6342	6.9065 [0.0000]*	Unidirectional	LEF does not homogeneously cause LFE	2.9097	2.9971 [0.0027]*	Unidirectional
LRE does not homogeneously cause LEF	0.6797	-0.7653 [0.4441]		LFE does not homogeneously cause LEF	0.9034	-0.3880 [0.6980]	
LRGDP does not homogeneously cause L	4.9585	6.4537 [0.0000]*	Bidirectional	LRGDP does not homogeneously cause L	2.2037	1.8059 [0.0709]*	Bidirectional

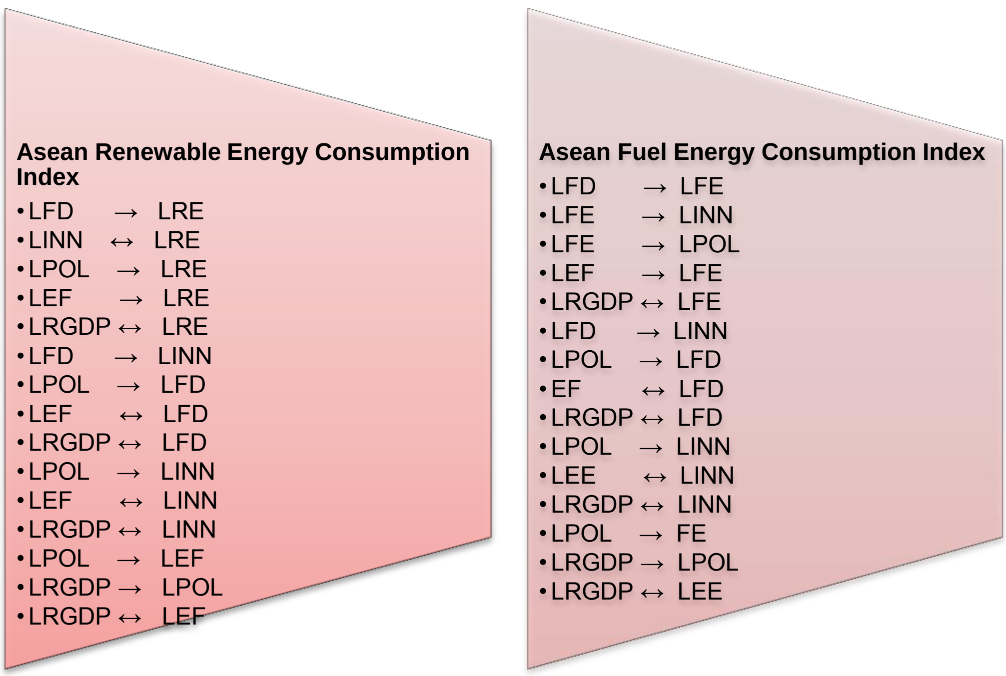
LRE does not homogeneously cause LRG	3.4505	3.9096 [0.0001]*		LFE does not homogeneously cause LRG	0.0405	-1.8437 [0.0652]*	
LINN does not homogeneously cause LFD	1.1692	0.0605 [0.9518]	Unidirectional	LINN does not homogeneously cause LFD	1.1692	0.0605 [0.9518]	Unidirectional
LFD does not homogeneously cause LINN	2.3081	1.9820 [0.0475]*		LFD does not homogeneously cause LINN	2.3081	1.9820 [0.0475]*	
LPOL does not homogeneously cause LFI	1.3147	0.3061 [0.0759]*	Unidirectional	LPOL does not homogeneously cause LFI	1.3147	0.3061 [0.0759]*	Unidirectional
LFD does not homogeneously cause LPO	4.8075	0.8731 [0.3826]]		LFD does not homogeneously cause LPO	4.8075	0.8731 [0.3826]]	
LEF does not homogeneously cause LFD	9.5210	2.1069 [0.0351]*	Bidirectional	EF does not homogeneously cause LFD	9.5210	2.1069 [0.0351]*	Bidirectional
LFD does not homogeneously cause LEF	2.3191	2.0005 [0.0154]*		LFD does not homogeneously cause EF	2.3191	2.0005 [0.0154]*	
LRGDP does not homogeneously cause L	2.1761	1.7594 [0.0785]*	Bidirectional	LRGDP does not homogeneously cause L	2.1761	1.7594 [0.0785]*	Bidirectional
LFD does not homogeneously cause LRG	9.6558	2.1747 [0.0297]*		LFD does not homogeneously cause LRG	9.6558	2.1747 [0.0297]*	
LPOL does not homogeneously cause LIN	6.7589	2.3666 [0.0180]*	Unidirectional	LPOL does not homogeneously cause LIN	6.7589	2.3666 [0.0180]*	Unidirectional
LINN does not homogeneously cause LPC	1.6808	0.9237 [0.3556]		LINN does not homogeneously cause LPC	1.6808	0.9237 [0.3556]	
LEF does not homogeneously cause LINN	6.5926	0.6335 [0.0264]*	Bidirectional	LEE does not homogeneously cause LINN	6.5926	0.6335 [0.0264]*	Bidirectional

LINN does not homogeneously cause LEF	3.3009	3.6571 [0.0003]*		LINN does not homogeneously cause LEE	3.3009	3.6571 [0.0003]*	
LRGDP does not homogeneously cause L	4.5149	2.3705 [0.0178]*	Bidirectional	LRGDP does not homogeneously cause LINN	4.5149	2.3705 [0.0178]*	Bidirectional
LINN does not homogeneously cause LRC	4.3856	6.4872 [0.000]*		LINN does not homogeneously cause LRGDP	4.3856	6.4872 [0.000]*	
LEF does not homogeneously cause LPOI	0.6063	-0.8893 [0.3739]	Unidirectional	FE does not homogeneously cause LPOL	0.6063	-0.8893 [0.3739]	Unidirectional
LPOL does not homogeneously cause LEI	2.7719	0.4766 [0.0337]*		LPOL does not homogeneously cause FE	2.7719	0.4766 [0.0337]*	
LRGDP does not homogeneously cause LPOL	1.1232	-0.0171 [0.0864]*	Unidirectional	LRGDP does not homogeneously cause LPOL	1.1232	-0.0171 [0.0864]	Unidirectional
LPOL does not homogeneously cause LRGDP	0.7239	-0.6908 [0.4897]		LPOL does not homogeneously cause LRGDP	0.7239	-0.6908 [0.4897]	
LRGDP does not homogeneously cause L	3.1226	3.3562 [0.0008]*	Bidirectional	LRGDP does not homogeneously cause L	3.1226	3.3562 [0.0008]*	Bidirectional
LEF does not homogeneously cause LRG	7.3024	10.4084 [0.0000]*		LEE does not homogeneously cause LRG	7.3024	10.4084 [0.0000]*	

Note: * denote the statistically significant. The value of the P-value between brackets.

Source: Researchers’ computations

Table [5.10] represents both unidirectional and bidirectional causality test results for nine Asian economies for fossil fuel energy consumption index. These results confirm a unidirectional causality between: financial developments and the utilization of fossil fuel energy; fossil fuel energy utilization causes technological innovation; fossil fuel energy consumption causes environmental pollution; and financial freedom causes consumption of fossil fuel energy. In addition to the bidirectional causality between Asean fossil fuel power consumption index and real gross domestic product per person ; economic freedom and financial development; real gross domestic product per person and financial development; economic freedom and technological innovation; real gross domestic product per person and technological innovation; real gross domestic product per person and economic freedom. The graphical Dumitrescu and Hurlin causality test results for nine member countries of the Asean+3 are shown in Figure [5.7]



below:

Figure 5. 7: Dumitrescu& Hurlin causality graphical results for Asean economics

Source: Researchers' computations

5.3. Chapter Summary

In this chapter the researchers presented panel ARDL results, CD-ARDL and causality test estimates for EEA and Asean+3 groups. The next chapter will delve into the discussion of the results in this chapter.

CHAPTER 6

DISCUSION

Introduction

In this chapter the researchers discuss the results presented in Chapter 5 and this will set the stage for both theoretical and strategy implications rising from this study, later to be presented in the conclusion and policy recommendation chapter. To be specific this chapter will address the how, why, and what questions arising from this research study.

6.1. European Economic Area Group [EEA]

The findings on the left side of Table [5.2] indicates that clean energy utilization is increased by financial developments in the long term as testified by the existence of growth of utilization of renewable power is gross domestic product per person and technological innovation growth. The findings from this research also attest that renewable energy consumption was responsible for the improvement of environmental quality in the EEA group of economies, hence responsible for less damage on the environment. The research findings suggested that financial development promotes environmental and economic sustainability due to its ability to increase industrial activities that rely on renewable energy and thus reduce environmental pollutants. Moreover, economic freedom indicated unclear findings.

The research findings in Table [5.2] on financial development in both models pointed that financial activity in EEA countries are not as dirty as they are thought of but are rather environmentally, economically, and sociality sustainable enough although more needs to be done. The reason for such findings in EEA countries in respect of renewable energy consumption index is traceable to maintaining economic sustainability; where renewable energy is based on facts that it is secure and unlimited. Further, based on the economic perspective, these countries have initiated to direct their financial instruments to be more productive, this could be through offering creative financial ideas to support the field of renewable energy, such as green-growth funds (GGF), providing various support plans and initiatives to accelerate renewable energy investments, as the European investment bank and the European strategic investment fund (EFSI) to help economic energy projects by giving companies with loans and other economic instruments to generate renewable energy and new economic activities that rely on it. High dependence on renewable sources of energy also provides a stronger cushion against fossil fuel energy market related crises. Social sustainability is another impact of financial developments to enhance the consumption of renewable energy consumption by creating new employment opportunities in the economy as a result of technological development and the emergence of new economic activities dependent on renewable energy. Thus, the level of luxury in society permits an increase in the demand for renewable energy, especially since this type of energy is less expensive than others because it is a natural resource available. Environmental sustainability is also another impact of financial development that leads to increased renewable energy consumption. Several centuries ago, environmental pollution caused by the use of fossil fuel energy led to the search for natural energy resources with fewer environmental impacts, where the role of financial development came to finance clean and safe energy projects. In the case of remnant fuel energy utilization model, it was affirmed that financial development supports sustainable energy by refusing to promote fossil fuel energy activities in economies and this was evident in the results for fossil fuel energy consumption model.

In order to examine the first robustness, this study applied the cross-sectional autoregressive distributed lags approach (CS-ARDL). As shown in Table [5.4], the last column is important for interpreting the results, as the cross-sectional dependence is eliminated in the shorter-term and longer-term. The results from CS-ARDL are in line with results of the PMG estimator in the case of financial development in both models where it was clear that financial development supports the renewable energy versus fuel energy. While the Dumitrescu-Hurlin Granger causality was the second robustness test, in Table [5.5], it was clear that the outcome show that financial developments has a unidirectional causal connection spanning from financial developments to renewable power utilization as well as to fossil fuel power consumption; an indication of the important role of financial development in economic growth.

Technological innovation also played a significant role in increasing the consumption of clean energy. Findings in Table [5.2] on the right side indicate that technological innovation was not supported in EEA countries in the case of the fossil fuel energy consumption index. Therefore, through that, EEA technological improvement on the one hand allows the exchange of natural capital with completed and accumulated capital and the reduction of protection on natural capital by raising the economic effectiveness of technical methods and products that create competitive market demand in the field of energy. The idea of cleaner creation in EEA countries is considered as the permanent function of an incorporated preventive environmental approach for production processes and products, to trim down risks to humans and also the environment, therefore investment capital found a new face to invest in new technologies and transforming consumption patterns and lifestyles in a manner that allows for an increase in the quality of life through new jobs and better, cheaper products and services. In addition the research findings in Table [5.2] have revealed that technological innovation is valid with respect to renewable energy consumption index while it is not valid with respect to fossil fuel energy consumption index. In Table [5.4], where the first robustness test was applied to confirm the role of technology innovation in both models, the results of the CS-ARDL correspond to the results of the PMG estimator, and therefore technology innovation supports renewable energy versus fossil fuel energy consumption. While the causality test (DH) in Table [5.5] shows that there is a bidirectional causality associated with the clean energy index, but there is no causal relationship with fossil fuel energy index.

It was apparent from these findings in Table [5.2] that economic freedom in EEA countries is increasing the renewable energy demand as it plays a fundamental role in the energy policy, markets, and deployment of renewable energy technologies. EEA countries policy directed to support R&D in this area, both the public and private sectors, lower tax rates on it, and providing legal protection for property rights for energy-innovations and its activities. While they incentivize the market through sustaining this industry's sales until the manufacturers attain cost reduction from education opportunities and economy of scale. It also supported domestic and international investment in this field and strengthened economic laws that allowed for the expansion of renewable energy demand and the free transfer of its activities between countries through trade openness. Table [5.4] shows the first robustness test confirmed the role of financial freedom in both models, the results of the CS-ARDL correspond to the results of the PMG estimator, and therefore economic freedom supports clean energy and fossil fuel energy utilization. It appears that these countries still have industrial activities dependent on fossil fuel energy. While the second robustness by (DH) test in Table [5.5] confirms that there is a unidirectional causality extending from economic freedom to renewable energy index and also fossil fuel energy index.

The outcome in Table [5.2] indicated that the downward and upward changes in environmental pollution in the countries of the European Economic Area are the result of the consumption of renewable energy up and down. For many years, these countries have paid attention to environmental quality. In order to reduce the costs of tackling climate change, reducing health care costs, and energy companies will not face any financial sanctions against polluting. Therefore they signed and ratified the Kyoto Convention on Climate Change, which aims to combat global warming by reducing carbon dioxide emissions. From that moment, countries in the European Economic Area followed natural resources in industrial use. The results of CS-ARDL in Table [5.4] are constant with the results of the PMG Estimator in Table [5.2]. Thus, environmental pollution in the European Economic Area countries is decreasing due to the increased use of renewable energy in economic activities versus fossil fuel energy consumption. While the second robustness in Table [5.5] confirms that there is a unidirectional causality extending from environmental pollution to clean energy index where the high level of pollution with the start of the oil energy revolution, called to hub on renewable energy industries in order to reduce pollution. Consequently, the fossil fuel energy consumption indicator shows that there is a one-way casualty extending to environmental pollution, which confirms the level of contamination that with the use of fossil fuel energy, and decreases with clean energy usage.

Moreover, the study found out that investing in renewable energy sources would appear more attractive and could significantly affect the amount of benefits that the EEA economies might reap. Table [5.2] shows a clear result of a strong growth in per capita GDP in recent years in renewable energy index, even as the economic structure has changed. Economic activities in both renewables and energy fuels support economic growth, but in a different way, energy systems affect sustainable growth, quality of life, health, and environmental quality in the long run. Per capita GDP results in both models in Table [5.4] appear to be increasing with either one, so the CD-ARDL test also confirms these results. Further, the causality test results in Table [5.5] shows that the causality is bidirectional between gross domestic product per capita and renewable energy utilization index, but the unidirectional causality extends from the gross domestic product per person to fossil fuel energy consumption index.

6.2. Association of Southeast Asian Nations Plus Three [Asean+3]

Findings for the Asean+3 countries presented in Table [5.7] pointed that the Keynesian hypothesis hold between growth and Asean+3 renewable energy index, however financial development, technological innovation, and economic freedom is responsible for renewable energy consumption index in the Asean+3. Although the majority of Asean countries are better developed, the consumption of fossil fuel energy could not be ruled out since the majority of construction vehicles, plant and equipment are diesel powered, hence emitting pollutants into the atmosphere while the results indicating less pollution rate by using renewable energy.

The Asean+3 findings suggest that economic sustainability is driven by clean energy consumption and financial developments. This finding is due to resourcefulness in the Asean which makes them benefit from renewable energy initiatives which they do on a larger scale to be relied upon to power the economy. In light of the competitive market in which the ASEAN countries appeared towards the peak, it was necessary to establish the basis strengthening the renewable energy market in front of other global markets, as these countries are depending on many strategies and instruments. The result in Table [5.7] can also be tracked to the ASEAN's ability to fully directing its financial development to use renewable energy resources including loans with low interest extended to new, renewable energy and rural power projects. Capacity Building to Remove Barriers to Renewable Energy (CBRED) project economic mechanisms by recognized funds to address financing barriers: Project groundwork fund; Loan guarantee Fund; and Micro finance Fund. Establishment of finances devoted to clean energy development through public and private partnerships. Credit enhancement such as threat and credit guarantees that make banks more prepared to extend credit to clean energy projects. Interest rate subsidy; and small and medium enterprises development capital funds that provide fairness or debt directly to projects. These results were investigated by applying the CS-ARDL test whose results are accessible in Table [5.9]. Financial developments boosts the renewable energy consumption index while not boosting the fossil fuel energy index in the long term. Moreover, the researchers also applied the causal test (DH) as a second test to ensure the validity of their results in Table [5.10]. It further indicates that financial development has a unidirectional causality extending to both renewable power utilization and fossil fuel energy use indexes. This shows a strong financial development role in supporting economic activities. The research findings also indicated that the Keynesian hypothesis holds in the ASEAN region with respect to technology innovation and the renewable energy consumption index. Asean members enjoy to advance renewable energy improvement in the context of inhibited options, contest for resources, and national financial development goals. In light of the competitive role of the ASEAN market, it should be focusing on basic points with regard to energy security; energy access; energy cost; international competitiveness; modernization; environmental sustainability. ASEAN economies focus on energy access which reduces energy poverty and expands entrée to secure, reliable, and low-cost energy leading to taking advantage of the available natural resources to generate renewable energy that achieve greater competition in the international energy markets. Governments also labor to guarantee that their improvement systems are successful in increasing the consumption of renewable energy at creating and giving out new knowledge; creating competence; creating joint networks; increasing infrastructure; providing finance; establishing governance and the regulatory environment, to attract private investment and reach new markets with their clean energy products, thus they create robust innovation systems entrepreneurs need to compete effectively. Further rapidly increasing operation of innovation technology such as photovoltaics, battery storage, electric vehicles, and smart grids to increase demand of renewable energy. In order to ensure environmental sustainability in these regions, there is need to accelerate sustainable energy innovation and induce technology and knowledge transfer among countries is one of the reasons to more consumption of renewable energy. These results were confirmed by applying the CS-ARDL test whose results were presented in Table [5.9]. Technological innovation boosts renewable energy consumption index while not boosting fossil fuel energy index in the long term. Moreover, the researchers also applied the causal test (DH) as a second test to ensure the validity of the results in Table [5.10]. It also indicated that technological innovation has a bidirectional causation with renewable energy consumption index while it is not a cause of fuel energy consumption.

Generally, the findings in Table [5.7] have revealed that the Keynesian hypothesis holds with respect to economic freedom and Asean renewable energy consumption index, but it does not hold an increase in fossil fuel energy consumption index. Most ASEAN country have already undertook necessary steps in the evolution process towards more sustainable power systems by focusing on five categories; national strategies and targets; policy instruments; grid access; financial support; regional cooperation, ASEAN countries rely mostly on investment benefits and tax procedures (supply capacity category policy instruments). Income tax vacations, equipment duty exemption, property tax exemptions, and accelerated decrease for the equipment are the common monetary incentives in these countries. Non-fiscal incentives also include trouble-free repatriation of capital reserves and transfer of funds earned as well as authorization to bring in foreign experts and their family otherwise banned with the current employment rules. In order to further stimulate private investments on renewables there is need for expanding regional cooperation on exchanging renewable energy and sharing of experiences. Focus on swap of manufacturing capability, improvement of policy and institutional structure. These results confirmed by applying CS-ARDL test whose results are presented in Table [5.9]. Economic freedom boosts the renewable energy consumption index while not boosting fossil fuel energy index in the long term. Moreover, we also applied the causality test (DH) as a second test to ensure the validity of our results in Table [5.10]. It also indicates that economic freedom has a unidirectional causation that extends to clean e energy consumption index and fuel power consumption index.

Further findings in Table [5.7] from this study are indicating that there is strong support from lower environmental pollution in increasing the index of renewable energy consumption even though more environmental pollution comes from high consumption of fuel energy index. These findings also allude to an interesting realization that Asean members are promoting clean energy. ASEAN members rely on three fundamental points explaining the role of environmental pollution in increasing renewable energy consumption in order to maintain environmental quality and sustainability. Build capacity to maintain environmental quality by mobilizing finance, technology platforms and investment channels to obtain new and sufficient renewable energy resources for their use, and also supporting their use against other energies. Increased consciousness and awareness among Asian institutions and society of the need to use natural energy resources to get two of co-benefits. There are Social co-benefits which include improvements in health and safety and Environmental co-benefits which include maintaining environmental quality and sustainability. The agreements became a reaction to an environmental crisis that hit Asian countries. On regional level, it has established numerous agreements that call to maintain on environmental quality as ASEAN Agreement on Transboundary Haze Pollution. Internationally, the Paris Agreement on Climate Change and Kyoto Protocol were signed. These agreements have played a main role in increasing renewable energy demand through their strong support in their markets and economic system. These results confirmed by applying the CS-ARDL test whose results are presented in Table [5.9]. Environmental quality (less environmental pollution) boosts the renewable energy consumption index although environmental pollution promoting by the fuel energy index in long term. Moreover, the researcher also applied the causal test (DH) as a second test to ensure the validity of our results in Table [5.10]. It also indicates that environmental quality has a unidirectional causation that extends to renewable energy consumption index even though fuel energy consumption index has a unidirectional causation that extends to environmental pollution.

Table [5.7] indicates the research long-term findings which are suggesting the possibility of long-range benefits to gross domestic product per person in respect to renewable energy consumption indexes. However, GDP per unit of energy use are economic sustainability in the long-range for the Asean member’s country. This finding is due to technological obsolescence and also technological catch-up in renewable energy from Asean countries, mobilizing financial to support this field, and also economic freedom easy its spread. Even though clear from these results that GDP per capita increases both consumption indexes (renewable and fuel energy) but the GDP per capita with respect renewable energy more sustainability in both economically and environmentally scopes. These results were confirmed by applying the CS-ARDL test whose results are presented in Table [5.9]. GDP per capita boosts the renewable energy consumption index and also fuel energy index in long term. Moreover, the researcher also applied the causal test (DH) as a second test to ensure the validity of our results in Table [5.10]. It also indicates that GDP per capita has a bidirectional causation with respect the renewable energy consumption index also even fuel energy consumption index.

6.3. Chapter Summary

This chapter delved into the discussion of the findings from chapter [4] for European Economic Area Group [EEA] and Association of Southeast Asian Nations Plus Three [Asean+3] groups. This researcher provided the discussion of results in the research study, in which the reasons and proof was explained that indicated these results. The next chapter will conclude the research study and provide general and practical policy implications based on the Dumitrescu-Hurlin causality test results.

CHAPTER 7

CONCLUSIONS AND POLICY RECOMMENDATIONS

Introduction

In order to develop sound and robust public policy recommendations, this chapter employed findings from Dumitrescu-Hurlin causality test results. Both general and practical strategy suggestions were therefore made for European economic area group [EEA] and Association of Southeast Asian Nations Plus Three [Asean+3] group respectively. These causality tests findings are presented in Table [5.5] and Table [5.9] correspondingly.

7.1. Conclusion

This research study aimed at examining the global dynamic links between financial development, economic freedom, environmental pollution, technological innovation and energy consumption [renewable and fuel] between the European economic area [EEA] and Association of Southeast Asian nations plus Three [Asean+3] groups with a view to unleash robust public policy and regulatory interventions for global sustainable development. This study utilized the global data of 24 economics of EEA group members, and global data of 9 economics of Asean+3 group members over the duration 1998 to 2018.Further, the financial development, environmental pollution, economic freedom, technological innovation, energy consumption for renewable and fuel indices were all developed using principal component analysis (PCA) with respect to these economies. Moreover, a dynamic panel ARDL approach with Dumitrescu and Hurlin causality and CS-ARDL tests was used to analyze the variables for that period.

The study included two cases of groups of global economies, namely the European economic area [EEA] and Association of Southeast Asian nations plus Three [Asean+3] groups, where indicators of clean energy consumption and fuel were used as power variables. Therefore, the variables for both cases of groups of economies include financial development, fuel energy consumption, environmental pollution, technological innovation, real per capita gross domestic product, clean energy use, and financial freedom.

In the shorter and longer term, the outcome in respect to European Economic Area economies revealed that there is a Keynesian hypothesis between financial development and renewable energy consumption index while the Keynesian hypothesis does not hold linking financial developments and fuel energy consumption index. This indicates that financial developments of EEA group members' supports renewable power utilization and avoids supports fuel energy consumption.

In addition, the consumption of renewable energy proved beneficial to the decrease in environmental pollution in European Economic Area countries, as it is beneficial to the general environment in terms of reducing carbon dioxide emissions. Fuel energy consumption on the other hand wreaks havoc to carbon dioxide emissions and damaging to the environment in terms of increasing carbon dioxide emissions that make the environment unsustainable. In the same vein, environmental pollution is increased the consumption of fuel energy whereas environmental quality is increased renewable energy consumption.

Furthermore, the results confirmed in the short and long term that technological innovation holds the Keynesian hypothesis by supporting economic sustainability in the economies of the European Economic Area by escalating the index of the utilization of renewable energy while not supporting fuel energy consumption during that period.

Moreover, unclear results of economic freedom were revealed in the European Economic Area, noting that economic freedom supports both consumption indicators for (renewable energy and fuel). This implies that the level of financial freedom in European Economic Area supports both economic energy structures.

Finally, the Keynesian hypothesis remains between the EEA economies of real GDP per capita and both are indicators of consumption for renewable energy and energy consumption. Noting that consumption increased by grow up realgross domestic product per person.

On the other hand, in the short and long term, the results in respect of the Asean+3 economies revealed that first, there is a Keynesian hypothesis between financial development and renewable energy consumption index while the Keynesian hypothesis does not hold between financial development and fuel energy consumption index. This indicates that financial development of Asean+3 group members' supports renewable energy consumption and avoid supporting fuel energy consumption.

Second, the consumption of renewable energy consumption proved beneficial to reduce environmental pollution in the Asean+3 countries, as it is beneficial to the general environment in terms of reducing carbon dioxide emissions. Whereas, fuel energy consumption wreaks havoc to carbon dioxide emissions and damaging to the environment in terms of increasing carbon dioxide emissions that make the environment unsustainable. In the same vein, environmental pollution is increased the consumption of fuel energy whereas environmental quality is increased renewable power use.

Third, the outcome confirmed in the short and long term that technological innovation holds the Keynesian hypothesis by supporting economic sustainability in the economies of theAsean+3 by escalating the index of clean e energy consumption while not supporting fuel energy consumption during that period.

Fourth, clear results of financial freedom were revealed in the Asean+3 economy, noting that economic freedom supports strongly consumption indicator for renewable energy. This implies that the level of financial freedom in the Asean+3 economics supports the renewable energy economic structure.

Fifth, the Keynesian hypothesis remains between Asean+3 economies real GDP per capita and both are indicators of consumption for renewable energy and energy consumption. Noting that consumption increased by grow up real GDP per capita.

Finally, long-range findings in this study suggested that both economic and environmental sustainability is possible, however this will depend on the quality of public policy and regulatory interventions by authorities in both groups' economies.

7.2. Policy Analysis

In order to devise robust general and practical public policy and regulatory recommendations, Dumitrescu-Hurlin causality tests were employed. Right side of Table [5.5] and Table [5.10] reveals both unidirectional and bidirectional causality test results for both groups within both indices. The result for unidirectional causality tests in European Economic Area economics (EEA group) was confirmed between: financial developments and renewable power consumption index; environmental pollution and renewable power consumption index; economic freedom and renewable energy consumption index; financial developments and technological innovation indexes; environmental pollution and financial development indexes; financial freedom and financial developments indexes; environmental pollution and technological innovation indexes; environmental pollution and economic freedom index; financial developments and fuel energy use index; fuel energy consumption and environmental pollution index; economic freedom and fuel energy consumption index; realgross domestic product per person and fuel energy consumption index; technological innovation and environmental pollution index; and finally real GDP per capita and technological innovation index.

Furthermore, bidirectional causality results were confirmed between: the European Economic Area (EEA group) renewable energy use index and technological innovation; realgross domestic product per person and renewable energy consumption index; real GDP per capita and financial development index; economic freedom index and technological innovation index; realgross domestic product per person and technological innovation index; realgross domestic product per person and environmental pollution index; and real GDP per capita and financial freedom index. While no causal relationship has been confirmed between technology innovation and fuel energy consumption index.

Table [5.10] presents both unidirectional and bidirectional causality results for nine of Asean+3 countries group. Within two energy consumption indexes are renewable energy and fuel energy. The unidirectional causality was supported between: financial developments and renewable energy use index; technological innovation and renewable power consumption index; environmental pollution and renewable energy consumption index; financial freedom and clean energy use index; financial development and technological innovation index; environmental pollution and financial development index environmental pollution and technological innovation index; environmental pollution and financial freedom index; real gross domestic product per capita and environmental pollution index; financial development and fuel power utilization index; fuel energy consumption and technological innovation index; fuel energy consumption and environmental contamination index; and financial freedom and fuel energy use index.

On the contrary, bidirectional causality was exposed between: technological innovation and clean energy consumption index; real gross domestic product per person and real renewable energy consumption; economic freedom and financial development index; economic freedom and technological innovation index; real gross domestic product per person and technological innovation index; real gross domestic product per capita and economic freedom index; and also the real GDP per capita and fuel power consumption.

These causality relationships are important in crafting robust and sound public policy and regulatory interventions so as to achieve economic and environmental sustainability in a panel of countries:

1. Economic freedom led financial development
2. Economic freedom led fuel energy consumption
3. Economic freedom led renewable energy consumption
4. Environmental pollution led economic freedom
5. Environmental pollution led financial development
6. Environmental pollution led renewable energy consumption
7. Environmental pollution led renewable energy consumption
8. Environmental pollution led technological innovation
9. Financial development led fuel energy consumption
10. Financial development led renewable energy consumption
11. Financial development led technological innovation
12. Fuel energy consumption led environmental pollution
13. Fuel energy consumption led technological innovation
14. Real GDP per capita led environmental pollution
15. Real GDP per capita led fuel energy consumption index
16. Real GDP per capita led technological innovation index.
17. Technological innovation led environmental pollution
18. Technological innovation led renewable energy consumption

This strategy affords strong insight for crafting robust public policies so as to achieve economic sustainability in the group of member countries of the European economic area group [EEA] and Association of Southeast Asian Nations Plus Three [Asean+3] countries.

7.3. General Policy Implications

In this study, general policy implications were based on the overall results from the both panel groups that including of 33 countries. The overall findings from this research suggest the following procedure related implication in the European economic area group [EEA] and Association of Southeast Asian Nations Plus Three [Asean+3] countries:

a. Financial development directly impacts clean energy consumption in the EEA and Asean country groups. In this regard policies to attract financial development in renewable energy should be instigated in these countries since renewable energy consumption is a promising solution to sustain economic sustainability thereby mitigating future energy crises. Therefore these countries policy authorities should carefully assess the externalities associated with renewable energy developments within their jurisdictions and also bear in mind their energy profiles as they endeavor to attract financial development.
b. Renewable energy initiatives attract finance sectors in the EEA and Asean economy. Against this backdrop, policy authorities should leverage on putting in place measures that should enhance renewable energy within their jurisdictions and such interventions should mainstream incentives for local and international investors to leverage on. This will also go a long way in enhancing and promoting sustainable financial growth and expansion while ecological sustainability is enhanced in line with the Sustainable Development Goals.
c. Technological innovation directly impacts renewable energy consumption in these economies. In this regard, it is necessary to make outstanding improvement policies. Innovation policies also need to be able to implement efficiently to attract technological innovation in renewable energy field should be instigated in global since technological innovation is a promising solution to reducing energy and environmental pollution crises. Therefore policy authorities should carefully assess the externalities associated with technological innovation developments within their jurisdictions and also bear in mind their energy profiles as they endeavor to attract technological innovation investments.
d. Economic freedom substantially contributes to sustainable economic. Therefore, authorities should allow in place increase economic freedom level that would enhance the sustainable economic and quality of the environment and these should be embedded in green supply chain management and financing for economic and environmental sustainability to be realized for a healthy economic system.

e. Clean energy has a direct impact on financial and environmental sustainability in these economies. Therefore EEA and Asean policy authorities should craft renewable energy regulatory policies in such a way that increase in renewable energy investment field through initiatives to attract flow of local and international investment. Policy authorities should also promote investment green projects activities to sustain growing these economies.
f. Fuel power has a direct effect on the environmental pollution in these countries economy. Therefore global policy authorities should craft environmental sustainability regulatory policies in such a way that reduces CO2 emissions through initiatives to attract local and international investment in natural energy sources. Policy authorities should also promote healthy and sustainable economic activities to avoid face energy and environmental pollution crises.
g. Policy makers should have a clear understanding of opportunities provided by technological innovation in supporting renewable energy resources.

7.4. Practical Policy Implications

This section provides practical policy implications based on findings from Dumitrescu-Hurlin causality tests. The practical policy implications focuses on European economic area group [EEA] and Association of Southeast Asian Nations plus Three [Asean+3] group.

7.4.1. Practical Policy Implications for European Economic Area Group [EEA] Group

Rapid economic growth and sustained industrialization in EEA is economically sustainable since it leads to together with the use of clean energy sources. Therefore authorities in this region should rollout massive finance, and technological innovation initiatives and more economic freedom reforms. EEA policy and regulatory authorities should escalate green financing initiatives since it is paramount in promoting economic sustainability while enhancing sustainable economic growth simultaneously. This is achievable through strengthening conditions for economic freedom and directing household credit supply to the confidential subdivision with the aim of increases technological innovation.

Renewable energy consumption initiatives are the messiahs in achieving economic and environmental sustainability in EEA. However, technological innovation initiatives should therefore be cascaded across the economic value chains including households in such a way that will guarantee financial and ecological sustainability into the long-range. This should take the form of supporting green projects to support renewable energy through inventive and innovative.

There is assessment of the effect of an EEA financial and banking environment for renewable energy consumption. In the framework of this argument, especially in the aftermath of the ‘‘Great Recession’ and the European crisis, which augment the reputation of systemic risk and prompt policymakers to look for r new supervisory and macro-prudential policy frameworks. An additional challenge that is to deem whether ‘‘excessive’’ economic development may lead to monetary institutions’ tendency to take on bigger risks, which in turn may contribute to the recent EEA crises (energy and financial crisis).

In the same vein, financial freedom supports sustainable economic growth in the board of countries and this requires energy to power the growth momentum. It is therefore imperative for authorities in these countries to embed renewable energy and other cleaner alternatives to foster sustainable economic growth while promoting environmental sustainability at the same time.

Strengthening the capacity of the financial systems in these economies to finance alternative energy investments is critical in order to support economic growth, while enhanced environmental health is also important. Therefore, renewable energy for growth should be the economic mantra for policymakers in these selected countries since the environment will also benefit as well as future generations in general.

Take advantage of the level of economic freedom in these economics to expand the scope of renewable energy projects.

When it comes to complex technology sectors like energy, Policymakers need to standardize incentive packages and support across areas of joint technology launch. It is important to move away from the current legislative approach to the unique political designs of each technology, which often rely on the legislative influence underlying that particular technology rather than the critical features of the technology itself.

Legislate each energy technology separately and provide a different incentive structure for each. We say that the incentive structure must first be initiated in a way that maintains the neutrality of the underlying technology needed in this complex technology area.

Increased spending on research and progress in the power or energy field will affect green energy innovation and thus decrease in carbon dioxide in industrial activities.

Energy security, the fulfilment of Kyoto commitment, and the promotion of new technology policies in the border economies of the European Economic Area countries must be based on energy development from renewable sources and diversification of external suppliers.

EEA group of countries needs to evaluate system-level innovation policies to know system-wide effects and feedbacks, are not taken properly into account.

7.4.2. Practical Policy Implications for Association of Southeast Asian Nations Plus Three [Asean+3] Group

Asian+3 group economies are set to benefit from ongoing renewable energy initiatives which are ear marked at abating climate change and environmental pollution in the region. Notwithstanding these benefits, policy authorities should review available renewable energy resources within their jurisdictions and in the process consider opportunities and costs associated there with. Renewable energy production initiatives should be embedded in Asian energy policies as compliments so as to enhance economic and environmental sustainability in the region. Accelerated economic growth and massive industrialization in the Asian territory damages the environmental sustainability through promoting environmental pollution in the region. It is therefore important for policy authorities to integrate policy initiatives for ministries responsible for energy, financing, environment, technological innovation and economic freedom. Economic growth initiatives in the region should be aligned with the dictates of both the Paris agreement as well as the Kyoto protocol so as to realize environmental sustainability.

Economic freedom policies in Asia should integrate renewable energy and green financing initiatives such as innovative financing, priority lending, interest rates incentives and refinancing options which enhance economic and environmental sustainability. Such policies should also leverage on technological innovation developments in these countries to promote linkages among players in the economic value chain to enhance growth, and clean energy use. Therefore, joint regional initiatives such as economic agreement and environmental quality agreements should be embedded in financial development, energy, environmental and economic policies as a way to promote economic and environmental sustainability in the Asian region. Furthermore, economic freedom should be a policy priority in the Asian region and this can be an avenue to attract financing and investment in these countries.

Establishment of the officially authorized frame for high execution of innovation policies is needed. On this basis, Asean countries should established a plan for settling new challenges that was created from the post catch-up stage, providing an overarching guide for the conduct of STI policies and working on the implementation power of policies. Therefore, an authorized framework is supposed to be considered to augment the implementation power of improvement policies.

The use of innovation policies in Asean countries in solving social problems in addition increases financial growth through including issues for better human society and financial and scientific development issues. Even though innovation policies formerly aimed at financial growth they now seek to develop the quality of life and solve social problems, such as unemployment, , climate change, environment, diseases, , and lack of resources. Specified that social demands compel this change, ASEAN countries ought to appreciate their societal needs and use them on their innovation policies.

Using common innovation policy instruments by economic development phase can be helpful. This can be a guide to ASEAN countries to modification the Innovation Policy Instruments at different economic stages in future such as direct R&D grants, R&D tax credit, training and skills programs, construction of cluster or technical parks, and unfriendly set of laws for foreign firms were also utilized to advance the technological competitiveness of local firms' . They must also upgrade their industry and social structures in addition to institutional and legal systems. Private sector must produce innovation by themselves instead of relying on the government's direct aides, and improvement should spread to SMEs, start-ups, and large corporations. Therefore, primary policy instruments consist of the ratification of law, such as development of IPR system, private-led advancement, continuing technology development, social issue-solving-oriented innovation, demand- dominated R&D investment, encouraging start-ups (entrepreneurship), encouragement of open improvement with global R&D partners, and public procurement to promote SMEs' innovation.

Strengthening financial crisis impediment and organization mechanisms is important. Therefore, the global economic crisis highlighted that the Asean countries need a useful, regional, national and global structure to ensure economic steadiness. At national level, every country must entail that an inclusive framework and eventuality plan for economic institution malfunction is needed, including consumer safety measures such as deposit insurance. At regional level, establishing regional and sub-regional forum is of added advantage to support regional financial and economic cooperation, policy harmonization, and emergency assistance. Asia also needs to dynamically participate in the reorganization of the international economic structural design and establishment of global economic protection nets to improve crisis prevention and management.

Balancing guideline and improvement: The main obstacle for regulators in Asean economy is on how to promote and control economic market growth without stifling innovation. Regulators must be wary of compound innovations that formulate the fundamental risks of products and services more difficult to trace—whether by bank administration, regulators, or investors. On the other hand, a significant distinction ought to be made linking the critical elements for economic market growth and risky economic innovation. For many Asean+3 group finances, straightforward improvement—creating and utilizing new economic instruments, technology, and services such as securitization and derivative—might be exceedingly helpful to expand admittance to finance and promote economic efficiency and resiliency.

Existence of regional strategies and action plans for the environment. Regional Asean Policy should respond to environmental issues, Environmental amalgamation in sectors and in macro-economic policies and subsistence of SEA of the policy, legislation and institutions. Important measures should be taken by these Governments to solve environmental concerns. There should be usefulness in attaining targets. There should be authoritarian framework and endorsement status and implementation of Regional Environment Agreements Adequacy of regional strategies and environmental legislation. Stipulation and measures for public contribution in regional ecological issues must be well thought-out.

Encourage teamwork in technical individual ability development. ASEAN industry requires experienced technicians and engineers capable of designing, operating renewable energy technology equipment to the proper industry standards and installing ,) implementing power effectiveness measures. With the use of training programs and knowledge transfers among member's country to encourage technology facilitation. Power technology facilitation centers, in the form of a one-stop clearing house, should be set up in each ASEAN member and linked as an ASEAN network to facilitate innovation in enterprises, particularly small and medium-sized enterprises.

Services provided by the center should include advice for and access to technical and financial information, university talent research facilities, intellectual property, government incentive schemes and consultancy. Such an ASEAN network should facilitate intra-ASEAN technology and know-how transfer between members as well as from outside ASEAN, particularly in the field of renewable energy and energy efficiency.

Promote co-operation in technology R&D. Energy technology development and innovation at the ASEAN level requires a comprehensive and co-ordinated approach with a clear focus on selected technologies in specific sectors. Policies to promote energy technology development should include the establishment of regular, ASEAN-wide energy research programs that are tendered openly and transparently as research projects. Universities and applied research institutions should be encouraged to form consortia of various players and tender for ASEAN support. Also Promote co-operation in R&D personnel development.

Promote collaborative scientific research. Collaboration both bilateral and multilateral, and both within ASEAN and with its dialogue partners – in the advancement of energy science is required in order to lay a strong foundation for solving complex, long-term energy problems of common interest to ASEAN members. Examples of such problems include advanced biofuels, photovoltaics, solar-assisted cooling, marine energy, energy storage and CCS etc. To this end, ASEAN-wide joint scientific research programs should be developed and funded by ASEAN. Since each Member State has specific strengths in different areas, which are often complementary, ASEAN centers of excellence in different areas should be established in different countries with ASEAN-level support to act as the focal point of scientific research that would benefit ASEAN as a whole.

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APPENDIX

Appendix 4. 1: KMO and Bartlett's Tests for variables Index

Variables	Parameter	Asean+3 group			EEA group		
		Bartlett test	KMO test	C/M	Bartlett test	KMO test	C/M
LIFEC	5	1557.297 (0.000)	0.816	0.000	3982.017 (0.000)	0.763	0.000
LIREC	4	786.546 (0.000)	0.698	0.015	1198.473 (0.000)	0.761	0.000
LIFD	13	1659.007 (0.000)	0.674	0.000	4225.311 (0.000)	0.723	0.000
LIEPOL	3	1267.100 (0.000)	0.672	0.001	2115.814 (0.000)	0.690	0.015
LITIN	6	1567.755 (0.000)	0.764	0.000	2715.299 (0.000)	0.779	0.004
LIEF	9	1356.025 (0.000)	0.792	0.001	2486.404 (0.000)	0.757	0.007

Notes, D/F represent the degree of freedom, C/M represents determinant of the correlation matrix, KMO represents Kaiser-Meyer-Olkin Measure of Sampling Adequacy.

Appendix 4. 2: List of Asean+3 group member

1	China
2	Indonesia
3	Japan
4	Korea, Rep.
5	Malaysia
6	Philippines
7	Singapore
8	Thailand
9	Vietnam

Appendix 4. 3: List of EEA group members

1	Austria
2	Belgium
3	Bulgaria
4	Croatia
5	Cyprus
6	Czech Republic
7	Denmark
8	Estonia
9	Finland
10	France
11	Germany
12	Greece
13	Hungary
14	Italy
15	Latvia
16	Lithuania
17	Poland
18	Portugal
19	Romania
20	Slovak Republic
21	Slovenia
22	Spain
23	Sweden
24	United Kingdom

PLAGIARISM REPORT

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GLOBAL DYNAMIC ASSOCIATION BETWEEN FINANCIAL DEVELOPMENT AND ENERGY CONSUMPTION IN THE GROWTH CHANNELS OF EAST AND WEST POLES.

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ETHICS COMMITEE APPROVAL

21.09.2020

Dear Ala Assi Fathi,

Your project "Global Dynamic Association between Financial Development and Energy Consumption in the Growth Channels of East and West Poles" has been evaluated. Since only secondary data is used in the project it does not need to go through the ethics committee. You can start your research on the condition that you will use only secondary data.

Sincerely,

Assoc. Prof. Dr. Aliya Isiksal

Assoc. Prof. Dr. Turgut Tursoy