THE CAUSALITY RELATIONSHIP BETWEEN FINAL ENERGY CONSUMPTION, ECONOMIC GROWTH, AND CARBON DIOXIDE EMISSION FROM ENERGY COMBUSTION IN INDONESIA

ANDHYKA TYAZ NUGRAHA

DOCTOR OF PHILOSOPHY
UNIVERSITI UTARA MALAYSIA
JUNE 2020

THE CAUSALITY RELATIONSHIP BETWEEN FINAL ENERGY CONSUMPTION, ECONOMIC GROWTH, AND CARBON DIOXIDE EMISSION FROM ENERGY COMBUSTION IN INDONESIA

BY

ANDHYKA TYAZ NUGRAHA

Thesis Submitted to
School of Technology Management and Logistics,
Universiti Utara Malaysia,
in Fulfillment of the Requirement for the Degree of Doctor of Philosophy

Kolej Perniagaan
(College of Business)
Universiti Utara Malaysia

PERAKUAN KERJA TESIS / DISERTASI
(Certification of thesis / dissertation)

Kami, yang bertandatangan, memperakukan bahawa
(We, the undersigned, certify that)

ANDHYKA TYAZ NUGRAHA

calon untuk Ijazah **DOCTOR OF PHILOSOPHY**
(candidate for the degree of)

telah mengemukakan tesis / disertasi yang bertajuk:
(has presented his/her thesis / dissertation of the following title)

THE CAUSALITY RELATIONSHIP BETWEEN FINAL ENERGY CONSUMPTION,ECONOMICS GROWTH AND CARBON-DIOXIDE EMISSION FROM ENERGY COMBUSTION IN INDONESIA.

seperti yang tercatat di muka surat tajuk dan kulit tesis / disertasi.
(as it appears on the title page and front cover of the thesis / dissertation).

Bahawa tesis/disertasi tersebut boleh diterima dari segi bentuk serta kandungan dan meliputi bidang ilmu dengan memuaskan, sebagaimana yang ditunjukkan oleh calon dalam ujian lisan yang diadakan pada:
22 Julai 2019.
(That the said thesis/dissertation is acceptable in form and content and displays a satisfactory knowledge of the field of study as demonstrated by the candidate through an oral examination held on:
22 July 2019.

Pengerusi Viva *(Chairman for Viva)*	:	**Assoc. Prof. Dr. Santhirasegaran a/l S.R Nadarajan**	Tandatangan *(Signature)*
Pemeriksa Luar *(External Examiner)*	:	**Prof. Dr. Abdul Talib Bon**	Tandatangan *(Signature)*
Pemeriksa Dalam *(Internal Examiner)*	:	**Prof. Dr. Mohd Zaini Abd Karim**	Tandatangan *(Signature)*

Tarikh: **22 Julai 2019**

Nama Pelajar
(Name of Student) : **Andhyka Tyaz Nugraha**

Tajuk Tesis / Disertasi
(Title of the Thesis / Dissertation) : **The Causality Relationship Between Final Energy Consumption,Economics Growth and Carbon-Dioxide Emission From Energy Combustion in Indonesia.**

Program Pengajian
(Programme of Study) : **Doctor of Philosophy**

Nama Penyelia/Penyelia-penyelia
(Name of Supervisor/Supervisors) : **Assoc. Prof. Dr. Nor Hasni Osman**

Tandatangan

PERMISSION TO USE

In presenting this thesis in fulfillment of the requirements for a postgraduate degree from Universiti Utara Malaysia, I agree that the Universiti Library may make it freely available for inspection. I further agree that permission for the copying of this thesis in any manner, in whole or in part, for the scholarly purpose may be granted by my supervisor(s) or, in their absence, by the Dean of School of Technology Management and Logistics, College of Business, Universiti Utara Malaysia. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to Universiti Utara Malaysia for any scholarly use which may be made of any material from my thesis.

Requests for permission to copy or to make other use of materials in this thesis, in whole or in part, should be addressed to:

Dean of School of Technology Management and Logistics
College of Business
Universiti Utara Malaysia
06010 UUM Sintok
Kedah Darul Aman

ABSTRACT

The purpose of this study is to explore the causal linkage between final energy consumption, economic growth, and CO_2 emissions in Indonesia. This study uses the annual data of Indonesia over the period 1971-2014. Data series of final energy consumption and CO_2 emissions from energy combustion obtained from the International Energy Agency (IEA), while data series of the real Gross Domestic Product (GDP), the real gross domestic product (GDP) per capita, as well as the value-added of three main development sectors collected from World Development Indicators (World Bank). The Autoregressive Distributed Lag (ARDL) technique and the Granger causality test are applied in this study. This study generated several empirical findings. First, sectoral economic growth significantly influenced total final energy consumption in Indonesia, while sectoral final energy consumption did not significantly influenced economic growth in Indonesia. In the industry sector, final energy consumption and economic growth did not have relationship, but they have a causal relationship with CO_2 emissions. In the agriculture sector, economic growth has a significant impact on final energy consumption and CO_2 emissions, while final energy consumption and CO_2 emissions only have a short-run causal relationship. In the service sector, economic growth did not have influences on final energy consumption and CO_2 emissions, while final energy consumption and CO_2 emissions have a short-run causal relationship. In the residential sector, final energy consumption has a long-run relationship to economic growth and has a short-run causal relationship to CO_2 emission, while residential economic growth only has a short-run effect on CO_2 emission. Based on these findings, the policymakers expected to implement strategy and policy that considering conditions, situations, and challenges in those sectors, respectively. Moreover, all final energy users expected to use the new and renewable energy sources in order to reduce CO_2 emission from energy combustion in Indonesia.

Keywords: final energy consumption, economic development, co_2 emissions, autoregressive distributed lag, granger causality

ABSTRAK

Tujuan kajian ini adalah untuk meneroka hubungan kausal antara penggunaan tenaga akhir, pertumbuhan ekonomi, dan pelepasan CO_2 di Indonesia. Kajian ini menggunakan data tahunan Indonesia selama 1971-2014. Data penggunaan tenaga akhir dan pelepasan CO_2 dari pembakaran tenaga yang diperoleh dari Badan Tenaga Antarabangsa (IEA), sementara data Produk Domestik Kasar (KDNK) nyata, produk domestik kasar sebenar (KDNK) per kapita, serta nilai- ditambahkan daripada tiga sektor pembangunan utama yang dikumpulkan dari Petunjuk Pembangunan Dunia (Bank Dunia). Teknik Autoregressive Distributed Lag (ARDL) dan ujian penyebab Granger digunakan dalam kajian ini. Kajian ini menghasilkan beberapa penemuan empirikal. Pertama, pertumbuhan ekonomi sektoral secara signifikan mempengaruhi jumlah penggunaan tenaga akhir di Indonesia, sementara penggunaan tenaga akhir sektoral tidak mempengaruhi pertumbuhan ekonomi di Indonesia secara signifikan. Di sektor industri, penggunaan tenaga akhir dan pertumbuhan ekonomi tidak mempunyai hubungan, tetapi mereka mempunyai hubungan kausal dengan pelepasan CO_2. Di sektor pertanian, pertumbuhan ekonomi mempunyai kesan yang signifikan terhadap penggunaan tenaga akhir dan pelepasan CO_2, sementara penggunaan tenaga akhir dan pelepasan CO_2 hanya mempunyai hubungan sebab-akibat jangka pendek. Di sektor perkhidmatan, pertumbuhan ekonomi tidak berpengaruh pada penggunaan tenaga akhir dan pelepasan CO_2, sementara penggunaan tenaga akhir dan pelepasan CO_2 memiliki hubungan kausal jangka pendek. Di sektor perumahan, penggunaan tenaga akhir mempunyai hubungan jangka panjang dengan pertumbuhan ekonomi dan mempunyai hubungan sebab-akibat jangka pendek dengan pelepasan CO_2, sementara pertumbuhan ekonomi kediaman hanya mempunyai kesan jangka pendek terhadap pelepasan CO_2. Berdasarkan penemuan ini, para pembuat kebijakan diharapkan dapat menerapkan strategi dan kebijakan yang mempertimbangkan keadaan, situasi, dan cabaran di sektor-sektor tersebut. Lebih-lebih lagi, semua pengguna tenaga akhir diharapkan dapat menggunakan sumber tenaga baru dan boleh diperbaharui untuk mengurangkan pelepasan CO_2 dari pembakaran tenaga di Indonesia.

Kata Kunci: penggunaan tenaga akhir, pembangunan ekonomi, pelepasan co_2, autoregressive distributed lag, penyebab granger

ACKNOWLEDGMENT

In the name of Allah, the most gracious and most merciful. All praises, adorations, and glorifications are due to ALLAH SWT, the Most Exalted; and may His boundless blessings continue to shower on our Prophet Muhammad S.A.W. "Alhamdulillah", praise and gratitude to Allah SWT that blessing me to finish doctoral study and this dissertation.

Firstly and foremost, I would like to express my deepest thank to my supervisor, Associate Professor Noor Hasni Osman for her patience guiding me throughout the dissertation writing process and providing me with much-needed advice from the initial to the final steps even though my dissertation is not his main academic areas of interest. Without her advice, guidance and enduring support, this dissertation will not become a reality. She deserves special recognition for her unselfish attitude, thoroughness, and guidance especially in the research methodology and analysis findings.

I owe my loving thanks to my family, especially my beloved father Azwar Oemar (Alm), my beloved mother Sueztin Gustini, my beloved wife Sunarti, my brother Ade Satria Nugraha, and my sweety sister Febriany Syafitri that given moral support and spirit to me throughout my doctoral study journey until finally this Ph.D degree can be achieved successfully by me.

Not forgetting, special thanks to the staff of School of Technology Management and Logistics, Universiti Utara Malaysia, for their information, help and guidance during my study. Last but not least, I would like to thank to all scientists, colleagues, and friends that cannot mention one by one that directly or indirectly help me to finish doctoral study and this dissertation.

TABLE OF CONTENTS

PERMISSION TO USE i
ABSTRACT ii
ABSTRAK iii
ACKNOWLEDGMENT iv
TABLE OF CONTENTS v
LIST OF TABLES viii
LIST OF FIGURES xi
LIST OF APPENDICES xii
LIST OF ABBREVIATIONS xiii

CHAPTER ONE INTRODUCTION 1
1.1 Introduction 1
1.2 Background of Study 1
1.2.1 Energy, Economy and Environment Nexus 1
1.2.2 Overview of Indonesia 11
1.2.3 Overviews of Industry Sector in Indonesia 18
1.2.4 Overviews of Agriculture Sector in Indonesia 21
1.2.5 Overviews of Service Sector in Indonesia 23
1.2.6 Overviews of Residential Sector in Indonesia 26
1.3 Problem Statement 28
1.3.1 Issue from Previous Studies in Indonesia 28
1.3.2 Sectoral Issue in Indonesia 32
1.4 Research Questions 34
1.5 Research Objectives 35
1.6 Significance of Study 35
1.7 Research Gap 36
1.8 Organization of Study 37
1.9 Definition of Operational Variables 38

CHAPTER TWO LITERATURE REVIEW 41
2.1 Introduction 41
2.2 Definition and Type of Final Energy 41
2.3 Definition and Indicator of Economic Growth 44
2.4 Definition of Carbon-dioxide (CO_2) Emissions 48
2.5 The Classification Final Energy Users By Sectoral 51
2.5.1 Industry Sector 51
2.5.2 Agriculture Sector 52
2.5.3 Service Sector 53
2.5.4 Residential Sector 55
2.6 The Relationship Between Economic Growth and Energy Consumption 56
2.6.1 Growth Hypothesis 58
2.6.2 Conservation Hypothesis 59
2.6.3 Feedback Hypothesis 61

2.6.4 Neutrality Hypothesis 62
2.7 The Relationship Between Economy Growth and CO_2 emissions.................. 73
2.8 The Relationship Between Economic Growth, Energy Consumption and CO_2 Emissions 82
2.8.1 The Causality Linkage Between Economy Growth and Energy Consumption in Multivariate Modelling... 85
2.8.2 The Causality Linkage Between Energy Consumption and CO_2 Emissions in Multivariate Modelling.. 88
2.8.3 The Causality Linkage Between Economic Growth and CO_2 Emission In Multivariate Modelling 89

CHAPTER THREE DATA AND METHODOLOGY 109
3.1 Introduction 109
3.2 Data Collection and Operational Variables.. 109
3.3 Model Specification and Hypotheses 112
3.3.1 T............he Role of Economic Growth on Final Energy Consumption in Indonesia 113
3.3.2 The Role of Final Energy Consumption on Economic Growth in Indonesia 114
3.3.3 The Causality Relationship Between Final Energy Consumption, Economic Growth, and CO_2 Emission in Four Energy User Sectors in Indonesia 116
3.4 Measurement Procedures 120
3.4.1 Autoregressive Distributed Lag... 121
3.4.2 Granger Causality Test... 125
3.5 Flow Chart of Analysis Process 125

CHAPTER FOUR RESULTS AND DISCUSSION 127
4.1 Introduction 127
4.2 The Role of Economic Growth on Final Energy Consumption in Indonesia.... 127
4.3 The Role of Final Energy Consumption on Economic Growth in Indonesia.... 133
4.4 The Causality Linkage Between Final Energy Consumption, Economic Growth and CO_2 Emission in Four Energy User Sectors in Indonesia. 139
4.4.1 Analysis for Industry Sector 139
4.4.2 Analysis for Agriculture Sector 148
4.4.3 Analysis for Service Sector. 156
4.4.4 Analysis for Residential Sector.. 164
4.5 Summary of Analysis Findings 172
4.5.1 The Role of Economic Growth on Final Energy Consumption in Indonesia 172
4.5.2 The Role of Final Energy Consumption on Economic Growth in Indonesia 174
4.5.3 The causality relationship between final energy consumption, economic growth and CO_2 emissions on four final energy user sectors in Indonesia. 175
4.5.3.1 Summary of analysis on the industry sector 175

4.5.3.2 Summary of analysis on the agriculture sector. 177
4.5.3.3 Summary of empirical findings on the service sector. 178
4.5.3.4 Summary of analysis on the residential sector.................... 180

CHAPTER FIVE DISCUSSION AND CONCLUSION.................................. 182
5.1 Introduction 182
5.2 Discusion of Findings 182
5.2.1 The role of economic growth on final energy consumption in Indonesia. 182
5.2.2 The role of final energy consumption on economic growth in Indonesia. 185
5.2.3 The causality relationship between final energy consumption, economic growth and CO_2 emissions in the industry sector. 187
5.2.4 The causality relationship between final energy consumption, economic growth and CO_2 emissions in the agriculture sector. 188
5.2.5 The causality relationship between final energy consumption, economic growth and CO_2 emissions in the service sector............................... 189
5.2.6 The causality relationship between final energy consumption, economic growth and CO_2 emissions in the residential sector. 191
5.3 Contribution of Study 192
5.3.1 Contribution to Methodology 192
5.3.2 Contribution to Theory.. 193
5.3.3 Contribution to Final Energy Users 194
5.3.4 Contribution to Policymakers 194
5.4 Conclusions 195
5.5 Limitation and suggestion for future studies....................................... 197

REFERENCES 200

LIST OF TABLES

Table 1.1 Population, real GDP and real GDP per capita of Indonesia in 2004, 2009 and 2014. 12
Table 1.2 Total primary energy supply of Indonesia (in kilo tonnes of oil equivalent). 13
Table 1.3 Total final energy consumption of Indonesia by the category of energy users (in kilo tonnes of oil equivalent). 14
Table 1.4 Total final energy consumption in Indonesia by sources (in kilo tonnes of oil equivalent). 16
Table 1.5 Total CO_2 emissions from energy combustions in ASEAN countries (in Mt of CO_2). 17
Table 1.6 The amount of CO_2 emissions from fuel combustion by three development sectors and residential in Indonesia (Mt of CO_2). 18
Table 1.7 The composition of final energy consumption in Industry sector by products (in kilo tonnes of oil equivalent). 19
Table 1.8 The growth rate of value added in Industry sector by Industrial origin (in percent), 2011–2015. 20
Table 1.9 The composition of final energy consumption in agriculture sector by products (in kilo tonnes of oil equivalent). 22
Table 1.10 The growth rate of value added in agriculture sector by industrial origin (in percent), 2011–2015. 23
Table 1.11 The composition of final energy consumption in service sector by products (in kilo tonnes of oil equivalent). 24
Table 1.12 The growth rate of value-added in service sector by Industrial origin, 2011–2015 (in percent). 26
Table 1.13 The composition of final energy consumption in residential energy users by products in 2004, 2009 and 2014 (in kilo tonnes of oil equivalent). 28
Table 2.1 The summary of empirical studies about the relationship between economic growth and energy consumption in bivariate framework. 63
Table 2.2 The summary of empirical studies about the relationship between economic growth and CO_2 emissions. 80
Table 2.3 The summary of empirical studies about the causality relationship between energy consumption, economic growth, and CO_2 emissions in multivariate framework. 91
Table 3.1 Notation and description of operational variables. 110
Table 3.2 Hypotheses model 1 114
Table 3.3 Hypotheses Model 2 115
Table 3.4 Hypotheses Model 3 117
Table 3.5 Hypotheses Model 3. 118
Table 3.6 Hypotheses Model 5. 119
Table 3.7 Hypotheses Model 6. 120
Table 4.1 The result of unit root tests for the variables in model 1. 128
Table 4.2 The result of bound test for model 1. 129
Table 4.3 The result of diagnostics tests. 129
Table 4.4 The result of Chow test. 129
Table 4.5 The long-run coefficients of independent variables in model 1. 131

Table 4.6 The coefficients of short-run and error correction term in model 1. .. 132
Table 4.7 The results of Granger Causality test for model 1. 133
Table 4.8 The result of unit root tests for the variables in model 2. 134
Table 4.9 The result of bound test for model 2. 134
Table 4.10 The result of diagnostics tests.. 135
Table 4.11 The result of Chow test. 135
Table 4.12 The long-run coefficients of independent variables in model 2. 136
Table 4.13 The coefficients of short-run and error correction term in model 2. .. 137
Table 4.14 The results of Granger Causality test for model 2. 138
Table 4.15 The result of unit root tests for the variables in model 3. 140
Table 4.16 The result of bound test for model 3a, 3b, and 3c. 141
Table 4.17 The result of diagnostics tests.. 141
Table 4.18 The result of Chow test 142
Table 4.19 The long-run coefficients of independent variables in model 3a, 3b, and 3c. 145
Table 4.20 The coefficients of short-run and error correction term in model 3a, 3b, and 3c. 146
Table 4.21 The results of Granger Causality test for model 3a, 3b, and 3c. 147
Table 4.22 The result of unit root tests for the variables in model 4 148
Table 4.23 The result of bound test for model 4a, 4b, and 4c. 149
Table 4.24 The result of diagnostics tests.. 150
Table 4.25 The result of Chow test. 150
Table 4.26 The long-run coefficients of independent variables in model 4a, 4b, and 4c. 153
Table 4.27 The coefficients of short-run and error correction term in model 4a, 4b, and 4c. 154
Table 4.28 The results of Granger Causality test for model 4a, 4b, and 4c. 155
Table 4.29 The result of unit root tests for the variables in model 5. 156
Table 4.30 The result of bound test for model 5a, 5b, and 5c. 157
Table 4.31 The result of diagnostics tests.. 158
Table 4.32 The result of Chow test. 158
Table 4.33 The long-run coefficients of independent variables in model 5a, 5b, and 5c. 160
Table 4.34 The coefficients of short-run and error correction term in model 5a, 5b, and 5c. 161
Table 4.35 The results of Granger Causality test for model 5a, 5b, and 5c. 163
Table 4.36 The result of unit root tests for the variables in model 6. 164
Table 4.37 The result of bound test for model 6a, 6b, and 6c. 165
Table 4.38 The result of diagnostics tests.. 166
Table 4.39 The result of Chow test. 166
Table 4.40 The long-run coefficients in model 6a, 6b, and 6c. 169
Table 4.41 The coefficients of short-run and error correction term in model 6a, 6b, and 6c. 170
Table 4.42 The results of Granger Causality test for model 6a, 6b, and 6c. 171
Table 4.43 Summary of analysis the role of economic growth on final energy consumption in Indonesia... 173
Table 4.44 Summary of analysis the role of final energy consumption on economic growth of Indonesia. 175

Table 4.45 The summary of analysis the causality relationship between final energy consumption, economic growth and CO_2 emission in the industry sector........ 177
Table 4.46 The summary of analysis the causality relationship between final energy consumption, economic growth and CO_2 emission in the agriculture sector. 178
Table 4.47 The summary of analysis the causality relationship between final energy consumption, economic growth and CO_2 emission in the service sector. 179
Table 4.48 The summary of analysis the causality relationship between final energy consumption, economic growth and CO_2 emission in the residential sector. 181

LIST OF FIGURES

Figure 1.1 The linked between the development sectors and final energy users 5
Figure 2.1 The Environment Kuznets Curve (EKC) 76
Figure 3.1 Empirical Model 1. 113
Figure 3.2 Empirical Model 2 115
Figure 3.3 Emprical Model 3 116
Figure 3.4 Empirical Model 4. 117
Figure 3.5 Empirical Model 5. 118
Figure 3.6 Empirical Model 6. 119
Figure 3.7 Flow Chart Analysis Process 126
Figure 4.1 The plots of CUSUM and CUSUM of squared model 1. 130
Figure 4.2 The plots of CUSUM and CUSUM of squared model 2. 136
Figure 4.3 The plots of CUSUM and CUSUM of squared model 3a. 143
Figure 4.4 The plots of CUSUM and CUSUM of squared model 3b. 143
Figure 4.5 The plots of CUSUM and CUSUM of squared model 3c. 144
Figure 4.6 The plots of CUSUM and CUSUM of squared model 4a. 151
Figure 4.7 The plots of CUSUM and CUSUM of squared model 4b. 151
Figure 4.8 The plots of CUSUM and CUSUM of squared model 4c. 152
Figure 4.9 The plots of CUSUM and CUSUM of squared model 5a. 159
Figure 4.10 The plots of CUSUM and CUSUM of squared model 5b. 159
Figure 4.11 The plots of CUSUM and CUSUM of squared model 5c. 160
Figure 4.12 The plots of CUSUM and CUSUM of squared model 6a. 167
Figure 4.13 The plots of CUSUM and CUSUM of squared model 6b. 168
Figure 4.14 The plots of CUSUM and CUSUM of squared model 6c. 168

LIST OF APPENDICES

Appendix A The amount of final energy consumptions in Indonesia (in thousand tonnes of oil equivalent), 1971-2014 238
Appendix B The amount of CO2 emissions from energy combustion in Indonesia (in millions of CO2), 1971-2014 240
Appendix C The real GDP, the real GDP per capita and the value added of three main development sectors in Indonesia (in millions of USD at 2010 constant price), 1971-2014.. 242
Appendix D Estimation Model 1 244
Appendix E Estimation Model 2 250
Appendix F Estimation Model 3a 256
Appendix G Estimation Model 3b 260
Appendix H Estimation Model 3c 265
Appendix I Estimation Model 4a 269
Appendix J Estimation Model 4b 273
Appendix K Estimation Model 4c 278
Appendix L Estimation Model 5a 282
Appendix M Estimation Model 5b 287
Appendix N Estimation Model 5c 291
Appendix O Estimation Model 6a 295
Appendix P Estimation Model 6b 299
Appendix Q Estimation Model 6c 304

LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
APEC	Asia-Pacific Economic Cooperation
ARDL	Autoregressive Distributed Lag
ASEAN	Association of Southeast Asian Nations
AVA	Agricultural Value Added
BBO	Bruyn, Bergh and Opschoor
BEC	Biomass energy consumption
BRIC	Brazil, Russia, India and China
CEC	Commercial energy consumption
CO2	Carbon-dioxide emissions
CO2E	Carbon-dioxide emissions from energy consumption
CO2G	Carbon-dioxide emissions from natural gas consumption
CO2O	Carbon-dioxide emissions from oil consumption
COEC	Coal energy consumption
CP	Consumer prices
CUSUM	Cumulative sum
CUSUMSq	Cumulative sum of square
DOLS	Dynamic Ordinary Least Square
EC	Energy consumption
ECM	Error correction model
ECT	Error correction term
EEC	Electricity energy consumption
EG	Engle-Granger
EKC	Environment Kuznet Curve
EMP	Employment
EXP	Export
FD	Financial Development
FDI	Foreign Direct Investment
FEC	Fossil energy consumption
FMOLS	Fully Modified Ordinary Least Squares
G6	France, West Germany, Italy, Japan, the United Kingdom and the U.S
GCF	Gross Capital Formation
GDP	Gross Domestic Product
GDP2	Square of Gross Domestic Product
GDPP	Gross Domestic Product per capita
GDPP2	Square of Gross Domestic Product per capita
GEC	Natural gas energy consumption
GFCF	Gross Fixed Capital Formation
GH	Gregory and Hansen cointegration test
GHG	Greenhouse Gasses
GMM	Generalized method of moments
GNI	Gross National Income
GNP	Gross National Product
IEA	International Energy Agency
IRF	Impulse Response Function

ISIC	International Standard Industrial Classification
IVA	Industrial Value Added
JJ	Johansen Juselius cointegration test
JMC	Johansen Multivariate Cointegration Test
LF	Labour Force
LPR	Labour Participation Rate
MPR	Monetary Policy Rate
NFC	Non-Fossil Consumption
NIC	Newly Industrialized Countries
OEC	Oil/petroleum oil consumption
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
OPEC	Organisation of the Petroleum Exporting Countries
PECM	Panel Error Correction Model
PGMM	Panel Generalized Method of Moments
PP	Phillips-Perron
PVAR	Panel Vector Autoregressive
PVECM	Panel Vector Error Correction Model
REC	Renewable Energy Consumption
SIC	Schwarz Information Criterion
SMC	Stock Market Capitalization
ST	Stock Trade/Turnover
TC	Total Credit
TI	Technology Innovation
TR	Trade Openness
TY	Toda Yamamoto Causality Test
URB	Urbanization
VAR	Vector Autoregressive
VDC	Forecast Error Variance Decomposition
VECM	Vector Error Correction Model
WDI	World Development Indicator

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter provides a general overview of the study that consists of seven main sections. The first section explains the background of study. The second section describes the problem statements. The research questions presented in section third and the research objectives described in section fourth. Section fifth discussed the significance of study. Section sixth presents the structure and content of this dissertation, while the last section describes the definition of operational variables that use in this study.

1.2 Background of Study

1.2.1 Energy, Economy and Environment Nexus

In the last two centuries, energy has a significant role in the evolution of civilization. Energy has become integral a part of human life for nearly all daily activities (Hindrichs & Kleinbach, 2012; Tiwari & Mishra, 2012). The utilization of energy has associated with the complexity of a particular socio-economic system. It is because of almost all human activities in a complex system which closely linked to the interaction of production, transformation, conversion, and consumption of energy (Javid & Sharif, 2016). Energy is an essential commodity that is indispensable in all economic activities and indirectly related to human well-being. Scarcity access to affordable and reliable modern energy sources represents a constraint to economic development and social development in many countries worldwide (Alshehry & Belloumi, 2015). Therefore, adequate modern energy supply has assumed as an essential prerequisite that must be achieved to reduce poverty and unemployment, encourage sustainable development and accelerate the achievement of millennium development targets (Wolde-Rufael, 2005; Yusuf, 2014).

As a key component that encourages sustainable development process in a nation, energy has been considered as an essential instrument that stimulating economic growth and accelerating development activities on all productive sectors (Aramcharoen & Mativenga, 2014). Adequacy energy supply is indispensable to improving the standard of living society, quality and quantity of human resources, commercial and business activities, environmental sustainability, and efficiency of government policy in a country (Birol, 2007; Hindrichs & Kleinbach, 2012; Saez-Martinez, Modejar-Jimenez, & Modejar-Jimenez, 2015). Therefore, it can be concluded that the availability of energy sources is the main pre-required that must be fulfilled by a country to advancing their economic welfare level.

Economic growth in a nation often considered directly proportional to the ability of domestic resources to supply energy resources. The rapid pace of economic growth in a country requires adequate sustain potential energy supply (Aryani, 2012; Maczulak, 2009). The growth of energy consumption will encourage economic activities and the development of new and renewable energy resources that accordance to necessity and lifestyle of the community (Reddy & Assenza, 2009). In other words, the growth of energy demand indirectly linked to any activities of the society in developed and developing countries. Even the increased consumption of fuels currently closely linked to the possible change of higher living standards on the world communities (Newton, 2013).

In the economic growth process, the role of energy as a global commodity is highly imperative. Energy has considered as an essential commodity in economic and development activities because production, distribution and consumption process are directly related to energy consumption (J Chontanawat, Hunt, & Pierse, 2006; Koutroumanidis, Ioannou, & Arabatzis, 2009; Yazdi & Shakouri, 2014). Energy gave a valuable contribution to economic growth and gradually replaced human strength in agricultural, industrial and service activities. Increased availability of energy services indirectly stimulates economic activities as long as society utilizing energy sources and adaptable with their necessaries appropriate with social and cultural characteristics (Reddy & Assenza, 2009).

The growth of energy consumption influenced by economic performance in a variety of ways, in which high energy consumption often associated with a higher income. At the aggregate level, the energy demand associated with economic activity due to economic growth and energy consumptions reflects similar trends (Fouquet, Pearson, Hawdon, Robinson, & Stevens, 1997; Hunt & Ninomiya, 2005; Rapanos & Polemis, 2006). The same view was also previously expressed by Medlock III and Soligo (2001) who revealed the impact of income per capita growth indirectly contributing to energy user activities as an increase in the proportion of total energy demand. Therefore, it can be concluded that if the financial capability of energy users increases, it will be able to give effect to the expenditure budget of energy users.

The linkage of energy with various development sectors will affect economic activities both on micro and macro levels. At the macro level, the energy will affect productivity on strategic economic sectors, which indirectly will affect to GDP of a country's. The availability of energy affect investment, and even the long-term availability of energy will also indirectly affect economic development and economic distribution. At the micro-level, the impact of energy issues will affect economic activities in smaller scopes, such as the trade activities in traditional markets, distribution of agricultural commodities and household necessaries, as well as expenditures on commercial and public services (Esmaeili, Hasan-gholipour, & Jamalmanesh, 2012).

Any countries around the world have several characteristics which distinguish them from other countries, such as availability of domestic energy reserves, the growth rate of energy demand, the structure of economic development, society lifestyles, welfare level, etc. Individually, they have several categories of final energy users that certainly have different activity and necessity levels toward final energy products. The International Energy Agency (IEA) classified final energy users into seven categories based ISIC version 3 (United Nations, 2008) which consist of Industry, transport, commercial and public services, fishery, agriculture/forestry, residential, and non-specific user. As energy user, they generated CO_2 emissions from energy combustion, and hence they also classified as a producer of CO_2 emissions in a country's.

The performance of economic growth in a country associated with the growth pace of value-added that contributed by all development sectors to the real GDP of a country. The World Bank within the World Development Indicator (WDI) grouped the development sectors in a country into three main sectors, i.e. industry sector, agriculture sector, and service sector. These three development sectors are classified based on the criteria of industrial origins on ISIC version 3 (United Nations, 2008). These productive sectors are consists of one or more the category of final energy users (figure 1.1). Therefore, the sustainability of the supply of final energy sources for these development sectors is one of the fundamental factors that influence sustainability economic growth in a country's.

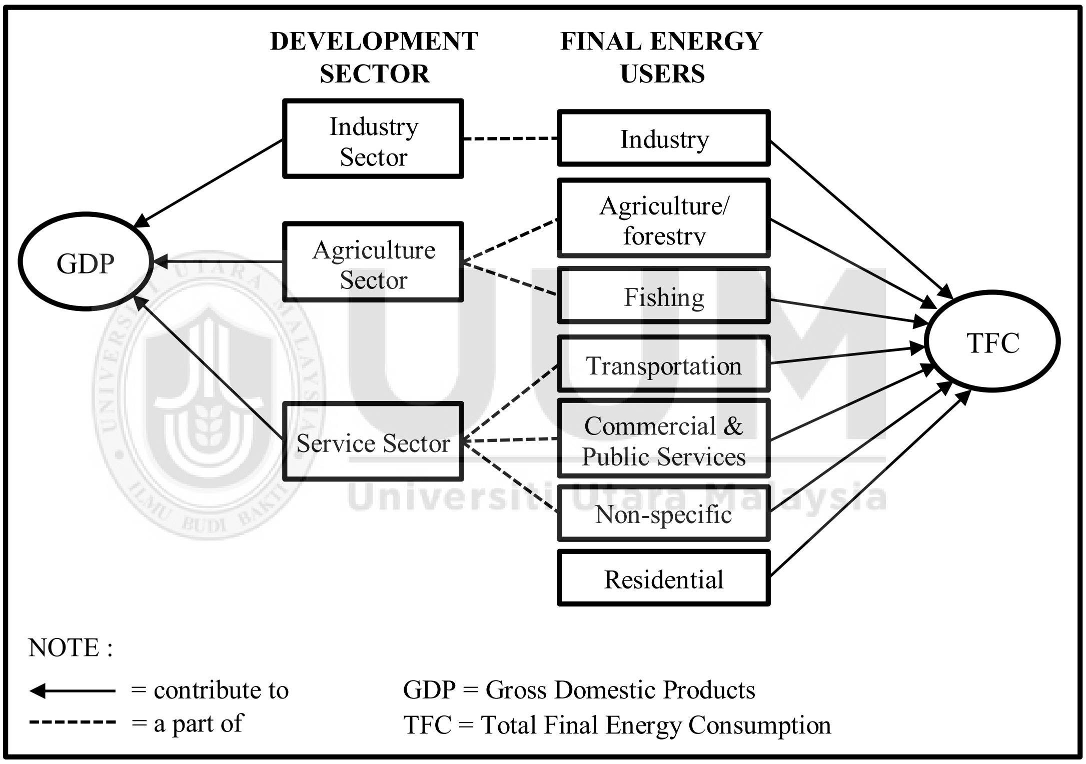


Figure 1.1 The linked between the development sectors and final energy users

Sustainability of economic growth often associated with increasing levels of energy usage as well as an increase several potential emission gasses that endangering environmental security and lead to global climate change (Asimakopoulos et al., 2011; Sovacool, 2013). One essential factor that causes the rising of CO_2 emissions is the expansion of economic activities which is not considering this effect toward the environmental quality. As a result of the economic growth process, accelerate environmental degradation and climate change (Oktavilia & Firmansyah, 2016; Omri, Daly, Rault, & Chaibi, 2015). These conditions provide a detrimental effect on society and sustainable development process in a region. Furthermore, environmental deterioration has not only associated with the quality and welfare of human life but rather a more serious issue involving decreased productivity on economic development and induce social anxiety in society (Azam, Khan, Abdullah, & Qureshi, 2016).

The CO_2 emissions are mostly generating from fossil energy combustions and commonly utilized for automobile machines and industrial equipment which indirectly associated with the economic and development activities in a country (Kasman & Duman, 2015; Yazdi & Shakouri, 2014). Increased fossil fuel consumptions since the beginning of industrial era have been gradually increasing the CO_2 concentration in the atmosphere and rising global temperatures, even lead to the melting of polar ice caps and rising sea levels are higher (Hindrichs & Kleinbach, 2012; Kasman & Duman, 2015). The sustainability of fossil energy consumption in the developed and developing countries certainly will face multiple challenges in the future such as rising fuel prices, depletion of fossil reserves, global warming and climate change, instability geopolitical situation, etc (Tiwari & Mishra, 2012).

The deterioration and degradation of environmental quality have been reached an alarming level and indirectly stimulate serious concerns about climate change and global warming. The accelerate of economic growth on industrial countries impels raised intensively consumption of energy and other natural resources which indirectly propel increasing harmful residues and wastes that could lead to environmental degradation (Heidari, Turan Katircioğlu, & Saeidpour, 2015). Meanwhile, the energy shortage issue due to over-exploitation and abuse of fossil energy has been a serious concern in many countries throughout the current past decades. Climate change and energy security issues directly threaten the development process, environmental quality, and the existence of humankind. These issues have become the standpoint of many countries worldwide to concern address climate change, reduces CO_2 emissions and implement sustainable development stratagem (Fei, Dong, Xue, Liang, & Yang, 2011; Kaygusuz, 2009).

Many empirical studies asserted the importance of technological contributions and economic structural changes to inhibit the growth rate of CO_2 emissions gradually (Hassanien, Li, & Dong Lin, 2016; Yii & Geetha, 2017). The evolution of energy intensity is a determinant factor that gradually influences this condition and indirectly associated with the conversion efficiency process and changes in the energy mix (Kahia, Jebli, & Belloumi, 2019). Energy intensity appears as a critical issue, initially, since occurring oil crises in the 1970s and indirectly encourages the rise of a serious concern about the importance of energy conservation (Appiah, 2018; Qureshi, Rasli, & Zaman, 2015). As a consequence, depended economies toward oil fuels has gradually changed with the implementation of new innovation that effectively diminishes energy-intensity per unit output and the capability improvement in the service sector with simplification on the productive structure (Aminu, Meenagh, & Minford, 2018; Erahman, Purwanto, Sudibandriyo, & Hidayatno, 2016).

The modernization in fuel-mix changes closely linked with the advancement of technological innovations and the availability of sufficient infrastructure

(Deendarlianto et al., 2017; Oh, Hasanuzzaman, Selvaraj, Teo, & Chua, 2018). The capability of production potentially improved when efficient technologies started to apply in the production process and certainly drive more output generated from the same quantity of energy (Kusumadewi & Limmeechokchai, 2015). In other words, decrease energy intensity gradually due to an increase in the use of new technology has indirectly provided benefit and net cumulative effect to outcome (Dogan & Ozturk, 2017; Omri et al., 2015). Nevertheless, energy intensity change is not common occurred in a country and maybe because there are consequences that must be faced when energy intensity diminished. Therefore the role of policies and regulations are needed to control intensity fossil energy use and motivated accelerate green technology development (Cicea, Marinescu, Popa, & Dobrin, 2014; Lin & Abudu, 2019).

The policymaker's willingness to implement strict environmental regulations are considered an essential factor that is controlling environment degradation (Dasgupta, Hong, Laplante, & Mamingi, 2006; Linh & Lin, 2015). The policymakers expected to remind correctly to society to improve public awareness regarding effect environmental degradation, especially when their income level grows (Chen, Chen, Hsu, & Chen, 2016). In this standpoint, economic growth is an essential requirement to control pollution. it does not only need adequate condition alone but also needs supporting better environmental quality which only can be achieved when supported with strict government policies, involvement social institutions, as well as the functioning and completeness of markets (Al-mulali, Tang, & Ozturk, 2015; Ojewumi & Akinlo, 2017). Nevertheless, in practice difficult to precisely appraise the effectiveness of government regulations and policies in a country's in terms of deciding appropriate strategy regarding the impact of economic development on environmental degradation.

Sustainable economic growth allows a suitable condition to improve environmental quality and governance institutions have the lawful authority to determining regulations and collected information related pollution or emission that allows local societies to applied a greater standard of environmental quality (Arroyo & Migue, 2019; Bimanatya & Widodo, 2017). Nevertheless, mostly regulation made by the policymakers is a periodic regulation, because the authority of government restricted by the political system and elected only for certain periods. Due to expensive political cost, this condition indirectly dissuades the government in imposing environmental regulations that can be continuing protecting environment and society from market distress which certainly creates long-term effects (Ansuategi & Escapa, 2002; Reddy & Assenza, 2009).

Sustainability of energy security, economic growth and environmental quality influenced by various determinants, including policy regulation, adequate infrastructure support, availability of technological innovations, as well as a stable social and geopolitical situation (Kanitkar, Banerjee, & Jayaraman, 2015; Tongsopit, Kittner, Chang, Aksornkij, & Wangjiraniran, 2016; Zaman & Moemen, 2017). Implementation of policy and regulation, on the one hand, needs to consider the conditions faced and certainly require well-organised evidence as a reference for determining the right policy (Auld & Gulbrandsen, 2013). While on the other hand, the application of regulations must take into account the diversity of existing phenomena and therefore a deeper approach is required to explore the differences that occur (Kusumadewi & Limmeechokchai, 2015). These standpoints then propel required an extensive investigation regarding the causal linkage among economic growth, energy consumption and CO_2 emissions in a country (Sasana & Aminata, 2019; Sugiawan & Managi, 2016).

Most economic activities and development process requires reliable and quality information to facilitate and improves the decision-making process. Information about energy has been valuable input which very essential on decision-making, especially for government, stakeholder and society. Historical analysis is a prerequisite in the decision-making process and conducted to obtain an accurate forecast and projection about future challenges and issues (Bhattacharyya, 2011). Among all energy information, energy balance reports afford a lot of information that illustrates the energy situation periodically for a country and usually employed as a comparison instrument with other countries. Specifically, energy balance provides detail information about the growth of final energy consumption by category of energy users which consist of different development sectors in a country.

Among the previous studies that explore energy and economic nexus, Zachariadis (2006, 2007) discussed methodology issues in the energy-economics literature studies. He applied different methods of Granger causality test and considering used the aggregate and disaggregate level of energy and economic indicators to explore energy-economic nexus in US and Germany (Zachariadis, 2006) and for the case in G7 countries (Zachariadis, 2007). He found that real GDP has a different linkage toward the primary and final energy consumption for the case in Canada and Germany. Moreover, he also discovered different empirical findings when used the different approach of Granger causality test. In particular, his studies revealed the different linkage between energy-economic indicators on four energy user categories (industry, residential, services, and transport). Based on his findings, it can be assumed that the link of energy consumption and economic growth on each category of energy user in a country probably are different.

Diversity of the category of energy users should be considered as a determinant factor in establishing an appropriate strategy, policy, and regulation in a country. The completeness of information and evidence relating to the existing diversity required for compiling sustainable development plans in a country. Therefore, an in-depth investigation related to the linkage between energy consumption, economic development, and CO_2 emissions in a country should be specifically developed within a sectoral approach. At least provide a complex reference for the policymakers and expected proffer valuable implication on scientific literature that discusses energy, economic, and environment issues.

1.2.2 Overview of Indonesia

Indonesia is the fourth most populous country in the world and an archipelago country which consist of more than 17,000 islands, so providing geographical challenges in terms of equalization of energy supply (Energy Information Administration, 2015; Handayani & Ariyanti, 2019). According to world development indicators (World Bank, 2015), the number population of Indonesia increased by 1.31 per cent annually from 1995 to 2015 and since 2011 more than half Indonesian people living in the urban area. Based on Indonesia population projection publication year 2010-2045 (Statistics Indonesia-Bappenas, 2014), Indonesia population growth predicted will be above 1%

annually throughout 2015-2020, decline to below 1 per cent annually over 2020-2040 and then below 0.5 per cent annually after 2040.

Table 1.1
Population, real GDP and real GDP per capita of Indonesia in 2004, 2009 and 2014.

Indicators	2004	2009	2014
Total Population[(a)]	223.27	238.47	254.45
• Urban population[(a)]	100.79	117.14	134.87
• Rural population[(a)]	122.47	121.32	119.59
GDP[(b)]	540.44	710.85	942.34
• Industry[(b)]	250.05	307.85	393.57
• Agriculture[(b)]	85.30	102.11	124.20
• Services[(b)]	195.18	283.23	401.07
GDP per capita[(c)]	2,420.58	2,980.95	3,703.37

Source : World Development Indicators (World Bank, 2015).
Note : [(a)] in million of people
[(b)] in billion of constant 2010 USD.
[(c)] in constant 2010 USD

Population growth profoundly influenced by the amount and composition of energy demand, both directly and indirectly, also given a significant impact on economic growth. From 2004 to 2014, the real GDP of Indonesia increased by approximately 5.72 per cent annually, while the real GDP per capita of Indonesia increased by 4.33 per cent annually. The real GDP of Indonesia dominated by the value-added of the service sector and the industry sector. These sectors respectively contributed 40 per cent of total real GDP of Indonesia, while the agriculture sector only contributed less than 15 per cent of the total GDP of Indonesia annually (Table 1.1). This condition indicated that economic growth of Indonesia depended by the performance of industry sector and service sector than the agriculture sector.

Indonesia is one of the non-OECD countries which has quite large potential reserves of fossil and non-fossil energy resources in the world. The unrenewable energy resources in Indonesia consists of fossil energy resources such as petroleum, natural gas, coal, and uranium (nuclear). Meanwhile, renewable energy resources in Indonesia are consist of biomass, hydropower, geothermal, wind energy, and solar energy (Indrawan, Thapa, Wijaya, Ridwan, & Park, 2018; National Energy Council, 2019). Currently, Indonesia strives to attract more investment and provide sufficient domestic energy consumption in order to driven accelerate economic growth (Energy Information Administration, 2015). Inadequate infrastructure and a complex regulatory environment have been a critical issue which should be faced by Indonesia currently (Erahman et al., 2016).

Table 1.2
Total primary energy supply of Indonesia (in kilo tonnes of oil equivalent).

Indicators	2004	2009	2014
Production	264,768	350,816	449,348
Imports	42,643	38,918	57,112
Exports	-130,662	-190,635	-280,563
International marine bunkers	-132	-167	-221
International aviation bunkers	-484	-635	-843
Stock changes	0	440	-6
TPES	176,134	198,738	224,826

Source: International Energy Agency (2016).

Indonesia's socio-economics activities indirectly influenced by the availability of final energy products as one of the essential input for any development activities in Indonesia. According to the International Energy Agency (2016), Indonesia’s primary energy production was increased by 69.71 per cent or approximately 5.51 per cent annually during the period of 2004-2014. In the same periods, Indonesia exported energy increased by 114.72 per cent, and Indonesia imported energy increased by 33.93 per cent (see table 1.2). Among the type of energy resources, coal was the most exported commodities, while natural gas, crude oil, and oil products were the highest imported commodities. In 2014, Indonesia's energy exports reached 62.44% of total energy production, while Indonesia's energy imports reached 12.71% of total primary energy supply. Overall, Indonesia primary energy supply was raised 27.64 per cent or 2.51 per cent annually from 2004 to 2014. These facts implied that Indonesia energy production grew gradually with fluctuation that possible occurring as a consequence unstable global economic situation during past years.

Table 1.3
Total final energy consumption of Indonesia by the category of energy users (in kilo tonnes of oil equivalent).

Category	2004	2009	2014
Industry	35,572	41,258	39,392
Transport	23,699	29,852	46,130
Residential	55,917	56,210	64,475
Commercial and public services	3,541	4,336	5,331
Agriculture/forestry	3,209	3,016	2,094
Non-specified	852	334	134
Non-energy use	9,590	10,094	7,708
Total	132,381	145,101	165,263

Source: International Energy Agency (2016).

Between 2004 and 2014, Indonesia's final energy consumption increased by 27.94 per cent or approximately 2.53 per cent annually (see table 1.3). More than a third of Indonesia's final energy consumption was consumed by residential, followed by transportation and industry, which respectively consumed more than a fourth of Indonesia's total final energy consumption. The category of commercial and public services as well as agriculture/forestry respectively only consumed approximately less than 5 per cent of total final energy consumption in Indonesia. While the lowest final energy consumer in Indonesia is a non-specific user that only consumed less than 1 per cent of total final energy consumption in Indonesia. These facts indicate that any category of energy users have differences quantity of final energy usage that consists of various type of final energy products.

Based on the type of final energy, most of Indonesia's final energy users consumed fuels, and more than half generated from fossil (Table 1.4). In 2014, the most type of final energy source that consumed by Indonesian final energy users was crude oil and oil products, followed by biofuels and wastes, electric power, as well as coal and coal products. Throughout 2004-2014, the growth rate of electricity consumption increased rapidly and even almost doubled (98.4%), the amount of natural gas consumption increased by 26.8%, the amount of crude oil and oil products increased by 24.9%, the amount consumption of biofuel and waste rose by 16%.

On the contrary, during the same periods, the amount of coal and coal products consumption declined slightly by 6.5%. The growth of electricity consumption in Indonesia driven by population growth and improvement of people's welfare in Indonesia and hence it is closely related to the rate of consumption growth in the residential sector. As commonly in developing countries, fuel consumption in Indonesia will continue to increase along with the economic growth in the industry sector and the services sector, especially the manufacturing industries.

Table 1.4
Total final energy consumption in Indonesia by sources (in kilo tonnes of oil equivalent).

Type of energy	2004	2009	2014
Coal and coal products	7,023	10,453	6,569
Crude oil and oil products	53,306	55.665	66,563
Natural gas	13,431	15,416	17,029
Biofuels and waste	50,012	51,867	58,022
Electricity	8,608	11,701	17,080
Total	132,381	145,101	165,263

Source: International Energy Agency (2016).

Population size, weak environmental control, and dependence most domestic energy users against fossil energy considered as several threats that caused the amount of CO_2 emissions in Indonesia increased gradually. According to the International Energy Agency (2016), Indonesia is the largest producer of CO_2 emissions from energy combustions in the Southeast Asia region throughout 2004-2014. During the period 2000-2014, the amount of CO_2 emissions from energy combustion in Indonesia increased gradually from 255.31 Mt of CO_2 to approximately 436.52 Mt of CO_2, even larger than other ASEAN countries (see Table 1.5). This condition shows that Indonesia currently facing severe environmental problems related to CO_2 emissions from energy use and is predicted to be sustainable if most of Indonesia's energy users are still dependent on energy sources from fossil and Indonesian policymakers did not determine appropriate strategy and regulation that concern to domestic environmental issues.

Table 1.5
Total CO_2 emissions from energy combustions in ASEAN countries (in Million tonnes of CO_2).

Country	2004	2009	2014
Brunei Darussalam	4.43	4.82	6.97
Cambodia	1.96	2.64	5.06
Indonesia	255.41	317.82	436.52
Malaysia	115.06	155.84	191.44
Myanmar	9.28	10.48	11.52
Philippines	68.13	71.50	80.39
Singapore	42.12	36.90	46.14
Thailand	152.29	200.20	238.96
Vietnam	44.24	79.23	127.18

Source : International Energy Agency (2016).

According to International Energy Agency (2016), more than a half of total CO_2 emissions from fuel combustion in Indonesia are generated by energy users in industrial category, followed by transport that contributed more than a fourth from the total number of CO_2 emissions from fuel combustion in Indonesia (see table 1.6). While, other categories such as residential, commercial and public services, agriculture/forestry and non-specific energy users in average only contributed less than a fifth of total CO_2 emissions from energy combustion in Indonesia. This situation indicates that the utilization of energy sources from fossil resources dominated by domestic energy users in the industry and transportation sectors. Therefore, important for Indonesian governance to provide more attention to this issue in order to establish economic development considering environment security and the sustainability of domestic energy resources.

Table 1.6
The amount of CO_2 emissions from fuel combustion by three development sectors and residential in Indonesia (Million tonnes of CO_2).

Category	2004	2009	2014
Industry	205.61	244.59	273.47
Agriculture	8.74	9.19	5.83
Service	77.14	106.05	137.63
Residential	27.04	16.91	19.59
Total	318.53	376.74	436.52

Source: International Energy Agency, 2016. Online database.
Note : The category of service sector is consist of commercial and public services, transportation and non-specified energy users.

1.2.3 Overviews of Industry Sector in Indonesia

The industry sector is the third-largest consumer of final energy products in Indonesia after the residential and service sector. The category of final energy users in the industry sector classified into one group by the International Energy Agency (IEA). Annually, this sector average consumed a fourth of the total final energy consumption in Indonesia. This sector is the largest consumer of natural gas and coal products in Indonesia (see table 1.7). Annually, this sector consumed more than 98 per cent of the total final energy consumption from natural gas and coal products in Indonesia. During the periods of 2004-2014, total final energy consumption in industry sector was increased about 7,943 Ktoe or 22.33 per cent, from 35,575 ktoe to 43,518 ktoe. In 2014, the most of final energy product that consumed by energy user in this sector is natural gas product (29.58 per cent), followed consecutively by oil product (24.65 per cent), coal product (17.57 per cent), biofuels and waste (15.17 per cent), and electric power (13.02 per cent).

Table 1.7
The composition of final energy consumption in Industry sector by products (in kilo tonnes of oil equivalent).

Final energy Products	2004	2009	2014	Growth (%) 2004-2014
Coal	7,023	10,453	7,648	8.90%
Oil products	11,385	10,114	10,726	-5.79%
Natural gas	7,114	11,382	12,873	80.95%
Biofuels and waste	6,734	6,506	6,603	-1.95%
Electricity	3,318	4,016	5,667	70.80%
Total	35,575	42,470	43,518	22.33%

Source : International Energy Agency (IEA), 2016.

Among all final energy products, the consumption of natural gas and electricity product raised drastically throughout 2004-2014. Between 2004 and 2014, the total natural gas consumption increased 80.95 per cent or average approximately 9.82 per cent annually, while the total electric power consumption raised 70.80 per cent or average 5.57 per cent annually. During the same periods, the use of final energy products that generated from coal, crude oil, biofuels and waste by this sector had experienced fluctuation. Total consumption of coal products increased from 7.023 ktoe in 2004 to 10.453 ktoe in 2009 and then declined to 7.648 in 2014. Total consumption of oil products fall from 11.385 ktoe in 2004 to 10.114 ktoe in 2009 and then slightly raised to 10.726 ktoe in 2014. While the consumption of final energy products from biofuels and waste declined from 6,734 ktoe in 2004 to 6,506 ktoe in 2009 and then gradually increased to 6,603 ktoe in 2014.

The rising of final energy consumption from fossil fuels encouraged to increase CO_2 emissions from energy combustions in the Industry sector. Based on the annual report of the International Energy Agency (IEA), the Industry sector is the largest producer of CO_2 emissions from energy combustions in Indonesia and more than a half of

Indonesian CO_2 emissions from energy combustions generated by energy user on this sector. The amount of CO_2 emissions from energy combustions by energy users in the Industry sector increased by 33.00 per cent or approximately 3.34 per cent annually throughout 1990-2014. This fact implies that the utilization of final energy products from fuels by energy users in this sector had been a severe threat for environmental quality and a big challenge for the policymakers that related to this sector in the future.

Table 1.8
The growth rate of value added in Industry sector by Industrial origin (in percent), 2011–2015.

SUB-SECTORS	2011	2012	2013	2014	2015
Mining and Quarrying	4.29	3.02	2.53	0.72	-5.08
Manufacturing	6.26	5.62	4.37	4.61	4.25
Electricity and Gas	5.69	10.06	5.23	5.57	1.21
Water supply	4.73	3.34	3.32	5.87	7.17
Construction	9.02	6.56	6.11	6.97	6.65

Sources : Statistical Yearbook of Indonesia 2017, Indonesia Statistics.
Note : The growth rate at 2010 constant market prices, LCU.

The industry sector is the second largest contributor of value-added to the real GDP of Indonesia in 2014, i.e. approximately 41.90 per cent of the total GDP of Indonesia. During the periods of 2004-2014, the share of value-added by industry sector was increased 4.64 per cent annually, from 250,054 billion of US dollars to 393,567 billion of US dollars. According to Indonesia statistics (2016), the sub-sector of construction has the highest growth rates than other sub-sector in the Industry sector during the periods of 2011-2014, followed by manufacture industries, electricity and gas industries, water supply industries, as well as mining and quarrying industry. This condition illustrates that currently the construction and manufacture industries have been an essential role for economic development on Industry sector in Indonesia (Table 1.8)

1.2.4 Overviews of Agriculture Sector in Indonesia

The agriculture sector is the lowest consumer of final energy products in Indonesia. During the periods of 2000-2014, the average of final energy consumption by energy users in this sector is 2.17 per cent from total final energy consumption by all energy users in Indonesia annually. Based on the classification of energy users by IEA, the energy users in this sector is consist of two categories of energy users, i.e. agriculture/forestry and fishery. However, only the category of agriculture/forestry consumes final energy products in the agriculture sector. Moreover, energy users in this sector have only consumed two types of final energy products, i.e. oil fuels and electric power.

According to the annual report of IEA, total final energy consumption in this sector has dominated by the type of final energy from oil products. During the periods of 2000-2014, averages the share of oil product and electric power to total final energy consumption in this sector annually were 93.49 per cent and 6.51 per cent, respectively. Nevertheless, in the same periods, oil products have gradually diminished an average annually about 2.03 per cent, while the use of electric power has steadily increased average at 2.29 per cent annually (Table 1.9). This condition indicates that energy users in this sector are gradually reducing to consume final energy from oil products and begin to use electric power as the primary energy source on their activities.

Table 1.9
The composition of final energy consumption in agriculture sector by products (in kilo tonnes of oil equivalent).

Final Energy Products	2004	2009	2014	Growth (%) 2004-2014
Oil products	3,047	2,823	1,881	-38.27%
Electricity	162	193	212	30.86%
Total	3,209	3,016	2,094	-34.75%

Source : International Energy Agency (IEA), 2016.

In recent years, utilization oil fuels as a primary energy source by energy user in the agriculture sector gradually declined, and electric power has begun consumed in agricultural activities which certainly will influence the amount of CO_2 emissions from energy combustion in the agriculture sector. Based on annual data from IEA, this sector is the lowest producer of CO_2 emissions from energy combustion because this sector is the lowest consumer of final energy products. During the periods of 2000-2014, the amount of CO_2 emissions from energy combustion generated by final energy users in this sector decreased by 2.52 Mt of CO_2 or approximately 30.18 per cent. The average of CO_2 emissions from energy combustion by energy users in this sector has gradually declined by 2.52 per cent annually during the periods of 2000-2014. It potentially will continue to decline if most of the energy users in this sector diminishing the use of final energy from fossil sources such as crude oil, coal and natural gas.

The Agriculture sector is the lowest contributor value-added to the real GDP of Indonesia compared than the industry sector and the service sector. However, this sector is the largest absorber of labour in Indonesia and potentially to be one of the largest producers of agricultural commodities and biofuels in Asia. From 2004 to 2014, the value-added of the agriculture sector was increased approximately 3.83 per cent annually, from 85.29 billion of US dollar to 124.20 billion of US dollar. According to Indonesian Statistics (2016), the sub-sector of food crops is an agricultural sub-sector that experienced the highest growth rates in 2015, followed subsector of fishing and sub-sector of hunting and agricultural services (Table 1.10).

Table 1.10
The growth rate of value added in agriculture sector by industrial origin (in percent), 2011–2015.

SUB-SECTORS	2011	2012	2013	2014	2015
Agriculture, Livestock, Hunting and Agriculture Service	3.47	4.58	3.85	3.85	3.31
Food Crops.	-1,00	4.90	1.97	0.06	3.48
Horticultural Crops	8.77	-2.21	0.67	5.15	2.49
Plantation Crops	4.94	6.95	6.15	5.94	3.54
Livestock	4.80	4.97	5.08	5.52	3.09
Hunting and Agriculture services	3.83	6.07	5.91	2.95	3.87
Forestry & Logging	1.04	0.24	0.61	0.58	0.66
Fishing	7.65	6.29	7.24	7.35	8.37

Sources : Statistical Yearbook of Indonesia 2017, Indonesia Statistics.
Note : The growth rate at 2010 constant market prices, LCU.

1.2.5 Overviews of Service Sector in Indonesia

The service sector is the second-largest final energy consumer in Indonesia and the largest consumer of oil products in Indonesia. During the periods of 2004-2014, this sector annually consumed more than half of total oil products that consumed by all final energy users in Indonesia. Based on the classification of final energy users by IEA, final energy users in the service sector can be grouped into three final energy categories, i.e. transport, commercial and public services, and non-specific energy user. Among these categories, transportation energy users are the largest final energy users in this sector, followed commercial and public services and non-specific energy user. During periods of 2004-2014, total final energy consumption by energy user in this sector grew fastly and even more than doubled, from 1822 ktoe to 4179 ktoe or raised approximately 6.81 per cent annually.

Table 1.11
The composition of final energy consumption in service sector by products (in kilo tonnes of oil equivalent).

Final Energy Products	2004	2009	2014	Growth (%) 2004-2014
Oil products	26,032	29,087	47,361	81.93%
Natural gas	34	108	227	567.65%
Biofuels and waste	208	252	1,289	519.71%
Electricity	1,822	2,906	4,179	129.36%
Total	28,096	32,353	53,057	88.84%

Source : International Energy Agency (IEA), 2016.

In 2014, total final energy consumption by energy user in the service sector dominated by oil products (89.26 per cent), which consecutively followed by electric power (7.88 per cent), biofuels and waste products (2.43 per cent), and natural gas products (0.43 per cent). From 2004 to 2014, total oil consumption by energy users in this sector has grown significantly, increased by 81.93 per cent or approximately 6.46 per cent annually. Nevertheless, another final energy products that also consumed by energy users in this sector raised more drastically. During the same periods, the total consumption of electric power increased more than doubled, while the total consumption of final energy products generated from natural gas, biofuels and waste raised more than five times (Table 1.11). Increased consumption of biofuels and waste at least implied that transportation energy users are beginning to use biofuels as a substitute for oil fuels.

A drastically increased the consumption of oil products in this sector certainly propel increased the amount of CO_2 emissions from energy combustion by energy users in this sector. According to IEA, the service sector is the second largest contributor of CO_2 emissions from energy combustions in Indonesia. In recent years this sector contributed more than a quarter of total CO_2 emission from energy combustion in Indonesia annually. During periods of 2004-2014, the amount of CO_2 emissions from energy combustions in this sector increased by 78.42 per cent or approximately 6 per cent annually. A larger increased the amount of CO_2 emissions from energy combustion certainly would be a serious threat to sustainable development in this sector.

The services sector is the largest contributor of value-added to the real GDP of Indonesia in 2014, i.e. 42.25 per cent of the total GDP of Indonesia. The share of value-added by services sector on the real GDP of Indonesia increased more than doubled or approximately 105.49 per cent during the periods of 2004-2014, from 195.18 billion of US dollar to 401.07 billion of US dollar. This sector divided into 11 subsectors, i.e. accommodation and food service activities, human health and social work activities, retail trade and wholesale, repair of motorcycles and motor vehicles, information and communication, defence and public administration, compulsory social security, financial and insurance, transportation and storage; real estate activities, education; business activities, and other services activities. According to Indonesia statistics (2016), the subsector of information and communication has the highest growth rate in 2014, followed by the subsector of business activities, the subsector of other services activities, the subsector of human health and social work activities, etc (Table 1.12).

Table 1.12
The growth rate of value-added in service sector by Industrial origin, 2011–2015 (in percent).

SUB-SECTORS	2011	2012	2013	2014	2015
Wholesale and Retail Trade, Repair of Motor Vehicles and Motorcycles	9.66	5.40	4.81	5.16	2.47
Transportation and Storage	8.31	7.11	6.97	7.36	6.68
Accommodation and Food Service Activities	6.86	6.64	6.80	5.77	4.36
Information and Communication	10.02	12.28	10.39	10.10	10.06
Financial and Insurance	6.97	9.54	8.76	4.68	8.53
Real Estate Activities	7.68	7.41	6.54	5.00	4.82
Business Activities	9.24	7.44	7.91	9.81	7.69
Public Administration and Defence; Compulsory Social Security	6.43	2.13	2.56	2.38	4.75
Education	6.68	8.22	7.44	5.55	7.45
Human Health and Social Work	9.25	7.97	7.96	7.96	7.10
Other Services Activities	8.22	5.76	6.40	8.93	8.08

Sources : Statistical Yearbook of Indonesia 2017, Indonesia Statistics.
Note : The growth rate at 2010 constant market prices.

1.2.6 Overviews of Residential Sector in Indonesia

The category of residential energy users is the largest consumer of final energy in Indonesia. Residential energy users can be divided into two groups, i.e. urban residents and rural residents. The disparity in income level, population growth, and lifestyle between urban residents and rural residents indirectly influenced the amount and composition of final energy consumption in both areas. During the periods of 2004-2014, The amount consumption of final energy by residential energy users in Indonesia increased 6,945 Ktoe or approximately 1.21 per cent annually (Table 1.13). In 2014, total final energy consumption by residential energy users dominated by biofuels and waste (76.26 per cent), followed by oil fuels (11.91 per cent), electric power (11.80 per cent) and natural gas (0.03 per cent).

During the periods of 2004-2014, the amount consumption of electricity by residential energy users increased more than doubled or approximately 112.34 per cent or average 7.85 per cent annually, while the amount consumption of biofuels and waste by residential energy users raised 12.80 per cent or roughly 1.23 per cent annually. Meanwhile, the amount consumption of oil fuels by residential energy users declined approximately 23,26 per cent or average 2.36 per cent annually and the amount of natural gas consumption by residential, although fluctuated, was insignificantly changed between 2004 and 2014. These conditions implied that residential energy users in Indonesia have begun to reduce their dependence on fossil fuels and gradually consume final energy products from non-fossil sources that more efficient and low emissions.

The substitution process from fossil energy sources to non-fossil energy sources in residential indirectly reduces the amount of CO_2 emission from energy combustion by residential energy users in Indonesia. According to the International Energy Agency, residential energy users is the second-lowest CO_2 emission producer from energy combustion in Indonesia. During the period of 2004-2014, the amount of CO_2 emission from energy combustion by energy users in residential was declined approximately 30.92 per cent, from 28.36 Mt of CO_2 to 19.59 Mt of CO_2 (Table 1.13). This condition implied that although the real GDP per capita and residential final energy consumption in Indonesia raised annually, the amount of CO_2 emission from energy combustion in residential precisely declined. Another word, economic growth progress gives a positive role and motivate the community to aware importance improvement environment quality.

Table 1.13
The composition of final energy consumption in residential energy users by products in 2004, 2009 and 2014 (in kilo tonnes of oil equivalent).

Final energy Products	2004	2009	2014	Growth (%) 2004-2014
Oil products	9,523	6,496	7,308	-23.26%
Natural gas	16	18	16	0.00%
Biofuels and waste	42,551	43,840	47,998	12.80%
Electricity	3,305	4,583	7,018	112.34%
Total**	55,395	54,937	62,340	12.54%

Source : International Energy Agency (IEA), 2016.

1.3 Problem Statement

1.3.1 Issue from Previous Studies in Indonesia

Over three decades, the causal linkage between energy consumption and economic development has been widely investigating and analyzing by many scientists (Chiou-Wei, Chen, & Zhu, 2008). Those studies produced various empirical findings which mostly showed different results. The difference of empirical findings on previous studies occurred probably caused the diversity of analysis method, data series, indicator, and characteristics of the region observed (Apergis & Tang, 2013; Ozturk, 2010; Shahbaz & Lean, 2012). The appropriate information and valuable knowledge about the direction of energy-economic nexus have perceived as an essential prerequisite on establishing the standpoint of theory, policy, and regulations related to energy and economy in a country (Ghali & El-Sakka, 2004; Omri, 2014).

The energy-economic nexus has widely studied by scientists and commonly examined under a bivariate approach which only uses two indicators which respectively representing the indicator of energy consumption and economic development for a country or a group of countries. However, this approach has a few limitations that need further study. First, this approach does not take into consideration that economic growth in a country affected by the performance of development sectors. Secondly, this approach also does not consider different type, composition, and quantity of energy consumed by development sectors nor residential. Generally, previous studies that investigated energy-economic nexus determined and concluded their empirical findings under four hypotheses, i.e. growth, conservation, feedback, and neutrality.

The growth hypothesis asserted that energy source is an essential input that drives the accelerate process of economic growth and hence the availability of adequate energy services is a critical factor that influences the sustainability of economic growth progress in a region. The conservation hypothesis implied that economic growth process stimulated increasing energy consumption and hence improvement economic performance will directly drive the growth of energy consumption in a country's or region. The feedback hypothesis expressed that energy consumption and economic growth has a mutual linkage or cause-effect relationship. Furthermore, the neutral hypothesis confirmed that energy consumption and economic growth in a country did not have interrelationship each other.

The energy-economics nexus in Indonesia has investigated by several researchers and generating various empirical evidence under four hypotheses, i.e. growth hypothesis (Asafu-Adjaye, 2000; Chandran & Tang, 2013; Soares, Kim, & Heo, 2014; Wahid, Azlina, & Mustapa, 2013), conservation hypothesis (Azam, Khan, Bakhtyar, & Emirullah, 2015; Azam, Khan, Zaman, & Ahmad, 2015; Hwang & Yoo, 2012), feedback hypothesis (Chiou-Wei et al., 2008; Mahadevan & Asafu-Adjaye, 2007), and neutrality hypothesis (Fatai, Oxley, & Scrimgeour, 2004; Saboori & Sulaiman, 2013;

Shahbaz, Hye, Tiwari, & Leitão, 2013; Soytas & Sari, 2003; Yildirim, Sukruoglu, & Aslan, 2014). Diversity of empirical findings from these studies certainly did not appropriate to be a reference for the policymakers in Indonesia. Moreover, there are no empirical studies that applied a multivariate approach to explore the linkage between energy consumption and economic development in Indonesia, specifically associated with several groups of final energy users in Indonesia.

Many scientists have widely studied the impact of economic growth toward environmental degradation, and one theory approach that commonly discussed is the Environment Kuznets Curve (EKC) hypothesis. This approach used real income (or real GDP) and real income squared (or squared of real GDP) to examines whether economic growth has a reversal effect and reduce environmental emissions in a region (Al-Mulali, Ozturk, & Solarin, 2016; Ozturk, Al-Mulali, & Saboori, 2015; Shahbaz, Arouri, Onchang, Islam, & Teulon, 2014). This theory confirmed that income or real GDP in a region would be caused increase CO_2 emissions since the beginning of economic growth process, but then potentially reduce CO_2 emissions after income or real GDP has achieved a certain level of economic growth.

Since applied energy conservation, most of EKC studies implies a positive link among economic development, CO_2 emission, and energy consumption (Luzzati & Orsini, 2009; Richmond & Kaufmann, 2006). This reinforces the empirical fact that a rise of energy consumption is prerequisite and complement of economic development, but in another side, dependence several countries toward fossil energy indirectly propel increase CO_2 emissions that harmful for environmental and humankind (Ang, 2007, 2008; Hamilton & Turton, 2002; Marrero, 2010). Therefore, decrement energy consumption that aims to reduce CO_2 emissions certainly afford a negative effect on economic growth (Jaruwan Chontanawat, Hunt, & Pierse, 2008). Therefore, it is necessary to consider further whether energy policy reforms that aimed at reducing CO_2 emissions obstructed sustainable economic growth.

The linkage between economic growth and CO_2 emissions in Indonesia investigated by some scientists such as Hwang & Yoo (2012), Shahbaz et al. (2013), Saboori & Sulaiman (2013), Wahid et al. (2013), and Chandran & Tang (2013). The evidence for a mutual linkage between real GDP and CO_2 emissions found by Saboori & Sulaiman (2013) and Shahbaz et al. (2013), while the evidence for a unidirectional linkage from GDP to CO_2 emissions found by Hwang & Yoo (2012), Wahid et al. (2013), and Chandran & Tang (2013).

Furthermore, the linkage between energy consumption and CO_2 emissions in Indonesia had discovered by some scientists. The evidence for bidirectional linkage between energy consumption and CO_2 emissions found by (Hwang & Yoo, 2012) and (Shahbaz et al., 2013). The evidence of a unidirectional linkage from CO_2 emissions to energy consumption has found by Chandran & Tang (2013), while the evidence of a unidirectional linkage from energy consumption to CO_2 emissions has found by (Saboori, Sulaiman, & Mohd (2012). Nevertheless, the study by Wahid et al. (2013) and Saboori & Sulaiman (2013) did not found a linkage between energy consumption and CO_2 emission in Indonesia.

Based on previous studies, author argues that difference empirical findings from previous studies regarding energy-economic nexus in Indonesia should be reinvestigate using the disaggregated approach that involved various energy user sectors. This approach expected to provide information about the effect of economic growth in a particular sector toward total Indonesia's energy consumption and also the impact of energy consumption in a particular sector toward economic growth in Indonesia. Furthermore, the causality relationship between energy consumption, economic growth and CO_2 emissions in Indonesia considered more appropriate if analysis by sectoral, so finally can revealed phenomena that are occurring on each energy user sectors in Indonesia.

1.3.2 Sectoral Issue in Indonesia

Since three decades ago, the share of value-added by the agriculture sector on the real GDP of Indonesia gradually decreased, and even Indonesia has been an importer country for several agriculture products. Modernization and utilize modern technology on various agriculture activities expected encourages economic growth in this sector. Nevertheless, most of agricultural machines consumed fuels which generating CO_2 emissions. A rise of CO_2 emissions from energy combustion certainly caused an adverse effect to productivity agriculture commodities and also assumed inhibiting the rate of economic growth in this sector. Overall, it can be concluded that modernization and utilize final energy sources in this sector have been an essential issue that linked with economic growth and environmental quality level in this sector.

The industry sector is the third-largest consumer of final energy products in Indonesia, after residential and services sector. Annually, this sector consumed a fourth of Indonesia's total final energy consumption and produces more than half of total CO_2 emissions from energy combustion in Indonesia. Almost all industrial activities in

Indonesia highly depend on the availability of final energy sources, especially fuels from fossil. The rapid of economic growth has been considered as an encouraging factor acceleration the growth of final energy consumption and CO_2 emissions from energy combustions in this sector.

The service sector is a development sector that consists of several categories of energy users such as transport, commercial and public services, and non-specific energy users. During the last two decades, this sector contributed value-added more than a third of Indonesia's real GDP. In this sector, transport energy users are the largest consumer of final energy sources and also the highest producer CO_2 emissions from energy combustion. Most of transportation energy user consumed fuels from fossil and hence indirectly encourage increasing the amount of CO_2 emissions from energy combustion in the service sector.

Residential is the largest consumer of final energy product in Indonesia. The rapid growth rate of population, inequality welfare level, and people lifestyle change are determinant effect that influences the growth of residential energy consumption in Indonesia. All of final energy users in this category are consuming final energy products for their daily activities such as cooking, lighting, washing, etc. The availability of final energy sources and the rising of energy prices certainly providing a significant impact to energy user on this category, even indirectly affect to the price of goods and services on domestic markets and the stability of social condition in Indonesia.

Overall, it can be concluded that each sector has various activity, challenge and dependence on specific energy sources. They have different necessary toward energy sources, both of quantity and types of energy sources. These differentials directly caused the growth rate of CO_2 emissions from energy use by each sector have differed each other. The varied economic growth performance on each energy user sector viewed as one of determinant factor that influences the growth of energy consumption and CO_2 emission from energy combustion in Indonesia. Therefore, it is important to examine whether economic growth, energy consumption and CO_2 emission from energy combustion on these sectors, respectively, have interrelationship and influenced each other. This study expected will provide valuable information which can be referred by the policymakers and stakeholder within making the sustainable energy, economic and environmental policies in Indonesia.

1.4 Research Questions

Based on the background of study and the problem statement, the research questions in this study can formulate as follows:

1. Are the growth of real GDP per capita and the value-added of three development sectors influenced Indonesia's final energy consumption?
2. Are the growth of final energy consumption on three development sectors and residential influenced the real GDP of Indonesia?
3. Are final energy consumption, economic growth and CO_2 emissions from energy combustion in four sectors (industry, agriculture, services and residential) have a significant linkage in Indonesia?

1.5 Research Objectives

Based on the problem statement and research questions discussed above, the objectives of this study written as follows:

1. To examine the role of real GDP per capita and the value-added of three development sectors toward Indonesia's final energy consumption.
2. To examine the role of final energy consumption by Industry sector, agriculture sector, service sector and residential sector toward the real GDP of Indonesia.
3. To examine the causality linkage between final energy consumption, economic growth, and CO_2 emissions on four sectors (industry, agriculture, services and residential) in Indonesia.

1.6 Significance of Study

This study introduces a new approach to exploring the linkage between final energy consumption and economic growth in a country. In one side, this study examines whether the value-added of three development sectors and real GDP per capita has significant effect to Indonesia's final energy consumption, while in another side this study investigates whether the growth of final energy consumption on four sectors has significant impact to the real GDP of Indonesia. The result from both these analyses expected can generate empirical evidence regarding the causality relationship between final energy consumption and economic growth in Indonesia.

Sustainability of energy security, economic development process and environmental quality in developed and developing countries generally depend on how policy-makers determine and implement policies and strategies following the conditions and problems faced by any categories of energy users. Therefore, this study also investigates the causality linkage between economic growth, final energy consumption and CO_2 emissions on four sectors (industry, agriculture, services and residential) in Indonesia. The diversity of empirical findings from these analyses expected can be a useful reference for Indonesia's government in order to determine appropriate strategy and policies related to energy, economy, and environmental issues in three development sectors and residential in Indonesia, respectively.

The awareness of energy users to more notice environmental quality and energy security prerequired for achieved sustainable economic growth in a country. Hence, empirical findings that obtained in this study supposed to motivate any category of energy users in Indonesia to diminish the combustion of fossil fuels and utilize the green technology that more efficient and environment-friendly in their activities. Moreover, this study also expected given a beneficial contribution to future studies which also examines the causal linkage between energy consumption, economic growth and CO_2 emissions in a country or a group of countries.

1.7 Research Gap

This study has specific distinctions with previous studies that explore the relationship among energy consumption, economic growth and CO_2 emissions. Difference between this study and previous studies can be described as follows:

a). This study considers two specific models that consist of disaggregated independent variables in order to examine the energy-economic nexus in a country. Meanwhile, in previous studies, this relationship usually examined within a bivariate model consisting of only two variables.

b). This study examines the relationship between energy consumption, economic growth and CO_2 emissions in four energy user sectors. Those sectors categorized according to the International Standard Industrial Classification (ISIC) version 3.

c). This study considers the value-added of three development sectors and real GDP per capita as a set of economic indicators that representing economic growth based on the energy user sector in a country.

d). This study considers the growth of final energy consumption as an energy consumption indicator that interpreting energy use in a country's, both aggregate (overall) and disaggregated (by sector).

e). This study considers CO_2 emissions from energy combustion as an indicator that illustrates the increase of CO_2 emissions in a country, both in aggregate (overall) and disaggregated (by sector).

1.8 Organization of Study

This dissertation is consist of five main chapters. Chapter One explains the background of study, problem statement, research objectives and significance of study. Chapter two provides literature reviews, such as the definition of final energy products, the classification of final energy users, description economic growth and it is indicators, overviews about global warming and CO_2 emissions, as well as empirical evidence from previous literature studies. Chapter Three outlines the research framework, research hypotheses, research process and methodology that uses in this study, which consists of data collection method, the definition of operational variables, the specification of models, and analysis methods. Chapter four presents the analysis process and empirical results from the analysis. Chapter fifth presents a discussion about findings, the implication of study, conclusion, as well as limitation and recommendations for future research.

1.9 Definition of Operational Variables

The short definition of operational variables that use in this study described as follows:

a). Total final energy consumption in Indonesia, i.e. total final energy consumption by all category of energy users in Indonesia which consist of industry, transport, residential, commercial and public service, agriculture/forestry, fishery, and non-specific energy users. This variable considered as an energy consumption indicator that reflected total energy consumption in Indonesia.

b). Total final energy consumption in the Industrial sector, i.e. total final energy consumption by final energy users in the category of Industry. This variable considered as an energy consumption indicator that reflected total energy consumption by industry sector in Indonesia.

c). Total final energy consumption in the agriculture sector, i.e. total final energy consumption by final energy users in the category of Agriculture/forestry and fishery in Indonesia. This variable considered as an energy consumption indicator that reflected total energy consumption by the agriculture sector in Indonesia.

d). Total final energy consumption in the services sector, i.e. total final energy consumption by final energy users in the category of transportation, commercial and public service, and non-specific energy users. This variable considered as an energy consumption indicator that reflected total energy consumption by the services sector in Indonesia.

e). Total final energy consumption by the residential sector, i.e. total final energy consumption by final energy users in the category of residential. This variable considered as an energy consumption indicator that reflected total energy consumption by the residential sector in Indonesia.

f). The real Gross Domestic Product (GDP) of Indonesia. This variable considered as an economic indicator that reflected economic growth in Indonesia.

g). The value-added of the industry sector is the share of value-added by industry sector on the real GDP of Indonesia. This variable considered an indicator that reflected the economic growth of the industry sector in Indonesia.

h). The value-added of the agriculture sector, i.e. the share of value-added by the agriculture sector on the real GDP of Indonesia. This variable considered an indicator that reflected the economic growth of the agriculture sector in Indonesia

i). The value-added of the services sector, i.e. the share of value-added by services sector on the real GDP of Indonesia. This variable considered an indicator that reflected the economic growth of the services sector in Indonesia.

j). The real Gross Domestic Product (GDP) per capita of Indonesia, i.e. the real GDP of Indonesia divided by population. This variable considered as an economic indicator that reflected the economic growth of the residential sector in Indonesia.

k). Total CO_2 emissions from energy combustion in the industry sector. This indicator reflected the amount of CO_2 emissions from energy combustions that generate by final energy users in the category of Industry in Indonesia. This variable reflected the amount of CO_2 emissions generated by the industry sector in Indonesia.

l). Total CO_2 emissions from energy combustion in the agriculture sector. This indicator reflected the amount of CO_2 emissions from energy combustions that generate by final energy users in the category of Agriculture/forestry and fishery in Indonesia. This variable reflected the amount of CO_2 emissions generated by the agriculture sector in Indonesia.

m). Total CO_2 emissions from energy combustion in the services sector. This indicator reflected the amount of CO_2 emissions from energy combustions that generate by final energy users in the category of transportation, commercial and public service, and non-specific energy users. This variable reflected the amount of CO_2 emissions in the services sector.

n). Total CO_2 emissions from energy combustions in the residential sector. This indicator reflected the amount of CO_2 emissions from energy combustions that generate by final energy users in residential. This variable reflected the amount of CO_2 emissions generated by the residential sector in Indonesia.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides literature reviews related to the topic of study. It includes eight main sections. The first section describes the final energy consumption. Section two described economic growth and it is indicators. Section three explains about CO_2 emissions from energy combustion. Section four defines the classification of final energy users by sectoral. Section fifth discusses empirical evidence from previous studies that investigated energy-economic nexus in the bivariate model. Section sixth presents empirical evidence from previous studies that examined the linkage between economic growth and CO_2 emissions. The last section discusses empirical evidence from previous studies that investigated the linkage between energy consumption, economic growth and CO_2 emissions in the multivariate model.

2.2 Definition and Type of Final Energy

According to engineering and economic perspectives, final energy is an intermediary material that used as power for machine, equipment and energy-converting devices to conduct work function. According to Zweifel et al. (2017, p. 27), the main purpose of final energy is the utility it creates, such as heat, work, light, and chemically bound energy. Final energy users consumed final energy sources when operating boilers, furnaces, motors, air conditioners, lighting systems, etc. Final energy, as a commodity, directly consumed by end energy users. Final energy generated from primary and secondary energy resources. The final energy sources are consists of oil products, coal products, gasses products, biofuel and wastes, as well as electric power and heat.

Crude oil is a liquid mineral resource that contains a mixture of natural origin hydrocarbons, and it consists of natural oil liquids, refinery feedstock, natural gas liquids, as well as additives and other hydrocarbons. Crude oil obtained under normal surface temperatures in the liquid phase and commonly their physical pressure characteristics are varied. Meanwhile, oil products are any oil-based products obtained from distillation and usually did not use in refining industries. Oil products generated from crude oil are consists of ethane, refinery gas, aviation gasoline, jet fuels, liquefied petroleum gas, bitumen, gas or diesel oil, white spirit, lubricant, kerosene, paraffin waxes, naphtha, petroleum coke, and another oil products (OECD/IEA, 2005).

Coal is a solid energy source that produces a lot of CO_2 emissions and pollution in the world (Elinur et al., 2010). Type of coal used as fuel is bituminous, anthracite, sub-bituminous, lignite and peat. Among these types, bituminous coals have dominated, and it is characterized by higher volatile matter than anthracite and lower fixed carbon. Meanwhile, coal and peat are consist of all coal types, both primary (including lignite and hard coal) and derived fuels (including gas coke, Braun-kohlen briquet, patent fuel, oxygen steel furnace gas, blast furnace gas, gas works gas, coke oven gas, etc).

Natural gas is a combustible mixture of hydrocarbon gases, colourless, shapeless, and commonly odourless in pure form. Natural gas is obtaining in underground deposits and located in deepest underground rock formations and mingled with another hydrocarbon in coal beds. Most natural gases formed within a long time under two mechanisms, i.e. biogenic and thermogenic. Natural gas is cleaner combusting compared to other fossil fuels and emitted potentially harmful by-products into the air at lower levels. Biogenic gas is obtained by methanogenic organisms in shallow sediments, marshes, and landfills. While thermogenic gas explored from buried organic materials. Generally, natural gas production in dry form marketable under domestic boundaries on each country, including offshore production that counted after extraction and purification of natural gas liquid and sulfur (OECD/IEA, 2005).

Biofuels and waste are consists of biogases, liquid-biofuels, solid-biofuels, municipal waste and industrial waste. Biofuel is gaseous and liquid fuels generated from biomass, such as organic matter from plants or animals. Biofuels are consists of bio-oil, bioethanol, bio-methanol, biodiesel, and bio-dimethyl ether. Liquid biofuels, such as biodiesel and bioethanol/ETBE, commonly used for transport vehicles. The first-generation of Biofuels are including ethanol (sugar and starch), oil-crop (vegetable oil), and biogas that acquired through anaerobic digestion. Typical feedstocks employing for produce biofuels are including soybean and oil palm, sugarbeet, sugarcane, oil crops (canola), animal fats, wheat and corn grains, as well as cooking used oils.

Electricity and heat are energy carriers which widely consumed for almost every kind of human activity. Electricity and heat are generated and consumed both as primary energy nor secondary energy. Primary electricity and heat generated from natural sources such as solar power, hydropower, wind power, as well as tide and wave power. While, the secondary electricity and heat generated and obtained from the geothermal heat and solar thermal heat, the heat of nuclear fission of nuclear fuels, as well as from burning primary combustible fuels such as natural gas, oil, coal and wastes, as well as renewables. In addition, heat also obtained from transforming electricity to heat in electric boilers or heat pumps. Once the electricity and heat produced, then distributed as an energy commodity to final consumers through national or international transmission and distribution grids.

2.3 Definition and Indicator of Economic Growth

Economic growth is a progressive field which widely interpreted in various standpoints. Carley et al. (2011, p. 283) defined economic growth as a sustainable process of increasing wealth and improving the economic opportunities for domestic residents that are living and working in a certain region. The outcome from this process includes reducing poverty levels and improved standards of living. Similarly, Malizia (1994, pp. 83–84) defined economic growth as the sustainable process for improves economic progress in which producers empower capital, financial, human, physical as well as scarce natural resources to generated marketable products, both of goods and services. The role of economic developers is contributing and driving creation process national wealth for the benefit of domestic producers and consumers by expediting the expansion of tax base and job opportunities as well as efficiency on domestic resources.

Economic growth is a sustainable process which aims to encourage a nation's wealth or income experiences an increase over time (Cornwall, 2014). Economic growth can also defined as a growth process on the market value of goods and services generated by the productive sectors over a certain period. According to Bjork (1999), the measurement of economic growth is carried out using national income accounting assessment and conventionally calculated as the growth rate of real GDP in a country's. Meanwhile, OECD (2002) defined GDP as an aggregate measure of production equal to the total of gross value-added of all resident institutional units involved in the production and distribution process. Simon Kuznets first introduced the GDP concept in 1934. In his report for US Congress, Kuznets proposed GDP as a tool to measure welfare a country. Furthermore, after the Bretton Woods conference in 1944, GDP became an essential instrument for estimating economic improvement progress in a country (Dickinson, 2011).

The GDP is an essential indicator that shows the economic growth level of a nation. GDP term is always discussed by economists when assessing welfare and economic progress of a country, they even tend to refer to GDP components rather than other statistics. In other hands, the GDP recognized as a relevant indicator of estimated economic growth trends. A country's GDP has considered as the comprehensive measurement describing the economic progress of a country. It defined as the monetary value of all goods and services generated by a country over a certain period, which commonly for one year. The GDP is a structured and detailed report which considering the market prices of goods and services.

The GDP measured as the total economic output of a country's which statistically described as the aggregate production of all goods and services distributed within the administrative boundaries of a nation. For international comparisons, the GDP value of a country converted from local currency unit to global currency or foreign exchange rates and commonly converted to US dollars. Furthermore, GDP usually measured within three general approaches, i.e. (1) by summation the value-added of all industrial production based on industrial origin (production approach); (2) by summation the remuneration accruing to all income-producing economy sectors (income approach); and (3) by summation the final expenditures of various economic sectors (expenditure approach).

Production approach defined GDP as total value-added of all economic sectors in a country over a certain period. Income approach defines GDP as total compensation received from production factors for producing goods and services in a country's throughout a certain period. The compensations consist of profits, wages, capital interest, land rent, and all of them are before taxes. Income approach considers depreciation and net indirect taxes as a part of GDP. Meanwhile, expenditure approach defined GDP as total components of final demand, such as government final consumption expenditures, household final consumption expenditures and non-profit private institutions serving households (NPISHs), change in inventories, gross domestic fixed capital (GDFC) formations, and net export. Overall, those three approaches should provide similar results, where total expenditures should be equal to the total income of production factors and the total final of goods and services. In conceptual, the measurement of GDP calculated with these approaches called "GDP at market prices".

The value-added is a net output of development sector after summing all outputs and deducting intermediate inputs and measured without making subtracting depreciation of fabricated assets or degradation and depletion of natural resources (World Bank, 2014). According to World Development Indicators (World Bank, 2013), the contributor of value-added to GDP can be group into three main sectors, i.e. industry sector, agriculture sector, and services sector. The industrial origins in these development sectors are classified by ISIC revision 3. The value-added of development sectors reflected economic growth by sectoral in a nation. These indicators even employed by Zachiadis (2006, 2007) as well as Nugraha and Osman (2017, 2018) as economic growth indicator sectoral in a nation when they investigated energy-economic nexus in a country's. According to Nugraha and Osman (2017, 2018), the development sectors contributed value-added to the real GDP of a country's, hence it can be assumed that the value-added of development sector illustrated the economic growth of a development sector in a country's.

Data of economic indicators for a country are reported and published annually for public consumption both in local institutions and international organizations. Specifically, these data provide information about structure economic development in a nation. A large of GDP value implied a strong capability of economic structure in a country, vice versa. One of economic indicator that common use for represented economic growth in a nation is "GDP at constant prices" or called as "real GDP" (Esso & Keho, 2016; Farhani & Ozturk, 2015). This indicator illustrated economic growth in a country and commonly accumulated into US dollars, either for the whole or particular sector annually. Furthermore, "GDP per capita at constant prices" defined as a useful indicator for assessed economic growth that accumulated with population growth. This indicator also commonly used to represented economic growth in a country, especially in energy-economic studies (Kahouli, 2017; Özokcu & Özdemir, 2017).

2.4 Definition of Carbon-dioxide (CO_2) Emissions

Carbon-dioxide (CO_2) emission is the most dangerous anthropogenic GHG's which naturally formed in the atmospheric layers as a part of the Earth's carbon cycle (Field & Field, 2006). CO_2 emission stems mostly from the combustion of fossil fuels on industrial, transportation, residential and other productive sectors (Szulejko et al., 2017; Trenberth et al., 2014). Apart from its natural existence, Carbon-dioxide (CO_2) is the primary GHG's that also generated from human activities. The largest human source of CO_2 emissions is from the combustion of fossil fuels and generally influenced by many factors, both in short-term and long-term (Archer et al., 2009). Since the industrial revolution, human activities such as burning fuels and deforestation has been causing raised global temperature and CO_2 concentrations in the atmosphere (Le Quere et al., 2012).

The sustainable growth of global energy consumption is leading to an increased reliance on energy resources from fossil. Rapidly emerging economies, in particular, are have become some of the world's leading GHG emitters and experiencing high rates of energy consumption growth. Burning fossil fuels to generate energy is mostly practised for produce electric power, heat, or driving power on train, plane, car, power plant, and industrial equipment (Le Quere et al., 2012). Among three types of fossil fuels, coal is responsible for 44 per cent of CO_2 emissions from fuel combustion, following by oil product that responsible for 35 per cent of CO_2 emissions from fuel combustion and natural gas product that responsible for 20 per cent of CO_2 emissions from fuel combustion (OECD/IEA, 2015). In general, the largest consumers of fossil fuels is electric/heat generation, transportation, and industry. The growth of energy consumption from fossil directly enlarged the amount of CO_2 emissions and certainly caused decreases environment quality.

The electric and heat power plants are the largest producer of CO_2 emissions from energy combustion. This energy sector relies heavily on coal products, i.e. the most carbon-intensive of fossil fuels (OECD/IEA, 2015). Almost all industrialized nations produce their electric power and heat from combustion fossil fuels (more than 60 per cent). Depending on the energy mix used by the local power companies, the electricity used at home and office has a considerable impact on GHG emissions. However, the electricity sector has gradually experienced liberalization and immense changes during the current past decades. The new and renewable energy resources that more environment-friendly have progressively employed in order to generate electric power, which certainly expected given a positive impact on environmental quality.

The transport sector is the second-largest producer of CO_2 emissions and accounted for approximately 23 per cent of global CO_2 emissions (OECD/IEA, 2015). This sector very relied upon fuels and most energy users in this sector consumed fossil fuels. Since three decades ago, transport-related emissions rapidly grows, raised approximately 45 per cent over less than two decades. In the transport sector, road transport is the largest producer of CO_2 emission from combustion fuels and accounted about 72 per cent of total CO_2 emissions global transport, following by Marine shipping which accounted 14 per cent of total CO_2 emissions global transport, Global aviation which contributed 11 per cent of total CO_2 emissions global transport, and the rest generated from air flights (International Civil Aviation Organization, 2010; OECD/IEA, 2015).

The industry sector is the third-largest producer of CO_2 emissions which consumed approximately 20 per cent of fossil fuels related to CO_2 emissions (OECD/IEA, 2015). Industry sector dominated by manufacturing industries, which consists of five main categories, i.e. petroleum refineries, chemicals, food and beverage, paper, and metal/mineral products. These categories covered the vast majority of fossil fuel users and producer CO_2 emissions. Almost all production and distribution processes in manufacturing industries generate various type of GHG, but the largest is CO_2 emissions. It is caused most of manufacturing machine and equipment use fossil fuels to obtained heat and steam on various production stages. Nevertheless, there are industrial processes that produce large amounts of CO_2 emissions from chemical reactions (by-product) which occurs during the production process (Le Quere et al., 2012).

Meanwhile, the other development sectors, such as agriculture, commercial and public services also consuming fossil fuels in their activities. The use of fossil fuels in agricultural machinery and power generation in farms also produce CO_2 emissions. Meanwhile, commercial and public services are commonly consuming the energy products fossil fuels for their power generators when faced a lack of electric power on their daily activities, so they also contributing CO_2 from energy use. Therefore, although the amount of energy consumed by these sectors is increasing gradually, but not necessarily the number of CO_2 emissions that produced by them from energy consumption activity also increased, even possibly would be declined.

2.5 The Classification Final Energy Users By Sectoral

Final energy user or end-energy user is who consumer final energy products and also generate CO2 emissions from energy combustions. International Energy Agency (2015) classified final energy users into seven main categories, namely Industry, commercial and public services, agriculture/forestry, residential, transportation, fishing, and non-specific energy users. Meanwhile, World Development Indicators (World Bank, 2013) grouped various development sectors in a country's into three main development sectors, i.e. industry sector, agriculture sector and service sector. Except for the residential sector, the classifications above based on ISIC version 3.0. Therefore, in this study the final energy users classified into four sectors, i.e. industry, agriculture, service and residential. Detail about these sectors described below.

2.5.1 Industry Sector

The industry sector is a productive development sector that contributing value-added to national income in a country's. The industrial classification related this sector based on ISIC version 3 divisions 10-45 are wholesale and retail trade, mining and quarrying, manufacturing, water supply, construction, etc. Economic growth process on this sector can be measured from the growth of value-added that contributed by this sector on the real GDP of a country's annually. Industrial activity is a processing business of raw materials or semi-finished goods into finished goods that have added value to benefit. Industry sector consuming approximately one-half of the total world's energy consumption and commonly necessary more energy than any other final energy users.

According to the International Energy Agency (2016), most of final energy users in the industry sector are manufacturing and construction industries, such as iron and steel industries, chemical and petrochemical industries, non-metallic mineral industries, pulp and paper industries, etc. However, energy converting process into another form or for generating fuels by industrial companies is excluded and reported separately under another end-use sector. Meanwhile, energy products used for transportation activity in this sector did not calculate in this category. Accurately, the amount of energy consumption for transport activity in this sector calculated as the amount of energy consumption by transportation energy user that is a part or sub-sector that classified under service sector based ISIC version 3.

The intensity and combination fuels consumed by final energy users in the industry sector are commonly varied across countries, depending on the type and level of technological development and economic activities as well as other determinants. Final energy products consumed by final energy users in the industry sector for various purposes, such as processing, assembly, heating, cogeneration, air conditioning, producing steam, as well as lighting in buildings. The industrial sector is also consuming natural gas and petroleum products as feedstocks to generating non-energy products, such as petrochemicals (for plastics industries) and agriculture fertilizers (International Energy Agency, 2016a).

2.5.2 Agriculture Sector

The agriculture sector is one from three main development sectors that contributing value-added to national income in a country's. The industrial classification related this sector based on ISIC version 3 divisions 1-5. It is consists of agriculture, fishing, forestry, logging and related service activities, hunting, etc. Economic growth process on this sector can be measured from the growth of value-added that contributed by this sector on the real GDP of a country's annually. Based on ISIC version 3, the International Energy Agency (2016b) classified agriculture energy users under two groups, i.e. agriculture/forestry and fishing. Generally, these categories are only using liquid fuels such as oil fuels, biofuels and waste, or mix both.

According to International Energy Agency (2018), agriculture/forestry consuming final energy sources for hunting, forestry, logging, crop and animal production, agriculture service activities and also includes energy consumed for traction as well as heating or power for agricultural and domestic. Meanwhile, the category of fishery energy users consumes final energy sources on fishing activities in coastal, inland and deep-sea. It also covers fuels that delivered to foreign ships that refuelled in a sea territory a particular country as well as energy sources used on the fishing and aquaculture industries.

2.5.3 Service Sector

The service sector is a productive development sector that contributing value-added to national income in a country's. The industrial classification related this sector based on ISIC version 3 divisions 50-99. Economic growth process on this sector can be calculated from the share of value-added by this sector to the real GDP of a country's annually. The income of the service sector collected from bank and financial service charges, real estate, wholesale and retail trade, transportation, professional and personal services, healthcare, education, etc. Based on ISIC version 3, International Energy Agency (2016b) classified energy users in service sector under three groups, i.e. transportation, commercial and public services, and non-specific energy users.

Transportation is an activity transporting people and goods by aeroplane, rail, road vehicles, and ships. Transportation systems have an essential role in trade activities, encourage economic competitiveness in the global market and improve the living standards of society. Trade and economic activities have been fundamental factors which determine the number of demand for freight transportation. According to International Energy Agency (2016a), transportation sector consuming final energy sources for transportation activities, such as for domestic aviation fuels, highway transport fuels, fuels for railways, fuels for pipeline transport; domestic navigation fuels for ship and boat, as well as fuels for other transport services.

The service sector is consists of a wide range of activities such as education services (school), health services (hospital, sports centre), food services (restaurant), accommodation services (hotel), public services (museum, library), financial service (bank), etc. Meanwhile, commercial and public services are essential subsector in the services sector which covered institutions, organization, and business that providing services. In commercial and public services, final energy sources commonly consumed for activity inside buildings, such as lighting, heating, cooking, washing and cooling. Nevertheless, final energy sources that consumed for services not associated with activity inside buildings such as city water, traffic lights as well as sewer services considered as energy use in commercial services.

International energy agency (2018) classifies energy user on commercial and public services based on business fields such as installation and repairing of equipment and machines, water-supply services, warehousing, postal and courier activities, accommodation, wholesale and retail, real estate, food and beverage, information and communication; insurance and financial business, scientific and technical activities, defence, public services, education, entertainment and arts, hospitality and recreation, compulsory social security (excluding defence activity), administration, operation and support of civil defence forces, health and social-work activities, activity in extraterritorial organizations, etc. Meanwhile, the category of non-specified energy users covered all fuels consumption which not elsewhere specified or not included in other energy user categories. These activities are consists of fuels consumption for all mobile and motionless military operations, despite whether those fuel utilised for the military in a country (domestic) or other countries (foreign).

2.5.4 Residential Sector

Energy use in residential can be defined as energy consumption activity by household but excluding transport. The physical size and structure of the residential buildings are one indicator that influences the amount of energy used by their occupants (Nejat et al., 2015). The larger home requires more energy for heating, lighting, air conditioner, and even include appliances that are intensively using energy such as washing machine, radio, refrigerator, and television. Smaller home structures commonly consume less energy because they possess less space to be cooled or heated and have fewer occupants. The amount of energy consumption by residential or household can be measured from the use of electrical appliances and cooking equipment in every home (Elinur et al., 2010). The type and amount of energy sources consumed by household commonly vary each other and depend on income, welfare levels, lifestyles, climate as well as availability energy services (Frederiks et al., 2015).

2.6 The Relationship Between Economic Growth and Energy Consumption

Initially, the classical economic theory only recognizes capital and labour as two essential inputs in the production process and did not consider energy as a production function and instead consider energy as an intermediatory input. Although traditional economic theories do not explicitly consider energy as a main input on the economic growth process, the linkage between economic growth and energy consumption has been one of the most attractive issues in the energy-economic literature (Kulionis, 2013). This topic became widely discussed in global scientific research since Kraft and Kraft (1978) explored the linkage between energy consumption and output in the US. Although formerly, several scientists such as Berndt and Wood (1975) as well as Griffin and Gregory (1976) expressed that energy consumption and economic growth have substitutability connection and complementarity each other.

A lot of technique and approach has developed in previous studies related the linkage between energy consumption and economic growth in a particular country or a panel of countries with different the structure and stage of economic growth (Chiou-Wei et al., 2008). In some of the latest literature, this area study growing using approach toward energy types (Alkhathlan & Javid, 2013; Yuan et al., 2008), the criteria of energy users (Jebli & Youssef, 2013; Nayan et al., 2013), and both of them (Zamani, 2007). While based on the methodology used, most of the literature studies in this area tend to use econometric analysis approach that employs Cointegration test, Granger causality test, Autoregressive Distributed lags (ARDL), VAR/VECM, etc. Furthermore, some of the latest studies even utilize a panel data model as an attempt to found evidence of causal relations in a variety of previous studies.

Many scientists had explored energy-economic nexus in different countries, both developed and developing countries. They employed a vary of time-series and proxy model variables as well as utilizing the variety of method and approach to examine the linkage between energy consumption and real GDP in a country or a panel of countries. However, some findings from previous studies for a case of a particular country generated inconsistent empirical evidence. Generally, the results displayed vary and usually determined based on the direction of linkages between both variables in the short-term and long-term. According to Chen et al. (2007), the diversity of empirical findings on previous studies due to several determinant factors such as data set, methodology, characteristics of societies, economic structure, supply and demand energy, geopolitical conditions, etc.

The energy-economic literature studies confirmed four hypotheses in order to examine whether energy consumption stimulating economic growth or vice versa. First is "growth hypothesis" which emphasizes that energy is an essential input that encourages economic growth. Second is "conservation hypothesis" which confirms that economic growth caused energy consumption increased. The third is "neutrality hypothesis" which asserts that energy consumption did not associate with economic growth and also vice versa. Fourth is "feedback hypothesis" which revealed that energy consumption and economic growth has a mutual linkage (Cheema & Javid, 2015). Furthermore, description and empirical findings related to these hypotheses will be described below, while detail summary regarding previous studies that investigate the linkage between energy consumption and economic growth within bivariate modelling can be seen in Table 2.1.

2.6.1 Growth Hypothesis

The growth hypothesis implies that energy is an essential factor that contributing valuable input to the economic growth process, notably as a complementary factor of capital and labour in the production process. In theory, the growth hypothesis occurs if increase energy consumption stimulates increasing output and improving income or economic growth. The implication for this hypothesis is any policies aimed for energy conservation may potentially hamper sustainability economic growth and decrease income. Therefore, it is important to consider that increase energy consumption indirectly given a negative effect on the real GDP of a country. This condition may occur when economic activities gradually shifted from production activities that intensive-energy to production activities that less intensive-energy. A negative impact of increased energy consumption to real GDP or national income of a country may occur because of several factors such as immensely energy consumption on unproductive activities, production capacity constraints, nor inefficient energy supply.

In the bivariate model, empirical evidence for "growth hypothesis" for a particular country was discovered by Erol and Yu (1987) in Canada; Nachane et al (1988) in Portugal, Chile, Argentina, France, Greece, Italy, Mexico, and the UK; Soytas et al. (2001) in Turkey; Soytas and Sari (2003) in Germany, France, and Japan; Wolde-Rufael (2005) in Nigeria, Morocco, and Cameroon; Chontanawat et al. (2006) in 24 OECD and non-OECD countries; Lee (2006) in Switzerland, Canada, Belgium, and the Netherlands; Ang (2007) in France; Ho and Siu (2007) in Hong Kong; Mehrara (2007a) in Saudi Arabia; Chiou-Wei et al (2008) in Taiwan and Hong Kong; Tsani (2010) in Greece; Warr and Ayres (2010) in the USA; Pirlogea and Cicea (2012) in Romania and Spain; Nindi and Odhiambo (2014) in Mozambique; Dergiades et al.

(2013) in Greece; Bildirici (2013) in Bolivia, Nicaragua, Costa Rica, Argentina, Peru, Jamaica, Cuba, and Panama; Yildirim et al. (2014) in Pakistan, Bangladesh, and Iran; Soares et al (2014) in Indonesia; as well as Talbi (2015) in Egypt and Iran.

Furthermore, several studies also revealed evidence of "growth hypothesis" within data panel approach. Start from Hossain and Saeki (2011) who applied panel Granger causality method and found this hypothesis in a panel of selected Asian countries; Narayan and Popp (2012) who employed panel Granger causality test and discovered this hypothesis in a panel of 20 Western European countries, a panel of 17 Asian countries, a panel of 17 Latin American and G6 countries; Behmiri and Manso (2013) who discovered this hypothesis for a panel of Sub-Saharan Africa importing countries using a multivariate panel Granger causality test.

2.6.2 Conservation Hypothesis

The conservation hypothesis illustrates that the implementation of energy conservation policies which intends to reducing CO_2 emission impact, improving efficiency energy and controlling waste management does not influence the rate of economic growth in a nation. This hypothesis accepted if economic growth stimulated and influenced the growth of energy consumption. This situation implies that economic growth can motivate the implementation of widely green technology policies and indirectly reduce CO_2 emissions from energy combustions in the energy sector. In other hands, although it rarely occurs (at least theoretically), an increase of GDP or GDP per capita may cause declining the amount of energy consumption. According to Payne (2010), this situation possibly occurs when economic growth process that constrained geopolitical issue, infrastructural, or mismanagement of resources which certainly causes inefficiency and declines demand for goods and services (included energy sources).

The empirical evidence of conservation hypothesis had been discovered by Kraft and Kraft (1978) in the US; Erol and Yu (1987) in Italy and Germany; Abosedra and Baghestani (1991) in the USA; Masih and Masih (1996) in India and Indonesia; Ghosh (2002) in India; Soytas and Sari (2003) in Korea and Italy; Wolde-Rufael (2005) in Ghana, Congo, Egypt, Ivory Coast, and Algeria; Chontanawat et al. (2006) in 20 countries (5 OECD countries and 15 Non-OECD countries); Lee (2006) in France, Italy and Japan; Lise and Montfort (2007) in Turkey; Mehrara (2007) in Iran and Kuwait; Chiou-Wei et al. (2008) in Singapore and the Philippines; Akinlo (2008) in Gambia, Ghana, Sudan, Zimbabwe and Congo; Ang (2008) in Malaysia; Zhang and Cheng (2009) in China; Souhila and Kourbali (2012) in Algeria; Ocal and Aslan (2013) in Turkey; Herrerias et al (2013) in China; Kalyoncu et al (2013) in Armenia, Georgia, and Azerbaijan; Yildirim et al (2014) in Mexico; Azam et al (2015) in Malaysia; Tang et al (2016) in Vietnam; as well as Faisal et al. (2017) in Belgium. Furthermore, there are previous studies that revealed the evidence of conservation hypothesis using panel data approach, such as Al-Iriani (2006) who investigated a panel of six Middle East countries; Mehrara (2007b) who examined a panel of eleven selected oil-exporting countries; Ozturk et al. (2010) who investigated a panel of fourteen low-income countries; as well as Lau et al. (2011) who examined a panel of seventeen Asian countries.

2.6.3 Feedback Hypothesis

The feedback hypothesis asserts that economic growth and energy consumption have a mutual linkage, where each indicator can control and influence another. This hypothesis shows that an increase or decrease the amount of energy consumption will cause an increase or a decrease in the real GDP, vice versa. This hypothesis can be accepted if energy consumption and economic growth has a mutual linkage and influenced each other. This condition implies that energy conservation policy has an insignificant effect on economic growth and even did not affect the growth rate of real GDP or real GDP per capita. Nevertheless, at least this condition propel the policymakers to considering an appropriate strategy for sustainable economic growth, energy security and improvement environmental quality in a country.

The evidence for feedback hypothesis for a particular country has found by Erol and Yu (1987) in Japan; Nachane et al. (1988) in Israel, Colombia, Brazil, Venezuela, Japan, Germany, and India; Hwang and Gum (1992) in Taiwan; Ebohon (1996) in Tanzania and Nigeria; Masih and Masih (1996) in Pakistan; Zarnikau (1997) in the USA; Glasure and Lee (1998) in South Korea and Singapore; Soytas and Sari (2003) in Turkey; Jumbe (2004) in Malawi; Wolde-Rufael (2005) in Gabon and Zambia; Lee (2006) in the U.S; Francis et al. (2007) in Jamaica, Haiti, and Trinidad; Chiou-Wei et al. (2008) in Indonesia; Chontanawat et al. (2008) in 32 countries; Erdal et al. (2008) in Turkey; Belloumi (2009) in Tunisia; Zhang (2011) in Russia; Fuinhas and Marques (2012) in Greece, Turkey, Italy, Spain and Portugal; Zhang and Xu (2012) in China; Shahiduzzaman and Alam (2012) in Australia; Wesseh Jr and Zoumara (2012) in Liberia; Bildirici (2013) in El Salvador; Yildirim et al. (2014) in Turkey; Talbi (2015) in Marocco; as well as Shakouri and Yazdi (2017) in South Africa. Meanwhile, empirical evidence of feedback hypothesis in a panel of countries was discovered by Eggoh et al. (2011) in a panel of 21 African countries (10 exporters and 11 importers); Belke et al. (2011) in a panel of 25 OECD countries; Sadorsky (2012) in a panel of 7 South American countries; Ozturk et al (2010) in a panel of middle-income countries; Narayan and Popp (2012) in a panel of 93 countries; Behmiri and Manso (2013) in a panel of Sub-Saharan Africa exporting countries; as well as Kahia et al (2017) in a panel of 11 MENA net oil importing countries.

2.6.4 Neutrality Hypothesis

The neutrality hypothesis indicated energy consumption did not have a significant effect on economic growth and also vice versa. The neutrality hypothesis implies that energy consumption only a minor component that did not hamper the economic growth process and hence the implementation of energy conservation policies may not have a favourable effect toward economic growth. Nevertheless, this condition provides intensive spacious for policymakers to determine long-term strategies and policies related to the conservation and mitigation of energy in a country. Furthermore, this condition also enables the applicability of clean technology that environmental-friendly and efficient on all energy user sectors and certainly given a beneficial effect for environmental quality.

The empirical evidence of neutrality hypothesis was discovered in a particular country by Akarca and Long (1980) as well as Yu and Jin (1992) in The USA; Erol and Yu (1987) in France and the UK; Masih and Masih (1996) in Singapore, Malaysia, and Philippines; Fatai et al (2002) in New Zealand; Soytas and Sari (2003) in Canada, United Kingdom, United State America, Indonesia, and Poland; Altinay and Karagol

(2004) in Turkey; Wolde-Rufael (2005) in South Africa, Congo, Zimbabwe, Senegal, Benin, Sudan, Togo, Kenya, and Tunisia; Lee (2006) in Germany, Sweden and United Kingdom; Akinlo (2008) in Nigeria, Senegal, Coted'Ivoire, Kenya, Cameroon, and Togo; Chontanawat et al. (2008) in 4 OECD countries and 26 Non-OECD countries; Chiou et al. (2008) in Korea, Malaysia, Thailand and the U.S; Bowden and Payne (2009) in the USA; Ozturk and Acaravci (2010) in Albania, Bulgaria and Romania; Kusuma and Muqorrobin (2013) in Malaysia; Yildirim et al (2014) in Egypt, Indonesia, Korea, and the Philippines; Talbi (2015) in Saudi Arabia; Furthermore, the empirical evidence of neutrality hypothesis within panel data modelling had found by Narayan and Popp (2012) in a panel of 12 middle east countries. Detail summary regarding previous studies that investigate the linkage between economic growth and CO_2 emissions in bivariate modelling can be seen in Table 2.2.

Table 2.1
The summary of empirical studies about the relationship between economic growth and energy consumption in bivariate framework.

Author(s)	Method(s)	Year	Scope	Findings
Kraft and Kraft (1978)	Granger and Sims causality	1947-1974A	USA	GDP → EC
Akarca and Long (1980)	Sims causality	1950-1970A	USA	GNP — EC
Yu and Choi (1985)	Sims and granger causality	1947-1979A 1950-1976A 1950-1976A 1950-1976A 1954-1976A	USA UK Poland Philippines South Korea	GNP — EC EC → GNP GNP — EC EC → GNP GNP → EC
Erol and Yu (1987)	Sims and Granger causality	1950-1982A 1950-1982A 1950-1982A 1950-1982A 1950-1980A 1950-1982A	Japan Germany Italy Canada France UK	EC ↔ GNP GNP → EC GNP → EC EC → GNP GNP — EC GNP — EC
Nachane et al. (1988)	EG	1950-1985A	Argentina Brazil Chile	CEC → GDP CEC ↔ GDP CEC → GDP

Continue…

Author(s)	Method(s)	Year	Scope	Findings
			Colombia	CEC ↔ GDP
			Greece	CEC → GDP
			Guatemala	CEC → GDP
			India	CEC ↔ GDP
			Israel	CEC ↔ GDP
			Portugal	CEC → GDP
			Mexico	CEC → GDP
			Venezuela	CEC ↔ GDP
			France	CEC → GDP
			Germany	CEC ↔ GDP
			Italy	CEC → GDP
			Japan	CEC ↔ GDP
			UK	CEC → GDP
Abosedra and Baghestani (1991)	Granger causality	1947-1987A	USA	GNP → EC
Hwang and Gum (1992)	Granger causality	1961–1990A	Taiwan	GNP ↔ EC
Yu and Jin (1992)	Granger causality	1974–1990A	USA	GDP — EC
Ebohon (1996)	Granger causality	1960-1981A	Tanzania	GDP ↔ EC
		1960-1984A	Nigeria	GDP ↔ EC
Masih and Masih (1996)	JJ and VDC	1955-1990A	India	GNP → EC
		1955-1990A	Pakistan	GNP ↔ EC
		1960-1990A	Indonesia	GNP → EC
		1955-1990A	Malaysia	GNP — EC
		1960-1990A	Singapore	GNP — EC
		1955-1991A	Philippines	GNP — EC
Zarnikau (1997)	Granger causality	1970-1992A	USA	GNP ↔ EC
Glasure and Lee (1998)	EG	1961-1990A	South Korea	GDP ↔ EC
			Singapore	GDP ↔ EC
Yang (2000)	EG	1954-1997A	Taiwan	EC ↔ GDP
Soytas et al. (2001)	Co-integration and Granger causality	1960-1995A	Turkey	EC → GDP
Fatai et al. (2002)	Granger causality, ARDL and TY	1960-1999A	New Zealand	GDP — EC
Ghosh (2002)	Cointegration	1950-1997A	India	GDP → EC
Soytas and Sari (2003)	JJ and VDC	1950-1990A	Argentina	GDP ↔ EC
		1950-1992A	Canada	GDP — EC
		1950-1992A	France	EC → GDP
		1950-1992A	Germany	EC → GDP
		1960-1992A	Indonesia	GDP — EC
		1953-1991A	Italy	GDP → EC
		1950-1992A	Japan	EC → GDP
		1953-1991A	Korea	GDP → EC
		1965-1994A	Poland	GDP — EC
		1950-1992A	Turkey	GDP ↔ EC

Continue…

Author(s)	Method(s)	Year	Scope	Findings
		1950-1992A	UK	GDP — EC
		1950-1992A	USA	GDP — EC
Altinay and Karagol (2004)	Granger causality	1950-2000A	Turkey	GDP — EC
Wolde-Rufael (2004)	TY	1952-1999A	Shanghai	EC → GDP
Jumbe (2004)	Cointegration test	1970-1999A	Malawi	GDP ↔ EC
Han et al (2004)	Granger causality	1978-2000A	China	EC ↔ GDP
Fatai et al. (2004)	JJ, Granger causality, TY, and ARDL	1960-1999A	Australia	GDP → EC
			New Zealand	GDP → EC
			India	EC → GDP
			Indonesia	EC → GDP
			Thailand	EC ↔ GDP
			Philippines	EC ↔ GDP
Wolde-Rufael (2005)	ARDL and TY	1971-2001A	Algeria	GDP → EC
			Benin	GDP — EC
			Cameroon	EC → GDP
			Congo, D. R	GDP → EC
			Congo	GDP — EC
			Egypt	GDP → EC
			Gabon	GDP ↔ EC
			Ghana	GDP → EC
			Ivory Coast	GDP → EC
			Kenya	GDP — EC
			Morocco	EC → GDP
			Nigeria	EC → GDP
			Senegal	GDP — EC
			South Africa	GDP — EC
			Sudan	GDP — EC
			Togo	GDP — EC
			Tunisia	GDP — EC
			Zambia	GDP ↔ EC
			Zimbabwe	GDP — EC
Lee and Chang (2005)	JJ	1954-2003A	Taiwan	EC ↔ GDP
Al-Iriani (2006)	Pedroni panel cointegration	1971-2002A	Panel of 6 countries in Middle East	GDP → EC
Chontanawat et al. (2006)	JJ and dynamic panel estimation	1960-2000A	OECD countries	
			Australia	GDP → EC
			Austria	EC → GDP
			Belgium	EC → GDP
			Canada	GDP → EC
			Czech	EC → GDP
			Denmark	EC → GDP

Continue…

Author(s)	Method(s)	Year	Scope	Findings
			Finland	GDP → EC
			France	GDP ↔ EC
			Germany	GDP ↔ EC
			Greece	GDP ↔ EC
			Hungary	GDP ↔ EC
			Iceland	GDP ↔ EC
			Ireland	EC → GDP
			Italy	GDP ↔ EC
			Japan	GDP ↔ EC
			Korea	EC → GDP
			Luxembourg	GDP — EC
			Mexico	EC → GDP
			The Netherlands	EC → GDP
			New Zealand	GDP ↔ EC
			Norway	GDP ↔ EC
			Poland	EC → GDP
			Portugal	GDP ↔ EC
			Slovakia	GDP ↔ EC
			Spain	GDP → EC
			Sweden	GDP → EC
			Switzerland	EC → GDP
			Turkey	GDP — EC
			UK	GDP — EC
			USA	GDP — EC
		1971-2000A	Non-OECD	
			Albania	GDP → EC
			Algeria	GDP → EC
			Angola	GDP ↔ EC
			Argentina	GDP ↔ EC
			Bahrain	GDP — EC
			Bangladesh	EC → GDP
			Benin	GDP — EC
			Bolivia	GDP → EC
			Brazil	GDP ↔ EC
			Brunei	GDP ↔ EC
			Bulgaria	GDP → EC
			Cameroon	GDP — EC
			Chile	EC → GDP
			China	GDP — EC
			Colombia	EC → GDP
			Congo	GDP — EC
			Congo, D. R	EC → GDP
			Costa Rica	GDP → EC
			Cote d'Ivoire	GDP — EC

Continue…

Author(s)	Method(s)	Year	Scope	Findings
			Cuba	GDP → EC
			Cyprus	EC → GDP
			Dominican Republic	EC → GDP
			Ecuador	GDP — EC
			Egypt	EC → GDP
			El Salvador	GDP → EC
			Ethiopia	GDP → EC
			Gabon	GDP — EC
			Ghana	GDP ↔ EC
			Gibraltar	GDP ↔ EC
			Haiti	GDP — EC
			Honduras	GDP — EC
			Hong Kong	GDP — EC
			India	GDP — EC
			Iran	GDP ↔ EC
			Iraq	GDP — EC
			Israel	EC → GDP
			Jamaica	GDP — EC
			Jordan	GDP ↔ EC
			Kenya	EC → GDP
			Kuwait	GDP ↔ EC
			Lebanon	GDP ↔ EC
			Libya	GDP — EC
			Malaysia	GDP — EC
			Malta	GDP — EC
			Morocco	GDP ↔ EC
			Mozambique	GDP ↔ EC
			Myanmar	GDP ↔ EC
			Nepal	EC → GDP
			Nicaragua	GDP — EC
			Nigeria	GDP — EC
			Oman	EC → GDP
			Pakistan	GDP — EC
			Panama	GDP → EC
			Paraguay	GDP → EC
			Peru	GDP → EC
			Philippines	EC → GDP
			Qatar	GDP ↔ EC
			Romania	GDP ↔ EC
			Saudi Arabia	GDP → EC
			Senegal	GDP — EC
			Singapore	GDP — EC
			Sri Lanka	GDP — EC
			Sudan	GDP ↔ EC

Continue…

Author(s)	Method(s)	Year	Scope	Findings
			Taiwan	GDP ↔ EC
			Tanzania	GDP — EC
			Thailand	GDP → EC
			Togo	GDP — EC
			Trinidad	GDP ↔ EC
			Tunisia	GDP ↔ EC
			UAE	GDP ↔ EC
			Uruguay	EC → GDP
			Venezuela	GDP → EC
			Vietnam	EC → GDP
			Yemen	GDP ↔ EC
			Zambia	GDP — EC
			Zimbabwe	GDP → EC
Francis et al. (2007)	EG	1971-2002A	Haiti	GDP ↔ EC
			Jamaica	GDP ↔ EC
			Trinidad and Tobago	GDP ↔ EC
Lise and Montfort (2007)	EG	1970-2003A	Turkey	GDP → EC
Lee (2006)	TY	1960-2001A	Belgium	EC → GDP
		1965-2001A	Canada	EC → GDP
		1960-2001A	France	GDP → EC
		1971-2001A	Germany	GDP — EC
		1960-2001A	Italy	GDP → EC
		1960-2001A	Japan	GDP → EC
		1960-2001A	The Netherlands	EC → GDP
		1960-2001A	Sweden	GDP — EC
		1960-2001A	Switzerland	EC → GDP
		1960-2001A	UK	GDP — EC
		1960-2001A	USA	GDP ↔ EC
		1960-2001A	Sweden	GDP — EC
		1960-2001A	Switzerland	EC → GDP
		1960-2001A	UK	GDP — EC
		1960-2001A	USA	GDP ↔ EC
Ang (2007)	VECM	1960-2000A	France	EC → GDP
Ho and Siu (2007)	VECM	1966–2002A	Hong Kong	EC → GDP
Mehrara (2007a)	Pedroni panel cointegration and panel causality test	1971-2002A	Panel of 7 countries in middle east	GDP → EC
Mehrara (2007b)	TY and JJ	1971-2002A	Iran	GDP → CEC
			Kuwait	GDP → CEC
			Saudi Arabia	CEC → GDP
Chiou et al. (2008)	JJ and Baek-Brock non-linear Granger causality	1954-2006A	Taiwan	EC → GDP
		1971-2003A	Hong Kong	EC → GDP
		1971-2003A	Singapore	GDP → EC

Continue…

Author(s)	Method(s)	Year	Scope	Findings
		1971-2003A	Korea	GDP — EC
		1971-2003A	Malaysia	GDP — EC
		1971-2003A	Indonesia	GDP ↔ EC
		1971-2003A	Philippines	GDP → EC
		1971-2003A	Thailand	GDP — EC
		1960-2003A	USA	GDP — EC
Ang (2008)	JJ and VECM	1971-1999A	Malaysia	GDP → EC
Erdal et al. (2008)	JJ and Pairwise Granger causality	1970-2006A	Turkey	GDP ↔ EC
Akinlo (2008)	ARDL	1980-2003A	Gambia	GDP → EC
			Ghana	GDP → EC
			Sudan	GDP → EC
			Zimbabwe	GDP → EC
			Congo	GDP → EC
			Senegal	GDP — EC
			Cameroon	GDP — EC
			Coted' Ivories	GDP — EC
			Nigeria	GDP — EC
			Kenya	GDP — EC
			Togo	GDP — EC
Belloumi (2009)	Granger causality and VECM	1971-2004A	Tunisia	GDP↔EC
Zhang and Cheng (2009)	Granger causality	1960-2007A	China	GDP→EC
Bowden and Payne (2009)	TY	1949-2006A	United States	GDP — EC
Tsani (2010)	TY	1960-2006A	Greece	EC → GDP
Ozturk et al. (2010)	Pedroni panel cointegration	1971-2005A	51 countries:	
			Low income 14	GDP → EC
			Lower middle 24	GDP ↔ EC
			Upper middle 13	GDP ↔ EC
Ozturk and Acaravci (2010a)	ARDL and ECM	1980-2006A	Albania	GDP — EC
			Bulgaria	GDP — EC
			Hungary	GDP ↔ EC
			Romania	GDP — EC
Ozturk and Acaravci (2010b)	ARDL	1968-2005A	Turkey	GDP — EC
Bartleet and Gounder (2010)	ARDL and ECM	1960-2004A	New Zealand	GDP → EC
Warr and Ayres (2010)	JJ and VECM	1946-2000A	USA	EC → GDP
Hossain and Saeki (2011)	Panel causality based Granger, EG and GMM	1971-2007A	Panel of South Asian countries	EC → GDP
Zhang (2011)	TY and Time-varying cointegration	1970-2008A	Russia	GDP ↔ EC
Kaplan et al (2011)	ECM	1971-2006A	Turkey	EC ↔ GDP

Continue…

Author(s)	Method(s)	Year	Scope	Findings
Belke et al. (2011)	Dynamic Panel causality	1981-2007A	Panel of 25 OECD countries	GDP ↔ EC
Eggoh et al. (2011)	Panel cointegration and Panel causality	1970-2006A	African countries (21) Energy exporters (11) Energy importers (10)	GDP ↔ EC GDP ↔ EC GDP ↔ EC
Lau et al. (2011)	Granger causality test and FMOLS	1980 – 2006A	Panel of 17 Asian countries	GDP → EC
Abid and Sebri (2012)	JJ and Granger based VECM	1980-2007A	Tunisia	GDP ↔ EC
Sadorsky (2012)	Panel cointegration and Panel causality	1980-2007A	Panel of 7 countries in South American	GDP ↔ EC
Narayan and Popp (2012)	Panel cointegration and Panel causality	1980-2006A	Global panel (93) Western European (20) Asian panel (17) Latin American (17) Middle East panel (12) African panel (25) G6 panel (6)	GDP ↔ EC EC → GDP EC → GDP EC → GDP GDP — EC GDP ↔ EC EC → GDP
Souhila and Kourbali (2012)	Threshold cointegration and Granger causality	1965-2008A	Algeria	GDP → EC
Pirlogea and Cicea (2012)	Co-integration tests	1990-2010A	Romania Spain	EC → GDP EC → GDP
Zhang and Xu (2012)	Panel cointegration and Panel causality	1995-2008A	China	GDP ↔ EC
Fuinhas and Marques (2012)	ARDL and Panel Causality test	1965-2009A	Panel Portugal Italy Greece Spain Turkey	GDP ↔ EC GDP ↔ EC GDP ↔ EC GDP ↔ EC GDP ↔ EC GDP ↔ EC
Shahiduzzaman and Alam (2012)	JJ and VECM	1960-2009A	Australia	GDP ↔ EC
Wesseh Jr and Zoumara (2012)	Parametric and non-parametric Granger causality.	1980-2008A	Liberian	GDP ↔ EC
Tian and Cui (2013)	Granger causality	1978-2010A	China	GDP — FEC
Ocal and Aslan (2013)	ARDL and TY	1990-2010A	Turkey	GDP → REC

Continue…

Author(s)	Method(s)	Year	Scope	Findings
Herrerias et al. (2013)	Panel cointegration test	1995-2009A	Chinese	GDP → EC
Dergiades et al. (2013)	Parametric and non-parametric test	1960-2008A	Greece	EC → GDP
Bildirici (2013)	ARDL and ECM	1980-2009A	Argentina Bolivia Cuba Costa Rica El Salvador Jamaica Nicaragua Panama Peru	BEC → GDP BEC → GDP BEC → GDP BEC → GDP BEC ↔ GDP BEC → GDP BEC → GDP BEC → GDP BEC → GDP
Abalaba and Dada (2013)	ECM	1971-2010A	Nigeria	EC → GDP
Menegaki and Ozturk (2013)	PECM	1975-2009A	26 European countries	FEC → GDP
Papież and Śmiech (2013)	Bootstrap panel Granger causality	1993-2011A	post-communist countries Bulgaria the Czech Republic Estonia Hungary Latvia Lithuania Poland Romania Slovakia	 EC → GDP GDP — EC GDP — EC GDP — EC EC ↔ GDP GDP — EC EC → GDP EC → GDP GDP — EC
Bildirici and Özaksoy (2013)	ARDL and Granger causality	1960–2010A	Austria Finland France Hungary Poland Portugal Romania Spain Sweden Turkey	GDP → EC BEC ↔ GDP BEC ↔ GDP BEC → GDP BEC → GDP BEC ↔ GDP BEC ↔ GDP BEC ↔ GDP BEC ↔ GDP GDP → EC
Kalyoncu et al (2013)	EG and Granger causality	1995-2009A	Armenia Georgia Azerbaijan	PGDP → PEC PGDP — PEC PGDP — EPC
Mugableh (2013)	ARDL	1971−2012A	Malaysia	EC → CO GDP → CO GDP ↔ EC

Continue…

Author(s)	Method(s)	Year	Scope	Findings
Kusuma and Muqorrobin (2013)	JJ and ECM	1980-2010A	Malaysia	GDP — EC
Behmiri and Manso (2013)	Panel Granger Causality	1985−2011A	Panel of 23 SSA countries Panel exporting countries Panel importing countries	 OEC ↔ GDP OEC → GDP
Shahateet et al (2014)	Granger causality	1970-2011A	Jordan	GDP → EC
Szep (2014)	VAR and Granger causality	1990-2009A 1990-2009A 1990-2009A 1990-2009A 1990-2008A	Hungary Poland Czech Republic Slovakia Slovenia	EC → GDP GDP — EC EC → GDP EC → GDP GDP — EC
Yildirim et al (2014)	TY and VAR	1971-2010A 1971-2010A 1971-2010A 1971-2007A 1971-2011A 1971-2011A 1971-2010A 1971-2010A 1960-2011A	Bangladesh Egypt Indonesia Iran Korea Mexico Pakistan Philippines Turkey	EC → GDP GDP — EC GDP — EC EC → GDP GDP — EC GDP — EC EC → GDP GDP — EC EC → GDP
Hou (2014)	Hsiao's granger causality	1953-2006A	China	EC ↔ GDP
Shahateet (2014)	ARDL	1982-2011A 1982-2011A 1982-2011A 1999-2011A 1982-2011A 1982-2011A 1990-2011A 2001-2009A 1982-2011A 1982-2011A 2002-2011A 1982-2011A 1982-2011A 1982-2010A 1982-2011A 1982-2011A 1992-2011A	Algeria Bahrain Egypt Iraq Jordan Kuwait Lebanon Libya Morocco Oman Qatar Saudi Arabia Sudan Syria Tunisia UAE Yemen	GDP — EC GDP — EC GDP — EC GDP — EC GDP — EC EC ↔ GDP GDP — EC GDP — EC GDP — EC GDP — EC GDP — EC GDP — EC GDP — EC GDP — EC GDP — EC GDP — EC GDP — EC
Pempetzoglou (2014)	Granger causality and Dicks-Panchenko causality	1945-2006A	Turkey	GNP — EC

Continue…

Author(s)	Method(s)	Year	Scope	Findings
Dogan (2014)	Granger causality	1971-2011A	Benin Congo Kenya Zimbabwe	GDP — EC GDP — EC EC → GDP GDP — EC
Muse (2014)	OLS, ECM, and Granger Causality	1980-2012A	Nigeria	GDP → EEC EC → COEC
Soares et al (2014)	VECM and Granger causality	1971-2010A	Indonesia	EC → GDP
Yildirim et al (2014)	TY and VAR	1971-2010A 1971-2010A 1971-2010A 1971-2007A 1971-2011A 1971-2011A 1971-2010A 1971-2010A 1960-2011A	Bangladesh Egypt Indonesia Iran Korea Mexico Pakistan Philippines Turkey	EC → GDP GDP — EC GDP — EC EC → GDP GDP — EC GDP — EC EC → GDP GDP — EC EC → GDP
Azam et al (2015b)	VAR and Granger causality	1980-2012A	Indonesia Malaysia Thailand Philippines Singapore	EC — GDP GDP → EC EC — GDP EC — GDP EC — GDP
Talbi (2015)	ARDL and VECM	1975-2012A	Egypt Iran Marocco Saudi Arabia	EC → GDP EC → GDP GDP ↔ EC EC — GDP
Tang et al (2016)	Modified Wald test	1971-2011A	Vietnam	GDP → EC
Faisal et al (2017)	TY	1960-2012A	Belgium	GDP → EC
Shakouri and Yazdi (2017)	ARDL	1971-2015A	South Africa	GDP ↔ EC GDP ↔ REC
Kahia et al (2017)	Panel Granger causality test	1980–2012A	11 MENA Net Oil Importing Countries	GDP ↔ REC GDP ↔ NREC

Note : The unidirectional causality, bidirectional causality and no causality between economic growth and energy consumption have been represented by the symbols →, ↔ and — respectively.

2.7 The Relationship Between Economy Growth and CO_2 emissions

The environmental degradation considered as a cause-effect factor that occurs from the improvement of economic activities. Many scientists attempt to explore the interrelationship between economic growth and environmental degradation. The pollution-income relationship (PIR) literature is one of the theoretical approaches that widely applied by economist, environmentalist, and scientists to explore the impact of economic growth against sustainable environmental quality. This approach assumed that the linkage between economy and environment emission could be determined within several forms, and one of the widest applied by many experts is the Environmental Kuznets Curve (EKC) approach. The EKC is examined empirically under considering the various type of emissions or pollutants.

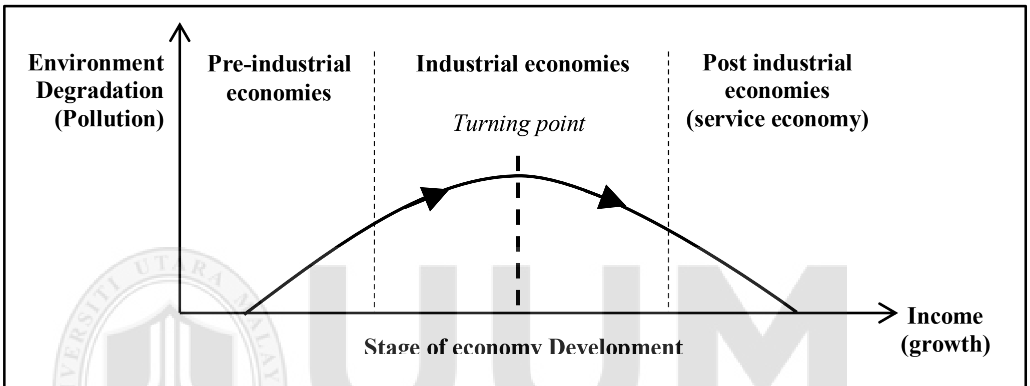
The EKC literature shifts the main issue such as depletion natural resources and diminishing environmental quality to be critical issues which associated with the impact of economic growth on environmental deterioration and increased emissions. Based on the EKC theory, once the economic growth reaches a certain level, environment emissions will decrease gradually (Kaika & Zervas, 2013; Niu & Li, 2014). According to Auci & Trovato (2018), the negative impact of economic growth toward environment quality needed action plans and strategic policies on the domestic and global levels. Increasing accumulation GHG in the atmosphere has led to the intensification of climate change policy analysis, and accelerate increase the number of empirical and theoretical models that provide evidence for inverted-U linkage between economic growth and environment emissions.

The EKC is affected by several determinant factors, such as the diversity of industries which has different pollution intensity levels, typical production ranges that diversify throughout economic growth process, and the changes of various input production which indirectly drive raised harmful and less environmentally inputs (Bilgili et al., 2016; Dogan & Turkekul, 2015). Economic growth that supports by technical advancement possibly created positive or negative effects on environmental quality. Production input rates that refer to the expansion of production activities with a range of processes and technology status certainly generated less pollution if the implementation of clean technology gradually adopted over production process (Farhani et al., 2014; Gill et al., 2018).

There are critical consequences that should be considered to determine environmental emission levels and utilization of resources. The first one is the case which increasing output will require more entry and more emission as a byproduct. For this reason, economic growth acts as a scale and creates a negative effect on the environment. Economic growth may have positive or negative effects on the environment with a technical impact. Second, changes in income or preferences cause policy differences that bring out changes in production methods and later in per unit emission of the output. It shows that the relationship between income and pollutant emission will be different with pollutants because they do not inflict the same perceived damage. Third, Economic growth may have a positive or negative impact on the environment through a composition effect. As the income increases, the structure of the economy may change and consequently there may emerge an increase in the activities of cleaners or pollutants. The net effect of these three impacts raises the EKC (Tsurumi and Managi, 2010).

The linkage between economic growth and the environment emissions has examined in previous studies within the bivariate approach. Azomahou and Phu (2001) found real GDP growth causes raised CO_2 emission and concluded that the economic growth process harms environmental quality throughout economic growth stages. Lindmark

(2002) also found a unidirectional linkage from GDP to CO_2 emission in Swedish using BBO model, structural time series model and EKC. Azomahou et al. (2006) applied a panel data approach for 100 countries and discovered that GDP did not have a mutual linkage with CO_2 emissions. Moreover, their results confirmed that both the nonparametric and first-difference estimations repudiate the existence of the EKC hypothesis.



Sources : Panaytou (1993, 2003:46)

Figure 2.1 The Environment Kuznets Curve (EKC)

Padilla and Serrano (2006) studied the linkage between inequality in the distribution of CO_2 emission and income inequality using four panels of countries using annual data from 1971 to 1999. Their findings concluded that although in a simple way inequality in CO_2 emissions may be declined, the disparity between the inhabitants of rich and poor countries has diminished to a lesser extent. Kuntsi-Reunanen (2007) analyzed CO_2 emission flows and energy use in Latin American countries using time series data from 1971 to 2001. Their results reveal that the changes in CO_2 intensities were quite similar for the selected Latin American countries. Nevertheless, energy use was varied slightly and indicating differences in energy utilization in the analyzed countries.

Jaunky (2011) has found a unidirectional linkage in both short and long terms from real GDP per capita to CO_2 emission in a panel model for 36 countries with a high-income level. Boopen and Vinesh (2011) discovered that the trajectory of CO_2 emission is strictly associated with the GDP path. In other words, their study revealed that the elasticity of CO_2 emissions on income raised over time although their result did not found the existence inverted-U on the EKC. In other words, their study concludes that CO_2 emission on income did not have a significant linkage. Saleh et al. (2014) have discovered a bidirectional linkage between GDP per capita and CO_2 per capita for three groups of countries. In addition, there was one-way causal linkage from GDP per capita to CO_2 emissions per capita for subgroups of countries with high average economic growth rates and the rest of the world countries which were not members OECD and do not have high GDP rate.

Karakas (2014) using a panel data model of 44 countries (22 OECD and 22 Non-OECD countries) has revealed a strong linkage between national income and CO_2 emission with the inverted-U shape in EKC. Ong and Sek (2013) investigated the linkage between income level and environmental quality for three income groups (high, middle and low-income) using annual data from 1970 to 2008. They revealed absence or low interaction between environmental quality and income. Hayfa and Rania (2014) developed a panel of fifteen countries during the period 1991-2011 and using Generalized Least Squares (GLS) and Generalize method of moments (GMM). Their results concluded that biomass provides a decisive role in carbon reduction and then found that growth level and CO_2 emission have a non-linear linkage.

Bakirtas et al. (2014) studied the linkage between GDP and CO_2 emission using a panel model for 34 OECD countries and 5 BRICS countries. Their findings implied CO_2 emission and GDP did not have any linkage. Furthermore, their results also confirm that the long-run income elasticity is smaller than the short-run income elasticity in 36 per cent of the sample countries. Robalino-López et al. (2014) checked possibility the rapid pace of GDP throughout a medium-term can control the intensity rate of CO_2 emissions in Ecuador for the period 1980-2025. However, their findings not revealed evidence the EKC hypothesis in Ecuador and concluded this country would achieve environmental stabilization in the medium term when this country combining economic growth, increased utilization of renewable energy with appropriate changes in the energy matrix, and improvement in productive sectoral structure.

Hakimi and Hamdi (2015) investigated the impacts of economic growth and trade liberalization toward the environmental quality in Tunisia and Morocco using annual data from 1971 to 2013. Their results concluded that trade liberalization harms the environmental quality in both countries. Robalino-Lopez et al. (2015) investigated economic growth-CO_2 emissions nexus for Venezuela and employing the Jaunky specification and cointegration techniques to check the existence of EKC hypothesis in this country. Their findings revealed that the EKC hypothesis does not fully occur in Venezuela. Nevertheless, over the medium term, this country predicted to achieve environmental stabilization. This stabilization would be achieved if economic growth progress stimulated increasing renewable energy consumption as well as created proper reforms in the productive sectoral structure and the energy matrix.

Xu and Lin (2015) examines the impacts of urbanization and industrialization on CO_2 emissions in China using provincial panel data from 1990 to 2011 and nonparametric additive regression models. Their results shown that GDP per capita, export, and industrialization significantly influenced CO_2 emissions in three regions in China, while urbanization has significant impact to CO_2 emissions only in two regions in China. Abbasi and Riaz (2016) studied the long-run linkage between carbon emissions and a set of financial and economic indicators in Pakistan. Their results indicated that financial indicators have an essential role in the emission mitigation process when a greater level of liberalization and financial development achieved. Rafiq et al. (2016) studied the impact of trade openness and urbanization on energy intensity and emissions in twenty-two emerging economies using annual data from 1980 to 2010 and found that population density stimulates increase emissions and energy intensity.

Saidi and Barek (2017) examines the relationship among CO_2 emissions, energy consumption, urbanization, trade openness, financial development and economic growth in Iran over the period 1975-2011 using Granger causality approach and found a unidirectional Granger causality running from per capita energy consumption, urbanization, financial development and per capita real income to per capita carbon emissions. Solarin et al. (2017) investigated the pollution haven hypothesis (PHH) in Ghana using annual data from 1980 to 2012 and discovered that GDP, foreign direct investment, urban population, financial development and international trade significantly influences CO_2 emission in Ghana. Akbota and Baek (2018) explored the effect of income growth on CO_2 emissions in Kazakhstan using annual data from 1991-2014 and the ARDL techniques. Their result indicated that this effect at a low level of income increases CO2 but at a high level decreases it. Based on this findings, they concluded that a rise of energy consumption caused increases CO_2 emissions and the EKC hypothesis appears for Kazakhstan. Detail summary regarding previous studies that investigate the linkage between economic growth and CO_2 emissions in bivariate modelling can be seen in Table 2.2.

Table 2.2
The summary of empirical studies about the relationship between economic growth and CO_2 emissions.

Author(s)	Method	Year	Variables	Scope	Findings
Azomahou & Phu (2001)	Panel nonparametric analysis with EKC approach.	1960-1996A	CO_2P and GDPP	100 countries	GDP → CO_2
Lindmark (2002)	BBO model, Structural time series models and EKC.	1870–1997A	CO_2, technology, fuel prices and GDP	Swedish	GDP → CO_2
Azomahou et al (2006)	nonparametric poolability test nonparametric regression, and a monotonicity test.	1960-1996A	GDPP and CO_2	a panel of 100 countries.	GDP — CO_2
Jaunky (2011)	Panel cointegration tests and PVAR.	1980-2005A	CO_2 and GNP	36 countries with high income levels	GDP → CO_2
Boopen & Vinesh (2011)	EKC	1975-2009A	CO_2 and GDP	Republic of Mauritius	GDP — CO_2
Saleh et al (2014)	VAR with the micro panel.	1990-2004A	GDPP and CO_2P	98 World Bank member countries	GDP ↔ CO_2
Author(s)	Method(s)	Year	Variables	Scope	Findings
Karakas (2014)	PVECM and Panel Granger causality	1990-2011A	GNP and CO_2	44 countries (22 in OECD countries and 22 Non-OECD countries)	CO_2 ↔ GNP
Ong & Sek (2013)	PVAR and non-panel VAR.	1970-2008A	CO_2P and GNP	215 countries (30 high income countries, 110 middle income countries, and 35 low income countries)	GNP — CO_2
Hayfa & Rania (2014)	Panel GLS and Panel GMM.	1991-2011A	CO_2, Elc-BW, GDP, POP.	15 countries	EL → CO_2 GDP — CO_2

Continue…

Author(s)	Method	Year	Variables	Scope	Findings
Bakirtas et al (2014)	Dynamic panel data	1990-2010A	CO_2 and GDP	34 OECD countries and 5 BRICS countries	GDP — CO_2
Omri et al (2014)	Arellamo-Bound GMM estimator	1990-2011A	CO_2, GDP, FDI, CS, TR, RER	Panel of 54 countries Europe and North Asia Latin America and Caribbean Middle East, North America, and SSA	 CO_2 → GDP FDI — CO_2 TR — CO_2 CO_2 → GDP FDI ↔ CO_2 TR — CO_2 CO_2 → GDP FDI ↔ CO_2 TR — CO_2
Hakimi & Hamdi (2015)	EG and VECM	1971-2013A	CO_2, GDP, FDI, CS, TR.	Tunisia Marocco Panel	GDP → CO_2 FDI → CO_2 TR — CO_2 CS → CO_2 GDP → CO_2 FDI → CO_2 TR — CO_2 CS → CO_2 GDP ↔ CO_2 FDI ↔ CO_2 TR — CO_2 CS — CO_2
Robalino-Lopez et al (2015)	DOLS	1980-2010A	GDP and CO_2	Venezuela	GDP → CO_2
Abbasi & Riaz (2016)	ARDL, VECM, and TY	1988-2011A	CO_2P, GDPP, TC, PSC, SMC, ST, FDI	Pakistan	TC — CO_2P PSC → CO_2P SMC → CO_2P ST — CO_2P FDI → CO_2P GDP → CO_2P
Rafiq et al (2016)	FMOLS, DOLS, and panel GMM	1980-2010A	CO_2, POP, GDP, GDP^2, URB, TR	Panel 22 emerging economies	GDP → CO_2 GDP2 → CO_2 POP → CO_2 URB → CO_2 TR → CO_2
Saidi & Mbarek (2017)	Panel GMM	1990-2013A	GDPP, $GDPP^2$, FD, TR, URB, CO_2	19 emergy economies	EC → CO_2 GDPP → CO_2 GDPP2 → CO_2 FD → CO_2 URB → CO_2

Continue…

Author(s)	Method	Year	Variables	Scope	Findings
Solarin et al (2017)	ARDL	1980-2012A	GDP, FDI, URB, FD, TR, and CO_2	Ghana	GDP → CO_2 FDI → CO_2 URB → CO_2 FD → CO_2 TR → CO_2
Akbota & Baek (2018)	ARDL	1991-2014A	GDP, GDP^2, EC, CO_2	Kazakhtan	GDP → CO_2 GDP2 → CO_2 EC → CO_2

Note : Unidirectional relationship, bidirectional relationship and no causality relationship between economic growth and CO_2 emissions have been represented by the symbols →, ↔ and —, respectively.

2.8 The Relationship Between Economic Growth, Energy Consumption and CO_2 Emissions

Energy has considered as an essential foundation in economic growth and human welfare which indirectly acting as a mediator that influence environmental degradation (Yazdi & Shakouri, 2014). This issue has been motivated many researchers to examine the linkage between energy consumption, economic growth and environmental emissions in various countries worldwide. Most of the previous studies commonly focus to explore and provide empirical evidence which expected usefully for the policymakers. These studies usually produced mixed results and varied depending on data series and methodology used (Alam et al., 2012; Joo et al., 2015). Even, some studies in the same country's with different methods provide different evidence and findings, and this issue certainly should be further re-investigated.

In concern with environmental degradation, both economic growth and energy consumption have a relevant connection to environmental impact. Some literature studies have provided evidence of the existence of the linkage between economic growth and energy consumption towards environmental impact, in particular in a case of rising CO_2 emissions as consequences an increased the use of fossil fuels and improvement of economic activities in a single country or a group of country (Bhattacharya et al., 2014; Kulionis, 2013; Wang et al., 2011). Specifically, this area study shows that CO_2 emissions may have a different connection with economic growth and energy consumption.

Karanfil (2008) concluded that empirical evidence that found on several studies that investigated for the case in developing countries might inaccurate because there are activities are unrecorded correctly into real GDP, therefore examine the causal linkage between real GDP and energy consumption may not provide reliable empirical evidence as results. Furthermore, most of previous studies which applied bivariate model has ignored to include other factors in their analysis model such as environmental emission which may have related effect toward economy growth (GDP), such as several recent studies that considering CO_2 emissions or GHG as proxy variables and suggest that some other indicators may play a vital role in both economic growth and energy consumption.

The bivariate analysis that only compared the linkage between two indicators in the model probably generated biased results due to the removal of other relevant variables (Glasure, 2002). The multivariate analysis considered should be neccesary because of the change in energy use is often influenced by the substitution of other production factors (Stern, 2000). Therefore, several recent studies now have been developed into multivariate modelling to investigate the linkage between economic growth, energy consumption and other relevant indicators, particularly indicator of environmental quality which assessed from the level of CO_2 emission.

The evidence regarding the causal linkage between economic growth, energy consumption and CO_2 emissions had motivated several studies developed a complicated model with a trivariate model (energy, economy, and emission) or multivariate model. In the multivariate frameworks, besides adding CO_2 emissions, some previous studies also considering to added other relevant indicators such as population growth, investment level, the share of value added to GDP, labour force, energy price, openness trade, and other economic variables into analysis model. Nevertheless, the outline of previous studies only focus to explores the interrelationship among economic, energy, and environment indicators in a country without considered diversity of energy users in a country, both in developed and developing countries.

Many literature studies are developing with multivariate frameworks which added other indicators besides economic growth and energy consumption. However, this section only discusses the linkage between economic growth, energy consumption, and CO_2 emission in several studies employing multivariate modelling. Therefore, this section divided into three sub-sections. First, discussing empirical evidence regarding the linkage between energy consumption and economic growth in multivariate studies. Second, presenting empirical evidence regarding the linkage between energy consumption and CO_2 emission in multivariate studies. Third, discussing empirical evidence regarding the linkage between economic growth and CO_2 emissions.

2.8.1 The Causality Linkage Between Economy Growth and Energy Consumption in Multivariate Modelling

The economic-energy nexus has studied by many scientists on the multivariate model under similar hypotheses (growth, conservation, feedback, and neutral). The evidence of growth hypothesis has found by Stern (1993, 2000) in The U.S; Cheng (1997) in Brazil; Masih and Masih (1998) in Thailand and Sri Lanka; Asafu-Adjaye (2000) in India and Indonesia; Soytas and Sari (2006b) in France and The U.S; Mahadevan and Asafu-Adjaye (2007) in India, Senegal, South Korea and Thailand; Zachariadis (2007) in France, Germany, and Japan; Odhiambo (2010) in South Africa and Kenya; Hwang and Yo (2012) in Indonesia; Hossein et al. (2012) in Algeria, Angola, Ecuador, Kuwait, Libya, Nigeria, and Venezuela; Saboori and Sulaiman (2013a) in Malaysia, Philippines, and Thailand; Jebli and Youssef (2015b) in Tunisia; Bozkurt and Akan (2014) in Turkey; Ghosh et al. (2014) in Bangladesh; Yang and Zhao (2014) in India; Esso and Keho (2016) in Congo and Gabon; as well as Bekhet et al. (2017) in Kingdom Saudi Arabia and Qatar. In the panel data approach, the evidence of growth hypothesis has discovered by Lee (2005) in a panel of eighteen developing countries; Mahadevan and Asafu-Adjaye (2007) in a panel of seven importers developing countries; Narayan and Smyth (2007) in a panel of G7 countries; Lee and Chang (2008) in a panel of Asian countries, a panel of APEC countries, and a panel of ASEAN countries; Jebli and Youssef (2015a) in a panel of five North Africa countries; Ucan et al. (2014) in a panel of fifteen European Union countries; Akin (2014) in a panel of eighty-five countries.

The empirical evidence of conservation hypothesis in multivariate studies had found Cheng and Lai (1997) in Taiwan; Cheng (1999) in India; Aqeel and Butt (2001) in Pakistan; Oh and Lee (2004) in South Korea; Zachariadis (2007) in Canada, Germany and United Kingdom; Zamani (2007) in Iran; Acaravci and Ozturk (2010) in Greece and Italy; Odhiambo (2010a) in Congo; Hatzigeorgiou et al. (2011) in Greece; Hossein et al. (2012) in Iran, Iraq, Qatar, United Arab Emirates, and Saudi Arabia; Jebli and Youssef (2013) in Algeria, Cyprus, Egypt, Iran, Israel, Sudan, Syria, Tunisia, and Turkey; Ishida (2013) in Japan; Palamalai et al. (2014) in India; Cowan et al. (2014) in South Africa; as well as Esso and Keho (2016) in Ghana. While the evidence of conservation hypothesis within panel model had discovered by Lee (2005) in a panel of 12 developing countries; Huang et al. (2008) in a panel of middle-income countries and a panel of high-income countries; Constantini and Martini (2010) in a panel of 71 countries and a panel of 45 non-OECD countries; Hossain (2011) in a panel of 9 Newly Industrialized countries (NIC); Farhani and Rejeb (2012) in a panel of 15 MENA countries; Jebli and Youssef (2013) in a panel of 11 MENA countries; Nayan et al. (2013) in a panel of 23 selected countries; and Akin (2014) in a panel of 85 countries.

The empirical evidence for feedback hypothesis between energy consumption and economic growth for individual country had found by Masih and Masih (1997) in Korea and Taiwan; Asafu-Adjaye (2000) in Thailand and Philippines; Glasure (2002) in Korea; Hondroyiannis et al (2002) in Greece; Ghali and El-Saka (2004) in Canada; Oh and Lee (2004) in Korea; Paul and Bhattacharya (2004) in India; Soytas and Sari (2006b) in Germany, Italy, Japan, United Kingdom, and The USA; Climent and Pardo (2007) in Spain; Mahadevan and Asafu-Adjaye (2007) in Australia, Norway, UK, Argentina, Indonesia, Kuwait, Malaysia, Nigeria, Saudi Arabia, Venezuela, Japan, Sweden, The U.S, Ghana, South Africa, and Singapore; Zachariadis (2007) in France, Germany, Italy and Japan; Yuan et al (2008) in China; Acaravci and Ozturk (2010) in Switzerland; Shahbaz et al (2012) in Pakistan; Saboori and Sulaiman (2013a) in

Malaysia; Sebri and Salha (2014) in Brazil and South Africa; Jebli and Youssef (2013) in Egypt; Lim et al (2014) in Philippines; Yusuf (2014) in Nigeria; Withey (2014) in Canada; Kuo et al (2014) in Hong Kong; as well as Bekhet et al. (2017) in UEA and Oman.

In panel data modelling, a mutual linkage between energy consumption and economic growth had found by Mahadevan and Asafu-Adjaye (2007) in a panel of three exporters developed countries, a panel of seven exporters developing countries, and a panel of three importers developed countries; Huang et al. (2008) in a panel of 82 selected countries; Costantini and Martini (2010) in a panel of 26 OECD countries; Apergis and Payne (2010) in a panel of 20 OECD countries; Pao & Tsai (2011) in a panel of 4 BRIC countries; Wang et al. (2011) in a panel of 28 provinces in China; Al-Mulali and Sab (2012) in a panel of 19 selected countries; as well as Dritsaki and Dritsaki (2014) in a panel of three Southern European countries.

The evidence for neutrality hypothesis in individual country within multivariate model had found by Yu and Hwang (1984), Soytas et al (2007) and Payne (2009) in the USA; Cheng (1997) in Mexico and Venezuela; Soytas and Sari (2006a) in China; Jobert and Karanfil (2007) and Soytas and Sari (2009) in Turkey; Zachariadis (2007) in France, Germany, Italy and The USA; Acaravci and Ozturk (2010) in Austria, Belgium, Denmark, Finland, France, Germany, Hungary, Iceland, Ireland, Luxenburg, Netherlands, Portugal, Spain, Sweden, and The UK; Ozturk and Acaravci (2010) in Turkey; Alam et al (2011) in India; Abalaba and Dada (2013) in Nigeria; Saboori & Sulaiman (2013a) in Indonesia and Singapore; Alkhathlan and Javid (2013) in Saudi Arabia; Kulionis (2013) in Denmark; Leitao (2014) in Portuguese; Arouri et al (2014) in Thailand; Cowan et al (2014) in Brazil, India, and China; Yusuf (2014) in Nigeria; Alshehry and Belloumi (2014) in Saudi Arabia; Azam et al (2015) in Indonesia, Thailand, Philippines, and Singapore; Esso and Keho (2016) in Benin, Cameroon, Democratic Republik Congo, Cote d'Ivoire, Kenya, Nigeria; Senegal, South Africa, and Togo; as well as Bekhet et al. (2017) in Kuwait and Bahrain. Furthermore, the neutrality hypothesis also discovered using the panel analysis method, such as Huang et al. (2008) who found this hypothesis on a panel of nineteen low-income countries and Jebli et al. (2014) who discovered this hypothesis on a panel of twenty-two Central and South America countries.

2.8.2 The Causality Linkage Between Energy Consumption and CO_2 Emissions in Multivariate Modelling

The evidence of a unidirectional linkage from energy consumption to CO_2 emission has revealed by Soytas et al. (2007) in The USA; Al-Mulali and Sab (2012) in a panel of 30 Sub-Saharan African countries; Farhani et al. (2013) in a panel of 11 MENA countries; Leitao (2014) in Portuguese; and Jebli et al. (2014) in a panel of 22 Central and South America countries; Esso and Keho (2016) in Nigeria; as well as Bekhet et al. (2017) in Oman. Otherwise, evidence for a unidirectional linkage from CO_2 emission to energy consumption obtained by Soytas and Sari (2008) in Turkey; Farhani and Ben (2012) in a panel of 15 MENA countries; Sebri and Salha (2014) in India and South Africa; Jebli and Youssef (2015a) in Egypt and Sudan; Palamalai et al. (2014) in India (for coal, oil and natural gas consumption); Kuo et al. (2014) in Hong Kong; Esso and Keho (2016) in Ghana; as well as Bekhet et al. (2017) in Kingdom Saudi Arabia, UEA, and Qatar.

The evidence of mutual linkage between CO_2 emission and energy consumption in the multivariate model was discovered by Wang et al. (2011) in China; Alam et al. (2011) in India; Hwang & Yo (2012) in Indonesia; Saboori et al. (2013) in Malaysia; Saboori and Sulaiman (2013a) in Malaysia and Singapore; Alkhathlan and Javid (2013) in Saudi Arabia; Kohler (2013) in South Africa; Palamalai et al. (2014) in India (for electricity); Lim et al. (2014) in the Philippines (for oil); Dritsaki and Dritsaki (2014) in a panel of three Southern European countries; as well as Bekhet et al. (2017) in Kuwait and Oman. Furthermore, the neutrality hypothesis between energy consumption and CO_2 emission also had been discovered by Acaravci and Ozturk (2010) in Denmark, Greece, Iceland, Italy, and Switzerland; Hossain (2011) in a panel of nine Newly Industrialized Countries; Saboori & Sulaiman (2013a) in Indonesia, Philippines, and Thailand; Sebri and Salha (2014) in Brazil; Jebli and Youssef (2015a) in Algeria and Tunisia; Ucan et al. (2014) in a panel of 50 European Union countries; Akin (2014) in a panel of 85 selected countries; Magazzino (2014) in a panel of six ASEAN countries; Arouri et al. (2014) in Thailand; Cowan et al. (2014) in Brazil, Russia, China, and South Africa; Withey (2014) in Canada; Bhattacharya et al. (2014) in India; as well as Alshehry and Belloumi (2014) in Saudi Arabia; Esso and Keho (2016) in Benin, Cameroon, Democratic Republik Congo, Cote d'Ivoire, Gabon, Kenya, Senegal; South Africa, and Togo; as well as Bekhet et al. (2017) in Bahrain.

2.8.3 The Causality Linkage Between Economic Growth and CO_2 Emission In Multivariate Modelling

The evidence for a unidirectional linkage from economic growth to CO_2 emission has discovered by Acaravci and Ozturk (2010) in Denmark and Italy; Hossain (2011) in a panel of nine newly industry countries (NIC); Wang et al. (2011) in China; Al-Mulali and Sab (2012) in a panel of 30 Sub-Saharan African countries; Hwang & Yo (2012) in Indonesia; Farhani et al. (2013) in a panel of eleven MENA countries; Jebli & Youssef (2014) in Algeria; Akin (2014) in a panel model of eighty-five countries; Magazzino (2014) in a panel of six ASEAN countries; and Bhattacharya et al. (2014) in India; Esso and Keho (2016) in Benin, Democratic Republik Congo, Ghana, and Senegal; as well as Bekhet et al. (2017) in Bahrain. Special in Saudi Arabia, Alshehry and Belloumi (2014) only found a unidirectional linkage from economic growth to CO_2 emissions generated from oil and natural gas consumptions.

On the contrary, a unidirectional linkage from CO_2 emission to economic growth within the multivariate model has found by Alkhathlan and Javid (2013) in Saudi Arabia; Sebri and Salha (2014) in Brazil and India; Saboori and Sulaiman (2013a) in the Philippines; Kohler (2013) in South Africa; Ucan et al. (2014) in a panel model of fifteen European Union countries; Bozkurt and Akan (2014) in Turkey; Palamalai et al. (2014) in India; Cowan et al. (2014) in Brazil; Lim et al. (2014) in the Philippines; and Kuo et al. (2014) in Hong Kong; Jebli and Youssef (2015a) in a panel model of five North Africa countries; Jebli and Youssef (2015b) in Tunisia; Esso and Keho (2016) in Congo and Togo; as well as Bekhet et al. (2017) in Oman. The feedback hypothesis discovered by Hatzigeorgiou et al. (2011) in Greece; Pao and Tsai (2011) in a panel of four BRIC countries; Saboori and Sulaiman (2013a) in Indonesia, Singapore, and Thailand; Saboori and Sulaiman (2013b) in Malaysia; Jebli and Youssef (2013) in Egypt and Sudan; Arouri et al. (2014) in Thailand; Cowan et al. (2014) in Russia; Dritsaki & Dritsaki (2014) in a balanced panel of three European Union members; as well as Esso and Keho (2016) in Nigeria. Meanwhile, absence link between economic growth and CO_2 emission in multivariate studies has found by

Soytas et al. (2007) in the USA; Soytas & Sari (2009) in Turkey; Acaravci & Ozturk (2010) in Greece, Iceland, Italy, and Switzerland; Ozturk and Acaravci (2013) in Turkey; Alam et al. (2011) in India; Saboori and Sulaiman (2013b) in Malaysia; Kulionis (2013) in Denmark; Sebri & Salha (2014) in South Africa; Ghosh et al. (2014) in Bangladesh; Leitao (2014) in Portuguese; Cowan et al. (2014) in India and China; Yusuf (2014) in Nigeria; Withey (2014) in Canada; Alshehry and Belloumi (2014) in Saudi Arabia; Jebli et al. (2014) in a panel of twenty-two Central and South America countries; Shaari et al. (2014) in a panel of fifteen developing countries; Esso and Keho (2016) in Cameroon, Cote d'Ivoire, Gabon, Kenya, and South Africa; Bekhet et al. (2017) in Kingdom Saudi Arabia, UEA, Kuwait, and Qatar. Detail summary regarding previous studies that investigate the linkage between economic growth, energy consumption and CO_2 emissions in multivariate modelling can be seen in Table 2.3.

Table 2.3
The summary of empirical studies about the causality relationship between energy consumption, economic growth, and CO_2 emissions in multivariate framework.

Author(s)	Method	Periods	Additional variables	Scope	Findings
Yu & Hwang (1984)	Sims and Granger causality	1947-1979A	EMP	USA	GNP — EC EC → EMP
Stern (1993)	Granger causality and VAR	1947-1990A	EMP and capital	USA	EC → GDP
Cheng (1996)	EG	1947-1990A	Capital	USA	EC — GNP
Cheng (1997)	EG	1963-1993A 1949-1993A 1952-1993A	Capital	Brazil Mexico Venezuela	EC → GDP EC — GDP EC — GDP
Cheng & Lai (1997)	EG	1955-1993A	EMP	Taiwan	GDP → EC EC → EMP
Masih & Masih (1997)	JJ, VDC and IRF	1961-1990A	CP	Korea Taiwan	GDP ↔ EC GDP ↔ EC
Cheng (1998)	JJ and Hsiao's Granger causality	1952-1995A	Capital and EMP	Japan	GNP → EC
Masih & Masih (1998)	JJ, VDC and IRF	1955-1991A	CP	Thailand Sri Lanka	EC → GDP EC → GDP

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
Cheng (1999)	JJ, ECM and Granger causality	1952-1995A	Capital and population	India	GNP → EC
Asafu-Adjaye (2000)	JJ	1973-1995A 1973-1995A 1971-1995A 1971-1995A	CP	India Indonesia Thailand Philippines	EC → GDP EC → GDP EC ↔ GDP EC ↔ GDP
Stern (2000)	JJ and Granger causality	1948-1994A	EMP and capital	USA	EC → GDP
Aqeel & Butt (2001)	EG	1955-1996A	EMP	Pakistan	GDP → EC
Glasure (2002)	JJ and VDC	1961-1990A	Energy prices	Korea	EC ↔ GDP
Hondroyiannis et al. (2002)	JJ and VECM	1960-1999A	CP	Greece	EC ↔ GDP
Ghali & El-Sakka (2004)	JJ, VDC and VEC	1961-1997A	Capital and EMP	Canada	EC ↔ GDP
Oh & Lee (2004a)	JJ, VECM, and Granger causality	1970-1999A	Capital and labor	Korea	EC ↔ GDP
Oh & Lee (2004b)	JJ	1981-2000Q	Capital, labor and EP	South Korea	GDP → EC
Paul & Bhattacharya (2004)	EG and JJ	1950-1996A	Population and capital	India	EC ↔ GDP
Lee (2005)	Pedroni panel cointegration	1975-2001A	Capital	Panel of 18 Developing countries	EC → GDP
Soytas & Sari (2006a)	TY and VDC	1971-2002A	LF and capital	China	EC — GDP
Soytas &Sari (2006b)	JJ and VDC	1960-2004A 1970-2002A 1971-2002A 1960-2004A 1960-2004A 1960-2004A 1960-2004A	LF and real GFCF	Canada France Germany Italy Japan UK USA	EC ↔ GDP EC → GDP EC ↔ GDP EC ↔ GDP EC ↔ GDP EC ↔ GDP EC → GDP
Climent & Pardo (2007)	JJ	1984-2003Q	CP and EMP	Spain	EC ↔ GDP
Jobert & Karanfil (2007)	JJ	1960-2003A	IVA	Turkey	EC — GNP EC — IVA
Narayan & Smyth (2007)	Pedroni panel cointegration	1972-2002A	Capital	Panel of 7 western countries	EC → GDP
Soytas et al. (2007)	TY and VDC	1960-2000A	Real GFCF, LF and CO_2	USA	EC — GDP EC → CO CO_2 — GDP

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
Mahadevan & Asafu-Adjaye (2007)	Pedroni panel cointegration; JJ and VECM	1971-2002A	CP	Exporters developed	EC ↔ GDP
				Australia	EC ↔ GDP
				Norway	EC ↔ GDP
				UK	EC ↔ GDP
				Exporters developing	EC ↔ GDP
				Argentina	EC ↔ GDP
				Indonesia	EC ↔ GDP
				Kuwait	EC ↔ GDP
				Malaysia	EC ↔ GDP
				Nigeria	EC ↔ GDP
				Saudi Arabia	EC ↔ GDP
				Venezuela	EC ↔ GDP
				Importers developed	EC ↔ GDP
				Japan	EC ↔ GDP
				Sweden	EC ↔ GDP
				USA	EC ↔ GDP
				Importers developing	EC → GDP
				Ghana	EC ↔ GDP
				India	EC → GDP
				Senegal	EC → GDP
				South Africa	EC ↔ GDP
				South Korea	EC → GDP
				Singapore	EC ↔ GDP
				Thailand	EC → GDP
Zachariadis (2007)	JJ, ARDL and TY	1960-2004A	IVA	Canada	GDP → EC$^{(1,2,3)}$
				France	EC ↔ GDP$^{(1)}$
					EC → GDP$^{(2)}$
					EC — GDP$^{(3)}$
				Germany	EC ↔ GDP$^{(1)}$
					GDP → EC$^{(2)}$
					EC — GDP$^{(3)}$
				Italy	EC ↔ GDP$^{(1,2)}$
					EC — GDP$^{(3)}$
				Japan	EC ↔ GDP$^{(1,2)}$
					EC → GDP$^{(3)}$
				UK	GDP → EC$^{(1,2,3)}$
				USA	EC — GDP$^{(1,2,3)}$
Zamani (2007)	EG	1967-2003A	IVA and AVA	Iran	GDP → EC
Huang et al. (2008)	Dynamic panel estimation, GMM and VAR	1972-2002A	Capital stock and LF	Low income (19 countries)	EC — GDP

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
				Middle income (37 countries)	GDP → EC
				High income (26 countries)	GDP → EC
				Over all panel (82 countries)	EC ↔ GDP
Yuan et al. (2008)	JJ and IRF	1963-2005A	Capital and EMP	China	EC ↔ GDP
Lee & Chang (2008)	Pedroni panel cointegration	1971-2002A	Capital stock and LF	Asian panel	EC → GDP
				APEC	EC → GDP
				ASEAN	EC → GDP
Soytas & Sari (2008)	TY and VDC	1960-2000A	Real GFCF, LF and CO2	Turkey	EC — GDP
					GDP — CO_2
					CO_2 — EC
Payne (2009)	TY	1949-2006A	Real GFCF and EMP	USA	EC — GDP
Apergis & Payne (2009)	Pedroni panel cointegration	1980-2004A	Real GFCF and LF	Panel of 6 South America countries	EC → GDP
Costantini & Martini (2010)	PVECM	1960-2005A	EP	71 OECD and non-OECD countries	GDP → EC
					EC ↔ GDP
					GDP → EC
Acaravci & Ozturk (2010)	Cointegration, ARDL	1960-2005	CO_2	19 Europe countries	
				Austria	EC — GDP
				Belgium	EC — GDP
				Denmark	EC — GDP
					GDP → CO_2
					CO_2 — EC
				Finland	EC — GDP
				France	EC — GDP
				Germany	EC — GDP
				Greece	GDP → EC
					GDP — CO_2
					CO_2 — EC
				Hungary	EC — GDP
				Iceland	EC — GDP
					GDP — CO_2
					CO_2 — EC
				Ireland	EC — GDP
				Italy	GDP → EC
					GDP → CO_2
					CO_2 — EC
				Luxembourg	EC — GDP

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
				Netherlands Norway Portugal Spain Sweden Switzerland Switzerland United Kingdom	EC — GDP EC — GDP EC — GDP EC — GDP EC — GDP EC ↔ GDP GDP — CO CO_2 — EC EC ↔ GDP GDP — CO CO_2 — EC EC — GDP
Apergis & Payne (2010)	Cointegration and ECM	1985-2005A	Capital and labor force	20 OECD countries	EC↔GDP
Odhiambo (2010)	Cointegration, ARDL and ECM	1972-2006A	Energy prices	South Africa Kenya Congo	EC → GDP EC → GDP GDP → EC
Saad & Belloumi (2010)	VECM	1971-2010A	OP & CO_2	Saudi Arabia	EC → GDP EC → CO_2 GDP ↔ CO_2
Ozturk & Acaravci (2010b)	Cointegration, ARDL	1968-2005A	CO_2 and employment ratio	Turkey	EC — GDP GDP — CO_2
Hatzigeorgiou et al. (2011)	Cointegration, JJ and VECM	1977-2007A	CO_2	Greece	GDP → EC CO ↔ GDP
Pao & Tsai (2011)	Cointegration panel causality	1980-2007A	FDI and CO_2	Panel of 4 BRIC countries	EC ↔ GDP CO_2 ↔ GDP EC — CO_2
Hossain (2011)	Granger causality and EG	1971-2007A	CO_2	Panel of 9 NIC	GDP → EC EC — CO_2 GDP → CO_2
Wang et al. (2011)	Panel VECM	1995-2007A	CO_2	China	EC ↔ GDP CO_2 ↔ EC GDP → CO_2
Alam et al. (2011)	Dynamic modeling	1971-2006A	Fixed capital stock, labor force and CO_2	India	EC — GDP CO_2 ↔ EC GDP — CO_2
Hossein et al. (2012)	EG and ECM	1980-2008A	EP	Iran Iraq Qatar UAE Saudi Arabia Algeria	GDP → EC GDP → EC GDP → EC GDP → EC GDP → EC EC → GDP

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
				Angola Kuwait Libya Ecuador Kuwait Libya Nigeria Venezuela	EC → GDP EC → GDP EC → GDP EC → GDP EC → GDP EC → GDP EC → GDP EC → GDP
Hossain (2012)	ARDL, EG & VECM	1960-2009A	CO_2	Japan	GDP — EC EC → CO_2 CO_2 → GDP
Farhani & Ben (2012)	Panel causality test	1973 2008A	CO_2	15 MENA countries	GDP → EC CO_2 → EC
Ahmed & Long (2012)	ARDL	1971-2008A	TR, PO & CO_2	Pakistan	GDP → CO_2 EC → CO_2
Shahbaz et al. (2012)	ARDL and VECM	1972-2011A	Capital and labor	Pakistan	EC ↔ GDP EC ↔ GDP
Al-mulali and Che Sab (2012)	Panel cointegration, Panel causality	1980-2008A	FD and CO_2	Panel of 30 Sub-Saharan African countries	EC ↔ GDP GDP → CO_2 EC → CO_2
Hwang & Yoo (2012)	Granger causality and VECM	1965–2006A	CO_2	Indonesia	EC ↔ CO_2 GDP → EC GDP → CO_2
Abalaba & Dada (2013)	ECM and JJ	1971-2010A	FD, MPR, and CP	Nigeria	EC — GDP
Farhani et al (2013)	PECM	1980-2009A	TR, URB, and CO_2	11 MENA countries Panel A Panel B	 GDP → CO_2 EC → CO_2 GDP → CO_2 EC → CO_2
Saboori & Sulaiman (2013a)	ARDL and JJ	1980-2009A	CO_2	Malaysia	EC ↔ GDP EC ↔ CO_2 GDP ↔ CO_2
Ishida (2013)	JJ and VECM	1970-2010A	labor and stock	Japan	GDP → FEC
Kulionis (2013)	TY and Granger Causality	1972-2012A	CO_2	Denmark	REC → CO_2 GDP — CO_2 GDP — REC
Alkhathlan & Javid (2013)	ARDL, VECM	1980-2011A	CO_2	Saudi Arabia	EC — GDP EC ↔ CO_2 CO → GDP

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
Nayan et al (2013)	PGMM	2000-2011A	GCF and population	Panel 23 countries	GDP → EC
Kohler (2013)	ARDL	1960-2009A	Foreign Trade and CO_2	South African	CEC ↔ CO_2 CO → GNI CEC ↔ GNI
Kanjilal & Ghosh (2013)	EKC and ARDL bound test	1971-2008A	CO_2	India	EC → CO_2 EC → CO_2
Ozturk & Acaravci (2013)	ARDL	1960-2007A	CO_2	Turkey	CO_2 — GDP EC — GDP CO_2 — EC
Shahbaz et al (2013)	ARDL & VECM	1975-2011Q	CO_2	Indonesia	EC ↔ CO_2 GDP ↔ CO_2 EC — GDP
Wandji (2013)	VECM	1971-2009A	EEC, OEC, & BEC	Cameroon	OEC → GDP EEC — GDP BEC — GDP
Wahid et al (2013)	VECM	1975-2011A	CO_2, IVA, REC, & TR	Malaysia	CO_2 → GDP EC → GDP CO_2 — EC CO_2 → IVA EC → IVA REC → GDP REC — CO_2 REC → IVA
				Indonesia	GDP → CO_2 EC → GDP CO_2 — EC IVA → CO_2 IVA → EC REC — IVA GDP — REC REC — CO_2
				Singapore	GDP — CO_2 GDP — EC EC — CO_2 IVA → CO_2 IVA → EC REC — IVA GDP → REC REC — CO_2
Shakeel et al (2013)	Panel VECM & Panel DOLS	1980-2009A	GCF, LB & EXP	South Asian Countries	EC ↔ GDP
Tang & Tan (2013)	ARDL & VECM	1970-2009A	EP & TI	Malaysia	EEC ↔ GDP

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
Sbia et al (2013)	ARDL & VECM	1975-2011Q	FDI, GEC, TR & CO_2	Uni Arab Emirates	GDP ↔ EC
					EC — CO_2
					CO — GDP
					NEC — CO_2
					GDP — NEC
Saboori & Sulaiman (2013b)	ARDL and VECM	1971-2009A	CO2	Indonesia	GDP ↔ CO_2
					EC — GDP
					CO_2 — EC
				Malaysia	EC ↔ CO_2
					CO_2 — GDP
					EC → GDP
				Philippines	CO_2 — EC
					EC → GDP
					CO_2 → GDP
				Singapore	GDP ↔ CO_2
					EC ↔ CO_2
					GDP — EC
				Thailand	EC → GDP
					GDP ↔ CO_2
					CO_2 — EC
Chandran & Tang (2013)	VECM	1971-2008A	CO_2 and FDI	Indonesia	GDP → CO_2
					EC → GDP
					CO_2 → EC
				Malaysia	CO_2 — GDP
					EC ↔ GDP
					CO_2 → EC
				Philippines	GDP → EC
					CO_2 → GDP
					EC ↔ CO_2
				Singapore	EC → GDP
					GDP ↔ CO_2
					CO_2 — EC
				Thailand	EC — GDP
					GDP → CO_2
					CO ↔ EC
Jebli & Youssef (2013)	Granger causality, ECM, DOLS, FMOLS	1975-2008A	EXP	MENA countries	
				Algeria	GDP → REC$^{(a,b)}$
				Cyprus	GDP → REC$^{(a,b)}$
				Egypt	GDP → REC$^{(a,b)}$
				Iran	GDP → REC$^{(a,b)}$
				Israel	GDP → REC$^{(a,b)}$
				Jordan	GDP — REC$^{(a,b)}$
				Morocco	GDP — REC$^{(a,b)}$

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
				Sudan Syria Tunisia Turkey Panel 	GDP → REC(a,b) GDP — REC(a) GDP → REC(b) GDP → REC(a,b) GDP → REC(a,b) GDP → REC(a) GDP — REC(b)
Kivyiro & Arminen (2013)	ARDL & VECM	1971-2009A	CO_2	Congo Democratic Republik Congo Kenya South Africa Zambia Zimbabwe 	EC → GDP CO_2 → GDP EC — CO_2 GDP → CO_2 EC — GDP EC — CO_2 GDP — EC GDP → CO_2 EC → CO_2 GDP — EC GDP — CO_2 EC → CO_2 GDP → EC GDP — CO_2 CO — EC GDP — EC GDP — CO_2 CO_2 — EC
Solarin & Shahbaz (2013)	ARDL & VECM	1971-2009A	URB	Angola	EC → GDP
Ghosh et al (2014)	JMC and IRF	1972-2011A	CO_2	Bangladesh	EC → GDP CO_2 — GDP
Akin (2014)	DMOLS, FMOLS, and PECM	1990-2011A	CO_2 and TO	Panel of 85 countries	GDP → EC GDP → CO_2 EC — CO_2
Magazzino (2014)	PVAR	1971-2007A	CO_2	Panel of 6 ASEAN countries	GDP → CO_2 EC — CO_2 GDP — EC
Jebli & Youssef (2014)	DOLS, FOMLS, and Granger causality	1971-2008A	CO_2	Algeria Egypt Morocco 	GDP → CO_2 REC — CO_2 GDP — REC REC ↔ GDP CO_2 ↔ GDP CO_2 → REC REC → CO_2 GDP — REC

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
				Sudan	GDP → CO CO_2 ↔ GDP CO_2 → REC
				Tunisia	GDP — REC REC → GDP CO_2 → GDP
				Panel of five North Africa countries	REC — GDP REC → GDP CO_2 → GDP REC → CO_2
Sebri & Salha (2014)	ARDL and ECM	1971-2010A	CO_2 and TR	3 BRICS countries	
				Brazil	GDP ↔ REC CO_2 → GDP REC — CO_2
				India	CO_2 → GDP GDP → REC CO_2 → REC
				South Africa	GDP ↔ REC CO_2 — GDP CO_2 → REC
Leitão (2014)	OLS, GMM, ECM and Granger causality	1970-2010A	Globalization and CO_2	Portuguese	EC — GDP REC → GDP EC → CO_2 REC → CO_2 GDP — CO_2
Yusuf (2014)	VAR and IRF	1981-2011A	CO_2, LPR, and GCF	Nigeria	GDP ↔ EEC GDP — EC GDP — CO_2 CO_2 — EEC EC → CO_2
Bozkurt & Akan (2014)	JMC and IRF	1960-2010A	CO_2	Turkey	EC → GDP CO_2 → GDP
Arouri et al (2014)	ARDL	1971-2010A	CO_2, TR, and URBP.	Thailand	GDP ↔ CO_2 EC — GDP EC — CO_2
Cowan et al (2014)	Panel Granger causality	1990-2010A	CO_2	BRICS countries	
				Brazil	CO_2 → GDP EC — CO_2 GDP — EC
				Russia	CO_2 ↔ GDP EC — CO_2 GDP ↔ EC
				India	CO_2 — GDP

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
				  China South Africa	EC → CO_2 GDP — EC CO_2 — GDP EC — CO_2 GDP — EC GDP → CO_2 EC — CO_2 GDP → EC
Lim et al (2014)	ECM	1965–2012A	CO2	Philippines	GDP ↔ OEC OEC ↔ CO_2 CO_2 → GDP
Alshehry & Belloumi (2014)	JMC and ECM	1971–2012A	CO_2E, CO_2O, and CO_2G	Saudi Arabia	GDP — COE GDP → CO_2O GDP → CO_2G EC — GDP OEC — GDP GEC — GDP EC — CO_2E OEC — CO_2O GEC — CO_2G
Palamalai et al (2014)	GH and ECM	1970-2012A	TR and CO_2	India	GDP → EC CO_2 → GDP CO_2 → COEC CO_2 ↔ EEC CO_2 → OEC CO_2 → GEC
Bhattacharya et al (2014)	TY and Granger Causality	1980-2010A	CO_2	India	GDP → CO_2 CO_2 ↔ GDP CO_2 — EC
Ucan et al (2014)	FMOLS, ECM and Granger Causality	1990-2011A	CO_2 and energy technology.	Panel of 50 European Union countries	EC → GDP CO_2 → GDP EC — CO_2
Yang & Zhao (2014)	Granger causality and DAG	1979-2008A	CO_2	India	EC → GDP EC → CO_2
Withey (2014)	TY and Granger Causality	1960-2005A	CO_2, Labor, GCF	Canada	EC ↔ GDP CO_2 — GDP EC — CO_2
Kuo et al (2014)	Granger causality	1965-2010A	CO_2	Hong Kong	CO_2 → EC CO_2 → GDP GDP ↔ EC
Yusuf (2014)	VECM	1981-2011A	GCF, LB & CO_2	Nigeria	GDP — EC GDP — CO_2

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
					EC → CO EEC ↔ GDP CO_2 → EEC
Dritsaki & Dritsaki (2014)	DMOLS, FMOLS and PECM	1960-2009A	CO_2	3 Southern Europe countries	EC ↔ CO_2 GDP ↔ EC CO_2 ↔ GDP
Jebli et al (2014)	DMOLS, FMOLS, and Granger causality	1995-2010A	CO_2, the number of tourist arrivals and TR	22 Central and South America countries	REC → CO_2 CO_2 — GDP GDP — REC
Karanfil & Li (2014)	Panel VECM	1980-2010A	EIM & UR	Panel of 160 Countries	EEC ↔ GDP
				Panel Non-OECD	EEC ↔ GDP
				Panel Upper Middle Income	GDP — EC
				Panel Lower Middle Income	GDP → EC
				Panel Lower Income	EEC ↔ GDP
				Panel Europe & Central Asia	EEC ↔ GDP
				Panel Latin America & Caribean	EEC ↔ GDP
				Panel South Asia	GDP → EC
				Panel Sub-Saharan Africa	GDP — EC
Shahbaz et al (2014a)	ARDL, VECM, Panel DOLS & Panel FMOLS	1973-2011A	FD, CO_2, and TR	Pakistan	GDP → CO EC → GDP EC → CO_2
Shahbaz et al (2014b)	ARDL & VECM	1975-2011Q	GDP2, UR, EX & CO_2.	Uni Arab Emirates	GDP ↔ EEC GDP — CO_2 EEC → CO_2
Saboori et al (2014)	Panel FMOLS	1960-2008A	CO_2	Australia	EC ↔ GDP GDP ↔ CO_2 CO_2 ↔ EC
		1960-2008A		Austria	EC ↔ GDP GDP ↔ CO_2 CO_2 ↔ EC
		1960-2008A		Belgium	EC ↔ GDP GDP ↔ CO_2

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
		1960-2008A		Canada	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1971-2008A		Chile	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1960-2008A		Denmark	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1960-2008A		Estonia	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1960-2008A		Finland	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1971-2008A		Germany	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1960-2008A		Greece	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1965-2008A		Hungary	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1960-2008A		France	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1960-2008A		Iceland	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1960-2008A		Italy	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1960-2008A		Japan	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1971-2008A		Korea	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1960-2008A		Luxenbourg	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$ $GDP \leftrightarrow CO_2$
		1971-2008A		Mexico	$CO_2 \leftrightarrow EC$ $EC \leftrightarrow GDP$

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
		1960-2008A		Netherlands	GDP ↔ CO_2 CO_2 ↔ EC EC ↔ GDP
		1960-2008A		Norway	GDP ↔ CO_2 CO_2 ↔ EC EC ↔ GDP
		1980-2008A		New Zealand	GDP ↔ CO_2 CO_2 ↔ EC EC ↔ GDP
		1960-2008A		Portugal	GDP ↔ CO_2 CO_2 ↔ EC EC ↔ GDP
		1960-2008A		Sweden	GDP ↔ CO_2 CO_2 ↔ EC EC ↔ GDP
		1960-2008A		Turkey	GDP ↔ CO_2 CO_2 ↔ EC EC ↔ GDP
		1960-2008A		United Kingdom	GDP ↔ CO_2 CO_2 ↔ EC EC ↔ GDP
		1960-2008A		United States	GDP ↔ CO_2 CO_2 ↔ EC EC ↔ GDP
		1980-2008A		Switzerland	GDP ↔ CO_2 CO_2 ↔ EC EC ↔ GDP GDP ↔ CO_2 CO_2 ↔ EC
Odhiambo (2014)	ARDL & Granger Causality	1980-2011A	EX	Democratic Rep. Congo	EEC ↔ GDP
Shaari et al (2014a)	FMOLS	1992-2012A	FDI	15 developing countries	GDP — CO_2
Shaari et al (2014b)	VECM	1975-2008A	CO_2	Malaysia	GDP ↔ CO_2 EC → GDP EC → CO_2
Nasren & Anwar (2014)	Panel VECM, Panel DOLS, and Panel FMOLS	1980-2011A	TR & EP	15 Asian Countries	EC ↔ GDP
Hwang & Yoo (2014)	VECM & Granger Causality	1965-2006A	CO_2	Indonesia	GDP → EC GDP → CO_2 EC ↔ CO_2
Ohlan (2015)	ARDL & VECM	1970-2013A	CO_2 & TO	India	GDP — EC EC — CO_2 CO_2 → GDP

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
Jammazi & Aloui (2015)	Wavelet Windowed Cross Correlation (WWCC) & Granger Causality	1980-2012A	CO_2	6 GCC Countries Saudi Arabia Bahrain Oman Uni Arab Emirates Qatar Kuwait	 GDP — EC GDP — CO_2 GDP → EC GDP ↔ CO_2 GDP — EC GDP → CO_2 GDP → EC GDP — CO_2 GDP — EC CO_2 → GDP GDP — EC GDP → CO_2
Bastola & Sapkota (2015)	ARDL	1980-2011A	CO_2	Nepal	GDP — EC EC — CO_2 CO_2 — GDP
Joo et al. (2015)	VECM & Granger Causality	1965-2010A	CO_2	Chile	EC → GDP EC → CO_2 CO_2 → GDP
Srinivasan (2015)	GH & VECM	1970-2012A	CO_2 & TO	India	EC → GDP CO_2 → GDP EC → CO_2
Heidari et al (2015)	PSTR	1980-2008A	CO_2	Panel of 5 ASEAN Countries	GDP → CO_2 EC → CO_2
Linh & Lin (2015)	Panel Granger Causality	1980-2010A	CO_2	Panel 12 Asian populous Countries	GDP → EC GDP → CO_2 CO_2 ↔ EC
Azam et al (2015a)	OLS	1980-2012A	FDI, TO, PO and HDI	Indonesia Thailand Malaysia	GDP → EC GDP → EC GDP → EC
Azam et al (2015c)	Panel FMOLS	1971-2013A	CO_2	Panel 4 countries (USA, India, China, Japan)	EC → GDP CO_2 → GDP
Salahuddin et al (2015)	Panel DOLS, Panel FMOLS & Panel VECM	1980-2012A	FDI & CO2	Panel of GCC countries	GDP → EEC CO → EC GDP — CO
Kasman & Duman (2015)	Panel FMOLS & Panel Granger Causality	1992-2010A	CO2, TO, UR & GDP^2	Panel of EU new members	GDP → EC GDP — CO_2 CO_2 — EC
Cheema & Javid (2015)	Panel FMOLS & Panel Granger Causality	1990-2010A	CO_2	Panel 8 Asian developing countries	EC → GDP GDP → CO_2 EC ↔ CO_2

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
Mercan & Karakaya (2015)	EG & VECM	1970-2011A	CO_2	Brazil	EC → CO_2 GDP → CO_2
				France	EC → CO_2 GDP → CO_2
				Greece	EC → CO_2 GDP → CO_2
				Italy	EC → CO_2 GDP → CO_2
				Korea Republic	EC → CO_2 GDP → CO_2
				Mexico	EC → CO_2 GDP → CO_2
				Netherland	EC → CO_2 GDP — CO_2
				Poland	EC → CO_2 GDP → CO_2
				Spain	EC → CO_2 GDP → CO_2
				United Kingdom	EC → CO_2 GDP → CO_2
				Turkey	EC → CO_2 GDP → CO_2
				USA	EC → CO_2 GDP → CO_2
				Panel	EC → CO_2 GDP — CO_2
Baek (2016)	PMG	1981-2010A	FDI and CO_2	5 ASEAN Countries	
				High Income Economies	GDP → CO_2 EC → CO_2
				Low Income Economies	GDP → CO_2 EC → CO_2
Esso & Keho (2016)	ARDL	1971-2010A	CO_2	Benin	GDP — EC EC — CO_2 GDP → CO_2
				Cameroon	GDP — EC EC — CO_2 CO_2 — GDP
				Congo	EC → GDP EC — CO_2 CO_2 → GDP
				Democratic Rep. Congo	GDP — EC EC — CO_2 GDP → CO_2

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
				Cote d'Ivoire	GDP — EC EC — CO_2 CO_2 — GDP
				Gabon	EC → GDP EC — CO_2 CO_2 — GDP
				Ghana	GDP → EC CO_2 → EC GDP → CO_2
				Kenya	GDP — EC EC — CO_2 CO_2 — GDP
				Nigeria	GDP — EC EC → CO_2 GDP ↔ CO_2
				Senegal	GDP — EC EC — CO_2 GDP → CO_2
				South Africa	GDP — EC EC — CO_2 CO_2 — GDP
				Togo	GDP — EC EC — CO_2 CO_2 → GDP
Ridzuan et al (2017)	ARDL	1971-2013A	CO_2, TR, GINI, and domestic investment (DI)	Malaysia	GDP → CO_2 DI → CO_2 TO → CO_2 EC → CO_2 GINI → CO_2
				Indonesia	GDP → CO_2 DI → CO_2 TO → CO_2 EC → CO_2 GINI → CO_2
				Philippines	GDP → CO_2 DI → CO_2 TO → CO_2 EC → CO_2 GINI — CO_2
				Thailand	GDP — CO_2 DI → CO_2 TO → CO_2 EC → CO_2 GINI → CO_2

Continue…

Author(s)	Method	Periods	Additional variables	Scope	Findings
Bekhet et al (2017)	ARDL & Granger Causality	1980-2011A	CO_2 and FD	KSA	CO_2 → EC
					EC → GDP
					CO_2 → FD
					FD → GDP
					GDP — CO_2
				UEA	CO_2 → EC
					GDP ↔ EC
					FD → CO_2
					GDP → FD
					FD → EC
					GDP — CO_2
				Kuwait	CO_2 ↔ EC
					FD → CO_2
					GDP — CO_2
					EC — GDP
					GDP — FD
					FD — EC
				Qatar	CO_2 → EC
					EC → GDP
					CO_2 → FD
					GDP — CO_2
					EC — FD
					FD → GDP
				Bahrain	GDP → CO_2
					FD → EC
					EC — CO2
					CO_2 — FD
					GDP — EC
					FD — GDP
				Oman	GDP ↔ EC
					FD → CO_2
					CO_2 → GDP
					EC → CO_2
					CO_2 ↔ EC
					GDP → FD

Note : Unidirectional relationship, bidirectional relationship and no causality relationship between economic growth, CO_2 emissions and energy consumption have been represented by the symbols →, ↔ and —, respectively. (a) and (b) are results based DOLS and FMOLS, respectively. (1), (2) and (3) are results based VECM, ARDL and both, respectively.

CHAPTER THREE

DATA AND METHODOLOGY

3.1 Introduction

This chapter provides a general overview of data and methodology that use in this study. It includes six main sections. The first section explains the data collection method and the definition of operational variables. The third provides information about research framework and hypotheses that use for each analysis in this study. The fourth section shows the specification equation models that apply in this study. The fifth section explains the measurement procedures and analysis method that use in this study. The last describes the analysis procedures that use in this study.

3.2 Data Collection and Operational Variables

Data that use in study is secondary data, annual data for Indonesia from 1971 to 2014. Data of final energy consumption and CO_2 emissions from energy combustion are collecting from the International Energy Agency (IEA), while data economic indicators such as the value-added of three development sectors (industry, agriculture, and service), the real GDP and the real GDP per capita obtained from World Development Indicators (World Bank). Those data classified into three groups, i.e. the indicators of final energy consumptions, the indicators of economic growth, and the indicators of CO_2 emissions. Detail about notation and description of operational variables can be seen in Table 3.1 below.

Table 3.1
Notation and description of operational variables.

Indicators	Notation	Description
Final energy consumptions	FET	Total final energy consumption by all final energy users in Indonesia.
	FEI	Total final energy consumption by final energy users in the industry sector.
	FEA	Total final energy consumption by final energy users in the agriculture sector.
	FES	Total final energy consumption by final energy users in the services sector.
	FER	Total final energy consumption by final energy users in the residential sector.
CO_2 emission (environment emission)	COI	Total CO_2 emissions from energy combustion in the industry sector.
	COA	Total CO_2 emissions from energy combustion in the agriculture sector.
	COS	Total CO_2 emissions from energy combustion in the service sector.
	COR	Total CO_2 emissions from energy combustion in residential sector.
The indicators of economic growth.	GR	The real GDP of Indonesia.
	VAI	The share of value-added by the industry sector on the real GDP of Indonesia.
	VAA	The share of value-added by the agriculture sector on the real GDP of Indonesia.
	VAS	The share of value-added by the service sector on the real GDP of Indonesia.
	GRP	The real GDP per capita of Indonesia

The definition of operational variables used in this study are as follows:

a). Total final energy consumption in Indonesia is the annual of total final energy consumption by all category of final energy users in Indonesia. Data measured within kilo tonnes of oil equivalent (ktoe).

b). Total final energy consumption in the Industrial sector, i.e. total final energy consumption by final energy users on the category of Industry in Indonesia. Data measured within kilo tonnes of oil equivalent (ktoe).

c). Total final energy consumption in the Agriculture sector, i.e. total final energy consumption by final energy users on the category of Agriculture/forestry and fishery in Indonesia. Data measured within kilo tonnes of oil equivalent (ktoe).

d). Total final energy consumption by the services sector in Indonesia, i.e. total final energy consumption by final energy users on the category of transportation, commercial and public services, and non-specific energy user in Indonesia. Data measured within kilo tonnes of oil equivalent (ktoe).

e). Total final energy consumption by Residential in Indonesia, i.e. total final energy consumption by final energy users on the category of residential in Indonesia. Data measured within kilo tonnes of oil equivalent (ktoe).

f). The real Gross Domestic Product (GDP) of Indonesia, i.e. the sum of gross value added by all resident producers in the Indonesian economy plus any product taxes and minus any subsidies which not included in the value of the products. Data measured in millions of U.S. dollars at 2010 constant price.

g). The real GDP per capita of Indonesia, i.e. the gross domestic product of Indonesia Data measured in U.S. dollars at 2010 constant price divided by the mid-year population.

h). The value-added of the industry sector, i.e. the share of value-added by industry sector on the real GDP of Indonesia. Data measured in millions of U.S. dollars at 2010 constant price.

i). The value-added of the agriculture sector, i.e. the share of value-added by the agriculture sector on the real GDP of Indonesia. Data measured in millions of U.S. dollars at 2010 constant price.

j). The value-added of the services sector, i.e. the share of value-added by industry sector on the real GDP of Indonesia. Data measured in millions of U.S. dollars at 2010 constant price.

k). The amount of CO_2 emission from energy combustion in the industry sector, i.e. the quantity of CO_2 emission from energy combustions by energy users in the category of Industry in Indonesia. Data measured within million tonnes of CO_2 emissions (Mt of CO_2).

l). The amount of CO_2 emission from energy combustion in the agriculture sector, i.e. the quantity of CO_2 emission from energy combustions by energy users in the category of agriculture/forestry and fishery in Indonesia. Data measured within million tonnes of CO_2 emissions (Mt of CO_2).

m). The amount of CO_2 emission from energy combustion in the service sector, i.e. the quantity of CO_2 emission from energy combustions by final energy users in the category of transportation, commercial and public services, and non-specified energy user in Indonesia. Data measured within million tonnes of CO_2 emissions (Mt of CO_2).

n). The amount of CO_2 emission from energy combustion in Residential, i.e. the quantity of CO_2 emission from energy combustions by energy users in the category of residential in Indonesia. Data measured within million tonnes of CO_2 emissions (Mt of CO_2).

3.3 Model Specification and Hypotheses

The analysis in this study consist of three stages. The first stage is examines the role of sectoral economic growth on total final energy consumption in Indonesia. The second stage is examines the role of final energy consumption by sector on Indonesia's economic growth. Third stage is examines the causality linkage between final energy consumption, economic growth and CO_2 emissions in four final energy user sectors (industry, agriculture, service and residential). Detail about research frameworks, operational variables and hypotheses that use for each analysis can be explained below.

3.3.1 The Role of Economic Growth on Final Energy Consumption in Indonesia

In order to examine the role of economic growth on Indonesia's final energy consumptions, a model that consists of five variables has established (figure 3.1). The value-added of industry sector (VAI), the value-added of agriculture sector (VAA), the value-added of service sector (VAS) and the real GDP per capita (GRP) determined as a set of economic indicators that represented sectoral economic growth in Indonesia (independent variables), while total Indonesia's final energy consumption (FET) defined as an energy consumption indicator that represented the growth of Indonesia's final energy consumption (dependent variable).

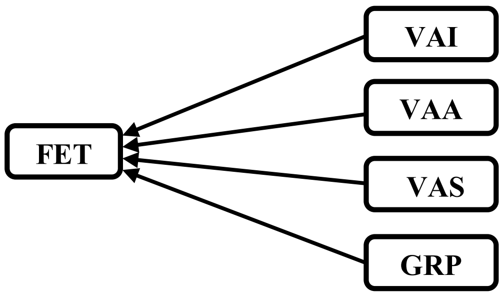


Figure 3.1 Empirical Model 1.

Based this model, author develops an equation model as follow:

$$FET = f(VAI, VAA, VAS, GRP) \quad (3.1)$$

Hereafter, equation 3.1 called as model 1. In this analysis, author examined the short-run and long-run relationships from the independent variables (VAI, VAA, VAS, GRP) to the dependent variable (FET). The hypotheses that use for making decision in this analysis can be seen at Table 3.2.

Table 3.2
Hypotheses model 1

	Hypotheses	Sign
H1 =	economic growth in industry sector stimulated indonesia's total final energy consumption.	VAI $\rightarrow$ FET
H2 =	economic growth in agriculture sector stimulated indonesia's total final energy consumption.	VAA $\rightarrow$ FET
H3 =	economic growth in service sector stimulated indonesia's total final energy consumption.	VAS $\rightarrow$ FET
H4 =	economic growth per capita stimulated indonesia's total final energy consumption.	GRP $\rightarrow$ FET

Note: $\rightarrow$ denotes direction relationship between the variables.

3.3.2 The Role of Final Energy Consumption on Economic Growth in Indonesia

In order to examine the role of final energy consumption by sector on Indonesia's economic growth, a model that consists of five variables then established (Figure 3.2). In this analysis, the consumption of final energy by industry sector (FEI), the consumption of final energy by agriculture sector (FEA), the consumption of final energy by services sector (FES), and the consumption of final energy by residential sector (FER) determined as a set of energy consumption indicator that represented the growth of final energy consumption by sectoral in Indonesia (independent variable), while the real GDP of Indonesia (GR) determined as an economic indicator that represented economic growth in Indonesia (dependent variable).

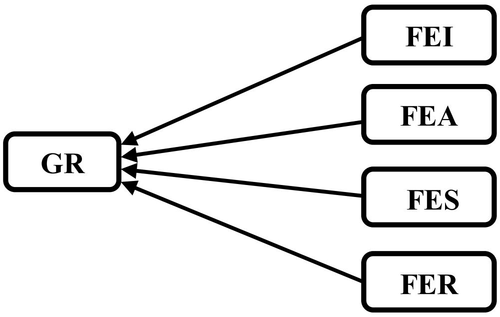


Figure 3.2 Empirical Model 2

Based this model, author develops an equation model as follow:

$$GR = f(FEI, FEA, FES, FER) \qquad (3.2)$$

Hereafter equation 3.2 called as model 2. In this analysis, author examined the short-run and long-run relationships from the independent variables (FEI, FEA, FES, FER) to the dependent variable (GR). The hypotheses that use for making decision in this analysis can be seen at Table 3.3.

Table 3.3
Hypotheses Model 2

	Hypotheses	**Sign**
H1 =	the growth of final energy consumption in industry sector stimulated Indonesia's economic growth.	FEI → GR
H2 =	the growth of final energy consumption in agriculture sector stimulated Indonesia's economic growth.	FEA → GR
H3 =	the growth of final energy consumption in service sector stimulated Indonesia's economic growth.	FES → GR
H4 =	the growth of final energy consumption in residential sector stimulated Indonesia's economic growth.	FER → GR

Note: → denotes direction relationship between the variables.

3.3.3 The Causality Relationship Between Final Energy Consumption, Economic Growth, and CO_2 Emission in Four Energy User Sectors in Indonesia

Generally, investigate the causality linkage between final energy consumption, economic growth and CO_2 emission in four final energy users in Indonesia using three operational variables, respectively. It is consist of final energy consumption indicator, economic growth indicator and CO_2 emission indicator. Furthermore, investigate on each final energy user sector examine using three empirical models, where each operational variable consecutively determined as the dependent variable in an equation model. In this analysis, the result based on the directional relationship between the variables in the short-run and long-run.

Analysis in the industry sector is employing the amount of CO_2 emissions from energy combustion by Industry sector (COI) as CO_2 emission indicator, the amount of final energy consumption by Industry sector (FEI) as energy consumption indicator, the value-added of industry sector (VAI) as economic growth indicators.

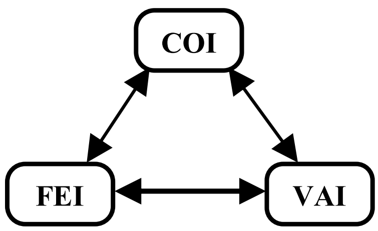


Figure 3.3 Emprical Model 3

Based this model, author develop three equation models as follow:

$$COI = f(FEI, VAI) \quad (3.3a)$$

$$FEI = f(VAI, COI) \quad (3.3b)$$

$$VAI = f(COI, FEI) \tag{3.3c}$$

Hereafter, equation 3.3a, 3.3b, and 3.3c called as model 3a, model 3b and model 3c. The hypotheses that use in this analysis can be seen in Table 3.4.

Table 3.4
Hypotheses Model 3

	Hypotheses	**Sign**
H1 =	the growth of final energy consumption in industry sector encouraged economic growth in industry sector.	FEI → VAI
H2 =	the growth of final energy consumption in industry sector caused CO_2 emissions from energy combustion in industry sector increased.	FEI → COI
H3 =	economic growth in industry sector stimulated the growth of final energy consumption in industry sector.	VAI → FEI
H4 =	economic growth in industry sector caused CO_2 emissions from energy combustion in industry sector increased.	VAI → COI
H5 =	an increased CO_2 emissions from energy combustion in industry sector influenced economic growth in industry sector.	COI → FEI
H6 =	an increased CO_2 emissions from energy combustion in industry sector lead to final energy consumption in industry sector.	COI → VAI

Note: → denotes direction relationship between the variables.

Analysis in the agriculture sector employing the amount of CO_2 emissions from energy combustion by agriculture sector (COA) as CO_2 emission indicator, the amount of final energy consumption by agriculture sector (FEA) as energy consumption indicator, the value-added of agriculture sector (VAA) as economic growth indicators.

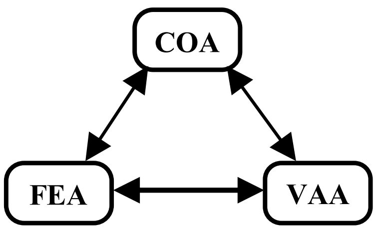


Figure 3.4 Empirical Model 4.

Based this model, author develop three equation models as follow:

$$COA = f(FEA, VAA) \tag{3.4a}$$

$$FEA = f(VAA, COA) \quad (3.4b)$$

$$VAA = f(COA, FEA) \quad (3.4c)$$

Hereafter, equation 3.4a, 3.4b, and 3.4c called model 4a, model 4b and model 4c. The hypotheses that use in this analysis can be seen in Table 3.5.

Table 3.5
Hypotheses Model 3.

	Hypotheses	Sign
H1 =	the growth of final energy consumption in agriculture sector encouraged economic growth in agriculture sector.	FEA → VAA
H2 =	the growth of final energy consumption in agriculture sector caused CO_2 emissions from energy combustion in agriculture sector increased.	FEA → COA
H3 =	economic growth in agriculture sector stimulated the growth of final energy consumption in agriculture sector.	VAA → FEA
H4 =	economic growth in agriculture sector caused CO_2 emissions from energy combustion in agriculture sector increased.	VAA → COA
H5 =	increased CO_2 emissions from energy combustion in agriculture sector influenced economic growth in agriculture sector.	COA → FEA
H6 =	increased CO_2 emissions from energy combustion in agriculture sector lead to final energy consumption in agriculture sector.	COA → VAA

Note: → denotes direction relationship between the variables.

Analysis in service sector employing the amount of CO_2 emissions from energy combustion by the service sector (COS) as CO_2 emission indicator, the amount of final energy consumption by the service sector (FES) as energy consumption indicator, the value-added of service sector (VAS) as economic growth indicators.

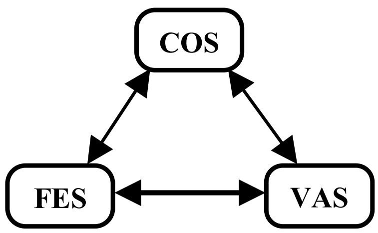


Figure 3.5 Empirical Model 5.

Based this model, author develop three equation models as follow:

$$COS = f(FES, VAS) \quad (3.5a)$$

$$FES = f(VAS, COS) \quad (3.5b)$$

$$VAS = f(COS, FES) \quad (3.5c)$$

Hereafter, equation 3.5a, 3.5b, and 3.5c called model 5a, model 5b and model 5c. The hypotheses that use in this analysis can be seen in Table 3.6.

Table 3.6
Hypotheses Model 5.

	Hypotheses	Sign
H1 =	the growth of final energy consumption in service sector encouraged economic growth in service sector.	FES → VAS
H2 =	the growth of final energy consumption in service sector caused CO_2 emissions from energy combustion in service sector increased.	FES → COS
H3 =	economic growth in service sector stimulated the growth of final energy consumption in service sector.	VAS → FES
H4 =	economic growth in service sector caused CO_2 emissions from energy combustion in service sector increased.	VAS → COS
H5 =	increased CO_2 emissions from energy combustion in service sector influenced economic growth in service sector.	COS → FES
H6 =	increased CO_2 emissions from energy combustion in service sector lead to final energy consumption in service sector.	COS → VAS

Note: → denotes direction relationship between the variables.

Analysis in residential sector using the amount of CO_2 emissions from energy combustion by residential sector (COR) as CO_2 emission indicator, the amount of final energy consumption by residential sector (FER) as energy consumption indicator, the real GDP per capita of Indonesia (GRP) as economic growth indicator.

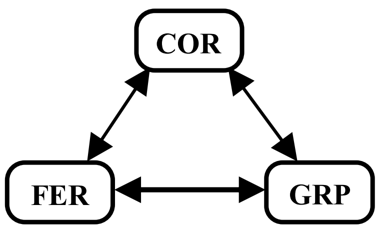


Figure 3.6 Empirical Model 6.

Based this model, author develop three equation models as follow:

$$COR = f(FER, GRP) \quad (3.6a)$$

$$FER = f(GRP, COR) \quad (3.6b)$$

$$GRP = f(COR, FER) \quad (3.6c)$$

Hereafter, equation 3.6a, 3.6b, and 3.6c called model 6a, model 6b and model 6c. The hypotheses that use in this analysis can be seen in Table 3.7.

Table 3.7
Hypotheses Model 6.

	Hypotheses	Sign
H1 =	the growth of final energy consumption in residential sector encouraged economic growth in residential sector.	FER $\rightarrow$ GRP
H2 =	the growth of final energy consumption in service sector caused CO_2 emissions from energy combustion in residential sector increased.	FER $\rightarrow$ COR
H3 =	economic growth in residential sector stimulated the growth of final energy consumption in residential sector.	GRP $\rightarrow$ FES
H4 =	economic growth in residential sector caused CO_2 emissions from energy combustion in residential sector increased.	GRP $\rightarrow$ COR
H5 =	increased CO_2 emissions from energy combustion in residential sector influenced economic growth in residential sector.	COR $\rightarrow$ FES
H6 =	increased CO_2 emissions from energy combustion in residential sector lead to final energy consumption in residential sector.	COR $\rightarrow$ GRP

Note: $\rightarrow$ denotes direction relationship between the variables.

3.4 Measurement Procedures

In this study, authors convert all operational variables into natural logarithm forms in order to address the issue of heteroskedasticity and induces stationary in the variance-covariance matrix (Ahmad et al. 2016, Fatai et al. 2004). Two analysis methods used in this study. First, author applying the Autoregressive Distributed Lag (ARDL) procedures that introduced by Pesaran and Shin (1999) and Pesaran et al. (2001) in order to check the existence of cointegration among the variables and the causal relationship among the variables. Second, author used Granger causality test in order to explore the causality relationship among the variables. In addition, all variables that used in this study are converting into natural logarithm forms to induce stationarity in the variance-covariance matrix and reduce heteroscedasticity issue (Alkhathlan & Javid, 2013; Tang & Tan, 2013).

3.4.1 Autoregressive Distributed Lag

This study is applying the Autoregressive Distributed Lag (ARDL) approach and the bound test procedure introduced by Pesaran and Shin (1999) and Pesaran et al. (2001). The ARDL model has been used extensively over three decades and has three advantages than other approaches. The single equation of ARDL model can be written as follows (Giles, 2013):

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \dots + \beta_m y_{t-m} + \sum_{j=0}^{p_1} \alpha_1 X_{1t-i} + \sum_{j=0}^{p_2} \alpha_2 X_{2t-i} + \dots \dots + \sum_{j=0}^{p_k} \alpha_n X_{nt-i} + \varepsilon_t \quad (3.7)$$

where ε_t is the random error term and assumed serially independent. Any explanatory variables can have own maximum lag length and it does not require the model has substance the current value of explanatory variables. The procedure of ARDL is consists of four stages. The first stage is checking the stationarity of data series and expected all series are stationary at I(0) and/or I(1). In this step, the author applied the ADF unit root test (Dickey & Fuller, 1979) and PP unit root test (Phillips & Perron, 1988) to verify neither series has integrated at I(2). The series is said to be stationary if and only if they do not contain unit roots and integrated of order zero, denotes as I(0). However, if the series have unit roots, this indicates that they are non-stationary at the level form. This problem can be treated by convert data series into the first difference form, I(1), and then re-checking with unit root tests until the series reaches stationary. In this study, as a requirement for apply ARDL procedure, all series expected reaches stationary at the level form, I(0), and/or the first different form, I(1). Moreover, this study only testing stationarity of data series under two equations: (1) using constant only and (2) using constant and trend.

The second stage, an unrestricted error-correction model (UECM) then developed and constructed by transforming equation 3.7. A conventional error correction model (ECM) for cointegrated variables can be written as follows:

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta Y_{1t-1} + \sum_{j=0}^{q1} \phi_j \Delta X_{1t-j} + \sum_{j=0}^{q2} \pi_j \Delta lnX_{2t-j} + \ldots\ldots + \sum_{j=0}^{qn} \eta_j \Delta lnX_{nt-j} + \mu ECT_{t-1} + \varepsilon_t \quad (3.8)$$

Where μ represents the speed of adjustment parameter and ECT denotes the error-correction term that represents ordinary least square (OLS) residuals derived from the long-run modelling which can be written as follows:

$$y_t = \theta_1 X_{1t} + \theta_2 X_{2t} + \ldots. + \theta_n X_{nt} + v_t \quad (3.9)$$

The ECT determined within following equation:

$$ECT_{t-1} = y_{t-1} - \delta_1 X_{1t-1} - \delta_2 X_{2t-1} - \ldots. - \delta_n X_{nt-1} \quad (3.10)$$

Where δ_i (*i =1, 2,..., n*) are the OLS estimates of θ_i (*i =1, 2,..., n*) . Thus, author estimate equation model:

$$\Delta lnY_t = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta lnY_{t-1} + \sum_{j=0}^{q_1} \phi_j \Delta lnX_{1t-1} + \sum_{j=0}^{q_2} \pi_j \Delta lnX_{2t-1}$$

$$+ \ldots\ldots + \sum_{j=0}^{q_3} \eta_{14} \Delta lnX_{3t-1} + \varphi_0 lnY_{t-1} + \varphi_1 lnX_{1t-1}$$

$$+ \varphi_2 lnX_{2t-1} + \ldots\ldots + \varphi_n lnX_{nt-1} + \varepsilon_t \quad (3.11)$$

This equation model called an unrestricted error correction model (UECM) because of the presence of unrestricted coefficients. However, this step requires determining an appropriate lag structure for specification unrestricted error correction model (UECM), verify autocorrelation of error terms in the model, and making sure that the regressors in the model are dynamically stable. The determination of the optimal lag becomes one of the essential procedures that have to be implemented in the modelling (Enders, 2004). Many parameters can be used to determine the optimal lag length. In this study, the maximum lags determined using Akaike information criterion (AIC) which proposed by Akaike (1974).

In this step, the diagnostic tests are conduct to ensure the fitness of the models, such as the Jarque-Bera statistics for check normality issue, the Breusch-Godfrey test or LM test to check serial correlation issue, Autoregressive Conditional Heteroscedasticity (ARCH) test to check heteroscedasticity issue, and Ramsey RESET test to check the correctness functional form the selected models. As the model has an autoregressive structure, author also checks the stability of regressors in the model over the observation periods using two approaches. First, based on the plots of CUSUM and CUSUMSQ proposed by Brown et al. (1975). Second, using the Chow test proposed by Chow (1960) for a certain observation period.

The third stage is applying a bounds test to check whether the variables in the model are cointegrated. The model will be tested with hypotheses, $H_0: \varphi_0 = \varphi_1 = \varphi_2 = \ldots. = \varphi_n = 0$; against the alternative $H_1: \varphi_0 \neq \varphi_1 \neq \varphi_2 \neq \ldots. \neq \varphi_n \neq 0$. If H_0 accepted, it indicates absence cointegration between the variables in the model. In contrary, the variables in the model cointegrated if H_0 rejected and H_1 accepted. To test these hypotheses, the statistics of F-test then applied. The value of F-test is determine based on critical value by Narayan (2005). Narayan (2005) described critical values from 30 to 80 observations within various sample sizes, the number of variables, and probability levels. It is consist of the lower critical values and the upper critical values. The lower critical values defined by supposing that data series are integrated at the level form or I(0), whereas the upper critical values defined by considering that data series are integrated at the first different form or I(1). Author's concluded that the variables in the model are cointegrated if the value of F-statistics higher than the upper critical values and in contrary will reject the existence of cointegration when the value of F-statistic is inferior to the lower critical values. While, if the value of F-statistic lied between the lower and upper critical values, author's decides that there are inconclusive cointegration among the variables in the model.

In the fourth step, author examines the long-run model that given by equation 3.9. The long-run model shows individual long-run effects from the independent variables to the dependent variable. In this step, author still keeps the long-run model as cointegration form although some variables are individually not significant or the result of ARDL bound test implied that there is no cointegration among the variables in selected ARDL models. The cointegration form that derived from the long-run model then converting into a specific variable which called as the error correction term (ECT) such as equation 3.10.

In the fifth step, author estimate a separate restricted error correction model (RECM) which given by Equation 3.8 to determine the short-run effects and the speed of adjustment from short-run to long-run. In equation 3.8, the coefficients of short-run imply an individual short-run effect from each independent variables to the dependent variable, while μ represents adjustment parameter speed and ECT_{t-1} implies the obtained residuals from the cointegration form which derived from equation 3.10. As mentioned earlier, ECT_{t-1} defines as the effectiveness of the feedback or correction mechanism in stabilizing disequilibrium in the model. The existence of a co-integration and adjustment of disequilibrium in the model occurred if the coefficient of error correction term (ECT) is negative and statistically significant (Narayan, 2005). According to Coakley et al. (2004), the higher coefficient of ECT_{t-1} will be better for the adjustment speed of long-run equlibrium.

3.4.2 Granger Causality Test

Generally, the ARDL procedures did not clearly shown the direction of the causality linkage between the variables in the model. In order to the determination of the short-run and long-run linkages among the variables, especially to examine the direction relationship among the variables, author use the Granger causality method (Granger, 1969). It is a composite of short-run and error correction estimates. The long-run causality is determined by the significance of the coefficient of error correction term (ECT_{t-1}) based the value of t-statistics. While, the direction of short-term causality can be tested statistically using the joint significance of the coefficients of each explanatory variable and it is determined by chi-square value from the Wald test.

3.5 Flow Chart of Analysis Process

The sequence of analysis and measurement steps carried out in this study can be seen in Figure 4.3 below.

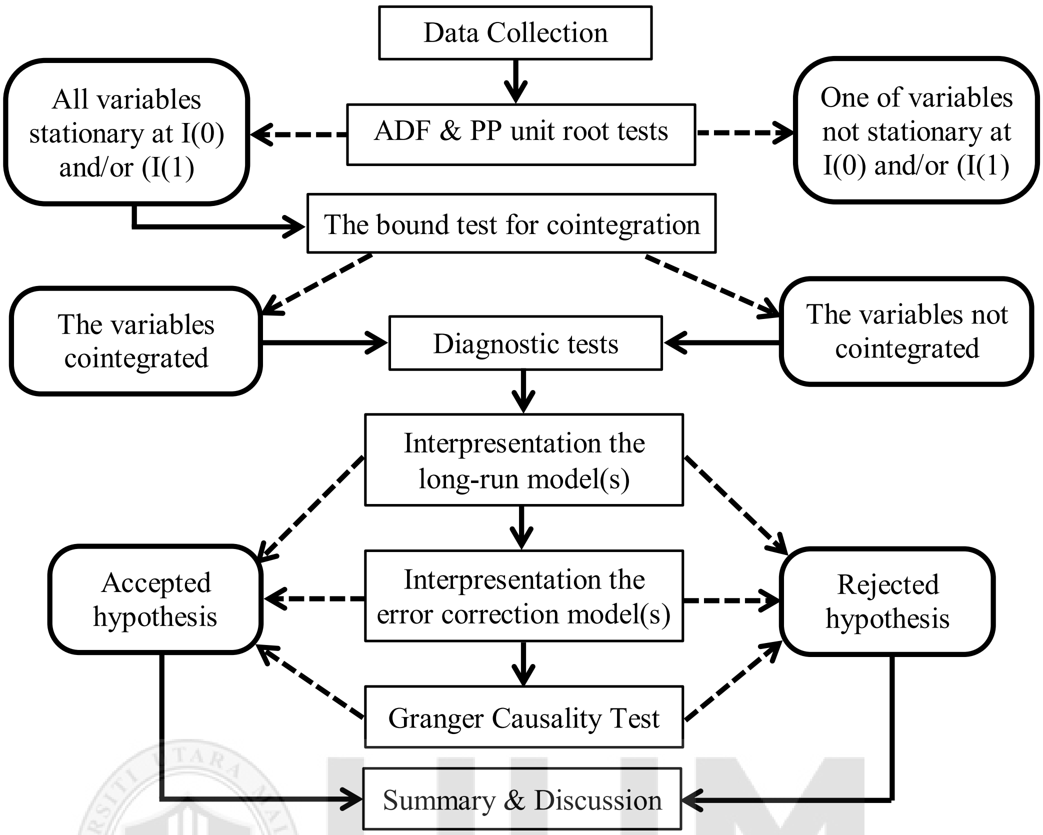


Figure 3.7 Flow Chart Analysis Process

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presenting the analysis process and empirical findings in this study. Overall, this chapter consists of five main sections. The first section shows the analysis process and results for investigates the role of economic growth on final energy consumption in Indonesia. Section two shows the analysis process and results for the role of final energy consumption on economic growth in Indonesia. Section third shows the analysis process and results for the causality linkage between economic growth, final energy consumption and CO_2 emission in four final energy user sectors in Indonesia, respectively. The last section provides a summary of the results for all analysis in this study.

4.2 The Role of Economic Growth on Final Energy Consumption in Indonesia

This analysis used five operational variables that denoted as LFET, LVAI, LVAA, LVAS, and LGRP. LFET is a natural logarithm form of Indonesia's total final energy consumption, LVAI is a natural logarithm form of the value-added of industry sector, LVAA is a natural logarithm form of the value-added of the agriculture sector, LVAS is a natural logarithm form of the value-added of the service sector, and LGRP is s a natural logarithm form of the real GDP per capita of Indonesia.

Table 4.1 reports the results of unit root tests for these variables under two specifications: (1) using constant only and (2) using constant and trend. The results revealed that when tested with constant only, the series of LVAI is stationary at I(0) and I(1), whereas data series of LFET, LVAA, LVAS, and LGRP only stationary at I(1). Furthermore, when all data series tested with constant and trend, the result of unit root tests indicated that all data series only stationary at I(1). Based on these results, author concluded that all data series are stationary at I(0) and/or I(1).

Table 4.1
The result of unit root tests for the variables in model 1.

Variables	Constant only		Constant with trend	
	ADF	PP	ADF	PP
LVAI	-3.090**	-3.090**	-2.296	-2.298
LVAA	-0.773	-0.757	-1.959	-2.012
LVAS	-1.107	-1.056	-1.705	-1.832
LGRP	-1.269	-1.187	-2.285	-2.031
LFET	-2.007	-2.007	0.189	-0.445
ΔLVAI	-5.611***	-5.601***	-6.033***	-6.033***
ΔLVAA	-5.634***	-5.800***	-5.490***	-5.823***
ΔLVAS	-5.703***	-5.731***	-5.759***	-5.770***
ΔLGRP	-4.777***	-4.777***	-4.792***	-4.792***
ΔLFET	-6.089***	-6.120***	-6.122***	-6.653***

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.3 reports the result of the bound test for model 1 within the specification model "unrestricted constant without trend". Determination of optimal lag for each variable on model 1 using AIC criterion with maximum lag is 4 and indicated that optimum lags for model 1 are 1,3,3,1,1. Furthermore, the value of F-statistic from the bound test is 14.93, which certainly exceeded the upper critical bound value at 1 per cent level and indicated that the variables in model 1 are cointegrated.

Table 4.2
The result of bound test for model 1.

Model		Lags	F-stat
Model 1 : $LFET = f(LVAI, LVAA, LVAS, LGRP)$		1,3,3,1,1	14.927***
Critical Bound	Significance level		
	1%	5%	10%
Lower Bound, I(0)	4.394	3.178	2.638
Upper Bound, I(1)	5.914	4.450	3.772

Note : ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively. The critical values for lower I(0) and upper I(1) bounds are taken from Narayan (2005) Case III, K=4, n=45).

The result of diagnostic tests for model 1 can be seen in Table 4.3. Jarque-Bera statistics and LM-test indicated that there is no normality and serial correlation problem, ARCH test indicated that there is no heteroscedasticity issue in the model, and RESET test confirmed that model free from general specification errors.

Table 4.3
The result of diagnostics tests.

JB Statistics	0.636 (0.728)	ARCH	2.571 (0.070)
LM test	1.804 (0.173)	RESET	2.232 (0.147)

Note: the value in parentheses is a probability of diagnostics test.

Table 4.4 reported the result of Chow test over observation periods from 1988 to 2014. This result shows that the value of F-statistics is insignificant at 5 per cent level and implied that regressors in model 1 are stable over observation periods.

Table 4.4
The result of Chow test.

Observation from	1984-2014
F-statistics	10.001 (0.246)

Note: the value in parentheses is a probability of diagnostics test.

Furthermore, the plots of CUSUM and CUSUMSQ shows that the blue line did not exceed the critical boundaries (see Figure 4.1). It is indicated that there are no structural breaks on model 1, which also confirms the stability of the regressors in model 1.

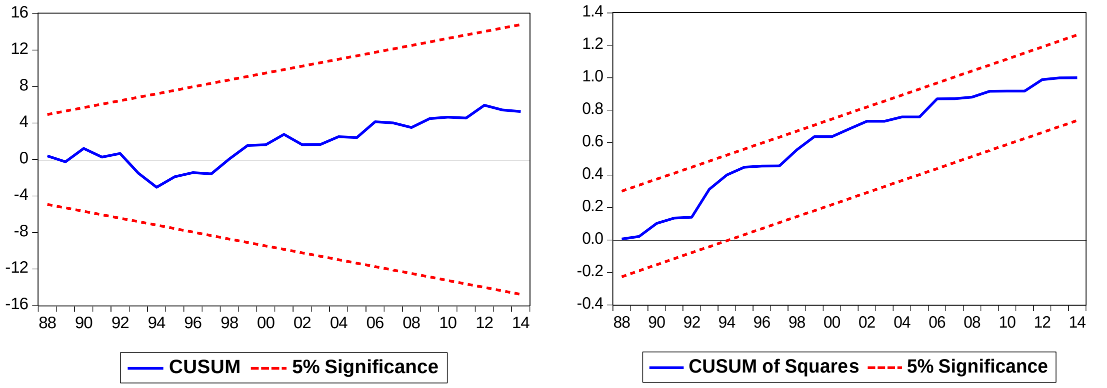


Figure 4.1 The plots of CUSUM and CUSUM of squared model 1.

Table 4.5 reports the long-run coefficients of independent variables in model 1. The coefficients of LVAI and LVAA have positive sign and significant at 1 per cent level. It is indicated that a rise of economic growth in the industry sector and the agriculture sector is potentially driven increased total final energy consumption of Indonesia in the long-term. The coefficient of LVAS is negative and significant at 1 per cent level. It is indicated that a rise of economic growth in the service sector caused the total final energy consumption of Indonesia decreased in the long-term, vice versa. The coefficient of LGRP is negative and insignificant, and it is implied that the growth of real GDP per capita of Indonesia did not have any effect on the total final energy consumption of Indonesia in the long-term.

Table 4.6 reports the coefficients of short-run and error correction term in model 1. The short-run coefficients of LVAI, LVAI(-1), LVAI(2) are negative and significant at 1 per cent level. It is indicated that a rise of economic growth in industry sector will caused increased final energy consumption of Indonesia in short-run, and also vice versa. The short-run coefficient of LVAA is negative and insignificant. This finding indicated that in the first period of short-term, economic growth of the agriculture sector did not influence Indonesia's final energy consumption.

Table 4.5
The long-run coefficients of independent variables in model 1.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVAI	0.855***	0.085	10.037	0.000
LVAA	0.605***	0.148	4.074	0.000
LVAS	-0.358***	0.121	-2.969	0.006
LGRP	-0.282	0.228	-1.238	0.226

Note : ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

The short-run coefficient of LVAA(-1) is positive and significant at 10 per cent level. This finding indicated that a rise of economic growth in the agriculture sector in the second period of short-term will increased the amount of Indonesia's final energy consumption. The short-run coefficient of LVAA(-2) is positive and significant at 5 per cent level. This finding indicated that a rise of economic growth in agriculture sector in the last period of short-term potentially declined the amount of Indonesia's final energy consumption.

The short-run coefficient of LVAS is negative and significant at 1 per cent levels. It is indicated that if economic growth in the service sector increased in short-term, Indonesia's total final energy consumption would be declined, vice versa. The short-run coefficient of LGRP is positive and significant at 1 per cent level. It is indicated that a rise of Indonesia's real GDP per capita potentially stimulated the amount of final energy consumption in Indonesia. Furthermore, the coefficient of ECT_{t-1} has a negative sign and significant at 1 per cent level. This finding indicated the existence of a long-run equilibrium in model 1 and also confirmed that deviation from short-term to long-term in model 1 predicted approximately 72.60 per cent. Furthermore, the adjustment R-square value indicated that the response of independent variables to explained dependent variable approximately 79.58 per cent, while the rest influenced by other determinants that not accounted in the model.

Table 4.6
The coefficients of short-run and error correction term in model 1.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.646	0.068	9.427	0.000
ΔLVAI	-0.561***	0.165	-3.397	0.002
ΔLVAI(-1)	-0.295***	0.057	-5.156	0.000
ΔLVAI(-2)	-0.138**	0.053	-2.619	0.014
ΔLVAA	-0.173	0.175	-0.993	0.329
ΔLVAA(-1)	0.276*	0.151	1.823	0.079
ΔLVAA(-2)	0.334**	0.145	2.298	0.029
ΔLVAS	-0.777***	0.186	-4.189	0.000
ΔLGRP	1.913***	0.430	4.454	0.000
ECT(-1)	-0.726***	0.078	-9.257	0.000
R-squared	0.796	DW statistics		0.736

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.7 shows the result of the Granger causality test using the Wald-test procedure. The result of the Granger causality test shows that the chi-square values of LVAI, LVAA, LVAS, and LGRP are significant at 1 per cent level. This result confirmed that economic growth in three development sectors and the real GDP per capita of Indonesia have a significant effect to total final energy consumption of Indonesia in the short-term period. Whilst, the t-statistics value of ECT_{t-1} is -9.25 and significant at 1 per cent level. It is confirmed the existence of a long-run equilibrium among the variables in model 1.

Table 4.7
The results of Granger Causality test for model 1.

DV	ΔLVAI	ΔLVAA	ΔLVAS	ΔLGRP	ECT (t-value)
	Chi-square				
ΔLFET	38.377***	9.421**	17.551***	19.839***	-9.257***

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

4.3 The Role of Final Energy Consumption on Economic Growth in Indonesia.

This analysis used five operational variables that denoted as LGR, LFEI, LFEA, LFES, and LFER. LGR is a natural logarithm form of the real GDP of Indonesia, LFEI is the natural logarithm form of total final energy consumption by the industry sector, LFEA is a natural logarithm form of total final energy consumption by the agriculture sector, LFES is a natural logarithm form of total final energy consumption by the service sector, and LFER is a natural logarithm form of total final energy consumption by the residential sector.

Table 4.8 shows the results of unit root tests under two specifications: (1) using constant only and (2) using constant and trend. The result of ADF unit root test indicated that when all series tested with constant only, the series of LFEA is stationary at I(0) and I(1), while the series of LFEI, LFES, and LFER are stationary only at I(1). The result of PP unit test indicated that when all series tested with constant only, the series of LFEI and LFEA have stationarity at I(0) and I(1), while the data series of LFES and LFER have stationarity at I(1). Meanwhile, when all series tested with constant and trend, the result of ADF and PP unit root tests indicated that all data series only stationarity at I(1). Based on these results, it can be concluded that all series are stationary at I(0) or/and I(1).

Table 4.8
The result of unit root tests for the variables in model 2.

Variables	Constant without trend		Constant with trend	
	ADF	PP	ADF	PP
LFEI	-2.579	-2.965**	-0.923	-0.669
LFEA	-2.695*	-2.695*	0.540	0.571
LFES	-1.076	-1.164	-2.427	-1.934
LFER	-0.900	-1.278	-2.738	-2.129
LGR	-2.067	-1.834	-2.081	-1.903
ΔLFEI	-6.803***	-6.796***	-7.912***	-8.163***
ΔLFEA	-4.046***	-4.126***	-4.658***	-4.484***
ΔLFES	-3.735***	-3.805***	-3.792**	-3.862**
ΔLFER	-3.767***	-3.678***	-3.773**	-3.670**
ΔLGR	-4.552***	-4.557***	-4.735***	-4.735***

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.9
The result of bound test for model 2.

Model		Lags	F-stat
Model 2 : $LGR = f(LFEI, LFEA, LFES, LFER)$		1,0,5,4,5	3.6516
Critical Bound	Significance level		
	1%	5%	10%
Lower Bound, I(0)	4.394	3.178	2.638
Upper Bound, I(1)	5.914	4.450	3.772

Note : ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively. The critical values for lower I(0) and upper I(1) bounds are taken from Narayan (2005, Appendix: Case II, K=4, n=45).

Table 4.9 reports the result of the ARDL bound test for model 2 within the specification model "unrestricted constant without trend". Determination of optimal lag for each variable on model 2 using AIC criterion with maximum lag is 5 and indicated that optimum lags for model 2 are 1,0,5,4,5. The result of the bound test shows that the value of F-statistic is 3.65 and lies between the upper and lower critical bound values at 10 per cent significant level. This result indicated inconclusive cointegration relationship between the variables in model 1. The result of diagnostic tests for model 2 can be seen in Table 4.10. The outcome of Jarque-Bera statistics and the LM test confirmed that the estimation of model 2 did not have normality and serial correlation issues. Furthermore, the ARCH test and RESET test confirmed that model 2 is free from heteroscedasticity and model specification error issues.

Table 4.10
The result of diagnostics tests

JB Statistics	0.948 (0.623)	ARCH	0.732 (0.606)
LM test	0.903 (0.506)	RESET	0.325 (0.575)

Note: the value in parentheses is a probability of diagnostics test.

Table 4.11 reports the result of Chow test over the periods of 1997-2014.This result shown that the value of F statistics did not significant at 5 per cent level and it is indicated absence structural breaks in model 2 or confirmed the stability of regressors in model 2.

Table 4.11
The result of Chow test.

Observation from	1984-2014
F-statistics	10.001 (0.246)

Note: the value in parentheses is a probability of diagnostics test.

Figure 4.2 shows the plots of CUSUM and CUSUMSq for model 2. It can be seen the blue line in the plots of CUSUM and CUSUMSq did not exceed the critical boundaries.

These results indicated that the regressors in model 2 are stable over the observation periods.

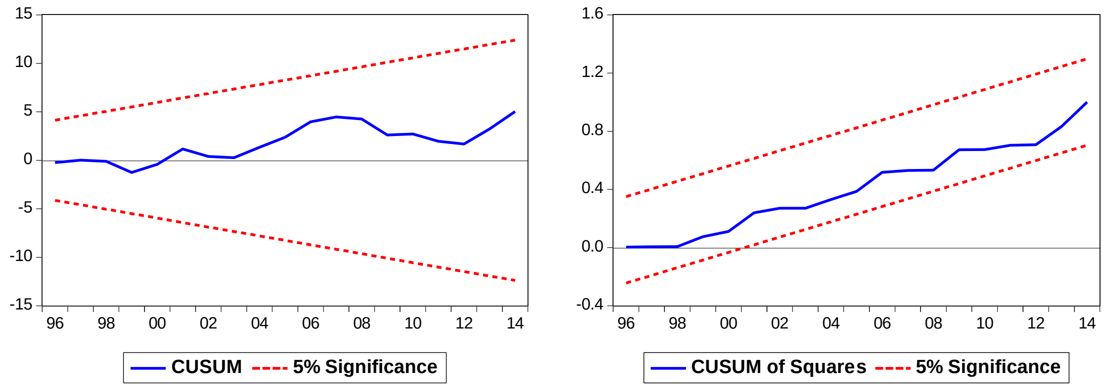


Figure 4.2 The plots of CUSUM and CUSUM of squared model 2.

Table 4.12 shows the long-run coefficients of independent variables in model 2. The result shows that the long-run coefficients of LFEI, LFER, LFEA and FES statistically insignificant. Therefore, author then concluded the growth of final energy consumption in four energy user sectors, respectively, did not have a significant effect to the real GDP of Indonesia in the long-term.

Table 4.12
The long-run coefficients of independent variables in model 2.

Variable	Coefficient	Std. Error	t-statistic	Prob.
LFEI	0.215	0.228	0.942	0.358
LFEA	-1.428	1.925	-0.742	0.467
LFES	-2.051	4.995	-0.411	0.686
LFER	13.818	22.790	0.606	0.551

Note : ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.13 reports the coefficients of short-run and error correction term in model 2. The short-run coefficient of LFEI is statistically insignificant. It is indicated that the growth of final energy consumption in industry sector did not have a significant effect to the real GDP of Indonesia in the short-term. The short-run coefficient of LFEA is negative and insignificant, while the short-run coefficients of LFEA(-1), LFEA(-2), and LFEA (4) are positive and significant at 1 per cent level. It is implied that after the first period of short-run, a rise of final energy consumption will be caused the real GDP of Indonesia increased gradually.

Table 4.13
The coefficients of short-run and error correction term in model 2.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-12.790***	2.842	-4.500	0.000
ΔLFEI	0.037	0.035	1.042	0.309
ΔLFEA	-0.033	0.056	-0.588	0.563
ΔLFEA(-1)	0.237***	0.074	3.201	0.004
ΔLFEA(-2)	0.188**	0.082	2.302	0.031
ΔLFEA(-3)	0.242***	0.066	3.672	0.001
ΔLFEA(-4)	0.214**	0.086	2.478	0.021
ΔLFES	0.366**	0.147	2.490	0.021
ΔLFES(-1)	0.011	0.159	0.067	0.947
ΔLFES(-2)	-0.018	0.149	-0.119	0.907
ΔLFES(-3)	0.339**	0.139	2.430	0.024
ΔLFER	0.458	0.490	0.934	0.360
ΔLFER(-1)	-2.292***	0.575	-3.988	0.000
ΔLFER(-2)	0.306	0.542	0.566	0.577
ΔLFER(-3)	-1.828***	0.641	-2.851	0.009
ΔLFER(-4)	-1.606*	0.859	-1.868	0.075
ECT(-1)	-0.120***	0.026	-4.513	0.000
R-squared	0.7211	DW statistics	1.9016	

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

The short-run coefficients of LFES and LFES(-4) are positive and significant, while the coefficients of LFES(-1) and LIFES(-2) are insignificant. It is indicated that the growth of final energy consumption in the service sector only has a significant effect to the real GDP of Indonesia in the first and last periods of short-term. The coefficients of LFER and LFER(-3) are insignificant, while the coefficients of LFER(-1), LFER(-2), and LFER(-4) are negative and statistically significant. It is indicated that residential final energy consumption has a negative effect on the real GDP of Indonesia in the second, third, and last periods of short-term. The coefficient of ECT_{t-1} is negative and significant at 5 per cent level. It is indicated that deviation from the short run to the long-run only approximately 11.96 per cent. Furthermore, the value of adjustment R-square indicated that the response of independent variables to explaining the dependent variable is 72.11 per cent, while the rest influenced by other determinants that not accounted in the model.

Table 4.14
The results of Granger Causality test for model 2.

DV	ΔLFEI	ΔLFEA	ΔLFES	ΔLFER	ECT (t-value)
	Chi-square				
ΔLGR	1.085	22.534***	15.079***	20.237***	-4.513***

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.14 report the result from the Granger causality test using the Wald-test procedure. The chi-square value of LFEI is insignificant and it is indicated that the growth of final energy consumption in the industry sector did not have a significant effect to the real GDP of Indonesia in the short-term. The chi-square values of LFEA, LFES, and LFER are statistically significant. It is implied that the growth of final energy consumption in the agriculture sector, service sector, and residential sector have a significant effect on the real GDP of Indonesia in the short-term. Furthermore, the t-statistics value of ECT_{t-1} is negative and significant at 1 per cent level. It is indicated the existence of a long-run equilibrium from independent variables to the dependent variable in the model 2. Based on these results, it can be concluded that the growth of final energy consumption in the agriculture sector, service sector, and residential sector influenced the growth of real GDP in Indonesia, while the growth of final energy consumption in the industry sector did not have any effect on the real GDP of Indonesia.

4.4 The Causality Linkage Between Final Energy Consumption, Economic Growth and CO_2 Emission in Four Energy User Sectors in Indonesia.

The third purpose of this study investigates the causality linkages between final energy consumption, economic growth, and CO_2 emissions on four energy user sectors in Indonesia. Therefore, the analysis process for this investigation divides into four parts. The first part shows the analysis process and result for investigating on the industry sector. The second part shows the analysis process and result for investigating on the agriculture sector. The third part shows the analysis process and result for investigating on the service sector. While the last part shows the analysis process and result for investigating on the residential sector.

4.4.1 Analysis for Industry Sector

This analysis used three operational variables that denoted as LCOI, FEI, and LVAI. LCOI is a natural logarithm form of total CO_2 emissions from energy combustion generated by energy users in the industry sector, LFEI is a natural logarithm form of total final energy consumption that consumed by energy users in the industry sector, LVAI is a natural logarithm form of the value-added of industry sector. Table 4.15 reports the result of unit root tests for all series that used in this analysis. The result of ADF unit root test indicated that when tested with constant, the series of LVAI is stationary at I(0) and I(1), while the series of LFEI and LCOI are stationary at I(1) only. The result of PP unit root test indicated that when tested with constant only, the series of LFEI and LVAI are stationary at I(0) and I(1), while the series of LCOI is stationary at I(1) only. Meanwhile, when all series tested with constant and trend, the result of unit root tests indicated all series are stationary at I(1) only. Based on these results, author concluded that all data series are stationarity at I(0) and/or I(1).

Table 4.15
The result of unit root tests for the variables in model 3.

Variables	Constant without trend		Constant with trend	
	ADF	PP	ADF	PP
LCOI	-2.443	-4.334	-0.904	-0.305
LFEI	-2.579	-2.965**	-0.923	-0.669
LVAI	-3.090**	-3.090**	-2.296	-2.298
ΔLCOI	-6.315***	-6.313***	-7.071***	-11.594***
ΔLFEI	-6.803***	-6.796***	-7.912***	-8.163***
ΔLVAI	-5.611***	-5.601***	-6.033***	-6.033***

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Furthermore, author checks the existence of cointegration among the variables in model 3a, model 3b, and model 3c. Table 4.16 report the result of the ARDL bound test for model 3a, model 3b, and model 3c within the specification model "unrestricted constant without trend". Determination optimum lags for all equation models based AIC criterion with maximum lag is 4. In model 3a, the AIC criterion selected optimum lags for model 3a are 4,1,1 and the result of the bound test shows that F-statistic value is larger than the upper critical bound at 1 per cent significance level. It is indicated that there is a cointegration among the variables in model 3a. In model 3b, the AIC criterion selected optimum lags for model 3b are 1,0,4 and the result of the bound test shows that F-statistic value is larger than the upper critical bound at 5 per cent significance level. It is also indicated that there is a cointegration linkage between the variables in model 3b. In model 3c, the AIC selected optimum lags for model 3c are 1,0,0 and the result of the bound test shows that the value of F-statistics stands among the lower and upper critical values at 10 per cent significance level. It is implied inconclusive cointegration among the variables in model 3c.

Table 4.16
The result of bound test for model 3a, 3b, and 3c.

ARDL model		LAGS	F- Statistics
Model 3a : $LCOI = f(LFEI, LVAI)$		4,1,1	7.905***
Model 3b : $LFEI = f(LVAI, LCOI)$		1,0,4	6.221**
Model 3c : $LVAI = f(LCOI, LFEI)$		1,0,0	3.508
Critical Bound	Significance level		
	1%	5%	10%
Lower bound, I(0)	5.920	4.083	3.33
Upper bound, I(1)	7.197	5.207	4.347

Notes: The null hypothesis is no cointegration. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively. The critical values are from Narayan (2005) case III, K=2, N=45.

The result of diagnostic tests for all selected models can be seen in Table 4.17. The result of diagnostic tests for model 3a indicated that this model is free from the issues of normality, serial correlation, homoscedasticity and general specification errors. The result of diagnostic tests for model 3b and model 3c indicated that both models have normality issues and did not have other issues such as serial correlation, homoscedasticity, and general specification errors.

Table 4.17
The result of diagnostics tests

	Model 3a	Model 3b	Model 3c
JB Statistics	0.078 (0.962)	11.455 (0.003)	19.170 (0.000)
LM test	0.200 (0.936)	0.264 (0.898)	0.409 (0.526)
ARCH	0.743 (0.571)	0.229 (0.920)	0.074 (0.787)
RESET	0.092 (0.764)	0.156 (0.696)	0.655 (0.423)

Note: the value in parentheses is a probability of diagnostics test.

Table 4.18 reported the result of Chow test for three selected models, respectively. In this test, the model 3a and model 3b tested for observation periods from 1986 to 2014, while model 3c tested for observation periods from 1980-2014. It can be seen that the F-statistics values from the Chow tests for three selected models are insignificant at 5 per cent level. It is indicated that the regressors in three selected models, respectively, are stable over the observation periods.

Table 4.18
The result of Chow test

	Model 3a	Model 3b	Model 3c
Observation from	1986-2014	1986-2014	1980-2014
F-statistics	1.398 (0.502)	1.965 (0.320)	1.288 (0.452)

Note: the value in parentheses is a probability of diagnostics test.

Figure 4.3 shows the plots of CUSUM and CUSUMSq for model 3a. It can be seen that the plot of CUSUM shows that the blue line did not exceed the critical boundaries, which indicated that the coefficients of model 3a are stable. On the contrary, the blue line in the plots of CUSUMSq exceeded the critical boundaries, which indicated that the coefficients of model 3a are not stable. In these cases, author concluded that the coefficients of regressors in model 3a are stable based on the plot of CUSUM and the Chow test.

Figure 4.4 shows the plots of CUSUM and CUSUMSq for model 3b. It can be seen that the blue line in the plot of CUSUM did not exceed the critical boundaries, which indicated that the coefficients of model 3b are stable. On the contrary, the blue line in the plot of CUSUMSq exceeded the critical boundaries, which indicated that the coefficients of model 3b are not stable. In this case, author concluded that the coefficients of regressors in model 3b are stable based on the plot of CUSUM and the Chow test.

Figure 4.5 shows the plots of CUSUM and CUSUMSq for model 3c. It can be seen that a blue line in the plot of CUSUM did not exceed the critical boundaries, which indicated that the coefficients of model 3c are stable. On the contrary, the blue line in the plot of CUSUMSq exceeded the critical boundaries, which indicated that the coefficients of model 3c are not stable. In these cases, author concluded that the coefficients of model 3c are stable based on the plot of CUSUM and the Chow test.

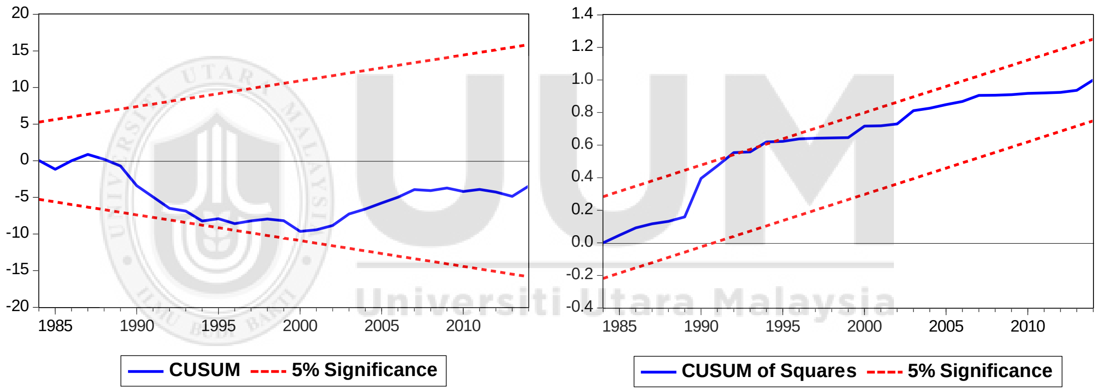


Figure 4.3 The plots of CUSUM and CUSUM of squared model 3a.

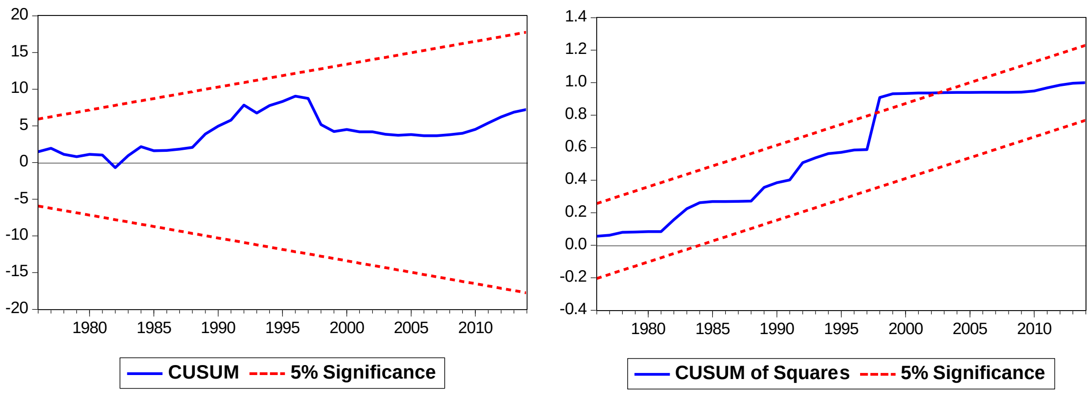


Figure 4.4 The plots of CUSUM and CUSUM of squared model 3b.

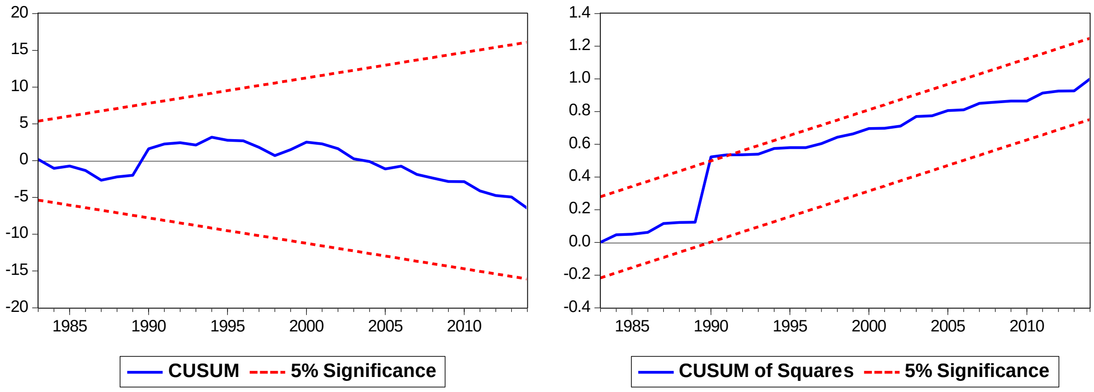


Figure 4.5 The plots of CUSUM and CUSUM of squared model 3c.

Table 4.19 reports the long-run coefficients of three selected ARDL models. In model 3a, the long-run coefficient of LFEI and LVAI are positive and statistically significant. It is indicated that a rise of final energy consumption and economic growth in the industry sector will be caused the amount of CO_2 emission in the industry sector increased in the long-term, vice versa. In model 3b, the long-run coefficient of LVAI is insignificant, and it is indicated that economic growth in the industry sector did not have any relationship with the final energy consumption of the industry sector.

The long-run coefficient of LCOI is positive and significant. It is indicated that a rise of CO_2 emission caused an increase in the amount of final energy consumption in the industry sector. In model 3c, the long-run coefficient of LCOI is positive and significant, while the long-run coefficient of LFEI is negative and insignificant. It is indicated that increasing CO_2 emission in the industry sector potentially stimulated economic growth in the service sector, while an increased amount of final energy consumption in the industry sector did not have any effect on economic growth in the industry sector over the long-term.

Table 4.19
The long-run coefficients of independent variables in model 3a, 3b, and 3c.

DV	Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCOI	LFEI	0.698***	0.126	5.527	0.000
	LVAI	0.370**	0.175	2.120	0.042
LFEI	LVAI	0.004	0.302	0.012	0.990
	LCOI	0.979***	0.221	4.439	0.000
LVAI	LCOI	0.916**	0.381	2.401	0.021
	LFEI	-0.285	0.395	-0.722	0.474

Note: ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.20 reports the short-run and error correction term coefficients in three selected models. In model 3a, the short-run coefficient of LFEI is positive and significant. It implied that the growth of final energy consumption in the industry sector would be encouraged increasing the amount of CO_2 emission in the industry sector in short-run. Meanwhile, the short-run coefficient of LVAI is negative and insignificant. It implied that economic growth in the industry sector did not have a short-run effect on CO_2 emission in the industry sector.

The coefficient of ECT_{t-1} in model 3a is -0.43 and significant at 1 per cent level. It is implied that deviations from short-run to long-run equilibrium in model 3a is approximately 42.93 per cent. Furthermore, the value of R-squared indicated that the capability of independent variables to explains the movement of dependent variables in model 3a is 79.25 per cent, while the rest influenced by other determinants that not accounted in the model. The result of Durbin-Watson statistics indicated the absence of autocorrelation in model 3a.

Table 4.20
The coefficients of short-run and error correction term in model 3a, 3b, and 3c.

Regressors	Model 3a DV: ΔLCOI	Model 3b DV: ΔLFEI	Model 3c DV: ΔLVAI
C	-2.793***	2.370***	1.7974***
ΔLCOI	-	1.265***	0.1797
ΔLCOI(-1)	-0.116	0.200	-
ΔLCOI(-2)	-0.177**	0.336**	-
ΔLCOI(-3)	-0.219**	0.229	-
ΔLFEI	0.508***	-	-0.0748
ΔLVAI	-0.117	0.192	
ECT(-1)	-0.429***	-0.466***	-0.1654***
R-squares	0.7925	0.7758	0.2336
DW stat	1.7974	2.0341	1.7933

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

In model 3b, the short-run coefficient of LVAI is positive and insignificant. It indicates that economic growth in the industry sector did not influence the growth of final energy consumption in the industry sector. The coefficient of LCOI and LCOI(-2) are positive and statistically significant. It indicates that increases CO_2 emission in the industrial sector in the first and last of short-term period potentially caused final energy consumption in the industry sector increased. Furthermore, the coefficient of ECT_{t-1} is -0.46 and significant at 1 per cent level. This finding expressed that deviations from short-run to long-run equilibrium in model 3b is approximately 46.58 per cent. Furthermore, the value of R-squared indicated that the capability of independent variables to explain the movement of the dependent variable is 77.58 per cent, while the rest influenced by other determinants that not accounted in the model. The Durbin-Watson statistics indicated absence autocorrelation in model 3b.

In model 3c, the short-run coefficients of LCOI and LFEI are insignificant. It indicates that the growth of CO_2 emission and final energy consumption in the industry sector did not have a significant effect on the economic growth process in the industry sector. Meanwhile, the coefficient of ECT_{t-1} is -0.17 and significant. This finding indicated that deviations from short-run to long-run equilibrium in model 3b are corrected by 16.54 per cent. Furthermore, the values of R-squared suggested that the capability of independent variables to explaining the movement of the dependent variable is 23.36 per cent, while the rest influenced by other determinants that not accounted in the model. The Durbin-Watson statistics indicated absence autocorrelation issue in model 3c.

Table 4.18 shows the result of the Granger causality test for three selected models. In the short-term, final energy consumption and CO_2 emission in the industry sector has a mutual linkage. Moreover, the final energy consumption and CO_2 emission in the industry sector did not have any significant effect on the economic growth process in the industry sector. Furthermore, t-value of ECT_{t-1} in three selected models are negative and significant at 5 per cent level, which indicated there is a long-run linkage between the variables in three selected models, respectively.

Table 4.21
The results of Granger Causality test for model 3a, 3b, and 3c.

Regressors	Model 3a DV: ΔLCOI	Model 3b DV: ΔLFEI	Model 3c DV: ΔLVAI
ΔLCOI		102.961***	1.385
ΔLFEI	93.998***		0.542
ΔLVAI	0.837	0.874	
ECT(-1)	-5.024***	-4.426***	-3.248***

Note: Δ is symbol of first different form. The chi-square statistics are reported for the variables while the t-statistic is reported for the ECT. The null hypothesis is no granger-causality. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

4.4.2 Analysis for Agriculture Sector

This analysis used three operational variables that denoted as LCOA, FEA, and LVAA. LCOA is a natural logarithm form of total CO_2 emissions from energy combustion generated by energy users in the agriculture sector, LFEA is a natural logarithm form of total final energy consumption that consumed by energy users in the agriculture sector, LVAA is a natural logarithm form of the value-added of the agriculture sector. Table 4.22 reported the result of unit root tests for all series that used in the analysis. The result of unit root tests indicated that when tested with constant only, the series of LCOA and LFEA are stationary at I(0), whereas the series of LVAA only stationary at I(1). Meanwhile, when all series tested with constant and trend, both unit root tests indicated that all series are only stationary at first different or I(1). Based on these results, it can be concluded that all data series are stationarity at I(0) and/or I(1).

Table 4.22
The result of unit root tests for the variables in model 4

Variables	Constant without trend		Constant with trend	
	ADF	PP	ADF	PP
LCOA	-2.742*	-2.742*	0.660	0.864
LFEA	-2.695*	-2.695*	0.540	0.571
LVAA	-0.773	-0.757	-1.959	-2.012
ΔLCOA	-4.165***	-4.165***	-4.885***	-4.762***
ΔLFEA	-4.046***	-4.126***	-4.658***	-4.484***
ΔLVAA	-5.634***	-5.800***	-5.490***	-5.823***

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.23 reports the result of the bound test for three selected models which tested with the specification model "unrestricted constant without trend". Determination optimum lags for all equation models based AIC criterion with maximum lag is 4. In model 4a, the result of the bound test shows that optimum lags for model 4a is 2,1,3 and the F-statistics value is lower than the lower critical bound value at 10 significance level.

Table 4.23
The result of bound test for model 4a, 4b, and 4c.

ARDL model		LAGS	F- Statistics
Model 4a : $LCOA = f(LFEA, LVAA)$		2,1,3	0.932
Model 4b : $LFEA = f(LVAA, LCOA)$		1,3,2	0.794
Model 4c : $LVAA = f(LCOA, LFEA)$		3,1,1	2.757
Critical Bound	Significance level		
	1%	5%	10%
Lower bound, I(0)	5.92	4.083	3.33
Upper bound, I(1)	7.197	5.207	4.347

Notes: The null hypothesis is no cointegration. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively. The critical values are from Narayan (2005) case III, K=2, N=45.

In model 4b, the result of the bound test shows that optimum lags for model 4b are 1,3,2 and the F-statistics value is lower than the lower critical bound value at 10 significance level. In model 4c, the result of the bound test shows that optimum lags for model 4c are 3,1,1 and the F-statistics value is lower than the lower critical bound value at 10 significance level. Based on these results can be concluded that there is no cointegration linkage among the variables in model 4a, model 4b, and model 4c.

The result of diagnostic tests for all selected models can be seen in Table 4.24. The result of Jarque-bera statistics indicated that model 4a and model 4b have normality issue, while model 4c did not have normality issue. Furthermore, the results of LM test, ARCH test, and RESET test implied that all selected models free from serial correlation, heteroscedasticity, and the general specification error issues.

Table 4.24
The result of diagnostics tests.

	Model 4a	Model 4b	Model 4c
JB Statistics	123.615 (0.000)	110.217 (0.000)	1.966 (0.374)
LM test	0.925 (0.441)	0.957 (0.426)	0.174 (0.913)
ARCH	0.072 (0.975)	0.071 (0.975)	1.563 (0.216)
RESET	3.001 (0.093)	2.888 (0.099)	2.935 (0.096)

Note: the value in parentheses is a probability of diagnostics test.

Table 4.25 reported the result of Chow test for three selected models, respectively. In this test, all selected models tested for observation periods from 1984 to 2014. It can be seen that the F-statistics values from the Chow tests for three selected models are insignificant at 5 per cent level. It is indicated that the regressors in three selected models, respectively, are stable over the observation periods.

Table 4.25
The result of Chow test.

	Model 4a	Model 4b	Model 4c
Observation from	1984-2014	1984-2014	1984-2014
F-statistics	10.001 (0.246)	11.142 (0.233)	0.947 (0.640)

Note: the value in parentheses is a probability of diagnostics test.

Figure 4.6 shows the plots of CUSUM and CUSUMSq for model 4a. It can be seen that blue line on the plot of CUSUM did not exceed the critical boundaries, while the blue line on the plot of CUSUMSq exceeded the critical boundaries. This finding implied that the regressors in model 4a are not stable. Nevertheless, author prefers accepted results from the Chow test and concluded that the regressors in model 4a are stable.

Figure 4.7 shows the plots of CUSUM and CUSUMSq for model 4b. It can be seen that blue line on the plot of CUSUM did not exceed the critical boundaries, while the blue line on the plot of CUSUMSq exceeded the critical boundaries. This finding implied that the regressors in model 4a are not stable. Nevertheless, author prefers accepted results from the Chow test and concluded that the regressors in model 4b are stable.

Figure 4.8 shows the plots of CUSUM and CUSUMSq for model 4c. It can be seen that the blue line on the plots of CUSUM and CUSUMSq exceed the critical boundaries. This finding implied that the regressors in model 4a are not stable. Nevertheless, author prefers accepted results from the Chow test and concluded that the regressors in model 4c are stable.

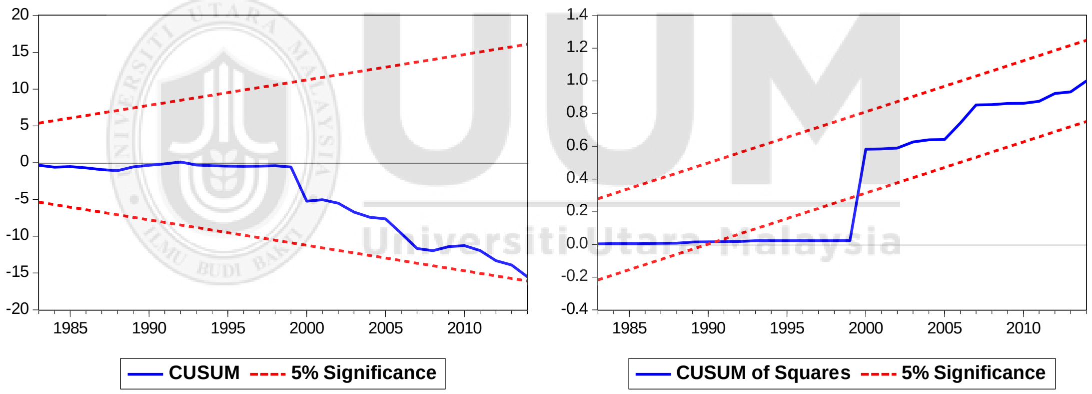


Figure 4.6 The plots of CUSUM and CUSUM of squared model 4a.

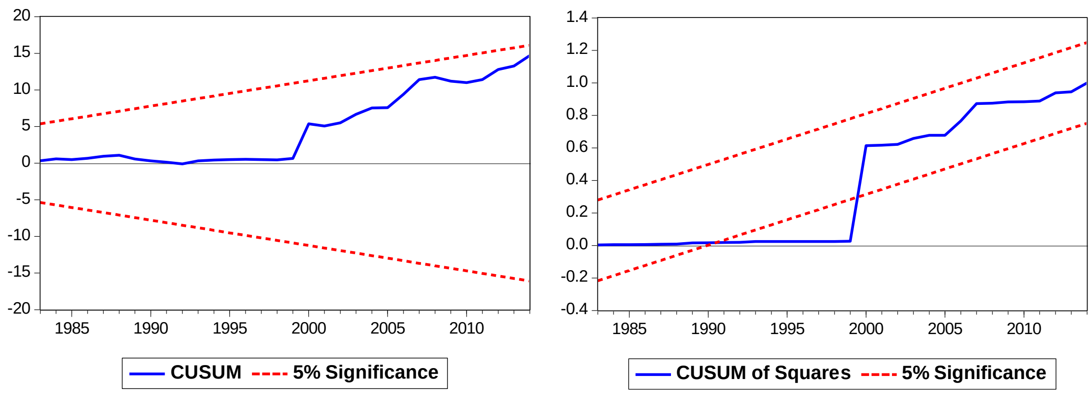


Figure 4.7 The plots of CUSUM and CUSUM of squared model 4b.

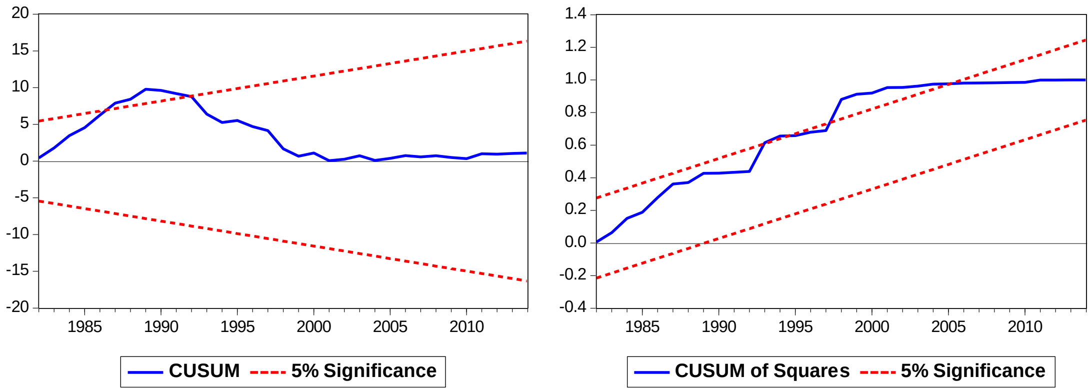


Figure 4.8 The plots of CUSUM and CUSUM of squared model 4c.

Table 4.26 shows the long-run coefficients in three selected models. In model 4a, the long-run coefficient of LFEA is positive and significant. It is indicated that a rise of final energy consumption in the agriculture sector in the long term will be caused the amount of CO_2 emission in the agriculture sector also increased. Furthermore, the long-run coefficient of LVAA is statistically insignificant, which indicated that increased or decreased economic growth in the agriculture sector in the long-term did not have any effect on the growth of CO_2 emission in the agriculture sector.

In model 4b, the long-run coefficients of LVAA and LCOA are statistically insignificant. It is indicated that a rise of economic growth and the growth of CO_2 emission in the agriculture sector did not have any effect on the final energy consumption in the agriculture sector in the long-term. In model 4c, the long-run coefficients of LCOA and LFEA also statistically insignificant. It is indicated that the growth of CO_2 emission and final energy consumption in the agriculture sector did not have a significant effect on the economic growth process in the agriculture sector over the long-term.

Table 4.26
The long-run coefficients of independent variables in model 4a, 4b, and 4c.

DV	Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCOA	LFEA	0.819**	0.328	2.493	0.018
	LVAA	0.414	0.854	0.485	0.631
LFEA	LVAA	-0.692	2.230	-0.310	0.758
	LCOA	1.308	0.911	1.435	0.161
LVAA	LCOA	30.512	71.257	0.428	0.671
	LFEA	-28.994	68.813	-0.421	0.676

Notes: ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.27 shows the short-run coefficients of independent variables and error correction term in three selected models. In model 4a, the coefficient of LFEA is positive and significant. It is indicated that the growth of final energy consumption in the agriculture sector will be encouraged increasing CO_2 emission in the agriculture sector over the short-term. Meanwhile, the short-run coefficients of LVAA and LVA(-1) are insignificant, while the short-run coefficient of LVAA(-2) is positive and significant. It implied a rise of economic growth in the agriculture sector potentially caused increasing CO_2 emission in the agriculture sector in the last period of short-term. Furthermore, the coefficient of ECT_{t-1} in model 4a is positive, which indicated absence long-run equilibrium among the variables in model 4a. The value of R-squared stated the capability of independent variables to explain the movement of the dependent variable is 99.46 per cent. The Durbin-Watson statistic value is near to 2, which mentioned the absence autocorrelation issue in model 4a.

In model 4b, the short-run coefficients of LVAA, LVAA(-1), and LVAA(-2) are negative, but only the short-run coefficient of LVAA(-2) statistically significant. It is implied that increased economic growth in the agriculture sector in the last period of short-term will caused the amount of final energy consumption in the agriculture sector to decline over the same period. The coefficients of LCOA and LCOA(-1) are positive and statistically significant. This finding implied that if the amount of CO_2 emission in the agriculture sector increased, the amount of final energy consumption in the agriculture sector also would be increased in the same period. The coefficient of ECT_{t-1} in model 4b is positive, which indicated absence long-run equilibrium between the variables in model 4b. Furthermore, the value of R-squared indicated that the capability of independent variables to explaining the movement of the dependent variable is 99.47 per cent. The Durbin-Watson statistics value is near to 2, which confirmed absence autocorrelation in model 4b.

Table 4.27
The coefficients of short-run and error correction term in model 4a, 4b, and 4c.

Regressors	Model 4a DV: ΔLCOA	Model 4b DV: ΔLFEA	Model 4c DV: ΔLVAA
C	0.425	-0.353	-2.196***
ΔLCOA	-	0.958***	0.212
ΔLCOA(-1)	-0.057***	0.056***	-
ΔLFEA	1.036***	-	-0.190
ΔLVAA	0.092	-0.082	-
ΔLVAA(-1)	0.053	-0.056	0.046
ΔLVAA(-2)	0.200***	-0.199***	-0.357**
ECT(-1)	0.048*	0.028	0.013***
R-squares	0.995	0.995	0.308
DW stat	1.980	1.932	1.849

Notes: Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

In model 4c, the short-run coefficients of LCOA and LFEA are insignificant. It is implied that the final energy consumption and CO_2 emission in the agriculture sector over the short-term did not have a significant effect on the economic growth process in the agriculture sector. Furthermore, the coefficient of ECT_{t-1} in model 4c is positive, which indicated that there is no long-run linkage between the variables in model 4c. Meanwhile, the value of R-squared shown that the capability of independent variables to explaining the movement of the dependent variable is 30.85 per cent. Furthermore, the Durbin-Watson statistics value is near to 2, which indicated absence autocorrelation issue in model 4c.

Table 4.28
The results of Granger Causality test for model 4a, 4b, and 4c.

Regressors	Model 4a DV: ΔLCOA	Model 4b DV: ΔLFEA	Model 4c DV: ΔLVAA
ΔLCOA		5235.746***	0.541
ΔLFEA	4850.019***		0.405
ΔLVAA	9.666**	10.255**	
ECT(-1)	1.724*	1.591	2.962***

Note: Δ is symbol of first different form. The chi-square statistics are reported for the variables, while the t-statistic is reported for the ECT. The null hypothesis is no granger-causality. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.28 shows the result of the Granger causality test for three selected models. In short-term, final energy consumption and CO_2 emission in the agriculture sector have a bidirectional linkage, which statistically significant at 5 per cent level. This finding indicated that final energy consumption potentially stimulating the amount of CO_2 emission in the agriculture sector, vice versa. Moreover, the value-added of the agriculture sector has a unidirectional effect on final energy consumption and CO_2 emission in the agriculture sector, respectively. This finding implied that sustainable economic growth process in agriculture sector significantly influenced the amount of final energy consumption and CO_2 emission in the agriculture sector. In long-run, the t-value of ECT_{t-1} in model 4a, model 4b, and model 4c are positive, which indicated there is no long-run equilibrium among the variables in these selected models.

4.4.3 Analysis for Service Sector.

This analysis used three operational variables that denoted as LCOS, FES, and LVAS. LCOS is a natural logarithm form of total CO_2 emission from energy combustion that generated by energy users in the service sector, LFES is a natural logarithm form of total final energy consumption that consumed by energy users in the service sector, LVAS is a natural logarithm form of the value-added of the service sector. Table 4.29 reported the result of unit root tests for all series that used in analysis. The result of unit root tests indicated that all data series are stationary only at I(1) when tested with constant only. Similarly, when tested with constant and trend, the result of both unit root tests indicated that all data series are stationary only at I(1). Based on these result, it can be concluded that the series of LCOS, LFES, and LVAS are not stationary at I(0) and only stationary when transformed into first different forms or I(1).

Table 4.29
The result of unit root tests for the variables in model 5.

Variables	Constant without trend		Constant with trend	
	ADF	PP	ADF	PP
LCOS	-1.161	-1.281	-2.399	-1.892
LFES	-1.076	-1.164	-2.427	-1.934
LVAS	-1.107	-1.056	-1.705	-1.832
ΔLCOS	-3.624***	-3.721***	-3.699**	-3.797**
ΔLFES	-3.735***	-3.805***	-3.792**	-3.862**
ΔLVAS	-5.703***	-5.731***	-5.759***	-5.770***

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Furthermore, author examines the existence of cointegration linkage between the variables in all selected models. Determination optimum lags for all models using AIC with maximum lag is 4 and tested within specification model "unrestricted constant without trend". Table 4.30 reports the result from ARDL bound test for three selected models. In model 5a, the AIC criterion selected optimum lags for model 4a is 1,2,2 and the result of bound test show that the value of F-statistics is lower than the lower critical bound value at 10 per cent significance level. In model 5b, the AIC criterion selected optimum lags for model 5b are 1,0,1 and the result of bound test show that the value of F-statistics is lower than the lower critical bound value at 10 per cent significance level. In model 5c, the AIC criterion selected optimum lags for model 5c are 1,1,0 and the result of bound test show that the value of F-statistics is lower than the lower critical bound value at 10 per cent significance level. Based on these results, it can be concluded that there is no cointegration linkage between the variables in model 5a, model 5b, and model 5c.

Table 4.30
The result of bound test for model 5a, 5b, and 5c.

ARDL model		LAGS	F- Statistics
Model 5a : $LCOS = f(LFES, LVAS)$		1,2,2	0.999
Model 5b : $LFES = f(LVAS, LCOS)$		1,0,1	0.622
Model 5c : $LVAS = f(LCOS, LFES)$		1,1,0	1.284
Critical Bound	Significance level		
	1%	5%	10%
Lower bound, I(0)	5.92	4.083	3.33
Upper bound, I(1)	7.197	5.207	4.347

Notes: The null hypothesis is no cointegration. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively. The critical values are from Narayan (2005) case III, K=2, N=45.

The result of diagnostic tests for all selected models can be seen in Table 4.31. The result of Jarque-bera statistics indicated that all selected models have normality issue. On the contrary, the results of LM test, ARCH test, and RESET test implied that all selected models free from serial correlation, heteroscedasticity, and the general specification error issues.

Table 4.31
The result of diagnostics tests.

	Model 5a	Model 5b	Model 5c
JB Statistics	50.158 (0.000)	95.491 (0.000)	33.510 (0.000)
LM test	0.170 (0.845)	0.677 (0.416)	0.347 (0.560)
ARCH	0.206 (0.814)	0.452 (0.505)	0.027 (0.869)
RESET	2.602 (0.116)	1.987 (0.167)	3.664 (0.063)

Note: the value in parentheses is a probability of diagnostics test.

Table 4.32 reported the result of Chow test for three selected models, respectively. In this test, all selected models tested for observation periods from 1982 to 2014. It can be seen that the F-statistics values from the Chow tests for three selected models are insignificant at 5 per cent level. It is indicated that the regressors in three selected models, respectively, are stable over the observation periods.

Table 4.32
The result of Chow test.

	Model 5a	**Model 5b**	**Model 5c**
Observation from	1982-2014	1982-2014	1982-2014
F-statistics	0.943 (0.689)	0.382 (0.958)	2.617 (0.143)

Note: the value in parentheses is a probability of diagnostics test.

Figure 4.9 shows the plots of CUSUM and CUSUMSq for model 5a. It can be seen that blue line on the plot of CUSUM did not exceed the critical boundaries, while the blue line on the plot of CUSUMSq exceeded the critical boundaries. These results are different, hence author then compared with the result from the Chow test and concluded that data series on model 5a is stable.

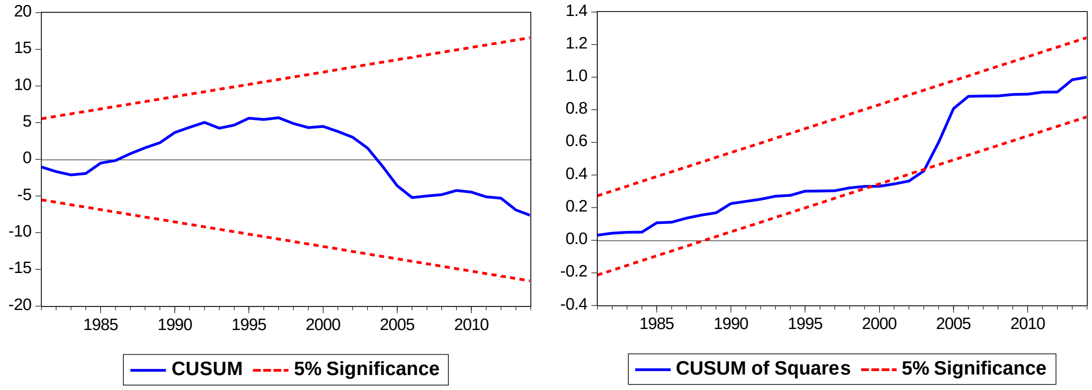


Figure 4.9 The plots of CUSUM and CUSUM of squared model 5a.

Figure 4.10 shows the plots of CUSUM and CUSUMSq for model 5b. It can be seen that blue line on the plot of CUSUM did not exceed the critical boundaries, while the blue line on the plot of CUSUMSq exceeded the critical boundaries. These findings are different, hence author then compares with the result from the Chow test and concludes that data series on model 5b is stable.

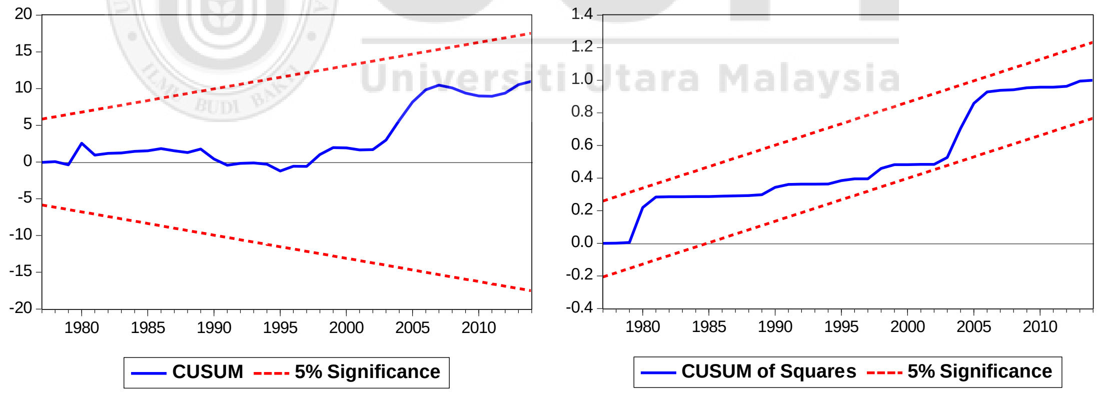


Figure 4.10 The plots of CUSUM and CUSUM of squared model 5b.

Figure 4.11 shows the plots of CUSUM and CUSUMSq for model 5c. It can be seen that the blue line in the plots of CUSUM and CUSUMSq did not exceed the critical boundaries. These findings implied that the regressors in model 5c are stable. Based on these results, author then concluded that the regressors in model 5c are stable.

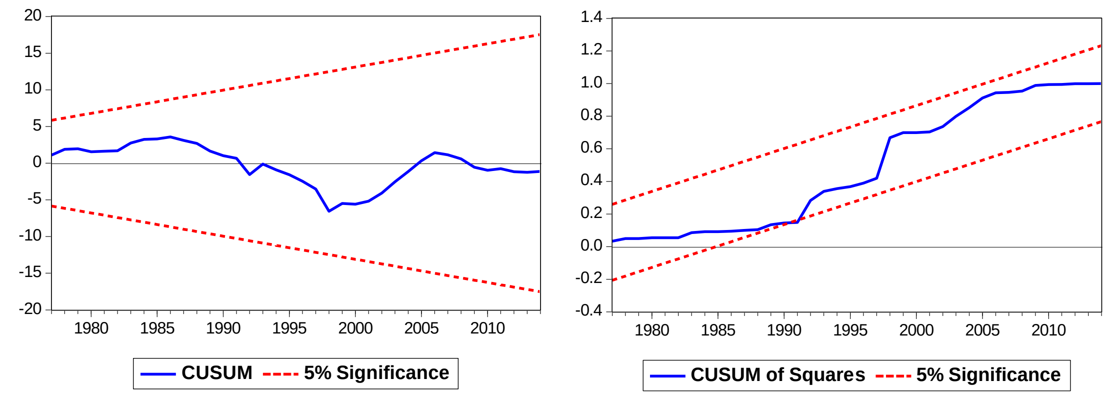


Figure 4.11 The plots of CUSUM and CUSUM of squared model 5c.

Table 4.33 shows the long-run coefficients of independent variables in three selected ARDL models. In model 5a, the coefficient of LFES is positive and significant, while the coefficient of LVAS is insignificant. These findings implied that arise in the final energy consumption of the service sector potentially caused the amount of CO_2 emission in the service sector increased in the long-term. Furthermore, a rise in economic growth in the service sector in the long-term did not have any effect on CO_2 emissions in the service sector.

Table 4.33
The long-run coefficients of independent variables in model 5a, 5b, and 5c.

DV	Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCOS	LFES	0.897***	0.143	6.286	0.000
	LVAS	0.057	0.141	0.406	0.687
LFES	LVAS	0.042	0.136	0.309	0.759
	LCOS	1.014***	0.136	7.449	0.000
LVAS	LCOS	-9.533	8.729	-1.092	0.282
	LFES	10.102	8.415	1.200	0.237

Note : ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

In model 5b, the long-run coefficient of LVAS is insignificant, while the long-run coefficient of LCOS is positive and significant. These findings indicated that a rise of

CO_2 emission in the service sector potentially caused the final energy consumption of the service sector increased in the long-term. In contrast, a surge of economic growth in the service sector did not have a significant effect on final energy consumption in the service sector in the long-term. In model 5c, the long-run coefficients of LCOS and LFES are insignificant. It is indicated that a rise of CO_2 emission and final energy consumption in the service sector did not influence the economic growth process in the service sector in the long-term.

Table 4.34
The coefficients of short-run and error correction term in model 5a, 5b, and 5c.

Regressors	Model 5a DV: ΔLCOS	Model 5b DV: ΔLFES	Model 5c DV: ΔLVAS
C	-0.377*	0.253	-4.935*
ΔLCOS		0.957***	0.469
ΔLFES	1.008***		0.044
ΔLFES(-1)	0.045**		
ΔLVAS	0.011	0.000	
ΔLVAS(-1)	-0.029*		
ECT(-1)	-0.067*	-0.047	-0.100*
R-squares	0.9915	0.9900	0.2637
DW stat	2.1103	2.2308	1.7202

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.34 reported the short-run and error correction term coefficients in three selected models. In model 5a, the short-run coefficients of LFES and LFES(-1) are positive and significant. It is indicated that if the final energy consumption in the service sector increased in the short term, the amount of CO_2 emission in the agriculture sector would be increased in the same periods. The short-run coefficient of LVAS is insignificant, while the short-run coefficient of LVAS(-1) is negative and significant. It implies that the increase the final energy consumption of service sector in the last period of short-term will reduce the amount of CO_2 emission in the service sector. The coefficient of ECT_{t-1} in model 5a is negative and insignificant at 5 per cent significance level. It is confirmed absence long-run linkage between the variables in model 5a. Furthermore, the value of R-squared indicated that the capability of independent variables to explaining the movement of the dependent variable is 99.15 per cent. Meanwhile, the value of Durbin-Watson statistic is near to 2, which indicated absence autocorrelation in model 5a.

In model 5b, the short-run coefficient of LVAS is insignificant, which implied that economic growth in the service sector did not influence the growth of final energy consumption in the service sector. The short-run coefficient of LFES is 0.96 and significant at 1 per cent level. It implies that if the amount of CO_2 emission in the service sector increased by 0.96 per cent, the amount of final energy consumption in the service sector would be increased by 1 per cent in the short-term, vice versa. The coefficient of ECT_{t-1} is negative but insignificant, which indicated absence long-run equilibrium between the variables in model 5b. Furthermore, the value of R-squared shows that the capability of independent variables to explaining the movement of the dependent variable is approximately 99 per cent. The value of Durbin-Watson statistic is near to 2, which indicated absence autocorrelation in model 5b.

In model 5c, the coefficients of LCOS and LFES are insignificant, which it is indicated that a change in the amount of CO_2 emission in the service sector and the final energy consumption of service sector did not influence economic growth process in the service sector. Meanwhile, the coefficient of ECT_{t-1} in model 5c is -0.10 and insignificant at 5 per cent level. This finding implied an absence long-run equilibrium between the variables in model 5c. Furthermore, the value of R-squared indicated that the capability of independent variables to explaining the movement of the dependent variable is 99.63 per cent, while the value of Durbin-Watson statistic is near to two, which indicated absence autocorrelation in model 5c.

Table 4.35 shows the result of the Granger causality test based on selected ARDL models. In short-run, there is a mutual linkage between the final energy consumption and CO_2 emission in the service sector. It is indicated that final energy consumption could be controlling the quantity of CO_2 emission in the service sector, vice versa. Meanwhile, both of final energy consumption and CO_2 emission in the service sector did not have any linkage with economic growth in the service sector over the short-term. This finding indicated that an increase and decrease in the amount of final energy consumption and CO_2 emission in the service sector did not have any effect on economic growth process in the service sector over the short-term period. In long-run, t-statistics values of ECT_{t-1} in three selected models are negative and insignificant at 5 per cent level. This result indicated that there is no significant long-run equilibrium between the variables in three selected models.

Table 4.35
The results of Granger Causality test for model 5a, 5b, and 5c.

Regressors	Model 5a DV: ΔLCOS	Model 5b DV: ΔLFES	Model 5c DV: ΔLVAS
ΔLCOS		3117.648***	0.086
ΔLFES	3131.738***		0.001
ΔLVAS	4.118	0.000	
ECT(-1)	-1.781*	-1.350	-1.958*

Note: Δ is symbol of first different form. The chi-square statistics are reported for the variables while the t-statistic is reported for the ECT. The null hypothesis is no granger-causality. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

4.4.4 Analysis for Residential Sector.

This analysis used three operational variables that denoted as LCOR, FER, and LGRP. LCOR is a natural logarithm form of total CO_2 emission from energy combustion that generated by energy users in the residential sector, LFER is a natural logarithm form of total final energy consumption that consumed by energy users in the residential sector, LGRP is a natural logarithm form of the real GDP per capita of Indonesia. Table 4.32 reports the result of unit root tests for all series that used in analysis. The result of ADF unit root test indicated that all series have only stationary at I(1) when tested with constant only and with constant and trend. The result of PP unit root test shows that when tested with constant only, LCOR has stationarity at I(0) and I(1), while the remains have only stationarity at I(1). Meanwhile, the result PP unit root test with constant and trend shows that all series only stationary at I(1). Based on these results, author then concluded that all data series that use in this analysis have stationarity at I(0) and/or I(1).

Table 4.36
The result of unit root tests for the variables in model 6.

Variables	Constant without trend		Constant with trend	
	ADF	PP	ADF	PP
LCOR	-2.549	-3.578**	-2.075	-2.105
LFER	-0.900	-1.277	-2.738	-2.129
LGRP	-1.269	-1.187	-2.285	-2.031
ΔLCOR	-3.182**	-3.182**	-3.439*	-3.439*
ΔLFER	-3.767***	-3.678***	-3.773**	-3.670**
ΔLGRP	-4.777***	-4.777***	-4.792***	-4.792***

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Furthermore, author checks the existence of cointegration among the variables in all selected models. Determination optimum lags for ARDL models using AIC criterion with maximum lag is 4 and tested within the specification model “unrestricted constant without trend”. Table 4.37 report the result of bound test for three selected ARDL models. In model 6a, the AIC criterion selected optimum lags for model 6a is 2,1,2. The bound test shows that the value of F-statistic is standing between lower and upper critical bounds at 10 significance level. This finding implies that there is an inconclusive cointegration between the variables in model 6a. In model 6b, the AIC criterion selected optimum lags for model 6b is 4,0,4. The result of bound test shows that the value of F-statistics is lower than the lower critical bound value at 10 significance level which indicated there is no cointegration linkage between the variables in model 6b. In model 6c, the AIC criterion selected optimum lags for model 6b is 2,2,0. The result of bound test shows that the value of F-statistics is lower than the lower critical bound value at 10 significance level, which indicated there is no cointegration linkage between the variables in model 6c.

Table 4.37
The result of bound test for model 6a, 6b, and 6c.

ARDL model		LAGS	F- Statistics
Model 6a : $LCOR = f(LFER, LGRP)$		2,1,2	3.633
Model 6b : $LFER = f(LGRP, LCOR)$		4,0,4	0.716
Model 6c : $LGRP = f(LCOR, LFER)$		2,0,0	1.409
Critical Bound	Significance level		
	1%	5%	10%
Lower bound, I(0)	5.92	4.083	3.33
Upper bound, I(1)	7.197	5.207	4.347

Notes: The null hypothesis is no cointegration. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively. The critical values are from Narayan (2005) case III, K=2, N=45.

The result of diagnostic tests for all selected models can be seen in Table 4.38. the result of Jarque-bera statistics indicated that model 6a and model 6b are free from normality issue, while model 6c has normality issue. Furthermore, the results of LM test, ARCH test, and RESET test implied that all selected models free from serial correlation, heteroscedasticity, and the general specification error issues.

Table 4.38
The result of diagnostics tests

	Model 6a	Model 6b	Model 6c
JB Statistics	0.970 (0.616)	3.287 (0.193)	479.924 (0.000)
LM test	0.745 (0.483)	0.578 (0.682)	0.325 (0.724)
ARCH	0.097 (0.907)	1.259 (0.307)	0.021 (0.979)
RESET	1.028 (0.318)	0.034 (0.855)	3.428 (0.072)

Note: the value in parentheses is a probability of diagnostics test.

Table 4.39 reported the result of Chow test for three selected models, respectively. In this test, model 6a and model 6c tested for observation periods from 1984 to 2014, while model 6b tested for observation periods from 1988 to 2014. It can be seen that the F-statistics values from the Chow tests for model 6a are insignificant at 5 per cent level, while the F-statistics values from the Chow tests for model 6a are significant at 5 per cent level. It is indicated that the regressors in model 6a are stable over the observation periods, while the regressors in model 6b and model 6c are unstable over the observation periods.

Table 4.39
The result of Chow test.

	Model 6a	Model 6b	Model 6c
Observation from	1984-2014	1988-2014	1984-2014
F-statistics	4.749 (0.112)	29.812 (0.033)	5.624 (0.019)

Note: the value in parentheses is a probability of diagnostics test.

Figure 4.12 shows the plots of CUSUM and CUSUMSq for model 6a. It can be seen that the blue line in the plot of CUSUM did not exceed the critical boundaries, which indicated that the coefficients in model 6a are stable. On the contrary, the blue line on the plot of CUSUMSq has slightly exceeded the critical boundaries, which indicated that the coefficients in model 6a are not stable. In this case, author prefers to accept the findings from the plots of CUSUM, which implied that regressors in model 6a are stable.

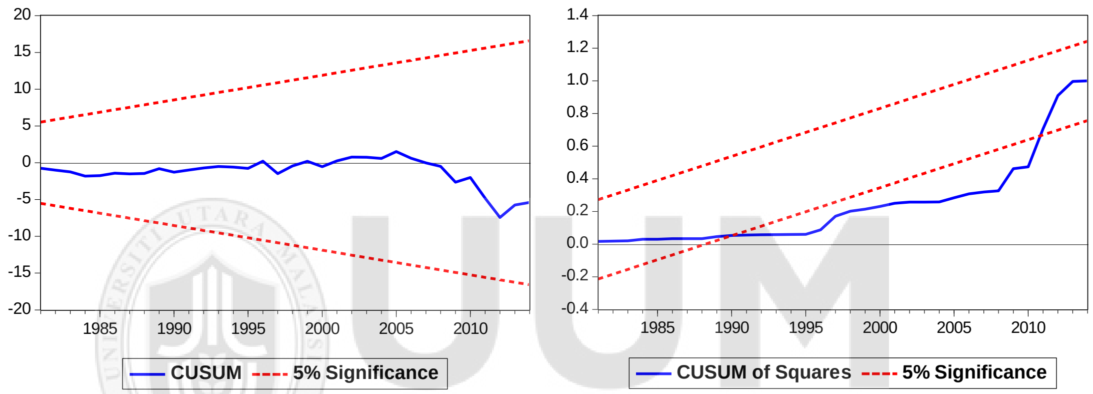


Figure 4.12 The plots of CUSUM and CUSUM of squared model 6a.

Figure 4.13 shows the plots of CUSUM and CUSUMSq for model 6b. It can be seen that the blue line in the plot of CUSUM did not exceed the critical boundaries, which indicated that the coefficients in model 6b are stable. In contrary, the blue line on the plot of CUSUMSq has slightly exceeded the critical boundaries, which meant that the coefficients in model 6b are not stable. In this case, author also prefers to accept the findings from the CUSUM plots, which implied that regressors in model 6b are stable.

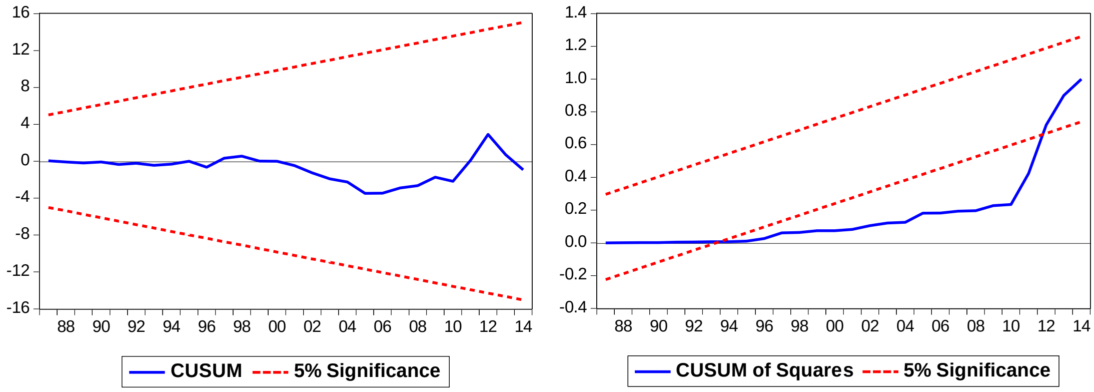


Figure 4.13 The plots of CUSUM and CUSUM of squared model 6b.

Figure 4.14 shows the plots of CUSUM and CUSUMSq for model 6c. It can be seen that the blue line in the plot of CUSUM did not exceed the critical boundaries, which indicated that the coefficients in model 6c are stable. In contrary, the blue line on the plot of CUSUMSq is slightly exceeded the critical boundaries, which indicated that the coefficients in model 6c are not stable. In this case, author prefers to accept the findings from the plots of CUSUM that implied that regressors in model 6c are stable.

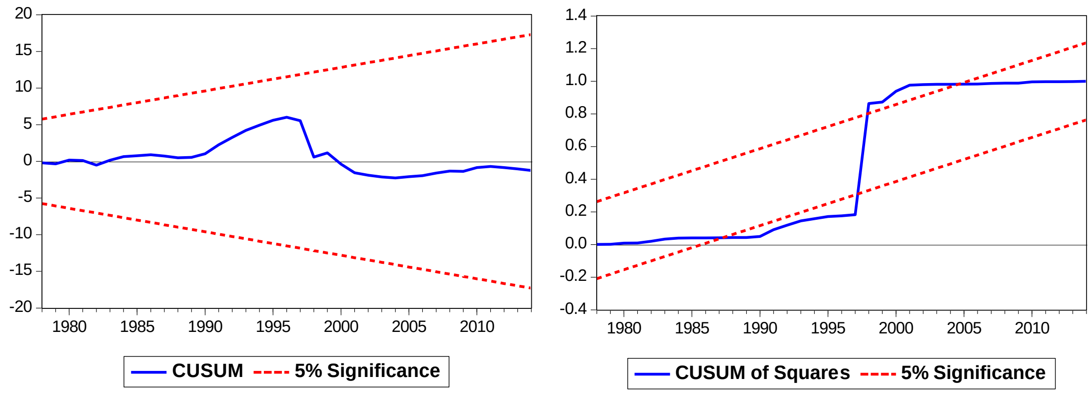


Figure 4.14 The plots of CUSUM and CUSUM of squared model 6c.

Table 4.40 shows the long-run coefficients of independent variables in three selected ARDL models. In model 6a, the long-run coefficients of LFER and LGRP are insignificant, which indicated that the final energy consumption of residential and the real GDP per capita did not have a long-run linkage to CO_2 emission in residential. In model 6b, the long-run coefficients of LGRP and LCOR are insignificant, which indicated absence long-run linkage from real GDP per capita and residential CO_2 emission to residential final energy consumption. In model 6c, the long-run coefficient of LCOR is insignificant, which indicated that a rise of residential CO_2 emission in the long-term did not influences real GDP per capita. While, the long-run coefficient of LFER is positive and significant, which indicated that the growth of final energy consumption in the residential sector over the long-term would be caused increased the real GDP per capita.

Table 4.40
The long-run coefficients in model 6a, 6b, and 6c.

DV	Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCOR	LFER	-3.152	6.532	-0.483	0.632
	LGRP	0.896	2.610	0.343	0.733
LFER	LGRP	-0.364	2.366	-0.154	0.879
	LCOR	0.905	2.350	0.385	0.703
LGRP	LCOR	-0.294	0.272	-1.079	0.288
	LFER	2.099***	0.325	6.461	0.000

Note : ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.41 shows the short-run coefficients of independent variables and error correction term in three selected models. In model 6a, the coefficients of LFER is positive and significant. It is implied that if the amount of final energy consumption in residential increased, the amount of CO_2 emission in residential also increased in the short-run. The coefficient of LGRP is insignificant, while the coefficient of LGRP(-1) has a negative sign and significant. It is indicated that a rise of the real GDP per capita in the last period of short-term potentially encouraged the amount of CO_2 emission in the residential sector increased. Furthermore, the coefficient of ECT_{t-1} in model 6a is -0.035 and significant at 1 per cent level. This finding shows that deviations from short-run to long-run equilibrium in model 6a is 3.5 per cent. Furthermore, the R-squared value indicated that the capability of independent variables to explaining the movement of dependent variable is 78.13 per cent, while the value of Durbin-Watson statistic is near to 2 which indicated absence autocorrection issue in model 6a.

Table 4.41
The coefficients of short-run and error correction term in model 6a, 6b, and 6c.

Regressors	Model 6a DV: ΔLCOR	Model 6b DV: ΔLFER	Model 6c DV: ΔLGRP
C	1.016***	-0.108	-1.555*
ΔLCOR		0.165***	-0.012
ΔLCOR(-1)	0.261***	0.039	
ΔLCOR(-2)		0.041	
ΔLCOR(-3)		-0.102***	
ΔLFER	2.780***		0.209
ΔLFER(-1)		-0.045	
ΔLFER(-2)		-0.315*	
ΔLFER(-3)		0.410*	
ΔLGRP	0.040	-0.011	
ΔLGRP(-1)	-0.372**		0.305**
ECT(-1)	-0.035***	0.012	-0.112*
R-squares	0.7813	0.7744	0.1728
DW stat	2.1832	1.9657	1.9783

Note : Δ is symbol of first different form. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

In model 6b, the coefficient of LGRP is insignificant, which implied that the growth of real GDP per capita did not have a significant affected to residential final energy consumption in the short-term. Meanwhile, the coefficients of LCOR, LCOR(-1) and LCOR(-2) are insignificant, while the coefficient of LCOR(-3) is negative and significant at 1 per cent level. It implies that a rise of residential CO_2 emission in the last period of short-run will caused the amount of final energy consumption in the residential sector decreased. Furthermore, the coefficient of ECT_{t-1} in model 6b is positive and insignificant, which indicated absence long-run linkage between the variables in model 6b. The R-squared value revealed that the capability of independent variables to explaining the movement of dependent variable is 77.44 per cent, while the value of Durbin-Watson statistic is near to two which indicated absence autocorrection issue in model 6b.

In model 6c, the coefficients of LCOR and LFER are insignificant. It is implied that the growth of final energy consumption and CO_2 emission in the residential sector did not have a significant effect to the real GDP per capita of Indonesia in the short-term. Furthermore, the coefficient of ECT_{t-1} is positive and insignificant at 5 per cent level. It is implied that there is no long-run linkage between the variables in model 6c. The value of R-squared indicated that the capability of independent variables to explaining the movement of the dependent variable in model 6c is 17.28 per cent. The value of Durbin-Watson statistics is near to two, which indicated that model 6c is free from autocorrelation issue.

Table 4.42
The results of Granger Causality test for model 6a, 6b, and 6c.

Regressors	Model 6a DV: ΔLCOR	Model 6b DV: ΔLFER	Model 6c DV: ΔLGRP
ΔLCOR		64.583***	0.005
ΔLFER	30.839***		0.084
ΔLGRP	4.549	0.107	
ECT(-1)	-3.397***	1.476	-1.945*

Note: Δ is symbol of first different form. The chi-square statistics are reported for the variables while the t-statistic is reported for the ECT. The null hypothesis is no granger-causality. ***,**,* denotes statistically significant at 1%, 5%, and 10% levels, respectively.

Table 4.36 shows the result from the Granger causality test for all selected models. In short-run, the granger test revealed that LFER and LCOR have a bidirectional linkage. It is indicated that the growth of final energy consumption in the residential sector potentially influences the amount of CO_2 emission in the residential sector over the short-term, vice versa. Moreover, the result also confirmed that residential final energy consumption and residential CO_2 emission did not have a short-run linkage with real GDP per capita of Indonesia. Furthermore, t-statistics of ECT_{t-1} in model 6a is negative and significant at 5 per cent level, which indicated that there is a long-run equilibrium among the variables in model 6a. In contrary, the t-statistics value of ECT_{t-1} in model 6b and model 6c are insignificant at 5 per cent level, which indicated that there is no long-run linkage among the variables in model 6b and model 6c.

4.5 Summary of Analysis Findings

This section provides a summary of empirical results, and it is divided into six sub-section. First sub-section provides a summary of empirical findings regarding the role of economic growth on total final energy consumption in Indonesia. Second sub-section provides a summary of empirical findings regarding the role of final energy consumption on economic growth in Indonesia. Subsection three provides a summary of findings regarding the causality linkage between final energy consumption, economic growth, and CO_2 emission on four final energy user sectors in Indonesia.

4.5.1 The Role of Economic Growth on Final Energy Consumption in Indonesia

In this analysis, the value-added of three development sectors and real GDP per capita determined as a set of dependent variables that representing economic growth in Indonesia, while the total of Indonesia's final energy consumption determined as the dependent variable. The result of unit root tests implied that all variables are stationary at I(0) and/or I(1), while the result of bound tests shows the existence of cointegration linkage among the variables in model 1. In the long-run model, the result indicates that the value-added of Industry sector and the value-added of agriculture sector have positive effects on total final energy consumption of Indonesia, while the value-added of the Service sector has a negative impact on total final energy consumption of Indonesia. These results implied that economic growth on three development sectors potentially caused the amount of Indonesia's final energy consumption increased in the long-term, while the growth of real GDP per capita did not have a significant effect on the final energy consumption of Indonesia.

In the error correction model, the value-added of agriculture sector and the value-added of service sector have positive effects on final energy consumption of Indonesia, while the value-added of Industry sector and real GDP per capita have adverse effects on final energy consumption of Indonesia. It is indicated that increases economic growth in the agriculture sector and the service sector will be caused increases Indonesia's final energy consumption in the short-term. On the contrary, economic growth in the industry sector and real GDP per capita potentially reduced Indonesia's final energy consumption in the short-term. Furthermore, the coefficient of ECTt-1 in model 1 confirmed the existence of a long-run equilibrium from all economic growth indicators to Indonesia's final energy consumption.

Table 4.43
Summary of analysis the role of economic growth on final energy consumption in Indonesia.

Long-run	Short-run	ECT
(+) LVAI → LFET	(-) LVAI → LFET	
(+) LVAA → LFET	(+) LVAA → LFET	-0.726***
(-) LVAS → LFET	(-) LVAS → LFET	

LGRP — LFET	(+) LGRP → LFET

Note: → denotes one-ways relationship between the variables, denotes — absence relationship between the variables, while (+) and (-) are implies the signs of positive and/or negative relationships between the variables, respectively.

Furthermore, the result of Granger causality test indicated that the value-added of three development sectors and real GDP per capita has a significant effect to Indonesia's final energy consumption, both in the short and long terms. This finding confirmed that economic growth in Indonesia potentially influenced the amount of Indonesia's final energy consumption.

4.5.2 The Role of Final Energy Consumption on Economic Growth in Indonesia

In this analysis, total final energy consumption by four energy user sectors determined as a set of energy consumption indicators, while the real GDP of Indonesia determined as an economic growth indicator. The result of unit root tests for all data series indicated that all variables are stationary at I(0) and/or I(1), and the result of bound tests implied inconclusive results. The results from the long-run model indicated that the growth of final energy consumption on four energy user sectors did not have a long-run effect on the real GDP of Indonesia. This finding confirmed that an increase or decrease of final energy consumption in four energy user sectors did not have any impact on the economic growth of Indonesia in the long-term.

The results of error correction model revealed that the growth of final energy consumption in the agriculture sector and the service sector caused increasing real GDP in Indonesia, an increase in residential final energy consumption has a negative impact toward the real GDP of Indonesia, and the final energy consumption of industry sector did not have any effect to the real GDP of Indonesia. Furthermore, the value of

ECT_{t-1} confirmed the existence of a long-run equilibrium from the final energy consumption of four energy user sectors to the real GDP of Indonesia.

The result of Granger causality test indicated that the growth of final energy in the agriculture sector, service sector and residential sector have a short-run effect on the real GDP of Indonesia. In contrary, the final energy of industry sector did not have a significant impact on the real GDP of Indonesia. This finding confirmed that the growth of final energy consumption by energy users in the agriculture sector, service sector, and residential potentially influenced economic growth in Indonesia. Furthermore, the t-statistics value of ECT_{t-1} in model 2 is negative and significant, which indicated that there is a long-run equilibrium among the variables in model 2.

Table 4.44
Summary of analysis the role of final energy consumption on economic growth of Indonesia.

Long-run	Short-run	ECT
FEI — GR	FEI — GR	
FEA — GR	(+) FEA → GR	-0.120***
FES — GR	(+) FES → GR	
FER — GR	(-) FER → GR	

Note: → denotes one-ways relationship between the variables, — denotes absence relationship between the variables, while (+) and (-) are implies the signs of positive and/or negative relationships between the variables, respectively.

4.5.3 The causality relationship between final energy consumption, economic growth and CO_2 emissions on four final energy user sectors in Indonesia.

4.5.3.1 Summary of analysis on the industry sector

In this analysis, three main variables used in the models, i.e. the consumption of final energy in the industry sector, the value-added of industry sector, and the amount of

CO_2 emission in the industry sector. In the first step, the result of unit root tests indicated that all series of operational variables are stationary at I(0) and/or I(1). In the second step, the result of bound tests revealed the existence of a cointegration relationship among the variables in three selected models. In the third step, the long-run model generated empirical findings as follows: (1) the final energy consumption of industry sector and the value-added of industry sector have a mutual linkage with the CO_2 emission in the industry sector.; (2) the final energy consumption of industry sector and the value-added of industry sector did not have a significant linkage.

Meanwhile, the result of error correction models implied several findings as follows: (1) the final energy consumption of industry sector and CO_2 emission in industry sector have a mutual linkage in short-term.; (2) the final energy consumption of industry sector and CO_2 emission in industry sector did not have a significant linkage with the value-added of industry sector in the short term.; and (3) the coefficients of error correction term in three selected models implied the existence of a long-run equilibrium from independent variables to dependent variable in three selected models, respectively.

In the last step, the result of Granger causality test confirmed several findings as follows: (1) the existence of a bidirectional linkage between final energy consumption and CO_2 emission in the industry sector. (2) final energy consumption and CO_2 emission did not have any effect to economic growth in the short-term.; and (3) the existence of a long-run equilibrium from independent variables to dependent variable in all selected models, respectively.

Table 4.45
The summary of analysis the causality relationship between final energy consumption, economic growth and CO_2 emission in the industry sector.

Model	Long-run	Short-run	ECT
LCOI = f(LFEI, LVAI)	(+) LFEI → LCOI	(+) LFEI → LCOI	-0.429***
	(+) LVAI → COI	LVAI — COI	
LFEI = f(LVAI, LCOI)	LVAI — LFEI	LVAI —LFEI	-0.466***
	(+) LCOI → LFEI	(+) LCOI → LFEI	
LVAI = f(LCOI, LFEI)	(+) LCOI → LVAI	LCOI — LVAI	-0.165***
	LFEI — LVAI	LFEI — LVAI	

Note: → denotes one-ways relationship between the variables, — denotes absence relationship between the variables, while (+) and (-) are implies the signs of positive and/or negative relationships between the variables, respectively.

4.5.3.2 Summary of analysis on the agriculture sector.

In this analysis, three main variables used in the models, i.e. the consumption of final energy in the agriculture sector, the value-added of agriculture sector, and the amount of CO_2 emission in the agriculture sector. In the first step, the result of unit root tests indicated that all series of operational variables that used on the models are stationary at I(0) and/or I(1). In the second step, the result of the bound test revealed the absence of a long-run equilibrium or cointegration relationship among the variables in three selected models. In the third step, the long-run models reported empirical findings as follows: (1) final energy consumption has a positive impact on CO_2 emission, but not vice versa.; (2) final energy consumption and CO_2 emission did not have any effect on economic growth in the agriculture sector.

Meanwhile, the result of error correction models shown empirical findings as follows: (1) final energy consumption and CO_2 emission has a bidirectional linkage in the short-term.; (2) economic growth caused increases CO_2 emission in the short-term.; (3)

economic growth significantly reduced final energy consumption in the short-term.; and (4) absence a long-run equilibrium from independent variables to dependent in three selected models.

In the last step, the results of Granger causality test confirmed several findings as follows: (1) a bidirectional linkage between the final energy consumption of agriculture sector and the CO_2 emission of agriculture sector in the short-term.; (2) a unidirectional linkage from the value-added of agriculture sector to the final energy consumption and CO_2 emission in the agriculture sector in the short-term, respectively.; (3) absence a long-run linkage among the variables in three selected models.

Table 4.46
The summary of analysis the causality relationship between final energy consumption, economic growth and CO_2 emission in the agriculture sector.

Model	Long-run	Short-run	ECT
LCOA = f(LFEA, LVAA)	(+) LFEA → LCOA	(+) LFEA → LCOA	0.048*
	LVAA — COA	(+) LVAA → COA	
LFEA = f(LVAA, LCOA)	LVAA — LFEA	(-) LVAA → LFEA	0.028
	LCOA — LFEA	(+) LCOA → LFEA	
LVAA = f(LCOA, LFEA)	LCOA — LVAA	LCOA — LVAA	0.013***
	LFEA — LVAA	LFEA — LVAA	

Note: → denotes direction relationship between the variables, — denotes absence relationship between the variables, while (+) and (-) are implies the sign of positive and negative relationships between the variables, respectively

4.5.3.3 Summary of empirical findings on the service sector.

In this analysis, three main variables used in the models, i.e. the consumption of final energy in the service sector, the value-added of the service sector, and the amount of

CO_2 emission in the service sector. In the first step, the result of unit root tests indicated that all series of operational variables are stationary at I(0) and/or I(1). In the second step, the result of the bound test indicated the absence of a long-run equilibrium or cointegration relationship among the variables in three selected models, respectively. In the third step, the long-run models revealed empirical findings as follows: (1) the final energy consumption has a mutual linkage with CO_2 emission in the long-term.; (2) economic growth did not have any relationship with final energy consumption and CO_2 emission in the long-term.

Table 4.47
The summary of analysis the causality relationship between final energy consumption, economic growth and CO_2 emission in the service sector.

Model	Long-run	Short-run	ECT
LCOS = f(LFES, LVAS)	(+) LFES → LCOS	(+) LFES → LCOS	-0.067
	LVAS — LCOS	LVAS — COS	
LFES = f(LVAS, LCOS)	LVAS — LFES	LVAS — LFES	-0.047
	(+) LCOS → LFES	(+) LCOS → LFES	
LVAS = f(LCOS, LFES)	LCOS — LVAS	LCOS — LVAS	-0.099*
	LFES — LVAS	LFES — LVAS	

Note: → denotes direction relationship between the variables, — denotes absence relationship between the variables, while (+) and (-) are implies the sign of positive and negative relationships between the variables, respectively.

Meanwhile, the result of error correction models implied several findings as follows: (1) final energy consumption and CO_2 emission have a mutual linkage in the short-term.; (2) final energy consumption and CO_2 emission did not have a significant linkage with economic growth in the short-term.; (3) absence a long-run equilibrium from independent variables to dependent variable in three selected models.

In the last step, the result of Granger causality test confirmed several findings as follows: (1) final energy consumption and CO_2 emission have a mutual linkage in the short-term.; (2) final energy consumption and CO_2 emission did not have a significant linkage with economic growth in the short-term.; (3) absence a long-run equilibrium from independent variables to dependent variable in three selected models.

4.5.3.4 Summary of analysis on the residential sector.

In this analysis, three main variables used in the models, i.e. real GDP per capita, residential CO_2 emissions from energy combustion, and residential final energy consumption. In the first step, the result of unit root tests indicated that all variables are stationary at I(0) and/or I(1). In the second step, the result of bound tests revealed that a cointegration relationship only exists from final energy consumption and economic growth to residential CO_2 emission (model 6a). In the third step, the long-run model revealed empirical findings as follows: (1) CO_2 emission did not have any linkage with economic growth and final energy consumption in the long-term.; (2) final energy consumption has a unidirectional linkage to economic growth in the long-term.

Meanwhile, the result of error correction models revealed empirical findings as follows: (1) CO_2 emission did not have a significant linkage with economic growth and final energy consumption.; (2) final energy consumption has a bidirectional linkage with economic growth in the short-term.; and (3) the existence of a long-run equilibrium that running from economic growth and final energy consumption to CO_2 emission.

In the last step, the result of Granger causality tests confirmed several findings as follows: (1) there is a mutual linkage between residential CO_2 emission and residential final energy consumption in the short-term.; (2) real GDP per capita and residential final energy combustion did not have any linkage to residential CO_2 emission in the short-term.; (3) there is only a long-run equilibrium that running from residential final energy consumption and real GDP per capita to residential CO_2 emissions.

Table 4.48
The summary of analysis the causality relationship between final energy consumption, economic growth and CO_2 emission in the residential sector.

Model	Long-run	Short-run	ECT
LCOR = f(LFER, LGRP)	LFER — LCOR	(+) LFER → LCOR	-0.035***
	LGRP — LCOR	(–) LGRP → LCOR	
LFER = f(LGRP, LCOR)	LGRP — LFER	LGRP — LFER	0.012
	LCOR — LFER	(+,–) LCOR → LFER	
LGRP = f(LCOR, LFER)	LCOR — LGRP	LCOR — LGRP	-0.112*
	(+) LFER → LGRP	LFER — LGRP	

Note: → denotes direction relationship between the variables, — denotes absence relationship between the variables, while (+) and (-) are implies the sign of positive and negative relationships between the variables, respectively.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.1 Introduction

This chapter consists of four main sections. The first section discusses the research findings as well as policy recommendations. The second section presents the research contributions. The third section provides conclusions from all empirical findings. The final section describes the limitations of study and input for further studies.

5.2 Discusion of Findings

This study produces several findings that are explicitly providing different information. Therefore the discussion of the research results is discussed separately following the objectives of study and then compares them with previous research literature that also examines the causal linkage between economic growth, final energy consumption, and CO_2 emissions in Indonesia.

5.2.1 The role of economic growth on final energy consumption in Indonesia.

Economic growth in the industrial sector influences the growth rate of Indonesia's final energy consumption. These results indicated that the economic growth rate in the industry sector caused total energy consumption in Indonesia significantly increased. However, it is essential to note that the majority of energy users in this sector are still dependent on the availability of fossil fuels. The future change in fossil fuel prices certainly will be a critical issue because it indirectly influences income in this sector. Sustainability of economic growth in the industry sector will continue to be overshadowed by the increasing the amount of final energy consumption by energy users in industry sector because energy sources have been an essential input in the long-term economic growth process in this sector. This fact, undoubtedly, creates a future challenge that closely related to providing energy services in the industrial sector. Modernization of production equipment and machinery that used in manufacturing industry factories and socialization of the use of non-fossil energy sources to all energy users in this sector is considered a requirement to stimulate economic growth in this sector.

Economic growth in the agricultural sector, despite providing a low contribution to Indonesia's real GDP, significantly affects Indonesia's total final energy consumption. Modernization and use of technology in agricultural activities indirectly driven the growth rate of Indonesia's final energy consumption, both in the short and long terms. Same as industry sector, energy users in the agricultural sector mostly consuming fuels as one of the inputs in the production process. Although the amount of energy consumption by final energy users in the agriculture sector decreased in recent years but potentially continue increases if modernization and utilization equipment or machinery on agriculture activities continuing applied in this sector. As an important sector that provide food commodities in the domestic market, modernization will cause dependence on energy sources, an increase in production costs and gradually stimulate increasing the prices of energy sources and agricultural commodities. Therefore, comprehensive policy related food and energy prices, as well as sustainable final energy supply services for this sector should be the main concerns of Indonesia's policymakers.

The pace of economic growth in the service sector provides a negative impact on Indonesia's total final energy consumption, both in the short and long term. This finding implies that the progress of economic growth in the service sector is driving the development of technological innovation and energy conservation, thus indirectly inhibiting the growth rate of Indonesia's final energy consumption. As one of the development sectors that contributes the largest value-added on Indonesia's real GDP, most of final energy consumption in this sector consumed by final energy users in transportation. Strategies and policies by Indonesia's government related to the development of mass transportation, increase vehicle tax and increase fuel prices in the transportation sector are considered to have a decisive role in controlling and reducing the amount of fossil fuel consumption in this sector and certainly minimizing dependence this sector against conventional energy sources.

The growth of Indonesia's per capita GDP potentially drives increases total final energy consumption in Indonesia over the short term. This fact indicates that changes in domestic people lifestyles and welfare affect the growth rate of Indonesia's final energy consumption. Residential final energy users are mostly consuming electric power and gas fuels which generally produced from fossil sources. Sustainability of the supply of these two energy sources will undoubtedly be a challenge for Indonesia's government in future. Therefore, to face the challenges of energy security issues, the use of non-fossil energy sources for electricity production and gas fuels should continue encouraging to ensure the sustainability of adequate energy supply for Indonesian residential energy users in the future.

Overall, these findings indicate that economic growth influences the growth of Indonesia's final energy consumption. This condition implies that the availability of energy resources is one of the supporting factors for the sustainability of Indonesia's economic growth. The limitation of fossil energy reserves and the rapid growth of energy demand have been essential issues that must be taken seriously by Indonesia's policymakers. Therefore, the acceleration development and production of non-fossil energy as an economical alternative energy source must be a top priority in determining long-term strategies and policies in Indonesia.

5.2.2 The role of final energy consumption on economic growth in Indonesia.

The final energy consumption growth in the industrial sector did not affect the growth rate of Indonesia's real GDP. It indicates that an increase or a decrease in the final energy consumption of industry sector will not affect Indonesia's economic growth. Most energy users in this sector consume final energy products from fossil, and it predicted increase gradually in the future. Therefore, strategies and policies related to energy conservation and mitigation might be steadily implemented in this sector to deal with environmental degradation and energy security issues in future. The application of economic and environment-friendly technology in the production and distribution process in this sector undoubtedly expected to make a positive contribution to the environment and driven increase income in this sector.

The growth of final energy consumption in the agriculture sector and service sector in the short term drove Indonesia's real GDP. This condition shows that the growth of energy consumption in these two sectors contributed positively to economic growth in Indonesia. The role of energy as a driver of income growth from these two sectors is undoubtedly related to modernization. The application of technology, both of equipment or machinery that requires energy sources, indirectly stimulate the growth of value-added in these two development sectors. Nevertheless, this condition is vulnerable to energy supply problems and unstable energy prices. Therefore, adequate energy supplies at affordable prices and environmentally friendly for all energy users in both sectors considered as an essential issue that should be a concern by Indonesia's government.

An increase in final energy consumption by residential energy users in the short term caused declining Indonesia's real GDP. This condition may be an impact of the energy subsidy policy implemented by the Indonesian government for several types of final energy products. The energy subsidy funds that taken from the Indonesian national income budget which indirectly influence the growth rate of Indonesia's real GDP. More increase energy subsidy provided by the Indonesian government to the residential energy users will drive the growth of final energy consumption and indirectly reduce the amount of Indonesia's national income. Therefore, the application of the subsidy policy to domestic energy prices must be reviewed by the Indonesian government and the socialization related to the use of non-fossil alternative energy needs to be improved to encourage sustainable economic growth in Indonesia.

Overall, the findings indicate that the final energy consumption growth by end-energy users does not affect Indonesia's economic growth in the long run. It is indicated that the application of energy efficiency and utilize clean energy can be applied by Indonesia's energy users because not hamper economic growth rate in Indonesia. The implementation of energy conservation and mitigation of energy by Indonesia's final energy users indirectly reducing import of conventional energy sources and minimize emission from energy combustion in Indonesia.

5.2.3 The causality relationship between final energy consumption, economic growth and CO_2 emissions in the industry sector.

The industrial sector is a productive sector that provides a large value-added to Indonesia's economic growth. Most activities in this sector are very dependent on the availability of final energy sources as one of the main inputs in the production and distribution of goods. It can be seen from the share of final energy consumption by this sector on Indonesia's total final energy consumption. Nevertheless, economic growth and final energy consumption in this sector do not have a significant relationship, both in the short and long term. This condition implied that energy products as one of the main inputs to production and distribution activities in this sector do not have a positive and significant contribution to the economic growth of this sector. Therefore, conservation strategies and mitigation policies might be appropriate to apply for energy users in this sector to make slow the growth rate of final energy consumption and encourage economic growth in this sector.

In the industrial sector, final energy consumption and CO_2 emissions have a two-way relationship and influence each other. This condition shows that the growth of final energy consumption caused a rise of CO_2 emissions from energy combustion in this sector. The assumption that can deduced from this result is that most energy users in this sector tend to consume more fossil energy and even use technologies that are not environment-friendly in their daily activities. This condition causes the amount of CO_2 emissions from energy combustion continues increasing following the growth rate of final energy consumption in this sector. The slow pace of technological innovation and application of clean energy in this sector is one critical issue that should be a concern for policymakers and energy users in this productive sector.

Strategies and policies related to conservation, mitigation and efficiency of energy should be implemented by final energy users in this sector to diminish the quantity of fossil energy consumption. Therefore, the Indonesian government expected to formulate specific policies relating to the use of clean energy in the industrial sector so that it can gradually minimize the amount of CO_2 emissions and encourage the acceleration of economic growth in this sector. Moreover, policymakers deemed necessary to draft regulations on industrial waste control so as not to pollute the environment and endanger densely populated areas around industrial areas in Indonesia.

5.2.4 The causality relationship between final energy consumption, economic growth and CO_2 emissions in the agriculture sector.

The agricultural sector is the lowest consumer of final energy products and the lowest contributor to CO_2 emissions from energy combustion. In recent years, the amount of final energy consumption and CO_2 emissions from energy combustion in this sector has gradually declined. Based on this study, the growth of final energy consumption causes an increase in the amount of CO_2 emissions from energy burning in the agricultural sector. This shows that most of the energy products consumed by energy users in the agricultural sector intensively produce a large of CO_2 emission. Hence a rise in the amount of final energy consumption indirectly stimulated increase CO_2 emissions from energy combustion in this sector.

In the short term, although economic growth in the agricultural sector has the potential to cause a decrease in the amount of energy consumption, but not control the growth rate of CO_2 emissions from energy combustion. This condition indicated that the consumption of fossil fuels in this sector provide a negative effect on environmental quality. Utilization machinery and equipment that intensively consumed fossil fuels on the production process considered to harmful impact on environmental. Strategy, regulation and policy related to energy conservation and mitigation may be implemented for this sector to minimize the environmental effects caused by the use of fossil energy products in the sector. However, this policy is undoubtedly expected not to impede the sustainability of modernization and the application of modern technology in the production and distribution process in the agricultural sector. The strategy of using environmentally friendly alternative energy on agricultural equipment and machinery assessed necessary to be optimized to be able to control the negative impacts of energy use in this sector.

5.2.5 The causality relationship between final energy consumption, economic growth and CO_2 emissions in the service sector.

The service sector is the third-largest consumer of final energy products and the second-largest producer of CO_2 emissions from energy combustion in Indonesia. Most of the final energy products consumed by this sector are oil fuels for transportation activities. The increase in oil fuels consumption indirectly causes an increase in CO_2 emissions from energy combustion in this sector. It is consistent with the findings of this study which found that the final energy consumption and CO_2 emissions from energy combustion have a two-way relationship and influence each other, both in the short and long term. Therefore, it can be explained that one of the main challenges in this sector is the environmental problem caused by the consumption of fuel oil in the transportation sector, which predicted to continuing increase along with advance transportation sector in Indonesia.

In recent years, the service sector has been the largest contributor of value-added on Indonesia's national income. The service sector earns income from a variety of goods and services trading activities which generally consume fuel oil, electricity and natural gas. However, economic growth in this sector does not have a significant impact on the amount of final energy consumption and CO_2 emissions from energy combustion in this sector. Likewise, final energy consumption and CO_2 emissions also have no significant effect on economic growth in this sector. This finding indicates that the rate of economic growth has no impact on the growth rate of energy consumption and CO_2 emissions from energy combustion in the service sector.

Overall, it can be concluded that the final energy consumption growth did not contribute significantly to economic growth and even led to an increase in the amount of CO_2 emissions from energy combustion in the service sector. Therefore, strategies and policies related to oil fuels on transportation activities should be of particular concern to Indonesia's policymakers. Several strategies, such as increasing the number of mass transportation that used electric power, increase tax for own-vehicle and optimizing biofuel production for transportation energy needs may be appropriate to apply to this sector. The implementation of energy conservation policies is considered not to affect the performance of the sector's economic growth because most of the revenue received from this sector is from trade in goods and services as well as financial businesses that mostly consumed electric power, biofuels and natural gas.

5.2.6 The causality relationship between final energy consumption, economic growth and CO_2 emissions in the residential sector.

The residential sector is the largest consumer of final energy sources and the second-lowest producer of CO_2 emissions from energy combustion in Indonesia. These facts implied that although this sector is the largest final energy users and continue experienced increasing accordance with population growth annually, it did not cause this sector being the largest producer of CO_2 emissions from energy combustion in Indonesia. Improved domestic people welfare reflected by Indonesia's real per capita GDP growth is considered as a significant factor affecting the amount of consumption of final energy sources in the residential sector. Changes in people's lifestyles, which are affected by income growth, accelerate the conservation and mitigation of energy in their homes, which of course indirectly causes the amount of CO_2 emissions from energy combustion in this sector gradually decreases.

The result of this study discovered that final energy consumption and CO_2 emissions from energy combustion in the residential sector have a bi-directional linkage over the short term. The growth of final energy consumption encourages an increase in CO_2 emissions from burning energy and conversely an increase in CO_2 emissions from energy combustion stimulates an increase in energy consumption at the beginning of short-term and then potentially reduces the amount of final energy consumption at the end of short-term. This situation shows that most final energy users in the residential sector still depend on final energy sources from fossil and hence produced a lot of CO_2 emissions from energy combustion. The consequences of consuming final energy products that endanger to environment prompted residential final energy users to limit and reduce their final energy consumption in their activities.

The real GDP per capita growth potentially reduced the amount of CO_2 emissions from energy combustion in the short-term, while final energy consumption only has a direct relationship to real GDP per capita over the long-term. This condition shows that per capita income growth in the short term indirectly causes energy users in the residential sector to reduce final energy consumption from fossil and indirectly caused CO_2 emissions from energy combustion decreased. Furthermore, growth in energy consumption indirectly also positively stimulated the growth of real GDP per capita over the long-term. Further, the real per capita GDP growth over the short term indirectly caused the amount of CO_2 emissions from energy combustion in residential declined. The growth of residential final energy consumption positively stimulated the real GDP per capita increases over the long run. Based on these conditions, the Indonesian government expected to optimize the supply of final energy products that environment-friendly and promote energy efficiency in the residential sector to preserve environmental quality and energy security in Indonesia.

5.3 Contribution of Study

5.3.1 Contribution to Methodology

This study applied a multivariate approach that provides two-way information to investigate the causal relationship between final energy consumption and economic growth in Indonesia. First, the role of economic growth in the three development sectors and real GDP per capita toward the growth of Indonesia's final energy consumption. Second, the role of final energy consumption by four final energy user sectors on the real GDP of Indonesia. This approach is an advance of bivariate approach that had widely applied in previous studies where the real GDP and total energy consumption usually used as the main indicators to examine the causality relationship between economic growth and energy consumption in a country's or a panel of countries. This approach assumed that the link between energy consumption and economic growth in a country might vary if investigated considering the diversity of final energy user categories.

In addition, this study investigates the links between economic growth, final energy consumption and CO_2 emissions from energy combustion in four energy user sectors in Indonesia. This approach initially began from a scarcity of literature studies that explored the relationship between energy consumption, economic growth, and environmental emissions in several different energy user groups. This approach expected to provide specific information that exposes various facts about the situation, conditions and challenges faced by the four energy user groups associated with energy security, sustainable economic growth and environmental quality. Moreover, this approach also indirectly provide a meaningful contribution toward subsequent studies that are also interested in examining the causal links between economic growth, energy consumption, and environmental emissions in a country's nor a group of countries.

5.3.2 Contribution to Theory

This research provides evidence that energy consumption, economic growth and CO_2 emissions from energy combustion in a country's influenced by condition or situation on diverse energy user groups. This fact contributes two valuable inputs on theory and previous findings. First, empirical study that considers the contribution of different energy user groups to estimates the relationship between energy consumption and economic growth in a country will be generating specific information that more reliable as a valuable reference for policymakers. Second, the relationship between energy consumption, economic growth and CO_2 emission in each group of energy users in a country has a diversity that should be considered as a reference on determining policies and strategies in a country. In other words, the determination of policy and strategy related energy, economic and environmental issues will more proper and reliable if the problems and facts that occur in each energy user groups in a country have identified separately and detail.

5.3.3 Contribution to Final Energy Users

This study suggests four valuable inputs to the final energy user. First, final energy users in productive sectors expected to gradually use more efficient, economical and environmentally friendly production equipment or machinery. Second, final energy users expected to reduce consumes final energy products from fossil source on their daily activities. Third, energy users expected to be able to meet their own energy needs by adapting new and renewable energy technologies. Lastly, final energy users expected more efficient consumes final energy sources on their activities. Overall, these recommendations expected to contribute to the long-term sustainability of economic growth, energy security and environmental quality in Indonesia.

5.3.4 Contribution to Policymakers

Economic growth provides a significant impact on the growth of Indonesia's final energy consumption, both in the short and long term. Any economic policies implemented by the government and decision-makers in Indonesia potentially influences the growth rate of Indonesia's final energy consumption. Sustainability of economic growth faces the most significant challenge from the energy demand side, hence requires the right strategies and regulations to faces the energy security issue in the future. Implementation of the conservation and mitigation of energy and sustainable new and renewable energy development in Indonesia must be optimally encouraged to anticipate the scarcity of final energy sources in all productive sectors in Indonesia.

The results of this study indicate that energy, economic and environmental policies related to the use of energy resources in Indonesia must take into account the condition, challenge and diversity of economic growth level and final energy consumption on four final energy user sectors in Indonesia. It is because the relationship between economic growth, final energy consumption, and CO_2 emissions from energy combustion on four final energy user groups differed each other. This condition should be the main concern of the government and stakeholders in Indonesia, the implementation of policy and regulation that unconsidering the situation and condition that occur on various categories of final energy users predicted will hamper sustainable development in Indonesia.

5.4 Conclusions

The growth of economic performance on three development sectors and per capita real GDP significantly influenced total final energy consumption in Indonesia, both in the short and long term. In contrast, the growth of final energy consumption by four final energy sectors did not have a significant impact on Indonesia's economic growth. These results confirmed the conservation hypothesis in Indonesia and this finding supported the result from Masih and Masih (1996), Murry and Nan (1994), Yoo and Kim (2006), Hwang and Yoo (2012), Soile (2012), and Azam et al. (2015a) that also concluded this hypothesis for Indonesia on their study.

Final energy consumption and economic growth did not have any relationship in the industry sector and the service sector. The causal relationship between economic growth and final energy consumption in the short term only found in the agriculture sector, while the causal relationship between final energy consumption and economic growth in the long term only revealed in the residential sector. Based on these results it can be concluded that the neutral hypothesis confirms in the industry sector and the service sector, the conservation hypothesis occurs in the agriculture sector, while the growth hypothesis found in the residential sector.

In concern to the causal relationship between final energy consumption and CO_2 emissions from energy combustion, this study obtained similar findings in the four energy user sectors in Indonesia. The evidence of feedback hypothesis is found in the agriculture and residential sectors over the short-term. While in the industry sector and service sector, this reciprocal relationship found in the short and long terms. Based on these results, it can be concluded that the final energy consumption growth and CO_2 emissions from energy combustion in the four energy user groups have a causal relationship or support for the feedback hypothesis. This condition shows that the majority of end-energy users in Indonesia are still very dependent on fuel products that are not environmentally friendly that potentially generated a lot of CO_2 emissions from energy combustion.

In the industry sector, economic growth and CO_2 emissions affect each other only in the long run. In the agriculture sector, economic growth drove an increase in CO_2 emissions in the short term. In the service sector, economic growth and CO_2 emissions did not have a significant relationship. Meanwhile, in the residential sector, the short term economic growth potentially caused diminishing CO_2 emissions from energy combustion. Based on these findings, it can be concluded that an increase of CO_2 emission from energy combustion and economic growth in the industry sector has a reciprocal relationship, a rise of economic growth in the agriculture sector and residential sector stimulates an increase CO_2 emission from energy combustion in both sectors, and absence relationship between economic growth and CO_2 emission from energy combustion in the service sector.

Based on findings from four energy user groups in Indonesia, it concluded that the links between energy consumption, economic growth and CO_2 emission from energy combustion in four energy user sectors have slightly differed each other. This fact implied that the four groups of energy users learned in this study have different conditions, situations and challenges to each other related to energy, economy and CO_2 emissions. Therefore, it can be concluded that the problems faced by these four final user sectors should be anticipated with different strategies and policy patterns. Implementation of proper approach, strategy and policy that considering diversity final energy users certainly more relevant than applies a similar approach, strategy or policy for all category of final energy users in a country's.

5.5 Limitation and suggestion for future studies

This study has several limitations which expected as input and motivation on further studies. First, this study only considered the diversity categories of final energy user and did not consider the diversity final energy types consumed by each final user energy categories. Moreover, this study only considered final energy consumption as an indicator reflected energy consumption on each final energy user sectors in

Indonesia. In other words, this study did not consider the amount of production, imports and exports of primary and secondary energy resources in Indonesia. Second, in concern to the impact of economic growth on final energy consumption, this study only considers the value-added of three development sectors and the growth of GDP per capita as a set of economic growth indicators. In other words, this study does not take into account the effects of other economic indicators (such as trade openness, foreign direct investment, energy prices, etc.) towards Indonesia's final energy consumption. In addition, this study uses the real GDP per capita as an economic growth indicator for final energy users in the residential sector and over ignoring the issue of income level disparities between rich and poor people in Indonesia.

Third, this study only uses indicators of growth in CO_2 emissions from energy combustion as an indicator of environmental emissions. In other words, the environmental emission indicators used in this study are limited to the amount of CO_2 emissions resulting from consumes various final energy products by all categories of final energy users in Indonesia. This amount of CO_2 emissions did not include from production, distribution and transformation process from primary energy to secondary energy. Therefore, further research expected to consider the use of other environmental emissions indicators in studies that are related to the impact of economic growth and energy consumption against environmental sustainability in a country's.

Based on these limitations, further studies expected to employ other indicators that did not use in this study and then generate additional findings that unexamined or undiscovered in this study. Moreover, future studies can consider the use of other approach or methods that can contribute valuable knowledge for developing strategies and policies related to energy security, economic growth and environmental sustainability in Indonesia and also other developed and developing countries. Lastly, further study expected to be able to explore phenomena that occur in each category of final energy users to build appropriate solutions in terms of facing challenges and issues in the future.

REFERENCES

Abalaba, B. P., & Dada, M. A. (2013). Energy consumption and economic growth nexus: New empirical evidence from Nigeria. *International Journal of Energy Economics and Policy, 3*(4), 412–423.

Abbasi, F., & Riaz, K. (2016). CO2 emissions and financial development in an emerging economy: An augmented VAR approach. *Energy Policy, 90*, 102–114. https://doi.org/10.1016/j.enpol.2015.12.017

Abosedra, S., & Baghestani, H. (1991). New evidence on the causal relationship between United States energy consumption and gross national product. *Journal of Energy and Development, 14*, 285–292.

Acaravci, A. (2010). Structural Breaks, Electricity Consumption and Economic Growth: Evidence From Turkey. *Romanian Journal of Economic Forecasting, 2*, 140–154. Retrieved from https://core.ac.uk/download/pdf/6716935.pdf

Acaravci, A., & Ozturk, I. (2010). On the relationship between energy consumption, CO2 emissions and economic growth in Europe. *Energy, 35*(12), 5412–5420. https://doi.org/10.1016/j.energy.2010.07.009

Ahmad, A., Zhao, Y., Shahbaz, M., Bano, S., Zhang, Z., Wang, S., & Liu, Y. (2016). Carbon emissions, energy consumption and economic growth: An aggregate and disaggregate analysis of the Indian economy. *Energy Policy, 96*, 131–143. https://doi.org/10.1016/j.enpol.2016.05.032

Akaike, H. (1974). A New Look at the Statistical Model Identification. IEEE *Transactions on Automatic Control, 19*(6), 716–723. https://doi.org/10.1109/TAC.1974.1100705

Akarca, A. T., & Long, T. V. (1980). On the relationship between energy and GNP: a re-examination. *Journal of Energy Development, 5*, 326–331.

Akbota, A., & Baek, J. (2018). The environmental consequences of growth: Empirical evidence from the Republic of Kazakhstan. *Economies, 6*(1), 1–11. https://doi.org/10.3390/economies6010019

Akin, C. S. (2014). The Impact of Foreign Trade, Energy Consumption and Income on CO2 Emissions. *International Journal of Energy Economics and Policy, 4*(3), 465–475.

Akinlo, A. E. (2008). Energy consumption and economic growth: Evidence from 11 Sub-Sahara African countries. *Energy Economics, 30*(5), 2391–2400. https://doi.org/10.1016/j.eneco.2008.01.008

Alam, M. J., Begum, I. A., Buysse, J., & Huylenbroeck, G. Van. (2012). Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis. *Energy Policy, 45*, 217–225. https://doi.org/10.1016/j.enpol.2012.02.022

Alam, M. J., Begum, I. A., Buysse, J., Rahman, S., & Van Huylenbroeck, G. (2011). Dynamic modeling of causal relationship between energy consumption, CO2 emissions and economic growth in India. *Renewable and Sustainable Energy Reviews, 15*(6), 3243–3251. https://doi.org/10.1016/j.rser.2011.04.029

Alkhathlan, K., & Javid, M. (2013). Energy consumption, carbon emissions and economic growth in saudi arabia: An aggregate and disaggregate analysis. *Energy Policy, 62*, 1525–1532. https://doi.org/10.1016/j.enpol.2013.07.068

Al-Mulali, U., & Sab, C. N. B. C. (2012). The impact of energy consumption and CO 2 emission on the economic and financial development in 19 selected countries.

Renewable and Sustainable Energy Reviews, 16(7), 4365–4369. https://doi.org/10.1016/j.rser.2012.05.017

Al-Mulali, U., Ozturk, I., & Solarin, S. A. (2016). Investigating the environmental Kuznets curve hypothesis in seven regions: The role of renewable energy. *Ecological Indicators, 67*, 267–282. https://doi.org/10.1016/j.ecolind.2016.02.059

Al-mulali, U., Tang, C. F., & Ozturk, I. (2015). Does financial development reduce environmental degradation? Evidence from a panel study of 129 countries. *Environmental Science and Pollution Research, 22*(19), 14891–14900. https://doi.org/10.1007/s11356-015-4726-x

Alshehry, A. S., & Belloumi, M. (2014). Investigating the Causal Relationship between Fossil Fuels Consumption and Economic Growth at Aggregate and Disaggregate Levels in Saudi Arabia. *International Journal of Energy Economics and Policy, 4*(4), 531–545.

Alshehry, A. S., & Belloumi, M. (2015). Energy consumption, carbon dioxide emissions and economic growth: The case of Saudi Arabia. Renewable and *Sustainable Energy Reviews, 41*, 237–247. https://doi.org/10.1016/j.rser.2014.08.004

Altinay, G., & Karagol, E. (2004). Structural break, unit root, and the causality between energy consumption and GDP in Turkey. *Energy Economics, 26*(6), 985–994. https://doi.org/10.1016/j.eneco.2004.07.001

Aminu, N., Meenagh, D., & Minford, P. (2018). The role of energy prices in the Great Recession — A two-sector model with unfiltered data. E*nergy Economics, 71*, 14–34. https://doi.org/10.1016/j.eneco.2018.01.030

Ang, J. B. (2007). CO2 emissions, energy consumption, and output in France. *Energy Policy, 35*(10), 4772–4778. https://doi.org/10.1016/j.enpol.2007.03.032

Ang, J. B. (2008). Economic development, pollutant emissions and energy consumption in Malaysia. *Journal of Policy Modeling, 30*(2), 271–278. https://doi.org/10.1016/j.jpolmod.2007.04.010

Ansuategi, A., & Escapa, M. (2002). Economic growth and greenhouse gas emissions. *Ecological Economics, 40*(1), 23–37. https://doi.org/10.1016/S0921-8009(01)00272-5

Apergis, N., & Payne, J. E. (2010). Coal consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy, 38*(3), 1353–1359. https://doi.org/10.1016/j.enpol.2009.11.016

Apergis, N., & Tang, C. F. (2013). Is the energy-led growth hypothesis valid? New evidence from a sample of 85 countries. *Energy Economics, 38*, 24–31. https://doi.org/10.1016/j.eneco.2013.02.007

Appiah, M. O. (2018). Investigating the multivariate Granger causality between energy consumption, economic growth and CO2 emissions in Ghana. *Energy Policy, 112*, 198–208. https://doi.org/10.1016/j.enpol.2017.10.017

Aramcharoen, A., & Mativenga, P. T. (2014). Critical factors in energy demand modelling for CNC milling and impact of toolpath strategy. *Journal of Cleaner Production, 78*, 63–74. https://doi.org/10.1016/j.jclepro.2014.04.065

Archer, D., Eby, M., Brovkin, V., Ridgwell, A., Cao, L., Mikolajewicz, U., … Tokos, K. (2009). Atmospheric Lifetime of Fossil Fuel Carbon Dioxide. *Annual Review of Earth and Planetary Sciences, 37*, 117–134. https://doi.org/10.1146/annurev.earth.031208.100206

Arouri, M., Shahbaz, M., Onchang, R., Islam, F., & Teulon, F. (2014). Environmental Kuznets Curve in Thailand: Cointegration and Causality Analysis. In *IPAG Working Paper* (No. 2014–204). Retrieved from http://www.ipag.fr/fr/accueil/la-recherche/publications-WP.html

Arroyo, F., & Migue, L. J. (2019). Analysis of Energy Demand Scenarios in Ecuador: National Government Policy Perspectives and Global Trend to Reduce CO2 Emissions. *International Journal of Energy Economics and Policy, 9*(2), 364–374. https://doi.org/10.32479/ijeep.7132

Aryani, D. (2012). Skenario kebijakan energi Indonesia hingga tahun 2035. Dissertation. Universitas Indonesia. Retrieved from http://www.academia.edu/download/53838337/digital_20314950-D_1341-Skenario_kebijakan-full_text.pdf

Asafu-Adjaye, J. (2000). The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries. *Energy Economics, 22*(6), 615–625. https://doi.org/10.1016/S0140-9883(00)00050-5

Asimakopoulos, D. N., Assimakopoulos, V. D., Chrisomallidou, N., Klitsikas, N., Mangold, D., Michel, P., Tsangrassoulis, A. (2011). *Energy and Climate in The Urban Built Environment*. New York: Routledge, Taylor & Francis Group.

Auci, S., & Trovato, G. (2018). The environmental Kuznets curve within European countries and sectors: greenhouse emission, production function and technology. *Economia Politica, 35*(3), 895–915. https://doi.org/sci-hub.se/10.1007/s40888-018-0101-y

Auld, G., & Gulbrandsen, L. H. (2013). Private Regulation in Global Environment Governance. *The Handbook of Global Climate and Environment Policy*, 394–411.

Azam, M., Khan, A. Q., Abdullah, H. Bin, & Qureshi, M. E. (2016). The impact of CO2 emissions on economic growth: evidence from selected higher CO2 emissions economies. *Environmental Science and Pollution Research, 23*(7), 6376–6389. https://doi.org/10.1007/s11356-015-5817-4

Azam, M., Khan, A. Q., Bakhtyar, B., & Emirullah, C. (2015a). The causal relationship between energy consumption and economic growth in the ASEAN-5 countries. *Renewable and Sustainable Energy Reviews, 47*, 732–745. https://doi.org/10.1016/j.rser.2015.03.023

Azam, M., Khan, A. Q., Zaman, K., & Ahmad, M. (2015b). Factors determining energy consumption: Evidence from Indonesia, Malaysia and Thailand. *Renewable and Sustainable Energy Reviews, 42*, 1123–1131. https://doi.org/10.1016/j.rser.2014.10.061

Azomahou, T., & Phu, N. Van. (2001). *Economic growth and CO2 emissions: a nonparametric approach*. Universite catholique de Louvain.

Azomahou, Théophile, Laisney, F., & Phu, N. Van. (2006). Economic growth and CO2 emissions: a nonparametric panel approach. *Journal of Public Economics, 90*(6–7), 1347–1363. https://doi.org/10.1016/j.jpubeco.2005.09.005

Bashiri Behmiri, N., & Pires Manso, J. R. (2013). How crude oil consumption impacts on economic growth of Sub-Saharan Africa? *Energy, 54*, 74–83. https://doi.org/10.1016/j.energy.2013.02.052

Bekhet, H. A., Matar, A., & Yasmin, T. (2017). CO2 emissions, energy consumption, economic growth, and financial development in GCC countries: Dynamic simultaneous equation models. *Renewable and Sustainable Energy Reviews, 70*, 117–132. https://doi.org/10.1016/j.rser.2016.11.089

Belke, A., Dobnik, F., & Dreger, C. (2011). Energy consumption and economic growth: new insights into the cointegration relationship. *Energy Economics, 33*(5), 782–789.

Belloumi, M. (2009). Energy consumption and GDP in Tunisia: Cointegration and causality analysis. *Energy Policy, 37*(7), 2745–2753. https://doi.org/10.1016/j.enpol.2009.03.027

Berndt, E. R., & Wood, D. O. (1975). Technology, prices, and the derived demand for energy. *The Review of Economics and Statistics, 57*(3), 259-268. Retrieved from https://www.jstor.org/stable/1923910

Bhattacharya, M., Lean, H. H., & Bhattacharya, S. (2014). *Economic Growth, Coal Demand, Carbon Dioxide Emissions: Empirical Findings from India with Policy Implications*. Discussion Paper 47/14. Monash University, Caulfield.

Bhattacharyya, S. C. (2011). *Energy Economics: Concepts, Issues, Markets and Governance*. Springer-Verlag, London. https://doi.org/10.1007/978-0-85729-268-1

Bildirici, M. E. (2013). Economic growth and biomass energy. *Biomass and Bioenergy, 50*, 19–24.

Bilgili, F., Koçak, E., & Bulut, Ü. (2016). The dynamic impact of renewable energy consumption on CO2emissions: A revisited Environmental Kuznets Curve approach. *Renewable and Sustainable Energy Reviews, 54*, 838–845. https://doi.org/10.1016/j.rser.2015.10.080

Bimanatya, T. E., & Widodo, T. (2017). Energy Conservation, Fossil Fuel Consumption, CO2 Emission and Economic Growth in Indonesia. In *Munich*

Personal RePEc Archive (No. 79989). Retrieved from https://mpra.ub.uni-muenchen.de/79989/1/MPRA_paper_79989.pdf

Birol, F. (2007). Energy economics: a place for energy poverty in the agenda? *Energy Journal, 28*(3), 1–6. Retrieved from https://pdfs.semanticscholar.org/9f4a/591b13a1e4188b9ddb6cd4afcb49d8147509.pdf

Bjork, G. C. (1999). *The way it worked and why it won't: structural change and the slowdown of US economic growth*. Greenwood Publishing Group.

Boopen, S., & Vinesh, S. (2011). On the Relationship between CO2 Emissions and Economic Growth: The Mauritian Experience. In *University of Mauritius, Mauritius Environment Outlook Report* (Vol. 14, p. 2015). Retrieved from http://www.csae.ox.ac.uk/conferences/2011-EDiA/papers/776-Seetanah.pdf

Bowden, N., & Payne, J. E. (2009). The causal relationship between U.S. energy consumption and real output: A disaggregated analysis. *Journal of Policy Modeling, 31*(2), 180–188. https://doi.org/10.1016/j.jpolmod.2008.09.001

Bozkurt, C., & Akan, Y. (2014). Economic Growth, CO2 Emissions and Energy Consumption: The Turkish Case. *International Journal of Energy Economics and Policy, 4*(3), 484–494.

Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society: Series B (Methodological), 37*(2), 149–163.

Carley, S., Lawrence, S., Brown, A., Nourafshan, A., & Benami, E. (2011). Energy-based economic development. *Renewable and Sustainable Energy Reviews, 15*(1), 282–295. https://doi.org/10.1016/j.rser.2010.08.006

Chandran, V. G. R., & Tang, C. F. (2013). The impacts of transport energy consumption, foreign direct investment and income on CO2 emissions in ASEAN-5 economies. *Renewable and Sustainable Energy Reviews, 24*, 445–453. https://doi.org/10.1016/j.rser.2013.03.054

Chen, P. Y., Chen, S. T., Hsu, C. S., & Chen, C. C. (2016). Modeling the global relationships among economic growth, energy consumption and CO2 emissions. *Renewable and Sustainable Energy Reviews, 65*, 420–431. https://doi.org/10.1016/j.rser.2016.06.074

Cheng, B. S. (1997). Energy consumption and economic growth in Brazil, Mexico and Venezuela: a time series analysis. *Applied Economics Letters, 4*(11), 671–674. https://doi.org/10.1080/758530646

Chiou-Wei, S. Z., Chen, C. F., & Zhu, Z. (2008). Economic growth and energy consumption revisited - Evidence from linear and nonlinear Granger causality. *Energy Economics, 30*(6), 3063–3076. https://doi.org/10.1016/j.eneco.2008.02.002

Chontanawat, J, Hunt, L., & Pierse, R. (2006). *Causality between energy consumption and GDP: evidence from 30 OECD and 78 non-OECD countries* (No. 113). Surrey Energy Economics Centre (SEEC), School of Economics, University of Surrey. Retrieved from https://ideas.repec.org/p/sur/seedps/113.html

Chontanawat, J., Hunt, L. C., & Pierse, R. (2008). Does energy consumption cause economic growth?: Evidence from a systematic study of over 100 countries. *Journal of Policy Modeling, 30*(2), 209–220. https://doi.org/10.1016/j.jpolmod.2006.10.003

Chow, G. C. (1960). Tests of Equality Between Sets of Coefficients in Two Linear Regressions. *Econometrica, 28*(3), 591–605. Retrieved from https://www.jstor.org/stable/1910133

Cicea, C., Marinescu, C., Popa, I., & Dobrin, C. (2014). Environmental efficiency of investments in renewable energy: Comparative analysis at macroeconomic level. *Renewable and Sustainable Energy Reviews, 30*, 555–564. https://doi.org/10.1016/j.rser.2013.10.034

Climent, F., & Pardo, A. (2007). Decoupling factors on the energy-output linkage: The Spanish case. *Energy Policy, 35*(1), 522–528. https://doi.org/10.1016/j.enpol.2005.12.022

Coakley, J., Fuertes, A., & Spagnolo, F. (2004). Is the Feldstein–Horioka puzzle history? *The Manchester School, 72*(5), 569–590.

Cornwall, J. L. (2014). Economic growth. Retrieved October 20, 2014, from Encyclopaedia Britania website: http://global.britannica.com/EBchecked/topic/178400/economic-growth

Costantini, V., & Martini, C. (2010). The causality between energy consumption and economic growth: A multi-sectoral analysis using non-stationary cointegrated panel data. *Energy Economics, 32*(3), 591–603. https://doi.org/10.1016/j.eneco.2009.09.013

Cowan, W. N., Chang, T., Inglesi-Lotz, R., & Gupta, R. (2014). The nexus of electricity consumption, economic growth and CO2 emissions in the BRICS countries. *Energy Policy, 66*, 359–368. https://doi.org/10.1016/j.energy.2010.09.041

Dasgupta, S., Hong, J. H., Laplante, B., & Mamingi, N. (2006). Disclosure of environmental violations and stock market in the Republic of Korea.

Ecological Economics, 58, 759–777. https://doi.org/10.1016/j.ecolecon.2005.09.003

Deendarlianto, Widyaparaga, A., Sopha, B. M., Budiman, A., Muthohar, I., Setiawan, I. C., Oka, K. (2017). Scenarios analysis of energy mix for road transportation sector in Indonesia. *Renewable and Sustainable Energy Reviews, 70*(2), 13–23. https://doi.org/10.1016/j.rser.2016.11.206

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the Estimators for Autoregressive Time Series With a Unit Root. Journal of the American Statistical Association, 74(336), 427–431.

Dickinson, E. (2011). GDP: a brief history. Retrieved November 20, 2014, from http://foreignpolicy.com/2011/01/03/gdp-a-brief-history/

Dogan, E., & Ozturk, I. (2017). The influence of renewable and non-renewable energy consumption and real income on CO2emissions in the USA: evidence from structural break tests. *Environmental Science and Pollution Research, 24*(11), 10846–10854. https://doi.org/10.1007/s11356-017-8786-y

Dogan, E., & Turkekul, B. (2015). CO2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. *Environmental Science and Pollution Research, 23*(2), 1203–1213. https://doi.org/10.1007/s11356-015-5323-8

Dritsaki, C., & Dritsaki, M. (2014). Causal relationship between energy consumption, economic growth and CO2 emissions: A dynamic panel data approach. *International Journal of Energy Economics and Policy, 4*(2), 125–136.

Ebohon, O. J. (1996). Energy, economic growth and causality in developing countries: a case study of Tanzania and Nigeria. *Energy Policy, 24*, 447–453.

Eggoh, J. C., Bangake, C., & Rault, C. (2011). Energy consumption and economic growth revisited in African countries. *Energy Policy, 39*(11), 7408–7421.

Elinur, Priyarsono, D. S., Tambunan, M., & Firdaus, M. (2010). Perkembangan Konsumsi dan Penyediaan Energi dalam Perekonomian Indonesia. *Indonesian Journal of Agricultural Economics, 2*(1), 97–119.

Enders, W. (2004). *Applied Econometric Time Series* (2nd Eds). Denver: John Wiley and Sons.

Energy Information Administration. (2015). International energy data and analysis: Indonesia. In *International energy data and analysis*. Retrieved from https://www.eia.gov/beta/international/analysis_includes/countries_long/Indonesia/indonesia.pdf

Erahman, Q. F., Purwanto, W. W., Sudibandriyo, M., & Hidayatno, A. (2016). An assessment of Indonesia's energy security index and comparison with seventy countries. *Energy, 111*, 364–376. https://doi.org/10.1016/j.energy.2016.05.100

Erdal, G., Erdal, H., & Esengun, K. (2008). The causality between energy consumption and economic growth in Turkey. *Energy Policy, 36*(10), 3838–3842.

Erol, U., & Yu, E. S. H. (1987). On the causal relationship between energy and income for industrialized countries. *Journal of Energy and Development, 13*(1), 113–122. Retrieved from https://www.jstor.org/stable/24807616

Esmaeili, A., Hasan-gholipour, T., & Jamalmanesh, A. (2012). The Evaluation of Demand Function for Industrial Power Studied in Khuzestan. *Journal of Basic and Applied Scientific Research, 2*(11), 10951–10957. Retrieved from https://www.textroad.com/pdf/JBASR/J. Basic. Appl. Sci. Res., 2(11)10951-10957, 2012.pdf

Esso, L. J., & Keho, Y. (2016). Energy consumption, economic growth and carbon emissions: Cointegration and causality evidence from selected African countries. *Energy, 114*, 492–497. https://doi.org/10.1016/j.energy.2016.08.010

Faisal, F., Tursoy, T., & Ercantan, O. (2017). The relationship between energy consumption and economic growth: Evidence from non-Granger causality test. *Procedia Computer Science, 120*, 671–675. https://doi.org/10.1016/j.procs.2017.11.294

Farhani, S., & Rejeb, J. Ben. (2012). Energy consumption, economic growth and CO2 emissions: Evidence from panel data for MENA region. *International Journal of Energy Economics and Policy, 2*(2), 71–81.

Farhani, S., Mrizak, S., Chaibi, A., & Rault, C. (2014). The environmental Kuznets curve and sustainability: A panel data analysis. *Energy Policy, 71*, 189–198. https://doi.org/10.1016/j.enpol.2014.04.030

Farhani, S., Shahbaz, M., & Arouri, M. E. H. (2013). Panel Analysis of CO2 Emissions, GDP, Energy Consumption, Trade Openness and Urbanization for MENA Countries. In *Munich Personal RePEc Archive* (No. 49258). Retrieved from http://mpra.ub.uni-muenchen.de/49258/

Fatai, K., Oxley, L., & Scrimgeour, F. (2002). Energy consumption and employment in New Zealand: searching for causality. In *NZAE Conference. Wellington* (Vol. 2).

Fatai, K., Oxley, L., & Scrimgeour, F. (2004). Modelling the Causal Relationship Between Energy Consumption and GDP in New Zealand, Australia, India, Indonesia, The Philippines and Thailand. *Mathematics and Computers in Simulation, 64*(3–4), 431–445.

Fei, L., Dong, S., Xue, L., Liang, Q., & Yang, W. (2011). Energy consumption-economic growth relationship and carbon dioxide emissions in China. *Energy Policy, 39*(2), 568–574. https://doi.org/10.1016/j.enpol.2010.10.025

Field, B. C., & Field, M. K. (2006). Environmental Economics: An Introduction. *Sustainable Human Development Review, 105*.

Fouquet, R., Pearson, P., Hawdon, D., Robinson, C., & Stevens, P. (1997). The future of UK final user energy demand. *Energy Policy, 25*(2), 231–240. https://doi.org/10.1016/S0301-4215(96)00109-7

Francis, B. M., Moseley, L., & Iyare, S. O. (2007). Energy consumption and projected growth in selected Caribbean countries. *Energy Economics, 29*, 1224–1232.

Fuinhas, J. A., & Marques, A. C. (2012). Energy consumption and economic growth nexus in Portugal, Italy, Greece, Spain and Turkey: An ARDL bounds test approach (1965-2009). *Energy Economics, 34*(2), 511–517. https://doi.org/10.1016/j.eneco.2011.10.003

Ghali, K. H., & El-Sakka, M. I. T. (2004). Energy use and output growth in Canada: a multivariate cointegration analysis. *Energy Economics, 26*, 225–238. https://doi.org/10.1016/S0140-9883

Ghosh, B. C., Alam, K. J., & Osmani, M. A. G. (2014). Economic Growth, CO2 Emissions and Energy Consumption: The Case of Bangladesh. *International Journal of Business and Economics Research, 3*(6), 220–227. https://doi.org/10.11648/j.ijber.20140306.13

Ghosh, S. (2002). Electricity consumption and economic growth in India. *Energy Policy, 30*, 125–129.

Giles, D. E. (2013). ARDL models–Part II–Bounds Tests. Retrieved December 18, 2015, from http://davegiles.blogspost.com/2013/06/ardl-models-part-ii-bounds-tests.html

Gill, A. R., Viswanathan, K. K., & Hassan, S. (2018). The Environmental Kuznets Curve (EKC) and the environmental problem of the day. *Renewable and Sustainable Energy Reviews, 81*, 1636–1642. https://doi.org/10.1016/j.rser.2017.05.247

Glasure, Y. U. (2002). Energy and national income in Korea: Further evidence on the role of omitted variables. *Energy Economics, 24*(4), 355–365. https://doi.org/10.1016/S0140-9883(02)00036-1

Glasure, Y. U., & Lee, A. R. (1998). Cointegration, error correction, and the relationship between GDP and energy: the case of South Korea and Singapore. *Resource and Energy Economics, 20*(1), 17–25.

Granger, C. W. J. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. Econometrica, 37(3), 424–438.

Griffin, J. M., & Gregory, P. R. (1976). An intercountry translog model of energy substitution responses. *The American Economic Review, 66*(5), 845–857. Retrieved from https://www.jstor.org/stable/1827496

Hakimi, A., & Hamdi, H. (2015). Trade liberalization, FDI inflows, Environmental quality and Economic growth: A comparative analysis between Tunisia and Morocco. *Renewable and Sustainable Energy Reviews, 58*, 1445-1456.

Hamilton, C., & Turton, H. (2002). Determinants of emissions growth in OECD countries. *Energy Policy, 30*(1), 63–71. https://doi.org/10.1016/S0301-4215(01)00060-X

Hassanien, R. H. E., Li, M., & Dong Lin, W. (2016). Advanced applications of solar energy in agricultural greenhouses. *Renewable and Sustainable Energy Reviews, 54*, 989–1001. https://doi.org/10.1016/j.rser.2015.10.095

Hatzigeorgiou, E., Polatidis, H., & Haralambopoulos, D. (2011). CO2 emissions, GDP and energy intensity: A multivariate cointegration and causality analysis for Greece, 1977-2007. *Applied Energy, 88*(4), 1377–1385. https://doi.org/10.1016/j.apenergy.2010.10.008

Hayfa, E., & Rania, B. H. (2014). The impact of the biomass energy use on CO2 emissions: A Panel data model for 15 countries. *IREC 2014 - 5th International Renewable Energy Congress*, 1–6. https://doi.org/10.1109/IREC.2014.6826986

Heidari, H., Turan Katircioğlu, S., & Saeidpour, L. (2015). Economic growth, CO2emissions, and energy consumption in the five ASEAN countries. *International Journal of Electrical Power and Energy Systems, 64*, 785–791. https://doi.org/10.1016/j.ijepes.2014.07.081

Herrerias, M. J., Joyeux, R., & Girardin, E. (2013). Short-and long-run causality between energy consumption and economic growth: Evidence across regions in China. *Applied Energy, 112*, 1483–1492.

Hindrichs, R. A., & Kleinbach, M. (2012). *Energy: Its Use and the Environment* (5th Ed.). Boston, USA: Brooks/Cole, Cengage Learning.

Hondroyiannis, G., Lolos, S., & Papapetrou, E. (2002). Energy consumption and economic growth: Assessing the evidence from Greece. *Energy Economics, 24*(4), 319–336. https://doi.org/10.1016/S0140-9883(02)00006-3

Hossain, M. S. (2011). Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. *Energy Policy, 39*(11), 6991–6999. https://doi.org/10.1016/j.enpol.2011.07.042

Hossein, S. S. M., Yazdan, G. F., & Hasan, S. (2012). Consideration the relationship between energy consumption and economic growth in oil exporting country. *Procedia-Social and Behavioral Sciences, 62*, 52–58.

Huang, B. N., Hwang, M. J., & Yang, C. W. (2008). Causal relationship between energy consumption and GDP growth revisited: A dynamic panel data approach. *Ecological Economics, 67*(1), 41–54. https://doi.org/10.1016/j.ecolecon.2007.11.006

Hunt, L. C., & Ninomiya, Y. (2005). Primary energy demand in Japan: An empirical analysis of long-term trends and future CO2 emissions. *Energy Policy, 33*(11), 1409–1424. https://doi.org/10.1016/j.enpol.2003.12.019

Hwang, D., & Gum, B. (1992). The causal relationship between energy and GNP: the case of Taiwan. *Journal of Energy and Development, 12*, 219–226.

Hwang, J. H., & Yoo, S. H. (2012). Energy consumption, CO2 emissions, and economic growth: Evidence from Indonesia. *Quality and Quantity, 48*(1), 63–73. https://doi.org/10.1007/s11135-012-9749-5

Indrawan, N., Thapa, S., Wijaya, M. E., Ridwan, M., & Park, D. H. (2018). The biogas development in the Indonesian power generation sector. *Environmental Development, 25*, 85–99. https://doi.org/10.1016/j.envdev.2017.10.003

International Civil Aviation Organization. (2010). *ICAO Environment Report 2010: Aviation and Climate Change*. International Civil Aviation Organization and FCM Communication Inc.

International Energy Agency. (2016a). *IEA Online Data Services*. Retrieved May 20, 2016, from http://wds.iea.org/wds/ReportFolders/ReportFolders.aspx

International Energy Agency. (2016b). *World Energy Balances: Database Documentation*. Retrieved from http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf

International Energy Agency. (2018). *World Energy Balances: Database Documentation* (2018 eds.). Retrieved from http://www.iea.org/statistics/topics/energybalances/

Jammazi, R., & Aloui, C. (2015). Environment degradation, economic growth and energy consumption nexus: A wavelet-windowed cross correlation approach. Physica A: Statistical Mechanics and Its Applications, 436, 110-125. https://doi.org/10.1016/j.physa.2015.05.058

Javid, M., & Sharif, F. (2016). Environmental Kuznets curve and financial development in Pakistan. *Renewable and Sustainable Energy Reviews, 54*, 406–414. https://doi.org/10.1016/j.rser.2015.10.019

Jebli, M. B., & Youssef, S. B. (2013). Combustible renewables and waste consumption, exports and economic growth: Evidence from panel for selected MENA countries. In *Munich Personal RePEc Archive* (No. 47767). Retrieved from http://mpra.ub.uni-muenchen.de/47767/

Jebli, M. B., & Youssef, S. B. (2015a). Economic growth, combustible renewables and waste consumption and emissions in North Africa. *Environmental Science and Pollution Research, 22*(20), 16022–16030. Retrieved from http://mpra.ub.uni-muenchen.de/55300/

Jebli, M. B., & Youssef, S. B. (2015b). The environmental Kuznets curve, economic growth, renewable and non-renewable energy, and trade in Tunisia. *Renewable and Sustainable Energy Reviews, 47*, 173–185. https://doi.org/10.1227/01.NEU.0000349921.14519.2A

Jebli, M. B., Youssef, S. B., & Apergis, N. (2014). The Dynamic Linkage between CO2 emissions, Economic Growth, Renewable Energy Consumption, Number of Tourist Arrivals and Trade. *Munich Personal RePEc Archive*. https://doi.org/10.1227/01.NEU.0000349921.14519.2A

Jobert, T., & Karanfil, F. (2007). Sectoral energy consumption by source and economic growth in Turkey. *Energy Policy, 35*(11), 5447–5456. https://doi.org/10.1016/j.enpol.2007.05.008

Joo, Y., Kim, C. S., & Yoo, S. (2015). Energy Consumption, CO2 Emission, and Economic Growth : Evidence from Chile. *International Journal of Green Energy, 12*(5), 543–550. https://doi.org/10.1080/15435075.2013.834822

Jumbe, C. B. L. (2004). Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi. *Energy Economics, 26*, 61–68.

Kahia, M., Jebli, M. Ben, & Belloumi, M. (2019). Analysis of the impact of renewable energy consumption and economic growth on carbon dioxide emissions in 12 MENA countries. *Clean Technologies and Environmental Policy, 21*(4), 871–885. https://doi.org/10.1007/s10098-019-01676-2

Kaika, D., & Zervas, E. (2013). The Environmental Kuznets Curve (EKC) theory-Part A: Concept, causes and the CO2 emissions case. *Energy Policy, 62*, 1392–1402. https://doi.org/10.1016/j.enpol.2013.07.131

Kalyoncu, H., Gürsoy, F., & Göcen, H. (2013). Causality relationship between GDP and energy consumption in Georgia, Azerbaijan and Armenia. *International Journal of Energy Economics and Policy, 3*(1), 111–117.

Kanitkar, T., Banerjee, R., & Jayaraman, T. (2015). Impact of economic structure on mitigation targets for developing countries. *Energy for Sustainable Development, 26*, 56–61. https://doi.org/10.1016/j.esd.2015.03.003

Karakas, A. (2014). Economic Growth-CO2 Emission Relationship in OECD and Non-OECD Countries: A Panel Data Analysis for the Period between 1990-2011. *The International Journal of Humanities & Social Studies, 2*(3), 57–62.

Karanfil, F. (2008). Energy consumption and economic growth revisited: Does the size of unrecorded economy matter? *Energy Policy, 36*(8), 3029–3035. https://doi.org/10.1016/j.enpol.2008.04.002

Kasman, A., & Duman, Y. S. (2015). CO2 emissions , economic growth , energy consumption , trade and urbanization in new EU member and candidate countries : A panel data analysis. *Economic Modelling, 44*, 97–103. https://doi.org/10.1016/j.econmod.2014.10.022

Kaygusuz, K. (2009). Energy and environmental issues relating to greenhouse gas emissions for sustainable development in Turkey. *Renewable and Sustainable Energy Reviews, 13*(1), 253–270. https://doi.org/10.1016/j.rser.2007.07.009

Kohler, M. (2013). CO2 emissions, energy consumption, income and foreign trade: A South African perspective. *Energy Policy, 63*, 1042–1050. https://doi.org/10.1016/j.enpol.2013.09.022

Koutroumanidis, T., Ioannou, K., & Arabatzis, G. (2009). Predicting fuelwood prices in Greece with the use of ARIMA models, artificial neural networks and a hybrid ARIMA–ANN model. *Energy Policy, 37*, 3627–3634. https://doi.org/10.1016/j.enpol.2009.04.024

Kraft, J., & Kraft, A. (1978). On the Relationship Between Energy On the Relationship Between Energy and GNP. *The Journal of Energy and Development, 3*(2), 401–403. Retrieved from https://www.jstor.org/stable/24806805

Kulionis, V. (2013). *The relationship between renewable energy consumption, CO2 emissions and economic growth in Denmark*. Lund University.

Kuntsi-Reunanen, E. (2007). A comparison of Latin American energy-related CO2 emissions from 1970 to 2001. *Energy Policy, 35*, 586–596. https://doi.org/10.1016/j.enpol.2006.01.003

Kuo, K. C., Poomlamjiak, B., & Lai, S. L. (2014). The causal Relationship between gross domestic product, exports, energy consumption, and CO2 in Thailand. *產研論集, 46*(47), 127–138. https://doi.org/10.6148/IJITAS.2014.0701.05

Kusuma, D. B. W., & Muqorrobin, M. (2013). The Relationship Between Energy Consumption and Economic Growth. *Trikonomika, 12*(2), 103–112.

Kusumadewi, T. V., & Limmeechokchai, B. (2015). Energy Efficiency Improvement and CO2 Mitigation in Residential Sector: Comparison between Indonesia and Thailand. *Energy Procedia, 79*, 994-1000. https://doi.org/10.1016/j.egypro.2015.11.599

Le Quere, C., Andres, R. J., Boden, T., Conway, T., Hougton, R. A., House, J. I., … Zeng, N. (2012). The global carbon budget 1959–2011. *Earth System Science Data Discussions, 5*, 1107–1157. https://doi.org/10.5194/essdd-5-1107-2012

Lee, C. C. (2005). Energy consumption and GDP in developing countries: a cointegrated panel analysis. *Energy Economics, 27*, 415–427.

Lee, C. C. (2006). The causality relationship between energy consumption and GDP in G-11 countries revisited. *Energy Policy, 34*(9), 1086–1093. https://doi.org/10.1016/j.enpol.2005.04.023

Leitão, N. C. (2014). Economic growth, carbon dioxide emissions, renewable energy and globalization. *International Journal of Energy Economics and Policy, 4*(3), 391–399.

Lim, K. M., Lim, S. Y., & Yoo, S. H. (2014). Oil consumption, CO2 emission, and economic growth: Evidence from the Philippines. Sustainability (Switzerland), 6(2), 967–979. https://doi.org/10.3390/su6020967

Lin, B., & Abudu, H. (2019). Changes in Energy Intensity During the Development Process: Evidence in Sub-Saharan Africa and Policy Implications. *Energy, 183*, 1012–1022. https://doi.org/10.1016/j.energy.2019.06.174

Lindmark, M. (2002). An EKC-pattern in historical perspective: carbon dioxide emissions, technology, fuel prices and growth in Sweden 1870–1997. *Ecological Economics, 42*(1–2), 333–347. https://doi.org/10.1016/S0921-8009(02)00108-8

Linh, D. H., & Lin, S. (2015). Dynamic Causal Relationships among CO2 Emissions, Energy Consumption, Economic Growth and FDI in the most Populous Asian Countries. *Advances in Management and Applied Economics, 5*(1), 69-88.

Lise, W., & Montfort, K. V. (2007). Energy consumption and GDP in Turkey: is there a co-integration relationship? *Energy Economics, 29*, 1166–1178.

Luzzati, T., & Orsini, M. (2009). Investigating the energy-environmental Kuznets curve. *Energy, 34*(3), 291–300. https://doi.org/10.1016/j.energy.2008.07.006

Maczulak, A. (2009). *Renewable energy: Sources and Methods*. Infobase Publishing. Retrieved from https://books.google.com.my/books?hl=en&lr=&id=D8iIwdbUuTgC&oi=fnd&pg=PP1&dq=maczulak+2009+sources+and+methods&ots=iZKPGwu_2b&sig=KF2jxlzDzZnmBgLiUtiAuCDhlAk

Magazzino, C. (2014). A panel VAR approach of the relationship among economic growth, CO2 emissions, and energy use in the ASEAN-6 countries. *International Journal of Energy Economics and Policy, 4*(4), 546–553.

Mahadevan, R., & Asafu-Adjaye, J. (2007). Energy consumption, economic growth and prices: A reassessment using panel VECM for developed and developing countries. *Energy Policy, 35*(4), 2481–2490. https://doi.org/10.1016/j.enpol.2006.08.019

Malizia, E. E. (1994). A Redefinition of Economic Development. *Economic Development Review, 12*(2), 83–84.

Marrero, G. A. (2010). Greenhouse gases emissions, growth and the energy mix in Europe. *Energy Economics, 32*(6), 1356–1363. https://doi.org/10.1016/j.eneco.2010.09.007

Masih, A. M. M., & Masih, R. (1996). Energy consumption, real income and temporal causality: Results from a multi-country study based on cointegration and error-correction modelling techniques. *Energy Economics, 18*(3), 165–183. https://doi.org/10.1016/0140-9883(96)00009-6

Masih, A. M. M., & Masih, R. (1997). On the temporal causal relationship between energy consumption, real income, and prices: Some new evidence from Asian-energy dependent NICs based on a multivariate cointegration/vector error-correction approach. *Journal of Policy Modeling, 19*(4), 417–440. https://doi.org/10.1016/s0161-8938(96)00063-4

Masih, A. M. M., & Masih, R. (1998). A multivariate cointegrated modelling approach in testing temporal causality between energy consumption, real income and prices -with an application to two Asian LDCs. *Applied Economics, 30*(10), 1287–1298. https://doi.org/10.1080/000368498324904

Medlock III, K. B., & Soligo, R. (2001). Economic Development and End-Use Energy Demand. *The Energy Journal, 22*(2), 77–105. https://doi.org/10.5547/issn0195-6574-ej-vol22-no2-4

Mehrara, M. (2007). Energy-GDP relationship for oil-exporting countries: Iran, Kuwait and Saudi Arabia. *OPEC Review, 31*(1), 1–16. https://doi.org/10.1111/j.1468-0076.2007.00173.x

Murry, D., & Nan, G. (1994). A definition of the gross domestic product-electrification interrelationship. *The Journal of Energy and Development, 19*(2), 275–283. Retrieved from https://www.jstor.org/stable/24808049

Nachane, D. M., Nadkarni, R. M., & Karnik, A. V. (1988). Cointegration and causality testing of the energy-GDP relationship: a cross-country study. *Applied Economics, 20*, 1511–1531.

Narayan, P. K. (2005). The saving and investment nexus for China: Evidence from cointegration tests. *Applied Economics, 37*(17), 1979–1990. https://doi.org/10.1080/00036840500278103

Narayan, P. K., & Popp, S. (2012). The energy consumption-real GDP nexus revisited: empirical evidence from 93 countries. *Economic Modelling, 29*(2), 303–308.

National Energy Council. (2019). *Indonesia Energy Outlook 2019*. Retrieved from https://www.esdm.go.id/assets/media/content/content-indonesia-energy-outlook-2019-english-version.pdf

Nayan, S., Kadir, N., Ahmad, M., & Abdullah, M. S. (2013). Revisiting Energy Consumption and GDP: Evidence from Dynamic Panel Data Analysis. *Procedia Economics and Finance, 7*, 42–47. https://doi.org/10.1016/s2212-5671(13)00216-5

Nejat, P., Jomehzadeh, F., Taheri, M., Gohari, M., & Majid, M. Z. A. (2015). A global review of energy consumption, CO2 emissions and policy in the residential sector (with an overview of the top ten CO2 emitting countries). *Renewable* *and Sustainable Energy Reviews, 43*, 843–862. https://doi.org/10.1016/j.rser.2014.11.066

Newton, D. E. (2013). *World Energy Crisis: A Reference Handbook*. Contemporary World Issues: Science, Technology, and Medicine. ABC-CLIO.

Niu, H., & Li, H. (2014). An Empirical Study on Economic Growth and Carbon Emissions of G20 Group. In *International Conference on Education Reform and Modern Management* (ERMM 2014), 318–321. https://doi.org/10.2991/ermm-14.2014.86

Ocal, O., & Aslan, A. (2013). Renewable Energy Consumption-Economic Growth Nexus in Turkey. *Renewable and Sustainable Energy Reviews, 28*, 494–499. https://doi.org/10.1016/j.rser.2013.08.036

Odhiambo, N. M. (2010). Finance-investment-growth nexus in South Africa : an ARDL-bounds testing procedure. *Economic Change and Restructuring, 43*, 205–219. https://doi.org/10.1007/s10644-010-9085-5

OECD. (2002). *Glosary of Statistical Terms: Gross Domestic Product* (GDP). Retrieved September 18, 2014, from https://stats.oecd.org/glossary/detail.asp?ID=1163

OECD/IEA. (2005). *Energy Statistics Manual*. OECD/IEA. https://doi.org/10.1787/9789264033986-en

OECD/IEA. (2015). Key Trends in CO2 Emissions, Excerpt from: CO2 Emission from Fuel Combustion. In *IEA Statistics* (2015 ed.). https://doi.org/10.2307/821459

Oh, T. H., Hasanuzzaman, M., Selvaraj, J., Teo, S. C., & Chua, S. C. (2018). Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth – An update. *Renewable and Sustainable Energy Reviews, 81*, 3021–3031. https://doi.org/10.1016/j.rser.2017.06.112

Oh, W., & Lee, K. (2004). Energy consumption and economic growth in Korea: Testing the causality relation. *Journal of Policy Modeling, 26*(8–9), 973–981. https://doi.org/10.1016/j.jpolmod.2004.06.003

Ojewumi, S. J., & Akinlo, A. E. (2017). Foreign Direct Investment, Economic Growth and Environmental Quality in Sub- Saharan Africa: A Dynamic Model Analysis. *African Journal of Economic Review, 5*(1), 48–68.

Oktavilia, S., & Firmansyah, F. (2016). International Journal of Economics and Financial Issues The Relationships of Environmental Degradation and Trade Openness in Indonesia. *International Jornal of Economics and Financial Issues, 6*(S6), 125–129. Retrieved from http:www.econjournals.com

Omri, A. (2014). An international literature survey on energy-economic growth nexus: Evidence from country-specific studies. *Renewable and Sustainable Energy Reviews, 38*, 951–959. https://doi.org/10.1016/j.rser.2014.07.084

Omri, A., Daly, S., Rault, C., & Chaibi, A. (2015). Financial development, environmental quality, trade and economic growth: What causes what in MENA countries. *Energy Economics, 48*, 242-252. https://doi.org/10.1016/j.eneco.2015.01.008

Ong, S. M., & Sek, S. K. (2013). Interactions between economic growth and environmental quality: Panel and non-panel analyses. *Applied Mathematical Sciences, 7*(14), 687–700. https://doi.org/10.12988/ams.2013.13062

Ozturk, I, Aslan, A., & Kalyoncu, H. (2010). Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. *Energy Policy, 38*(8), 4422–4428.

Ozturk, I. (2010). A literature survey on energy-growth nexus. *Energy Policy, 38*(1), 340–349. https://doi.org/10.1016/j.enpol.2009.09.024

Ozturk, I., Al-Mulali, U., & Saboori, B. (2015). Investigating the environmental Kuznets curve hypothesis: the role of tourism and ecological footprint. *Environmental Science and Pollution Research, 23*(2), 1916–1928. https://doi.org/10.1007/s11356-015-5447-x

Ozturk, Ilhan, & Acaravci, A. (2010). The causal relationship between energy consumption and GDP in Albania, Bulgaria, Hungary and Romania: Evidence from ARDL bound testing approach. *Applied Energy, 87*(6), 1938–1943. https://doi.org/10.1016/j.apenergy.2009.10.010

Ozturk, Ilhan, & Acaravci, A. (2013). The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. *Energy Economics, 36*, 262–267. https://doi.org/10.1016/j.eneco.2012.08.025

Padilla, E., & Serrano, A. (2006). Inequality in CO2 emissions across countries and its relationship with income inequality: a distributive approach. *Energy Policy, 34*(14), 1762–1772. https://doi.org/10.1016/j.enpol.2004.12.014

Palamalai, S., Ravindra, I. S., & Prakasam, K. (2014). Relationship between Energy Consumption, CO2 Emissions, Economic Growth and Trade in India. *International Journal of Economics, 2*(1), 1–17. https://doi.org/10.18533/jefs.v3i02.93

Pao, H. T., & Tsai, C. M. (2011). Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy, 36*(1), 685–693. https://doi.org/10.1016/j.energy.2010.09.041

Paul, S., & Bhattacharya, R. N. (2004). Causality between energy consumption and economic growth in India: A note on conflicting results. *Energy Economics, 26*(6), 977–983. https://doi.org/10.1016/j.eneco.2004.07.002

Payne, J. E. (2009). On the dynamics of energy consumption and output in the US. *Applied Energy, 86*(4), 575–577. https://doi.org/10.1016/j.apenergy.2008.07.003

Pesaran, M. H., & Shin, Y. (1998). An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis. *Econometric Society Monographs, 31*, 371–413. https://doi.org/10.1017/CCOL521633230

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Autoregressive Distributed Lag (ARDL) cointegration technique : application and interpretation. *Journal of Statistical and Econometric Methods, 5*(3), 63–91. https://doi.org/10.1002/jae.616

Phillips, P. C. B., & Perron, P. (1988). Testing for a Unit Root in a Time Series Regression. *Biometrika, 2*(75), 335–346. https://doi.org/10.1080/07350015.1992.10509923

Qureshi, M. I., Rasli, A. M., & Zaman, K. (2015). Energy crisis , greenhouse gas emissions and sectoral growth reforms : repairing the fabricated mosaic. *Journal of Cleaner Production, 112*, 3657–3666. https://doi.org/10.1016/j.jclepro.2015.08.017

Rafiq, S., Salim, R., & Nielsen, I. (2016). Urbanization, openness, emissions and energy intensity: A study of increasingly urbanized emerging economies. *Energy Economics, 56*, 20–28. https://doi.org/10.1016/j.eneco.2016.02.007

Rapanos, V. T., & Polemis, M. L. (2006). The structure of residential energy demand in Greece. *Energy Policy, 34*(17), 3137–3143. https://doi.org/10.1016/j.enpol.2005.05.017

Reddy, B. S., & Assenza, G. B. (2009). Climate change—a developing country perspective. *Current Science, 97*(1), 50–62. Retrieved from https://www.jstor.org/stable/24112082

Richmond, A. K., & Kaufmann, R. K. (2006). Is there a turning point in the relationship between income and energy use and/or carbon emissions? *Ecological Economics, 56*, 176–189. https://doi.org/10.1016/j.ecolecon.2005.01.011

Robalino-López, A., García-Ramos, J. E., Golpe, A. A., & Mena-Nieto, Á. (2014). System dynamics modelling and the environmental Kuznets curve in Ecuador (1980-2025). *Energy Policy, 67*, 923–931. https://doi.org/10.1016/j.enpol.2013.12.003

Robalino-Lopez, A., Mena-Nieto, A., Garcia-Ramos, J.-E., & Golpe, A. A. (2015). Studying the relationship between economic growth, CO2 emissions, and the environmental Kuznets curve in Venezuela (1980-2025). *Renewable and Sustainable Energy Reviews, 41*, 602–614. https://doi.org/10.1016/j.rser.2014.08.081

Saboori, B., & Sulaiman, J. (2013a). CO2 emissions, energy consumption and economic growth in Association of Southeast Asian Nations (ASEAN) countries: A cointegration approach. *Energy, 55*, 813–822. https://doi.org/10.1016/j.energy.2013.04.038

Saboori, B., & Sulaiman, J. (2013b). Environmental degradation, economic growth and energy consumption: Evidence of the environmental Kuznets curve in

Malaysia. *Energy Policy, 60*, 892–905. https://doi.org/10.1016/j.enpol.2013.05.099

Saboori, B., Sulaiman, J. Bin, & Mohd, S. (2012). An Empirical Analysis of the Environmental Kuznets Curve for CO2 Emissions in Indonesia: The Role of Energy Consumption and Foreign Trade. *International Journal of Economics and Finance, 4*(2), 243–252. https://doi.org/10.5539/ijef.v4n2p243

Sadorsky, P. (2012). Energy consumption output and trade in South America. Energy Economic. *Energy Economics, 34*(2), 476–488.

Saez-Martinez, F. J., Modejar-Jimenez, J., & Modejar-Jimenez, J. A. (2015). The energy challenge : energy and Environment Knowledge Week E2KW 2013. *Journal of Cleaner Production, 86*, 471–473. https://doi.org/10.1016/j.jclepro.2014.08.044

Saidi, K., & Mbarek, M. Ben. (2017). The impact of income, trade, urbanization, and financial development on CO2 emissions in 19 emerging economies. *Environmental Science and Pollution Research, 24*(14), 12748–12757. https://doi.org/10.1007/s11356-016-6303-3

Saleh, I., Abedi, S., & Abedi, S. (2014). A panel data approach for investigation of Gross Domestic Product (GDP) and CO2 causality relationship. *Journal of Agricultural Science and Technology, 16*(5), 947–956.

Sasana, H., & Aminata, J. (2019). Energy Subsidy, Energy Consumption, Economic Growth, and Carbon Dioxide Emission: Indonesian Case Studies. *International Journal of Energy Economics and Policy, 9*(2), 117–122. https://doi.org/10.32479/ijeep.7479

Sebri, M., & Salha, O. Ben. (2014). On the causal dynamics between economic growth, renewable energy consumption, CO2 emissions and trade openness:

Fresh evidence from BRICS countries. *Renewable and Sustainable Energy Reviews, 39*, 14–23. https://doi.org/10.1016/j.rser.2014.07.033

Shaari, M. S., Hussain, N. E., Abdullah, H., & Kamil, S. (2014). Relationship among foreign direct investment, economic growth and CO2 emission: A panel data analysis. *International Journal of Energy Economics and Policy, 4*(4), 706–715.

Shahbaz, M., & Lean, H. H. (2012). Does Financial Development Increase Energy Consumption? Role of Industrialization and Urbanization in Tunisia. *Energy Policy, 40*, 473–479. Retrieved from https://mpra.ub.uni-muenchen.de/33194/

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., & Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and CO 2 emissions in Indonesia. *Renewable and Sustainable Energy Reviews, 25*, 109–121. https://doi.org/10.1016/j.rser.2013.04.009

Shahbaz, M., Sbia, R., Hamdi, H., & Ozturk, I. (2014). Economic growth, electricity consumption, urbanization and environmental degradation relationship in United Arab Emirates. *Ecological Indicators, 45*, 622–631.

Shahbaz, M., Zeshan, M., & Afza, T. (2012). Is energy consumption effective to spur economic growth in Pakistan? New evidence from bounds test to level relationships and Granger causality tests. *Economic Modelling, 29*(6), 2310–2319. https://doi.org/10.1016/j.econmod.2012.06.027

Shahiduzzaman, M., & Alam, K. (2012). Cointegration and causal relationships between energy consumption and output: assessing the evidence from Australia. *Energy Economics, 34*(6), 2182–2188.

Soares, J. A., Kim, Y. K., & Heo, E. (2014). Analysis of causality between energy consumption and economic growth in Indonesia. *Geosystem Engineering, 17*(1), 58–62. https://doi.org/10.1080/12269328.2014.889267

Soile, I. (2012). Energy-Economy Nexus in Indonesia: Bivariate Co-integration Analysis. *Asian Journal of Empirical Research, 2*(6), 205–218. Retrieved from http://pakacademicsearch.com/pdf-files/ech/4/738-751 Volume 3 , Issue 6 June 2013.pdf

Solarin, S. A., Al-Mulali, U., Musah, I., & Ozturk, I. (2017). Investigating the pollution haven hypothesis in Ghana: An empirical investigation. *Energy, 124*, 706–719. https://doi.org/10.1016/j.energy.2017.02.089

Souhila, C., & Kourbali, B. (2012). Energy consumption and economic growth in Algeria: cointegration and causality analysis. *International Journal of Energy Economics and Policy, 2*(4), 238–249.

Sovacool, B. K. (2013). Energy Policy and Climate Change. In *The Handbook of Global Climate and Environment Policy* (pp. 446–467). Wiley-Blackwell, John Wiley & Sons Publication. Retrieved from http://philpapers.org/rec/MOETHO

Soytas, U., & Sari, R. (2003). Energy consumption and GDP: Causality relationship in G-7 countries and emerging markets. *Energy Economics, 25*(1), 33–37. https://doi.org/10.1016/S0140-9883(02)00009-9

Soytas, U., & Sari, R. (2006a). Can China contribute more to the fight against global warming? *Journal of Policy Modeling, 28*(8), 837–846. https://doi.org/10.1016/j.jpolmod.2006.06.016

Soytas, U., & Sari, R. (2006b). Energy consumption and income in G7 countries. *Journal of Policy Modeling, 28*, 739–750. https://doi.org/10.1016/j.jpolmod.2006.02.003

Soytas, U., & Sari, R. (2009). Energy consumption, economic growth, and carbon emissions: Challenges faced by an EU candidate member. *Ecological Economics, 68*(6), 1667–1675. https://doi.org/10.1016/j.ecolecon.2007.06.014

Soytas, U., Sari, R., & Ewing, B. T. (2007). Energy consumption, income, and carbon emissions in the United States. *Ecological Economics, 62*(3–4), 482–489. https://doi.org/10.1016/j.ecolecon.2006.07.009

Statistics Indonesia-Bappenas. (2014). *Indonesia Population Projection 2015-2045*. Statistics Indonesia, Bappenas and UNFPA. https://doi.org/10.22146/jp.11199

Stern, D. I. (1993). Energy and economic growth in the USA. A multivariate approach. *Energy Economics, 15*(2), 137–150. https://doi.org/10.1016/0140-9883(93)90033-N

Stern, D. I. (2000). A multivariate cointegration analysis of the role of energy in the US macroeconomy. *Energy Economics, 22*(2), 267–283. https://doi.org/10.1016/S0140-9883(99)00028-6

Sugiawan, Y., & Managi, S. (2016). The environmental Kuznets curve in Indonesia: Exploring the potential of renewable energy. *Energy Policy, 98*, 187–198. https://doi.org/10.1016/j.enpol.2016.08.029

Sulaiman, J., Azman, A., & Saboori, B. (2013). The potential of renewable energy: Using the environmental kuznets curve model. *American Journal of Environmental Sciences, 9*(2), 103–112. https://doi.org/10.3844/ajessp.2013.103.112

Szulejko, J. E., Kumar, P., Deep, A., & Kim, K. H. (2017). Global warming projections to 2100 using simple CO2 greenhouse gas modeling and comments on CO2 climate sensitivity factor. *Atmospheric Pollution Research,* 8(1), 136–140.

Talbi, B. (2015). Energy Consumption and Economic Growth in MENA : An Analysis Using the Bounds Testing Approach to Cointegration. *Bulletin of Energy Economics, 3*(3), 146–155.

Tang, C. F., & Tan, E. C. (2013). Exploring the nexus of electricity consumption , economic growth , energy prices and technology innovation in Malaysia. *Applied Energy, 104*, 297–305. https://doi.org/10.1016/j.apenergy.2012.10.061

Tang, C. F., Tan, B. W., & Ozturk, I. (2016). Energy consumption and economic growth in Vietnam. *Renewable and Sustainable Energy Reviews, 54*, 1506–1514. https://doi.org/10.1016/j.rser.2015.10.083

Tiwari, G. N., & Mishra, R. K. (2012). *Advanced Renewable Energy Sources*. Royal Society of Chemistry Publishing.

Tongsopit, S., Kittner, N., Chang, Y., Aksornkij, A., & Wangjiraniran, W. (2016). Energy security in ASEAN : A quantitative approach for sustainable energy policy. *Energy Policy, 90*, 60–72. https://doi.org/10.1016/j.enpol.2015.11.019

Trenberth, K. E., Dai, A., Van Der Schrier, G., Jones, P. D., Barichivich, J., Briffa, K. R., & Sheffield, J. (2014). Global warming and changes in drought. *Nature Climate Change, 4*(1), 17–22. Retrieved from www.nature.com/natureclimatechange

Ucan, O., Aricioglu, E., & Yucel, F. (2014). Energy consumption and economic growth nexus: Evidence from developed countries in Europe. *International Journal of Energy Economics and Policy, 4*(3), 411–419.

United Nations. (2008). *International Standard Industrial Classification of All Economic Activities (ISIC) version 3*. United Nations Publications. Retrieved from https://books.google.com.my/books?hl=en&lr=&id=FKOJK3vH6OwC&oi=fnd&pg=PR8&dq=international+standard+industrial+classification&ots=XZl58ePbGt&sig=QJRPcO5ENsguDYFhnbinPmK5PNU

Wahid, I. N., Azlina, A. A., & Mustapa, N. H. N. (2013). Energy consumption, economic growth and CO2 emissions in selected ASEAN countries. *Prosiding Perkembangan Kebangsaan Ekonomi Malaysia Ke VIII 2013, 2*, 758–765.

Wang, S. S., Zhou, D. Q., Zhou, P., & Wang, Q. W. (2011). CO2 emissions, energy consumption and economic growth in China: A panel data analysis. *Energy Policy, 39*(9), 4870–4875. https://doi.org/10.1016/j.enpol.2011.06.032

Wesseh Jr, P. K., & Zoumara, B. (2012). Causal independence between energy consumption and economic growth in Liberia: Evidence from a non-parametric bootstrapped causality test. *Energy Policy, 50*, 518–527.

Withey, P. (2014). Energy use, income and carbon dioxide emissions: Direct and multi-horizon causality in Canada. *International Journal of Energy Economics and Policy, 4*(2), 178–188.

Wolde-Rufael, Y. (2005). Energy demand and economic growth: The African experience. *Journal of Policy Modeling, 27*(8), 891–903. https://doi.org/10.1016/j.jpolmod.2005.06.003

World Bank. (2013). DataBank : World Development Indicators. Retrieved March 29, 2013, from https://databank.worldbank.org/reports.aspx?source=world-development-indicators

World Bank. (2014). DataBank: Metadata Glossary. Retrieved July 23, 2014, from https://databank.worldbank.org/metadataglossary/all/series?search=value added

World Bank. (2015). World Development Indicators. Retrieved September 17, 2016, from https://www.data.worldbank.org/products/wdi

Xu, B., & Lin, B. (2015). How industrialization and urbanization process impacts on CO2 emissions in China: Evidence from nonparametric additive regression models. *Energy Economics, 48*, 188–202. https://doi.org/10.1016/j.eneco.2015.01.005

Yang, Z., & Zhao, Y. (2014). Energy consumption, carbon emissions, and economic growth in India: Evidence from directed acyclic graphs. *Economic Modelling, 38*, 533–540.

Yazdi, S., & Shakouri, B. (2014). The impact of energy consumption, income, trade, urbanization and financial development on carbon emissions in Iran. *Advances in Environmental Biology, 8*(5), 1293–1301. Retrieved from http://www.aensiweb.com/old/aeb/2014/1293-1300.pdf

Yii, K. J., & Geetha, C. (2017). The Nexus between Technology Innovation and CO2 Emissions in Malaysia: Evidence from Granger Causality Test. *Energy Procedia, 105*, 3118–3124. https://doi.org/10.1016/j.egypro.2017.03.654

Yildirim, E., Sukruoglu, D., & Aslan, A. (2014). Energy consumption and economic growth in the next 11 countries: The bootstrapped autoregressive metric causality approach. *Energy Economics, 44*, 14–21. https://doi.org/10.1016/j.eneco.2014.03.010

Yoo, S. H., & Kim, Y. (2006). Electricity generation and economic growth in Indonesia. *Energy, 31*(14), 2890–2899.

Yu, E S H, & Jin, J. C. (1992). Cointegration tests of energy consumption, income, and employment. *Resources and Energy, 14*(3), 259–266. https://doi.org/10.1016/0165-0572(92)90010-E

Yu, Eden S.H., & Hwang, B. K. (1984). The relationship between energy and GNP. Further results. *Energy Economics, 6*(3), 186–190. https://doi.org/10.1016/0140-9883(84)90015-X

Yuan, J. H., Kang, J. G., Zhao, C. H., & Hu, Z. G. (2008). Energy consumption and economic growth: Evidence from China at both aggregated and disaggregated levels. *Energy Economics, 30*(6), 3077–3094. https://doi.org/10.1016/j.eneco.2008.03.007

Yusuf, S. A. (2014). Impact of Energy Consumption and Environmental Degradation on Economic Growth in Nigeria. *Munich Personal RePEc Archive*. Retrieved from http://mpra.ub.uni-muenchen.de/55529/

Zachariadis, T. (2006). On the Exploration of Causal Relationships between Energy and the Economy (Discussion Paper No. 2006–05). Retrieved from http://www.econ.ucy.ac.cy

Zachariadis, T. (2007). Exploring the relationship between energy use and economic growth with bivariate models: New evidence from G-7 countries. *Energy Economics, 29*(6), 1233–1253. https://doi.org/10.1016/j.eneco.2007.05.001

Zaman, K., & Moemen, M. A. (2017). Energy consumption, carbon dioxide emissions and economic development: Evaluating alternative and plausible environmental hypothesis for sustainable growth. *Renewable and Sustainable Energy Reviews, 74*, 1119–1130. https://doi.org/10.1016/j.rser.2017.02.072

Zamani, M. (2007). Energy consumption and economic activities in Iran. *Energy Economics, 29*(6), 1135–1140. https://doi.org/10.1016/j.eneco.2006.04.008

Zarnikau, J. (1997). A re-examination of the causal relationship between energy consumption and gross national product. *Journal of Energy and Development, 21*, 229–239.

Zhang, C., & Xu, J. (2012). Retesting the causality between energy consumption and GDP in China: evidence from sectoral and regional analyses using dynamic panel data. *Energy Economics, 34*(6), 1782–1789.

Zhang, X. P., & Cheng, X. M. (2009). Energy consumption, carbon emissions, and economic growth in China. *Ecological Economics, 68*(10), 2706–2712.

Zhang, Y. J. (2011). Interpreting the dynamic nexus between energy consumption and economic growth: empirical evidence from Russia. *Energy Policy, 39*(5), 2265–2272.

Zweifel, P., Praktiknjo, A., & Erdmann, G. (2017). *Energy economics: theory and applications*. Springer. https://doi.org/10.1007/978-3-662-53022-1

Appendix A

The amount of final energy consumptions in Indonesia (in thousand tonnes of oil equivalent), 1971-2014

YEAR	FEI	FEA	FES	FER	FET
1971	1,625	221	2,799	27,318	32,064
1972	1,760	259	3,019	28,026	33,170
1973	1,882	270	3,198	28,666	34,123
1974	2,046	304	3,659	29,363	35,581
1975	2,586	349	4,015	30,316	37,577
1976	2,605	358	4,252	31,076	38,630
1977	3,252	399	4,611	31,985	41,095
1978	4,397	436	5,106	32,893	43,957
1979	5,572	485	5,494	33,964	46,634
1980	6,746	561	6,311	34,810	49,640
1981	7,334	627	6,883	35,794	51,884
1982	7,365	675	7,309	36,310	52,926
1983	7,721	702	7,061	36,718	53,679
1984	6,858	719	7,210	37,084	53,983
1985	8,291	703	7,442	37,462	57,408
1986	9,801	671	7,873	38,088	60,584
1987	9,194	702	8,607	38,633	63,027
1988	10,511	800	9,341	39,480	66,029
1989	9,957	981	10,418	40,748	68,708
1990	18,153	991	11,755	41,629	79,883
1991	18,435	966	13,137	42,418	82,827
1992	19,322	1,226	14,006	43,317	85,913
1993	20,634	1,420	15,111	43,884	89,809
1994	23,151	1,487	16,899	44,662	94,428
1995	26,425	1,551	18,408	45,743	99,517
1996	26,771	1,667	20,522	46,509	105,550
1997	28,632	1,625	22,657	47,900	109,571
1998	27,209	1,778	22,267	48,923	107,330
1999	32,659	2,514	22,320	50,980	116,735
2000	30,127	2,849	24,682	52,757	120,220
2001	31,288	2,994	26,157	53,570	123,289
2002	29,819	2,947	26,586	53,939	122,992
2003	33,341	2,832	27,053	54,923	127,280

Continue…

YEAR	FEI	FEA	FES	FER	FET
2004	35,572	3,209	28,093	55,917	132,381
2005	35,458	2,981	28,062	55,868	133,376
2006	44,190	2,604	26,884	55,838	138,622
2007	41,863	2,504	28,258	56,868	139,045
2008	40,326	2,734	30,664	56,537	139,391
2009	41,258	3,016	34,524	56,210	145,101
2010	41,041	3,164	39,031	55,679	149,118
2011	37,666	2,700	41,980	57,615	148,655
2012	36,242	2,766	46,712	61,351	157,352
2013	36,892	2,514	49,833	62,962	160,619
2014	39,392	2,094	51,595	64,475	165,263

Appendix B

The amount of CO2 emissions from energy combustion in Indonesia (in millions of CO2), 1971-2014

YEAR	COI	COA	COS	COR	COT
1971	10.55	0.69	8.23	5.75	25.22
1972	11.90	0.80	8.88	6.75	28.33
1973	14.32	0.84	9.40	7.53	32.09
1974	14.78	0.94	10.80	8.73	35.25
1975	14.88	1.08	11.85	10.02	37.83
1976	14.28	1.11	12.51	10.88	38.78
1977	19.48	1.24	13.55	12.10	46.37
1978	23.01	1.35	14.98	13.18	52.52
1979	26.91	1.50	16.11	14.84	59.36
1980	31.70	1.74	18.17	15.99	67.60
1981	34.01	1.94	19.99	17.14	73.08
1982	35.50	2.09	21.19	16.92	75.70
1983	36.44	2.18	20.52	16.32	75.46
1984	37.74	2.23	20.91	15.75	76.63
1985	44.92	2.18	21.56	15.25	83.91
1986	53.11	2.08	22.74	15.47	93.40
1987	53.42	2.18	24.86	15.36	95.82
1988	59.20	2.48	26.95	15.97	104.60
1989	58.05	3.06	29.90	18.25	109.26
1990	78.36	3.09	33.94	18.50	133.89
1991	84.81	3.00	37.89	19.00	144.70
1992	88.64	3.82	40.26	19.85	152.57
1993	98.40	4.42	43.30	19.66	165.78
1994	105.52	4.62	48.39	20.14	178.67
1995	125.12	4.82	52.88	21.33	204.15
1996	128.24	5.18	58.52	22.59	214.53
1997	143.64	5.05	64.68	22.93	236.30
1998	150.63	5.53	63.05	23.77	242.98
1999	163.50	7.81	63.00	28.10	262.41
2000	147.64	8.35	69.91	29.41	255.31
2001	162.33	8.82	74.12	29.10	274.37
2002	168.34	8.66	75.15	27.84	279.99
2003	196.24	8.30	75.93	28.23	308.70

Continue…

YEAR	COI	COA	COS	COR	COT
2004	200.09	9.45	78.03	28.36	315.93
2005	205.61	8.74	77.14	27.04	318.53
2006	235.07	7.57	73.05	24.36	340.05
2007	245.63	7.23	76.33	24.64	353.83
2008	237.33	7.92	82.79	22.09	350.13
2009	244.19	8.76	93.55	18.48	364.98
2010	244.59	9.19	106.05	16.91	376.74
2011	246.25	7.76	113.90	16.75	384.66
2012	239.69	7.93	126.43	17.46	391.51
2013	239.88	7.13	133.79	18.84	399.64
2014	273.47	5.83	137.63	19.59	436.52

Appendix C

The real GDP, the real GDP per capita and the value added of three main development sectors in Indonesia (in millions of USD at 2010 constant price), 1971-2014

YEAR	VAI	VAA	VAS	GRP	GR
1971	24,705	29,275	25,000	688	81,087
1972	29,893	29,731	26,025	723	87,479
1973	36,086	32,501	26,109	773	96,031
1974	39,168	33,713	29,464	816	103,960
1975	40,178	33,713	34,211	844	110,388
1976	45,102	35,308	34,643	873	116,999
1977	51,268	35,752	38,108	926	127,103
1978	53,980	37,598	44,455	987	138,804
1979	57,079	40,100	48,326	1,032	148,648
1980	62,874	42,874	52,531	1,096	161,618
1981	66,679	44,934	59,096	1,158	174,787
1982	62,838	45,415	63,371	1,144	176,717
1983	72,700	46,265	67,734	1,213	191,649
1984	80,542	48,401	71,547	1,271	205,394
1985	82,051	50,458	74,728	1,288	212,537
1986	87,845	51,763	79,958	1,337	225,214
1987	93,391	52,873	84,913	1,381	237,150
1988	99,808	55,462	90,600	1,441	252,223
1989	115,916	59,783	93,904	1,544	275,137
1990	127,822	61,478	104,401	1,653	299,903
1991	140,479	61,596	117,407	1,770	326,678
1992	165,414	65,253	114,910	1,865	350,266
1993	163,042	66,640	137,486	1,968	375,674
1994	181,250	67,010	147,234	2,083	404,000
1995	200,137	69,942	159,046	2,223	437,922
1996	221,530	72,138	169,132	2,358	471,391
1997	232,987	72,861	178,576	2,433	493,546
1998	200,482	71,891	149,180	2,084	428,759
1999	204,427	73,446	147,642	2,071	432,151
2000	216,468	74,829	155,282	2,143	453,414
2001	222,387	77,265	162,869	2,191	469,934
2002	231,866	79,930	171,331	2,259	491,078
2003	240,573	82,958	182,225	2,336	514,553

Continue….

YEAR	VAI	VAA	VAS	GRP	GR
2004	250,054	85,296	195,182	2,421	540,440
2005	261,817	87,615	210,544	2,525	571,205
2006	273,568	90,555	225,977	2,629	602,627
2007	286,481	93,698	246,313	2,759	640,863
2008	297,190	98,222	267,642	2,887	679,403
2009	307,854	102,110	283,234	2,981	710,852
2010	322,998	105,179	307,067	3,125	755,094
2011	343,508	109,330	332,893	3,275	801,682
2012	361,732	114,344	355,596	3,427	850,024
2013	377,439	119,152	378,320	3,571	897,262
2014	393,567	124,202	401,071	3,703	942,339

Appendix D

Estimation Model 1

Dependent Variable: LFET
Method: ARDL
Date: 08/12/17 Time: 18:33
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments
Maximum dependent lags: 3 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (3 lags, automatic): LVAI LVAA LVAS LGRP
Fixed regressors: C
Number of models evalulated: 768
Selected Model: ARDL(1, 3, 3, 1, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LFET(-1)	0.273989	0.092353	2.966765	0.0062
LVAI	-0.561472	0.441246	-1.272469	0.2141
LVAI(-1)	0.887202	0.415441	2.135564	0.0419
LVAI(-2)	0.156643	0.077004	2.034222	0.0519
LVAI(-3)	0.138202	0.060795	2.273236	0.0312
LVAA	-0.173482	0.303142	-0.572280	0.5719
LVAA(-1)	0.888469	0.364935	2.434595	0.0218
LVAA(-2)	0.058092	0.239503	0.242551	0.8102
LVAA(-3)	-0.333905	0.173736	-1.921914	0.0652
LVAS	-0.777369	0.456039	-1.704609	0.0998
LVAS(-1)	0.517226	0.419618	1.232612	0.2283
LGRP	1.913416	1.095019	1.747381	0.0919
LGRP(-1)	-2.118036	1.031976	-2.052408	0.0499
C	0.645966	0.507584	1.272628	0.2140

R-squared	0.999270	Mean dependent var	11.35819
Adjusted R-squared	0.998918	S.D. dependent var	0.478109
S.E. of regression	0.015723	Akaike info criterion	-5.202165
Sum squared resid	0.006675	Schwarz criterion	-4.617043
Log likelihood	120.6444	Hannan-Quinn criter.	-4.989096
F-statistic	2842.963	Durbin-Watson stat	2.502111
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/12/17 Time: 18:34
Sample: 1974 2014
Included observations: 41
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	14.92738	4

Critical Value Bounds

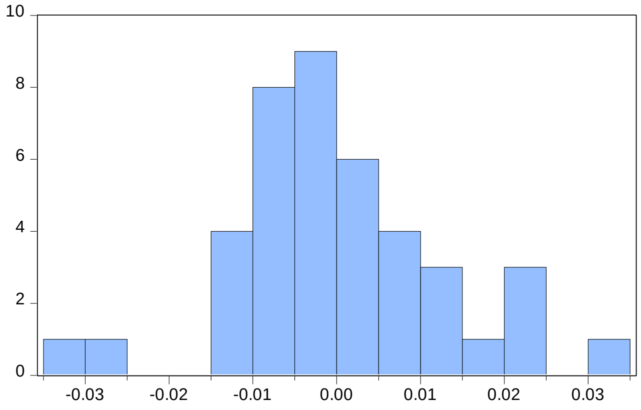
Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

Test Equation:
Dependent Variable: D(LFET)
Method: Least Squares
Date: 08/12/17 Time: 18:34
Sample: 1974 2014
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAI)	-0.561472	0.441246	-1.272469	0.2141
D(LVAI(-1))	-0.294845	0.065968	-4.469529	0.0001
D(LVAI(-2))	-0.138202	0.060795	-2.273236	0.0312
D(LVAA)	-0.173482	0.303142	-0.572280	0.5719
D(LVAA(-1))	0.275814	0.189342	1.456691	0.1567
D(LVAA(-2))	0.333905	0.173736	1.921914	0.0652
D(LVAS)	-0.777369	0.456039	-1.704609	0.0998
D(LGRP)	1.913416	1.095019	1.747381	0.0919
C	0.645966	0.507584	1.272628	0.2140
LVAI(-1)	0.620575	0.096830	6.408883	0.0000
LVAA(-1)	0.439173	0.124365	3.531323	0.0015
LVAS(-1)	-0.260142	0.092244	-2.820154	0.0089
LGRP(-1)	-0.204620	0.167280	-1.223220	0.2318
LFET(-1)	-0.726011	0.092353	-7.861260	0.0000

R-squared	0.795788	Mean dependent var	0.038477
Adjusted R-squared	0.697463	S.D. dependent var	0.028586
S.E. of regression	0.015723	Akaike info criterion	-5.202165
Sum squared resid	0.006675	Schwarz criterion	-4.617043
Log likelihood	120.6444	Hannan-Quinn criter.	-4.989096
F-statistic	8.093485	Durbin-Watson stat	2.502111
Prob(F-statistic)	0.000003		

Normality test:



Series: Residuals
Sample 1974 2014
Observations 41

Mean	-2.68e-15
Median	-0.001433
Maximum	0.033108
Minimum	-0.030906
Std. Dev.	0.012918
Skewness	0.110437
Kurtosis	3.568689
Jarque-Bera	0.635828
Probability	0.727665

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	1.804283	Prob. F(3,24)	0.1733
Obs*R-squared	7.545234	Prob. Chi-Square(3)	0.0564

Heteroskedasticity Test: ARCH

F-statistic	2.571150	Prob. F(3,34)	0.0703
Obs*R-squared	7.026776	Prob. Chi-Square(3)	0.0710

Ramsey RESET Test
Equation: UNTITLED
Specification: LFET LFET(-1) LVAI LVAI(-1) LVAI(-2) LVAI(-3) LVAA LVAA(-1) LVAA(-2) LVAA(-3) LVAS LVAS(-1) LGRP LGRP(-1) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.493929	26	0.1472
F-statistic	2.231824	(1, 26)	0.1472

ARDL Cointegrating And Long Run Form
Original dep. variable: LFET
Selected Model: ARDL(1, 3, 3, 1, 1)
Date: 08/12/17 Time: 18:40
Sample: 1971 2014
Included observations: 41

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAI)	-0.561472	0.165266	-3.397390	0.0021
D(LVAI(-1))	-0.294845	0.057188	-5.155698	0.0000
D(LVAI(-2))	-0.138202	0.052769	-2.619009	0.0143
D(LVAA)	-0.173482	0.174616	-0.993507	0.3293
D(LVAA(-1))	0.275814	0.151286	1.823124	0.0794
D(LVAA(-2))	0.333905	0.145270	2.298517	0.0295
D(LVAS)	-0.777369	0.185555	-4.189435	0.0003
D(LGRP)	1.913416	0.429587	4.454082	0.0001
C	0.645966	0.068521	9.427313	0.0000
CointEq(-1)	-0.726011	0.078427	-9.257117	0.0000

Cointeq = LFET - (0.8548*LVAI + 0.6049*LVAA -0.3583*LVAS -0.2818 *LGRP)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVAI	0.854774	0.085165	10.036700	0.0000
LVAA	0.604913	0.148497	4.073581	0.0004
LVAS	-0.358318	0.120668	-2.969463	0.0062
LGRP	-0.281842	0.227682	-1.237874	0.2264

Dependent Variable: D(LFET)
Method: Least Squares
Date: 07/10/17 Time: 23:32
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAI)	-0.561472	0.165266	-3.397390	0.0019
D(LVAI(-1))	-0.294845	0.057188	-5.155698	0.0000
D(LVAI(-2))	-0.138202	0.052769	-2.619009	0.0135
D(LVAA)	-0.173482	0.174616	-0.993507	0.3282
D(LVAA(-1))	0.275814	0.151286	1.823124	0.0779
D(LVAA(-2))	0.333905	0.145270	2.298517	0.0284
D(LVAS)	-0.777369	0.185555	-4.189435	0.0002
D(LGRP)	1.913416	0.429587	4.454082	0.0001
C	0.645966	0.068521	9.427313	0.0000
ECT1(-1)	-0.726011	0.078427	-9.257117	0.0000

R-squared	0.795788	Mean dependent var	0.038477
Adjusted R-squared	0.736500	S.D. dependent var	0.028586
S.E. of regression	0.014674	Akaike info criterion	-5.397287
Sum squared resid	0.006675	Schwarz criterion	-4.979343
Log likelihood	120.6444	Hannan-Quinn criter.	-5.245095
F-statistic	13.42253	Durbin-Watson stat	2.502111
Prob(F-statistic)	0.000000		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	12.79227	(3, 31)	0.0000
Chi-square	38.37681	3	0.0000

Null Hypothesis: C(1)=C(2)=C(3)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	-0.561472	0.165266
C(2)	-0.294845	0.057188
C(3)	-0.138202	0.052769

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	3.140444	(3, 31)	0.0392
Chi-square	9.421333	3	0.0242

Null Hypothesis: C(4)=C(5)=C(6)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-0.173482	0.174616
C(5)	0.275814	0.151286
C(6)	0.333905	0.145270

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-4.189435	31	0.0002
F-statistic	17.55136	(1, 31)	0.0002
Chi-square	17.55136	1	0.0000

Null Hypothesis: C(7)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(7)	-0.777369	0.185555

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	4.454082	31	0.0001
F-statistic	19.83884	(1, 31)	0.0001
Chi-square	19.83884	1	0.0000

Null Hypothesis: C(8)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(8)	1.913416	0.429587

Appendix E

Estimation Model 2

Dependent Variable: LGR
Method: ARDL
Date: 08/12/17 Time: 20:02
Sample (adjusted): 1976 2014
Included observations: 39 after adjustments
Maximum dependent lags: 5 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (5 lags, automatic): LFEI LFEA LFES LFER
Fixed regressors: C
Number of models evalulated: 6480
Selected Model: ARDL(1, 0, 5, 4, 5)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LGR(-1)	0.878702	0.193110	4.550262	0.0002
LFEI	0.026109	0.045599	0.572577	0.5736
LFEA	-0.034284	0.069551	-0.492939	0.6277
LFEA(-1)	0.099202	0.100499	0.987092	0.3360
LFEA(-2)	-0.049113	0.107057	-0.458757	0.6516
LFEA(-3)	0.053292	0.104964	0.507716	0.6175
LFEA(-4)	-0.031725	0.103932	-0.305250	0.7635
LFEA(-5)	-0.210549	0.100591	-2.093129	0.0500
LFES	0.370301	0.187857	1.971181	0.0634
LFES(-1)	-0.603736	0.277738	-2.173761	0.0426
LFES(-2)	-0.034761	0.286411	-0.121369	0.9047
LFES(-3)	0.365864	0.253929	1.440812	0.1659
LFES(-4)	-0.346427	0.176629	-1.961326	0.0647
LFER	0.475092	0.663741	0.715780	0.4828
LFER(-1)	-1.110999	0.889992	-1.248325	0.2271
LFER(-2)	2.646250	0.999584	2.647352	0.0159
LFER(-3)	-2.182874	1.101267	-1.982149	0.0621
LFER(-4)	0.285590	1.136443	0.251302	0.8043
LFER(-5)	1.562985	0.969711	1.611805	0.1235
C	-12.97607	4.394019	-2.953120	0.0082

R-squared	0.998902	Mean dependent var	12.79997
Adjusted R-squared	0.997804	S.D. dependent var	0.596061
S.E. of regression	0.027931	Akaike info criterion	-4.011624
Sum squared resid	0.014823	Schwarz criterion	-3.158515
Log likelihood	98.22667	Hannan-Quinn criter.	-3.705536
F-statistic	909.8173	Durbin-Watson stat	1.890197
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/12/17 Time: 20:03
Sample: 1976 2014
Included observations: 39
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	3.651605	4

Critical Value Bounds

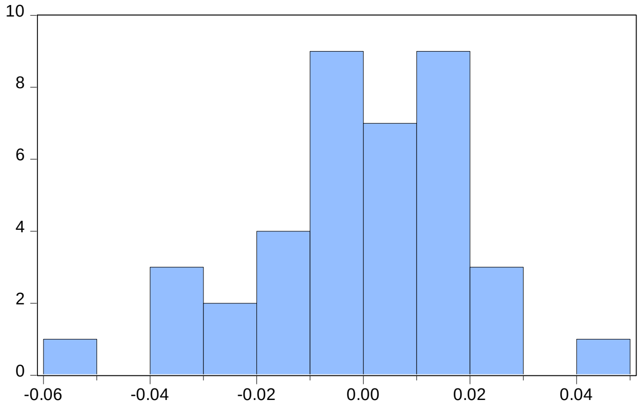
Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

Test Equation:
Dependent Variable: D(LGR)
Method: Least Squares
Date: 08/12/17 Time: 20:03
Sample: 1976 2014
Included observations: 39

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFEA)	-0.013776	0.072088	-0.191095	0.8505
D(LFEA(-1))	0.220378	0.127843	1.723820	0.1010
D(LFEA(-2))	0.174562	0.118041	1.478826	0.1556
D(LFEA(-3))	0.238841	0.093102	2.565369	0.0189
D(LFEA(-4))	0.194531	0.097512	1.994947	0.0606
D(LFES)	0.351501	0.190438	1.845745	0.0806
D(LFES(-1))	0.048797	0.198163	0.246249	0.8081
D(LFES(-2))	-0.005005	0.187472	-0.026695	0.9790
D(LFES(-3))	0.373142	0.171771	2.172318	0.0427
D(LFER)	0.602223	0.639844	0.941203	0.3584
D(LFER(-1))	-2.259473	0.666406	-3.390535	0.0031
D(LFER(-2))	0.570974	0.684006	0.834750	0.4142
D(LFER(-3))	-1.742936	0.721746	-2.414889	0.0260
D(LFER(-4))	-1.415887	0.951587	-1.487922	0.1532
C	-13.31243	4.421298	-3.010979	0.0072
LFEI(-1)	-0.003002	0.042916	-0.069945	0.9450
LFEA(-1)	-0.125032	0.128400	-0.973769	0.3424
LFES(-1)	-0.336678	0.200753	-1.677074	0.1099
LFER(-1)	1.663426	0.506551	3.283829	0.0039
LGR(-1)	-0.023955	0.170272	-0.140685	0.8896

R-squared	0.715226	Mean dependent var	0.054984
Adjusted R-squared	0.430453	S.D. dependent var	0.037324
S.E. of regression	0.028168	Akaike info criterion	-3.994774
Sum squared resid	0.015075	Schwarz criterion	-3.141665
Log likelihood	97.89809	Hannan-Quinn criter.	-3.688686
F-statistic	2.511563	Durbin-Watson stat	1.976020
Prob(F-statistic)	0.025715		

Normality test:



Series: Residuals	
Sample 1976 2014	
Observations 39	
Mean	1.36e-16
Median	0.002950
Maximum	0.047554
Minimum	-0.051375
Std. Dev.	0.019750
Skewness	-0.346455
Kurtosis	3.321259
Jarque-Bera	0.947912
Probability	0.622535

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.903350	Prob. F(5,14)	0.5059
Obs*R-squared	9.513181	Prob. Chi-Square(5)	0.0903

Heteroskedasticity Test: ARCH

F-statistic	0.731914	Prob. F(5,28)	0.6056
Obs*R-squared	3.930105	Prob. Chi-Square(5)	0.5595

Ramsey RESET Test
Equation: UNTITLED
Specification: LGR LGR(-1) LFEI LFEA LFEA(-1) LFEA(-2) LFEA(-3) LFEA(-4) LFEA(-5) LFES LFES(-1) LFES(-2) LFES(-3) LFES(-4) LFER LFER(-1) LFER(-2) LFER(-3) LFER(-4) LFER(-5) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.570426	18	0.5754
F-statistic	0.325386	(1, 18)	0.5754

ARDL Cointegrating And Long Run Form
Original dep. variable: LGR
Selected Model: ARDL(1, 0, 5, 4, 5)
Date: 08/12/17 Time: 20:07
Sample: 1971 2014
Included observations: 39

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFEI)	0.036598	0.035127	1.041874	0.3105
D(LFEA)	-0.033164	0.056443	-0.587571	0.5637
D(LFEA(-1))	0.236763	0.073962	3.201155	0.0047
D(LFEA(-2))	0.187985	0.081665	2.301900	0.0328
D(LFEA(-3))	0.241960	0.065890	3.672182	0.0016
D(LFEA(-4))	0.213848	0.086298	2.478016	0.0228
D(LFES)	0.366468	0.147144	2.490539	0.0222
D(LFES(-1))	0.010741	0.159150	0.067491	0.9469
D(LFES(-2))	-0.017686	0.149101	-0.118620	0.9068
D(LFES(-3))	0.338599	0.139315	2.430463	0.0252
D(LFER)	0.457622	0.489852	0.934205	0.3619
D(LFER(-1))	-2.292087	0.574768	-3.987850	0.0008
D(LFER(-2))	0.306382	0.541560	0.565739	0.5782
D(LFER(-3))	-1.827936	0.641068	-2.851391	0.0102
D(LFER(-4))	-1.605719	0.859548	-1.868096	0.0773
C	-12.790525	2.842060	-4.500442	0.0002
CointEq(-1)	-0.119579	0.026498	-4.512726	0.0002

Cointeq = LGR - (0.2152*LFEI -1.4277*LFEA -2.0508*LFES + 13.8176*LFER)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LFEI	0.215248	0.228437	0.942262	0.3579
LFEA	-1.427717	1.925067	-0.741645	0.4674
LFES	-2.050817	4.995230	-0.410555	0.6860
LFER	13.817625	22.790265	0.606295	0.5515

Dependent Variable: D(LGR)
Method: Least Squares
Date: 08/12/17 Time: 20:09
Sample (adjusted): 1976 2014
Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFEI)	0.036598	0.035127	1.041874	0.3088
D(LFEA)	-0.033164	0.056443	-0.587571	0.5628
D(LFEA(-1))	0.236763	0.073962	3.201155	0.0041
D(LFEA(-2))	0.187985	0.081665	2.301900	0.0312
D(LFEA(-3))	0.241960	0.065890	3.672182	0.0013
D(LFEA(-4))	0.213848	0.086298	2.478016	0.0214
D(LFES)	0.366468	0.147144	2.490539	0.0208
D(LFES(-1))	0.010741	0.159150	0.067491	0.9468
D(LFES(-2))	-0.017686	0.149101	-0.118620	0.9067
D(LFES(-3))	0.338599	0.139315	2.430463	0.0237
D(LFER)	0.457622	0.489852	0.934205	0.3603
D(LFER(-1))	-2.292087	0.574768	-3.987850	0.0006
D(LFER(-2))	0.306382	0.541560	0.565739	0.5773
D(LFER(-3))	-1.827936	0.641068	-2.851391	0.0093
D(LFER(-4))	-1.605719	0.859548	-1.868096	0.0751
C	-12.79053	2.842060	-4.500442	0.0002
ECT(-1)	-0.119579	0.026498	-4.512726	0.0002

R-squared	0.721144	Mean dependent var	0.054984
Adjusted R-squared	0.518340	S.D. dependent var	0.037324
S.E. of regression	0.025903	Akaike info criterion	-4.169619
Sum squared resid	0.014762	Schwarz criterion	-3.444477
Log likelihood	98.30757	Hannan-Quinn criter.	-3.909444
F-statistic	3.555863	Durbin-Watson stat	1.901556
Prob(F-statistic)	0.003255		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	1.041874	22	0.3088
F-statistic	1.085501	(1, 22)	0.3088
Chi-square	1.085501	1	0.2975

Null Hypothesis: C(1)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.036598	0.035127

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	4.506811	(5, 22)	0.0056
Chi-square	22.53405	5	0.0004

Null Hypothesis: C(2)=C(3)=C(4)=C(5)=C(6)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	-0.033164	0.056443
C(3)	0.236763	0.073962
C(4)	0.187985	0.081665
C(5)	0.241960	0.065890
C(6)	0.213848	0.086298

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	3.769749	(4, 22)	0.0176
Chi-square	15.07900	4	0.0045

Null Hypothesis: C(7)=C(8)=C(9)=C(10)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(7)	0.366468	0.147144
C(8)	0.010741	0.159150
C(9)	-0.017686	0.149101
C(10)	0.338599	0.139315

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	4.047402	(5, 22)	0.0093
Chi-square	20.23701	5	0.0011

Null Hypothesis: C(11)=C(12)=C(13)=C(14)=C(15)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(11)	0.457622	0.489852
C(12)	-2.292087	0.574768
C(13)	0.306382	0.541560
C(14)	-1.827936	0.641068
C(15)	-1.605719	0.859548

Appendix F

Estimation Model 3a

Dependent Variable: LCOI
Method: ARDL
Date: 07/08/17 Time: 11:08
Sample (adjusted): 1975 2014
Included observations: 40 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LFEI LVAI
Fixed regressors: C
Number of models evalulated: 100
Selected Model: ARDL(4, 1, 1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LCOI(-1)	0.454825	0.138391	3.286507	0.0025
LCOI(-2)	-0.061439	0.116453	-0.527587	0.6015
LCOI(-3)	-0.041716	0.119588	-0.348834	0.7296
LCOI(-4)	0.219069	0.096846	2.262034	0.0309
LFEI	0.507951	0.063840	7.956580	0.0000
LFEI(-1)	-0.208515	0.083806	-2.488066	0.0184
LVAI	-0.116947	0.141423	-0.826929	0.4146
LVAI(-1)	0.275891	0.151375	1.822566	0.0780
C	-2.792670	0.844831	-3.305594	0.0024

R-squared	0.998053	Mean dependent var	4.508795
Adjusted R-squared	0.997551	S.D. dependent var	0.894982
S.E. of regression	0.044292	Akaike info criterion	-3.200907
Sum squared resid	0.060816	Schwarz criterion	-2.820909
Log likelihood	73.01814	Hannan-Quinn criter.	-3.063512
F-statistic	1986.559	Durbin-Watson stat	1.797437
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 09:42
Sample: 1975 2014
Included observations: 40
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	7.904956	2

Critical Value Bounds

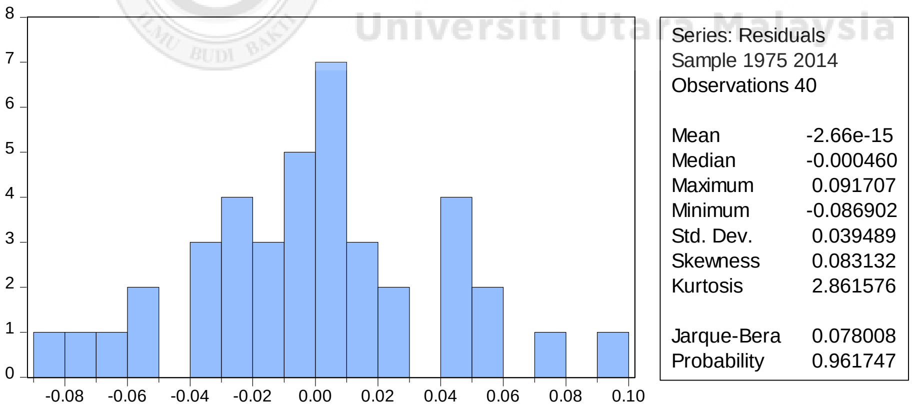
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LCOI)
Method: Least Squares
Date: 08/06/17 Time: 09:42
Sample: 1975 2014
Included observations: 40

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOI(-1))	-0.115914	0.096740	-1.198204	0.2399
D(LCOI(-2))	-0.177353	0.094875	-1.869329	0.0710
D(LCOI(-3))	-0.219069	0.096846	-2.262034	0.0309
D(LFEI)	0.507951	0.063840	7.956580	0.0000
D(LVAI)	-0.116947	0.141423	-0.826929	0.4146
C	-2.792670	0.844831	-3.305594	0.0024
LFEI(-1)	0.299436	0.071388	4.194468	0.0002
LVAI(-1)	0.158944	0.092217	1.723596	0.0947
LCOI(-1)	-0.429262	0.093725	-4.580016	0.0001

R-squared	0.792511	Mean dependent var	0.072948
Adjusted R-squared	0.738965	S.D. dependent var	0.086692
S.E. of regression	0.044292	Akaike info criterion	-3.200907
Sum squared resid	0.060816	Schwarz criterion	-2.820909
Log likelihood	73.01814	Hannan-Quinn criter.	-3.063512
F-statistic	14.80066	Durbin-Watson stat	1.797437
Prob(F-statistic)	0.000000		

Normality test :



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.200532	Prob. F(4,27)	0.9359
Obs*R-squared	1.154052	Prob. Chi-Square(4)	0.8856

Heteroskedasticity Test: ARCH

F-statistic	0.742904	Prob. F(4,31)	0.5701
Obs*R-squared	3.149046	Prob. Chi-Square(4)	0.5332

Ramsey RESET Test
Equation: UNTITLED
Specification: LCOI LCOI(-1) LCOI(-2) LCOI(-3) LCOI(-4) LFEI LFEI(-1) LVAI LVAI(-1) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.302622	30	0.7643
F-statistic	0.091580	(1, 30)	0.7643

Equation: UNTITLED
Specification: LCOI LCOI(-1) LCOI(-2) LCOI(-3) LCOI(-4) LFEI LFEI(-1) LVAI LVAI(-1) C
Test predictions for observations from 1986 to 2014

	Value	df	Probability
F-statistic	1.397978	(29, 2)	0.5025
Likelihood ratio	122.2932	29	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LCOI
Selected Model: ARDL(4, 1, 1)
Date: 07/08/17 Time: 14:53
Sample: 1971 2014
Included observations: 40

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOI(-1))	-0.115914	0.082823	-1.399534	0.1716
D(LCOI(-2))	-0.177353	0.082184	-2.157994	0.0388
D(LCOI(-3))	-0.219069	0.085005	-2.577130	0.0149
D(LFEI)	0.507951	0.052392	9.695282	0.0000
D(LVAI)	-0.116947	0.127831	-0.914857	0.3673
C	-2.792670	0.566080	-4.933352	0.0000
CointEq(-1)	-0.429262	0.085435	-5.024426	0.0000

Cointeq = LCOI - (0.6976*LFEI + 0.3703*LVAI)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LFEI	0.697560	0.126201	5.527368	0.0000
LVAI	0.370273	0.174619	2.120469	0.0421

Dependent Variable: D(LCOI)
Method: Least Squares
Date: 07/11/17 Time: 00:32
Sample (adjusted): 1975 2014
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOI(-1))	-0.115914	0.082823	-1.399534	0.1710
D(LCOI(-2))	-0.177353	0.082184	-2.157994	0.0383
D(LCOI(-3))	-0.219069	0.085005	-2.577130	0.0146
D(LFEI)	0.507951	0.052392	9.695282	0.0000
D(LVAI)	-0.116947	0.127831	-0.914857	0.3669
C	-2.792670	0.566080	-4.933352	0.0000
ECT(-1)	-0.429262	0.085435	-5.024426	0.0000

R-squared	0.792511	Mean dependent var	0.072948
Adjusted R-squared	0.754785	S.D. dependent var	0.086692
S.E. of regression	0.042929	Akaike info criterion	-3.300907
Sum squared resid	0.060816	Schwarz criterion	-3.005353
Log likelihood	73.01814	Hannan-Quinn criter.	-3.194044
F-statistic	21.00738	Durbin-Watson stat	1.797437
Prob(F-statistic)	0.000000		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	9.695282	33	0.0000
F-statistic	93.99849	(1, 33)	0.0000
Chi-square	93.99849	1	0.0000

Null Hypothesis: C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	0.507951	0.052392

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-0.914857	33	0.3669
F-statistic	0.836964	(1, 33)	0.3669
Chi-square	0.836964	1	0.3603

Null Hypothesis: C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5)	-0.116947	0.127831

Appendix G

Estimation Model 3b

Dependent Variable: LFEI
Method: ARDL
Date: 07/08/17 Time: 14:54
Sample (adjusted): 1975 2014
Included observations: 40 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LVAI LCOI
Fixed regressors: C
Number of models evaluated: 100
Selected Model: ARDL(1, 0, 4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LFEI(-1)	0.542114	0.113295	4.784981	0.0000
LVAI	0.001680	0.138359	0.012146	0.9904
LCOI	1.272126	0.160120	7.944838	0.0000
LCOI(-1)	-0.620139	0.235554	-2.632682	0.0129
LCOI(-2)	0.137815	0.187521	0.734931	0.4677
LCOI(-3)	-0.127339	0.189717	-0.671206	0.5069
LCOI(-4)	-0.214097	0.160242	-1.336083	0.1909
C	2.339339	1.318819	1.773814	0.0856

R-squared	0.994313	Mean dependent var	9.735610
Adjusted R-squared	0.993069	S.D. dependent var	0.860457
S.E. of regression	0.071634	Akaike info criterion	-2.257638
Sum squared resid	0.164206	Schwarz criterion	-1.919862
Log likelihood	53.15275	Hannan-Quinn criter.	-2.135508
F-statistic	799.3001	Durbin-Watson stat	2.057404
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 09:53
Sample: 1975 2014
Included observations: 40
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	6.220612	2

Critical Value Bounds

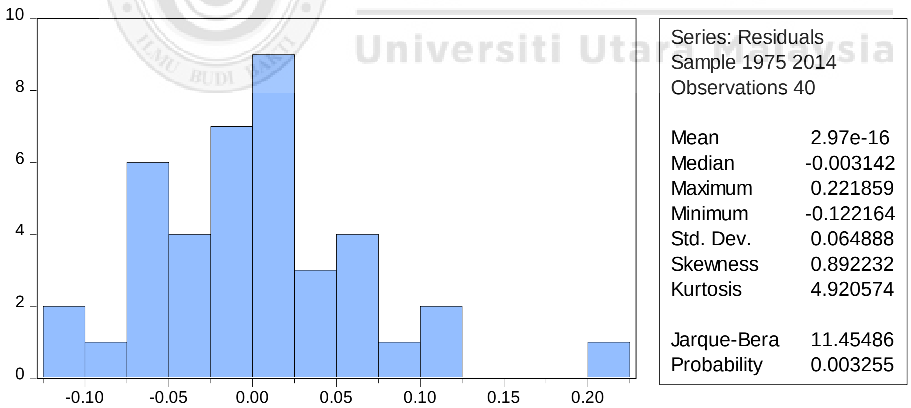
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LFEI)
Method: Least Squares
Date: 08/06/17   Time: 09:53
Sample: 1975 2014
Included observations: 40

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOI)	1.316308	0.165348	7.960817	0.0000
D(LCOI(-1))	0.177019	0.153477	1.153395	0.2573
D(LCOI(-2))	0.318072	0.147898	2.150624	0.0392
D(LCOI(-3))	0.207894	0.155733	1.334938	0.1913
C	3.232283	1.469368	2.199778	0.0352
LVAI(-1)	-0.098620	0.152140	-0.648216	0.5215
LCOI(-1)	0.529698	0.169798	3.119586	0.0038
LFEI(-1)	-0.464454	0.112939	-4.112438	0.0003

R-squared	0.772959	Mean dependent var	0.073937
Adjusted R-squared	0.723294	S.D. dependent var	0.135294
S.E. of regression	0.071168	Akaike info criterion	-2.270678
Sum squared resid	0.162078	Schwarz criterion	-1.932902
Log likelihood	53.41357	Hannan-Quinn criter.	-2.148549
F-statistic	15.56338	Durbin-Watson stat	2.009440
Prob(F-statistic)	0.000000		

Normality test:



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.264200	Prob. F(4,28)	0.8984
Obs*R-squared	1.454806	Prob. Chi-Square(4)	0.8346

Heteroskedasticity Test: ARCH

F-statistic	0.229376	Prob. F(4,31)	0.9198
Obs*R-squared	1.034861	Prob. Chi-Square(4)	0.9045

Ramsey RESET Test
Equation: UNTITLED
Specification: LFEI LFEI(-1) LVAI LCOI LCOI(-1) LCOI(-2) LCOI(-3) LCOI(
-4) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.394660	31	0.6958
F-statistic	0.155756	(1, 31)	0.6958

Chow Forecast Test
Equation: UNTITLED
Specification: LFEI LFEI(-1) LVAI LCOI LCOI(-1) LCOI(-2) LCOI(-3) LCOI(
-4) C
Test predictions for observations from 1986 to 2014

	Value	df	Probability
F-statistic	1.965532	(29, 3)	0.3207
Likelihood ratio	119.8296	29	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LFEI
Selected Model: ARDL(1, 0, 4)
Date: 07/08/17 Time: 15:00
Sample: 1971 2014
Included observations: 40

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAI)	0.191926	0.205252	0.935076	0.3568
D(LCOI)	1.265466	0.131513	9.622337	0.0000
D(LCOI(-1))	0.199883	0.135796	1.471941	0.1508
D(LCOI(-2))	0.335918	0.130595	2.572209	0.0150
D(LCOI(-3))	0.229228	0.138169	1.659038	0.1069
C	2.370288	0.546008	4.341126	0.0001
CointEq(-1)	-0.465840	0.105254	-4.425842	0.0001

Cointeq = LFEI - (0.0037*LVAI + 0.9792*LCOI)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVAI	0.003670	0.302135	0.012147	0.9904
LCOI	0.979208	0.220592	4.438998	0.0001

Dependent Variable: D(LFEI)
Method: Least Squares
Date: 07/11/17 Time: 00:40
Sample (adjusted): 1975 2014
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAI)	0.191926	0.205252	0.935076	0.3565
D(LCOI)	1.265466	0.131513	9.622337	0.0000
D(LCOI(-1))	0.199883	0.135796	1.471941	0.1505
D(LCOI(-2))	0.335918	0.130595	2.572209	0.0148
D(LCOI(-3))	0.229228	0.138169	1.659038	0.1066
C	2.370288	0.546008	4.341126	0.0001
ECT(-1)	-0.465840	0.105254	-4.425842	0.0001

R-squared	0.775815	Mean dependent var	0.073937
Adjusted R-squared	0.735054	S.D. dependent var	0.135294
S.E. of regression	0.069640	Akaike info criterion	-2.333339
Sum squared resid	0.160039	Schwarz criterion	-2.037785
Log likelihood	53.66677	Hannan-Quinn criter.	-2.226476
F-statistic	19.03333	Durbin-Watson stat	2.034093
Prob(F-statistic)	0.000000		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	0.935076	33	0.3565
F-statistic	0.874367	(1, 33)	0.3565
Chi-square	0.874367	1	0.3497

Null Hypothesis: C(1)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.191926	0.205252

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	25.74013	(4, 33)	0.0000
Chi-square	102.9605	4	0.0000

Null Hypothesis: C(2)=C(3)=C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	1.265466	0.131513
C(3)	0.199883	0.135796
C(4)	0.335918	0.130595
C(5)	0.229228	0.138169

Appendix H

Estimation Model 3c

Dependent Variable: LVAI
Method: ARDL
Date: 07/08/17 Time: 15:14
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LCOI LFEI
Fixed regressors: C
Number of models evaluated: 100
Selected Model: ARDL(1, 0, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LVAI(-1)	0.835527	0.097108	8.604125	0.0000
LCOI	0.150663	0.104285	1.444719	0.1565
LFEI	-0.046956	0.062262	-0.754180	0.4553
C	1.787367	0.907439	1.969682	0.0560

R-squared	0.995140	Mean dependent var	11.81324
Adjusted R-squared	0.994766	S.D. dependent var	0.756231
S.E. of regression	0.054710	Akaike info criterion	-2.885120
Sum squared resid	0.116736	Schwarz criterion	-2.721287
Log likelihood	66.03008	Hannan-Quinn criter.	-2.824703
F-statistic	2661.843	Durbin-Watson stat	1.788796
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 09:55
Sample: 1972 2014
Included observations: 43
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	3.508118	2

Critical Value Bounds

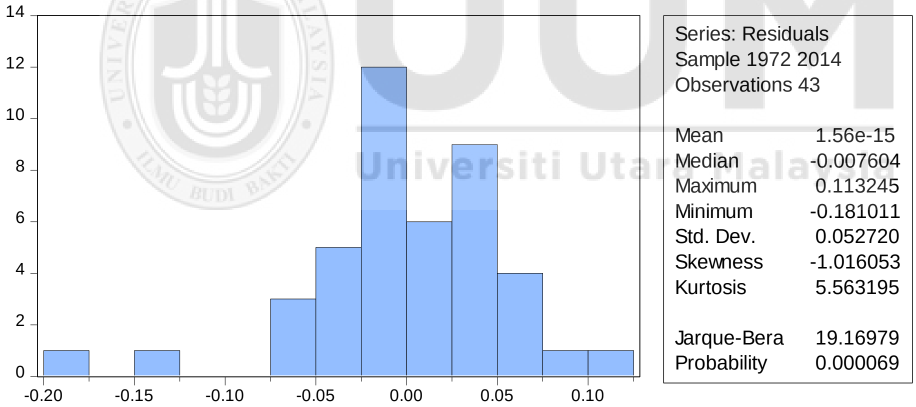
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LVAI)
Method: Least Squares
Date: 08/06/17 Time: 09:55
Sample: 1972 2014
Included observations: 43

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.380094	0.872922	1.581004	0.1220
LCOI(-1)	0.095284	0.099341	0.959163	0.3434
LFEI(-1)	-0.020109	0.064312	-0.312684	0.7562
LVAI(-1)	-0.130590	0.093022	-1.403867	0.1683

R-squared	0.212509	Mean dependent var	0.064378
Adjusted R-squared	0.151932	S.D. dependent var	0.060162
S.E. of regression	0.055404	Akaike info criterion	-2.859923
Sum squared resid	0.119714	Schwarz criterion	-2.696090
Log likelihood	65.48834	Hannan-Quinn criter.	-2.799506
F-statistic	3.508118	Durbin-Watson stat	1.748622
Prob(F-statistic)	0.024055		

Normality test:



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.408938	Prob. F(1,38)	0.5263
Obs*R-squared	0.457819	Prob. Chi-Square(1)	0.4986

Heteroskedasticity Test: ARCH

F-statistic	0.074172	Prob. F(1,40)	0.7868
Obs*R-squared	0.077736	Prob. Chi-Square(1)	0.7804

Ramsey RESET Test
Equation: UNTITLED
Specification: LVAI LVAI(-1) LCOI LFEI C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.809597	38	0.4232
F-statistic	0.655447	(1, 38)	0.4232

Chow Forecast Test
Equation: UNTITLED
Specification: LVAI LVAI(-1) LCOI LFEI C
Test predictions for observations from 1980 to 2014

	Value	df	Probability
F-statistic	1.288239	(35, 4)	0.4519
Likelihood ratio	107.8151	35	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LVAI
Selected Model: ARDL(1, 0, 0)
Date: 07/08/17 Time: 15:21
Sample: 1971 2014
Included observations: 43

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOI)	0.179737	0.152736	1.176780	0.2464
D(LFEI)	-0.074793	0.101577	-0.736317	0.4659
C	1.797373	0.536433	3.350600	0.0018
CointEq(-1)	-0.165437	0.050941	-3.247629	0.0024

Cointeq = LVAI - (0.9160*LCOI -0.2855*LFEI)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCOI	0.916036	0.381516	2.401045	0.0212
LFEI	-0.285497	0.395305	-0.722219	0.4745

Dependent Variable: D(LVAI)
Method: Least Squares
Date: 07/11/17 Time: 00:52
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOI)	0.179737	0.152736	1.176780	0.2464
D(LFEI)	-0.074793	0.101577	-0.736317	0.4659
C	1.797373	0.536433	3.350600	0.0018
ECT(-1)	-0.165437	0.050941	-3.247629	0.0024

R-squared	0.233614	Mean dependent var	0.064378
Adjusted R-squared	0.174661	S.D. dependent var	0.060162
S.E. of regression	0.054657	Akaike info criterion	-2.887089
Sum squared resid	0.116506	Schwarz criterion	-2.723257
Log likelihood	66.07242	Hannan-Quinn criter.	-2.826673
F-statistic	3.962730	Durbin-Watson stat	1.793311
Prob(F-statistic)	0.014724		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	1.176780	39	0.2464
F-statistic	1.384810	(1, 39)	0.2464
Chi-square	1.384810	1	0.2393

Null Hypothesis: C(1)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.179737	0.152736

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-0.736317	39	0.4659
F-statistic	0.542162	(1, 39)	0.4659
Chi-square	0.542162	1	0.4615

Null Hypothesis: C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	-0.074793	0.101577

Appendix I

Estimation Model 4a

Dependent Variable: LCOA
Method: ARDL
Date: 07/09/17 Time: 15:05
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LFEA LVAA
Fixed regressors: C
Number of models evaluated: 100
Selected Model: ARDL(2, 1, 3)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LCOA(-1)	0.991566	0.085397	11.61122	0.0000
LCOA(-2)	0.056618	0.018255	3.101564	0.0040
LFEA	1.035588	0.016562	62.52879	0.0000
LFEA(-1)	-1.075048	0.086758	-12.39127	0.0000
LVAA	0.091872	0.089523	1.026243	0.3125
LVAA(-1)	-0.058879	0.119938	-0.490909	0.6268
LVAA(-2)	0.147230	0.106983	1.376191	0.1783
LVAA(-3)	-0.200174	0.080172	-2.496789	0.0179
C	0.424888	0.517179	0.821549	0.4174

R-squared	0.999884	Mean dependent var	1.350592
Adjusted R-squared	0.999855	S.D. dependent var	0.727662
S.E. of regression	0.008756	Akaike info criterion	-6.446988
Sum squared resid	0.002453	Schwarz criterion	-6.070838
Log likelihood	141.1633	Hannan-Quinn criter.	-6.310015
F-statistic	34528.39	Durbin-Watson stat	1.980166
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 10:04
Sample: 1974 2014
Included observations: 41
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	0.932416	2

Critical Value Bounds

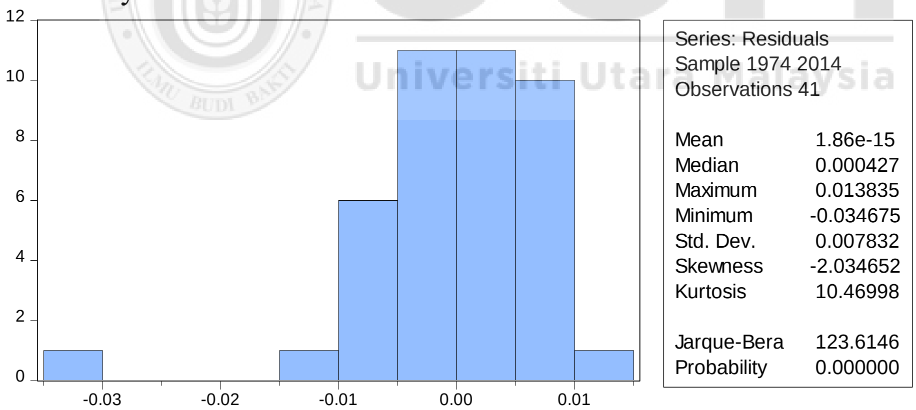
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LCOA)
Method: Least Squares
Date: 08/06/17 Time: 10:04
Sample: 1974 2014
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOA(-1))	-0.056618	0.018255	-3.101564	0.0040
D(LFEA)	1.035588	0.016562	62.52879	0.0000
D(LVAA)	0.091872	0.089523	1.026243	0.3125
D(LVAA(-1))	0.052944	0.077967	0.679055	0.5020
D(LVAA(-2))	0.200174	0.080172	2.496789	0.0179
C	0.424888	0.517179	0.821549	0.4174
LFEA(-1)	-0.039460	0.088937	-0.443686	0.6603
LVAA(-1)	-0.019951	0.015324	-1.301944	0.2022
LCOA(-1)	0.048184	0.091097	0.528934	0.6005

R-squared	0.994594	Mean dependent var	0.047253
Adjusted R-squared	0.993242	S.D. dependent var	0.106510
S.E. of regression	0.008756	Akaike info criterion	-6.446988
Sum squared resid	0.002453	Schwarz criterion	-6.070838
Log likelihood	141.1633	Hannan-Quinn criter.	-6.310015
F-statistic	735.8518	Durbin-Watson stat	1.980166
Prob(F-statistic)	0.000000		

Normality test:



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.924768	Prob. F(3,29)	0.4412
Obs*R-squared	3.579824	Prob. Chi-Square(3)	0.3106

Heteroskedasticity Test: ARCH

F-statistic	0.071993	Prob. F(3,34)	0.9746
Obs*R-squared	0.239865	Prob. Chi-Square(3)	0.9709

Ramsey RESET Test
Equation: UNTITLED
Specification: LCOA LCOA(-1) LCOA(-2) LFEA LFEA(-1) LVAA LVAA(-1) LVAA(-2) LVAA(-3) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.732258	31	0.0932
F-statistic	3.000717	(1, 31)	0.0932

Chow Forecast Test
Equation: UNTITLED
Specification: LCOA LCOA(-1) LCOA(-2) LFEA LFEA(-1) LVAA LVAA(-1) LVAA(-2) LVAA(-3) C
Test predictions for observations from 1984 to 2014

	Value	df	Probability
F-statistic	10.00148	(31, 1)	0.2460
Likelihood ratio	235.3376	31	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LCOA
Selected Model: ARDL(2, 1, 3)
Date: 07/09/17 Time: 15:09
Sample: 1971 2014
Included observations: 41

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOA(-1))	-0.056618	0.016905	-3.349224	0.0021
D(LFEA)	1.035588	0.014870	69.642076	0.0000
D(LVAA)	0.091872	0.078979	1.163240	0.2533
D(LVAA(-1))	0.052944	0.069980	0.756558	0.4548
D(LVAA(-2))	0.200174	0.069770	2.869055	0.0072
C	0.424888	0.253408	1.676696	0.1033
CointEq(-1)	0.048184	0.027950	1.723971	0.0944

Cointeq = LCOA - (0.8189*LFEA + 0.4141*LVAA)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LFEA	0.818943	0.328472	2.493186	0.0180
LVAA	0.414055	0.854074	0.484800	0.6311

Dependent Variable: D(LCOA)
Method: Least Squares
Date: 07/11/17 Time: 01:13
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOA(-1))	-0.056618	0.016905	-3.349224	0.0020
D(LFEA)	1.035588	0.014870	69.64208	0.0000
D(LVAA)	0.091872	0.078979	1.163240	0.2528
D(LVAA(-1))	0.052944	0.069980	0.756558	0.4545
D(LVAA(-2))	0.200174	0.069770	2.869055	0.0070
C	0.424888	0.253408	1.676696	0.1028
ECT(-1)	0.048184	0.027950	1.723971	0.0938

R-squared	0.994594	Mean dependent var	0.047253
Adjusted R-squared	0.993639	S.D. dependent var	0.106510
S.E. of regression	0.008494	Akaike info criterion	-6.544549
Sum squared resid	0.002453	Schwarz criterion	-6.251988
Log likelihood	141.1633	Hannan-Quinn criter.	-6.438014
F-statistic	1042.457	Durbin-Watson stat	1.980166
Prob(F-statistic)	0.000000		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	69.64208	34	0.0000
F-statistic	4850.019	(1, 34)	0.0000
Chi-square	4850.019	1	0.0000

Null Hypothesis: C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	1.035588	0.014870

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	3.222081	(3, 34)	0.0347
Chi-square	9.666244	3	0.0216

Null Hypothesis: C(3)=C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	0.091872	0.078979
C(4)	0.052944	0.069980
C(5)	0.200174	0.069770

Appendix J

Estimation Model 4b

Dependent Variable: LFEA
Method: ARDL
Date: 07/09/17 Time: 16:29
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LVAA LCOA
Fixed regressors: C
Number of models evalulated: 100
Selected Model: ARDL(1, 3, 2)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LFEA(-1)	1.028071	0.085651	12.00306	0.0000
LVAA	-0.081969	0.086292	-0.949909	0.3493
LVAA(-1)	0.044871	0.115507	0.388469	0.7002
LVAA(-2)	-0.142590	0.102844	-1.386476	0.1752
LVAA(-3)	0.199125	0.076576	2.600375	0.0140
LCOA	0.957796	0.015318	62.52879	0.0000
LCOA(-1)	-0.938759	0.087306	-10.75251	0.0000
LCOA(-2)	-0.055743	0.017428	-3.198389	0.0031
C	-0.353264	0.498698	-0.708374	0.4838

R-squared	0.999900	Mean dependent var	7.150687
Adjusted R-squared	0.999875	S.D. dependent var	0.752449
S.E. of regression	0.008421	Akaike info criterion	-6.525078
Sum squared resid	0.002269	Schwarz criterion	-6.148928
Log likelihood	142.7641	Hannan-Quinn criter.	-6.388104
F-statistic	39920.14	Durbin-Watson stat	1.931801
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 10:08
Sample: 1974 2014
Included observations: 41
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	0.793841	2

Critical Value Bounds

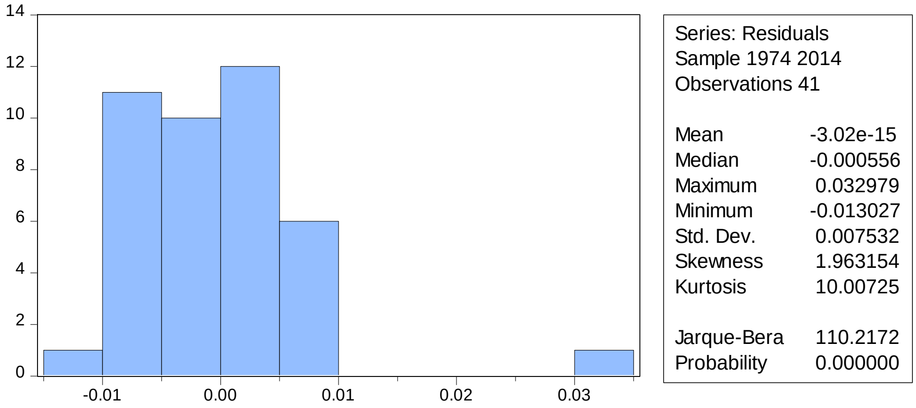
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LFEA)
Method: Least Squares
Date: 08/06/17 Time: 10:08
Sample: 1974 2014
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAA)	-0.081969	0.086292	-0.949909	0.3493
D(LVAA(-1))	-0.056535	0.074856	-0.755248	0.4556
D(LVAA(-2))	-0.199125	0.076576	-2.600375	0.0140
D(LCOA)	0.957796	0.015318	62.52879	0.0000
D(LCOA(-1))	0.055743	0.017428	3.198389	0.0031
C	-0.353264	0.498698	-0.708374	0.4838
LVAA(-1)	0.019436	0.014727	1.319776	0.1963
LCOA(-1)	-0.036706	0.087751	-0.418292	0.6785
LFEA(-1)	0.028071	0.085651	0.327737	0.7452

R-squared	0.994748	Mean dependent var	0.049964
Adjusted R-squared	0.993435	S.D. dependent var	0.103926
S.E. of regression	0.008421	Akaike info criterion	-6.525078
Sum squared resid	0.002269	Schwarz criterion	-6.148928
Log likelihood	142.7641	Hannan-Quinn criter.	-6.388104
F-statistic	757.6046	Durbin-Watson stat	1.931801
Prob(F-statistic)	0.000000		

Normality test:



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.956766	Prob. F(3,29)	0.4263
Obs*R-squared	3.692535	Prob. Chi-Square(3)	0.2966

Heteroskedasticity Test: ARCH

F-statistic	0.070750	Prob. F(3,34)	0.9752
Obs*R-squared	0.235747	Prob. Chi-Square(3)	0.9716

Ramsey RESET Test
Equation: UNTITLED
Specification: LFEA LFEA(-1) LVAA LVAA(-1) LVAA(-2) LVAA(-3) LCOA LCOA(-1) LCOA(-2) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.699320	31	0.0993
F-statistic	2.887688	(1, 31)	0.0993

Chow Forecast Test
Equation: UNTITLED
Specification: LFEA LFEA(-1) LVAA LVAA(-1) LVAA(-2) LVAA(-3) LCOA LCOA(-1) LCOA(-2) C
Test predictions for observations from 1984 to 2014

	Value	df	Probability
F-statistic	11.14219	(31, 1)	0.2335
Likelihood ratio	239.7523	31	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LFEA
Selected Model: ARDL(1, 3, 2)
Date: 07/09/17 Time: 16:48
Sample: 1971 2014
Included observations: 41

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAA)	-0.081969	0.076085	-1.077344	0.2894
D(LVAA(-1))	-0.056535	0.067513	-0.837386	0.4086
D(LVAA(-2))	-0.199125	0.067139	-2.965869	0.0057
D(LCOA)	0.957796	0.013567	70.597653	0.0000
D(LCOA(-1))	0.055743	0.016082	3.466245	0.0015
C	-0.353264	0.229516	-1.539174	0.1336
CointEq(-1)	0.028071	0.017647	1.590713	0.1215

Cointeq = LFEA - (-0.6924*LVAA + 1.3076*LCOA)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVAA	-0.692400	2.229818	-0.310519	0.7582
LCOA	1.307603	0.911079	1.435225	0.1609

Dependent Variable: D(LFEA)
Method: Least Squares
Date: 07/11/17 Time: 02:22
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAA)	-0.081969	0.076085	-1.077344	0.2889
D(LVAA(-1))	-0.056535	0.067513	-0.837386	0.4082
D(LVAA(-2))	-0.199125	0.067139	-2.965869	0.0055
D(LCOA)	0.957796	0.013567	70.59765	0.0000
D(LCOA(-1))	0.055743	0.016082	3.466245	0.0014
C	-0.353264	0.229516	-1.539174	0.1330
ECT(-1)	0.028071	0.017647	1.590713	0.1209

R-squared	0.994748	Mean dependent var	0.049964
Adjusted R-squared	0.993821	S.D. dependent var	0.103926
S.E. of regression	0.008169	Akaike info criterion	-6.622639
Sum squared resid	0.002269	Schwarz criterion	-6.330077
Log likelihood	142.7641	Hannan-Quinn criter.	-6.516104
F-statistic	1073.273	Durbin-Watson stat	1.931801
Prob(F-statistic)	0.000000		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	3.418275	(3, 34)	0.0281
Chi-square	10.25483	3	0.0165

Null Hypothesis: C(1)=C(2)=C(3)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	-0.081969	0.076085
C(2)	-0.056535	0.067513
C(3)	-0.199125	0.067139

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2617.873	(2, 34)	0.0000
Chi-square	5235.746	2	0.0000

Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	0.957796	0.013567
C(5)	0.055743	0.016082

Appendix K

Estimation Model 4c

Dependent Variable: LVAA
Method: ARDL
Date: 07/09/17 Time: 18:28
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LCOA LFEA
Fixed regressors: C
Number of models evaluated: 100
Selected Model: ARDL(3, 1, 1)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LVAA(-1)	1.058652	0.141892	7.460945	0.0000
LVAA(-2)	-0.403334	0.201158	-2.005063	0.0532
LVAA(-3)	0.357319	0.149664	2.387478	0.0228
LCOA	0.211587	0.297689	0.710765	0.4822
LCOA(-1)	-0.597181	0.306253	-1.949959	0.0597
LFEA	-0.189818	0.307874	-0.616544	0.5418
LFEA(-1)	0.556225	0.311842	1.783676	0.0837
C	-2.196306	0.800153	-2.744859	0.0097

R-squared	0.998296	Mean dependent var	11.08020
Adjusted R-squared	0.997934	S.D. dependent var	0.372779
S.E. of regression	0.016944	Akaike info criterion	-5.144641
Sum squared resid	0.009474	Schwarz criterion	-4.810285
Log likelihood	113.4651	Hannan-Quinn criter.	-5.022887
F-statistic	2761.207	Durbin-Watson stat	1.848884
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 10:11
Sample: 1974 2014
Included observations: 41
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	2.757258	2

Critical Value Bounds

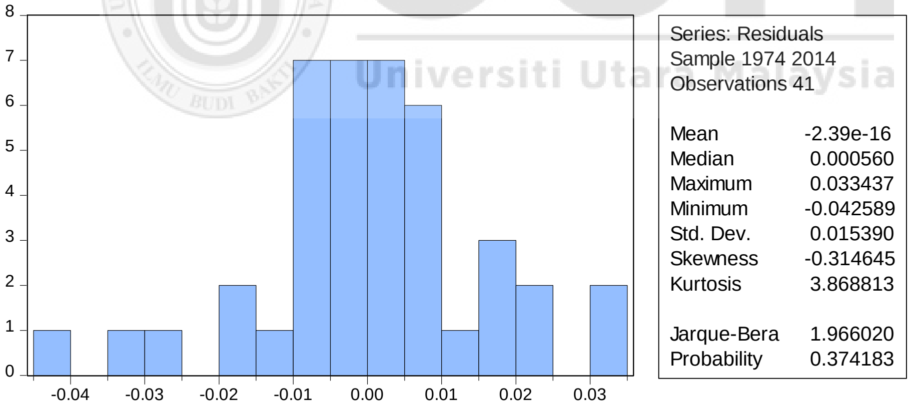
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LVAA)
Method: Least Squares
Date: 08/06/17 Time: 10:11
Sample: 1974 2014
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAA(-1))	0.046014	0.142688	0.322484	0.7491
D(LVAA(-2))	-0.357319	0.149664	-2.387478	0.0228
D(LCOA)	0.211587	0.297689	0.710765	0.4822
D(LFEA)	-0.189818	0.307874	-0.616544	0.5418
C	-2.196306	0.800153	-2.744859	0.0097
LCOA(-1)	-0.385594	0.148052	-2.604462	0.0137
LFEA(-1)	0.366407	0.147409	2.485651	0.0182
LVAA(-1)	0.012637	0.027925	0.452546	0.6538

R-squared	0.308472	Mean dependent var	0.032698
Adjusted R-squared	0.161785	S.D. dependent var	0.018507
S.E. of regression	0.016944	Akaike info criterion	-5.144641
Sum squared resid	0.009474	Schwarz criterion	-4.810285
Log likelihood	113.4651	Hannan-Quinn criter.	-5.022887
F-statistic	2.102919	Durbin-Watson stat	1.848884
Prob(F-statistic)	0.070985		

Normality test:



Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.174412	Prob. F(3,30)	0.9129
Obs*R-squared	0.702833	Prob. Chi-Square(3)	0.8725

Heteroskedasticity Test: ARCH

F-statistic	1.563529	Prob. F(3,34)	0.2161
Obs*R-squared	4.606866	Prob. Chi-Square(3)	0.2030

Ramsey RESET Test
Equation: UNTITLED
Specification: LVAA LVAA(-1) LVAA(-2) LVAA(-3) LCOA LCOA(-1) LFEA
LFEA(-1) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.713329	32	0.0963
F-statistic	2.935496	(1, 32)	0.0963

Chow Forecast Test
Equation: UNTITLED
Specification: LVAA LVAA(-1) LVAA(-2) LVAA(-3) LCOA LCOA(-1) LFEA
LFEA(-1) C
Test predictions for observations from 1984 to 2014

	Value	df	Probability
F-statistic	0.947278	(31, 2)	0.6399
Likelihood ratio	112.8552	31	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LVAA
Selected Model: ARDL(3, 1, 1)
Date: 07/09/17 Time: 18:42
Sample: 1971 2014
Included observations: 41

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAA(-1))	0.046014	0.135328	0.340021	0.7360
D(LVAA(-2))	-0.357319	0.140197	-2.548697	0.0156
D(LCOA)	0.211587	0.287682	0.735489	0.4672
D(LFEA)	-0.189818	0.298154	-0.636643	0.5287
C	-2.196306	0.754198	-2.912106	0.0064
CointEq(-1)	0.012637	0.004267	2.961941	0.0056

Cointeq = LVAA - (30.5124*LCOA -28.9941*LFEA)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCOA	30.512372	71.257203	0.428201	0.6713
LFEA	-28.994067	68.812908	-0.421346	0.6762

Dependent Variable: D(LVAA)
Method: Least Squares
Date: 07/11/17 Time: 03:08
Sample (adjusted): 1974 2014
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAA(-1))	0.046014	0.135328	0.340021	0.7359
D(LVAA(-2))	-0.357319	0.140197	-2.548697	0.0154
D(LCOA)	0.211587	0.287682	0.735489	0.4669
D(LFEA)	-0.189818	0.298154	-0.636643	0.5285
C	-2.196306	0.754198	-2.912106	0.0062
ECT(-1)	0.012637	0.004267	2.961941	0.0055

R-squared	0.308472	Mean dependent var	0.032698
Adjusted R-squared	0.209683	S.D. dependent var	0.018507
S.E. of regression	0.016453	Akaike info criterion	-5.242202
Sum squared resid	0.009474	Schwarz criterion	-4.991435
Log likelihood	113.4651	Hannan-Quinn criter.	-5.150887
F-statistic	3.122516	Durbin-Watson stat	1.848884
Prob(F-statistic)	0.019608		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	0.735489	35	0.4669
F-statistic	0.540944	(1, 35)	0.4669
Chi-square	0.540944	1	0.4620

Null Hypothesis: C(3)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	0.211587	0.287682

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-0.636643	35	0.5285
F-statistic	0.405315	(1, 35)	0.5285
Chi-square	0.405315	1	0.5244

Null Hypothesis: C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-0.189818	0.298154

Appendix L

Estimation Model 5a

Dependent Variable: LCOS
Method: ARDL
Date: 07/09/17 Time: 18:45
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LFES LVAS
Fixed regressors: C
Number of models evalulated: 18
Selected Model: ARDL(1, 2, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LCOS(-1)	0.932863	0.065070	14.33624	0.0000
LFES	1.008057	0.022495	44.81196	0.0000
LFES(-1)	-0.903130	0.077186	-11.70074	0.0000
LFES(-2)	-0.044723	0.021391	-2.090732	0.0441
LVAS	0.011282	0.016274	0.693254	0.4929
LVAS(-1)	-0.036466	0.022437	-1.625239	0.1133
LVAS(-2)	0.029041	0.016097	1.804060	0.0801
C	-0.377285	0.356104	-1.059478	0.2969

R-squared	0.999969	Mean dependent var	3.699132
Adjusted R-squared	0.999963	S.D. dependent var	0.778482
S.E. of regression	0.004760	Akaike info criterion	-7.687375
Sum squared resid	0.000770	Schwarz criterion	-7.356391
Log likelihood	169.4349	Hannan-Quinn criter.	-7.566057
F-statistic	156640.3	Durbin-Watson stat	2.110270
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 10:24
Sample: 1973 2014
Included observations: 42
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	0.998888	2

Critical Value Bounds

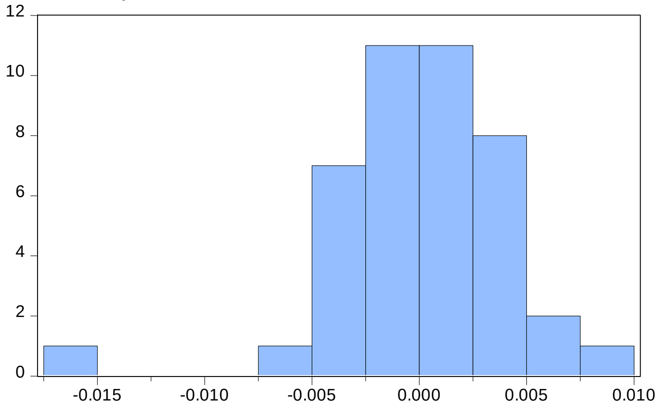
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LCOS)
Method: Least Squares
Date: 08/06/17 Time: 10:24
Sample: 1973 2014
Included observations: 42

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFES)	1.008057	0.022495	44.81196	0.0000
D(LFES(-1))	0.044723	0.021391	2.090732	0.0441
D(LVAS)	0.011282	0.016274	0.693254	0.4929
D(LVAS(-1))	-0.029041	0.016097	-1.804060	0.0801
C	-0.377285	0.356104	-1.059478	0.2969
LFES(-1)	0.060205	0.065090	0.924948	0.3615
LVAS(-1)	0.003857	0.007866	0.490266	0.6271
LCOS(-1)	-0.067137	0.065070	-1.031769	0.3095

R-squared	0.991463	Mean dependent var	0.065256
Adjusted R-squared	0.989705	S.D. dependent var	0.046916
S.E. of regression	0.004760	Akaike info criterion	-7.687375
Sum squared resid	0.000770	Schwarz criterion	-7.356391
Log likelihood	169.4349	Hannan-Quinn criter.	-7.566057
F-statistic	564.0857	Durbin-Watson stat	2.110270
Prob(F-statistic)	0.000000		

Normality test:



Series: Residuals
Sample 1973 2014
Observations 42

Mean	1.34e-15
Median	0.000197
Maximum	0.008406
Minimum	-0.017485
Std. Dev.	0.004335
Skewness	-1.387494
Kurtosis	7.578349
Jarque-Bera	50.15822
Probability	0.000000

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.169766	Prob. F(2,32)	0.8446
Obs*R-squared	0.440957	Prob. Chi-Square(2)	0.8021

Heteroskedasticity Test: ARCH

F-statistic	0.206436	Prob. F(2,37)	0.8144
Obs*R-squared	0.441423	Prob. Chi-Square(2)	0.8019

Ramsey RESET Test
Equation: UNTITLED
Specification: LCOS LCOS(-1) LFES LFES(-1) LFES(-2) LVAS LVAS(-1) LVAS(-2) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.613011	33	0.1163
F-statistic	2.601804	(1, 33)	0.1163

Chow Forecast Test
Equation: UNTITLED
Specification: LCOS LCOS(-1) LFES LFES(-1) LFES(-2) LVAS LVAS(-1) LVAS(-2) C
Test predictions for observations from 1982 to 2014

	Value	df	Probability
F-statistic	0.942926	(33, 1)	0.6894
Likelihood ratio	145.7136	33	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LCOS
Selected Model: ARDL(1, 2, 2)
Date: 07/09/17 Time: 18:48
Sample: 1971 2014
Included observations: 42

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFES)	1.008057	0.021053	47.881332	0.0000
D(LFES(-1))	0.044723	0.020502	2.181448	0.0362
D(LVAS)	0.011282	0.015015	0.751395	0.4576
D(LVAS(-1))	-0.029041	0.015140	-1.918196	0.0635
C	-0.377285	0.208573	-1.808887	0.0793
CointEq(-1)	-0.067137	0.037691	-1.781274	0.0838

Cointeq = LCOS - (0.8967*LFES + 0.0574*LVAS)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LFES	0.896735	0.142649	6.286314	0.0000
LVAS	0.057443	0.141467	0.406050	0.6873

Dependent Variable: D(LCOS)
Method: Least Squares
Date: 07/11/17 Time: 03:15
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFES)	1.008057	0.021053	47.88133	0.0000
D(LFES(-1))	0.044723	0.020502	2.181448	0.0358
D(LVAS)	0.011282	0.015015	0.751395	0.4573
D(LVAS(-1))	-0.029041	0.015140	-1.918196	0.0630
C	-0.377285	0.208573	-1.808887	0.0788
ECT(-1)	-0.067137	0.037691	-1.781274	0.0833

R-squared	0.991463	Mean dependent var	0.065256
Adjusted R-squared	0.990277	S.D. dependent var	0.046916
S.E. of regression	0.004626	Akaike info criterion	-7.782614
Sum squared resid	0.000770	Schwarz criterion	-7.534375
Log likelihood	169.4349	Hannan-Quinn criter.	-7.691624
F-statistic	836.1740	Durbin-Watson stat	2.110270
Prob(F-statistic)	0.000000		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	1565.869	(2, 36)	0.0000
Chi-square	3131.738	2	0.0000

Null Hypothesis: C(1)=C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	1.008057	0.021053
C(2)	0.044723	0.020502

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2.058860	(2, 36)	0.1424
Chi-square	4.117719	2	0.1276

Null Hypothesis: C(3)=C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	0.011282	0.015015
C(4)	-0.029041	0.015140

Appendix M

Estimation Model 5b

Dependent Variable: LFES
Method: ARDL
Date: 07/09/17 Time: 19:27
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LVAS LCOS
Fixed regressors: C
Number of models evaluated: 18
Selected Model: ARDL(1, 0, 1)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LFES(-1)	0.952806	0.060790	15.67380	0.0000
LVAS	0.001993	0.007021	0.283809	0.7781
LCOS	0.956575	0.017855	53.57455	0.0000
LCOS(-1)	-0.908731	0.062728	-14.48695	0.0000
C	0.256219	0.330418	0.775439	0.4429

R-squared	0.999971	Mean dependent var	9.527651
Adjusted R-squared	0.999968	S.D. dependent var	0.830526
S.E. of regression	0.004673	Akaike info criterion	-7.785286
Sum squared resid	0.000830	Schwarz criterion	-7.580495
Log likelihood	172.3836	Hannan-Quinn criter.	-7.709765
F-statistic	331725.1	Durbin-Watson stat	2.247867
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 10:31
Sample: 1972 2014
Included observations: 43
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	0.621663	2

Critical Value Bounds

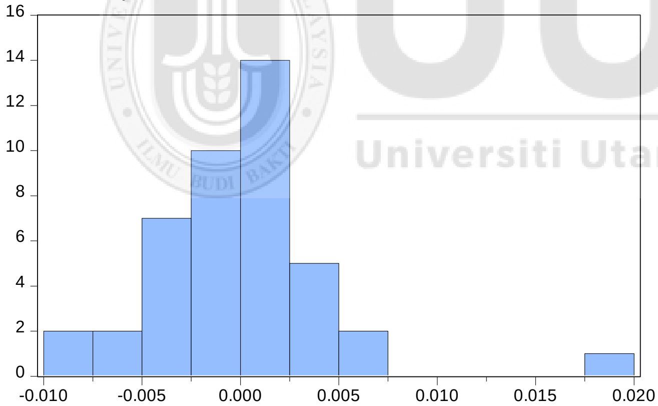
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LFES)
Method: Least Squares
Date: 08/06/17 Time: 10:31
Sample: 1972 2014
Included observations: 43

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOS)	0.957336	0.016778	57.05971	0.0000
C	0.248944	0.324019	0.768301	0.4471
LVAS(-1)	0.002220	0.007103	0.312541	0.7563
LCOS(-1)	0.046617	0.058935	0.790984	0.4339
LFES(-1)	-0.046229	0.058854	-0.785482	0.4370

R-squared	0.989994	Mean dependent var	0.067768
Adjusted R-squared	0.988941	S.D. dependent var	0.044421
S.E. of regression	0.004671	Akaike info criterion	-7.785736
Sum squared resid	0.000829	Schwarz criterion	-7.580945
Log likelihood	172.3933	Hannan-Quinn criter.	-7.710215
F-statistic	939.9200	Durbin-Watson stat	2.229425
Prob(F-statistic)	0.000000		

Normality test:



Series: Residuals	
Sample 1972 2014	
Observations 43	
Mean	9.35e-16
Median	5.05e-05
Maximum	0.019209
Minimum	-0.008493
Std. Dev.	0.004444
Skewness	1.618957
Kurtosis	9.543198
Jarque-Bera	95.49141
Probability	0.000000

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.677025	Prob. F(1,37)	0.4159
Obs*R-squared	0.772675	Prob. Chi-Square(1)	0.3794

Heteroskedasticity Test: ARCH

F-statistic	0.452552	Prob. F(1,40)	0.5050
Obs*R-squared	0.469864	Prob. Chi-Square(1)	0.4930

Ramsey RESET Test
Equation: UNTITLED
Specification: LFES LFES(-1) LVAS LCOS LCOS(-1) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.409532	37	0.1670
F-statistic	1.986781	(1, 37)	0.1670

Chow Forecast Test
Equation: UNTITLED
Specification: LFES LFES(-1) LVAS LCOS LCOS(-1) C
Test predictions for observations from 1982 to 2014

	Value	df	Probability
F-statistic	0.382141	(33, 5)	0.9577
Likelihood ratio	54.13985	33	0.0116

ARDL Cointegrating And Long Run Form
Dependent Variable: LFES
Selected Model: ARDL(1, 0, 1)
Date: 07/09/17 Time: 19:34
Sample: 1971 2014
Included observations: 43

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAS)	0.000121	0.014894	0.008099	0.9936
D(LCOS)	0.957473	0.017148	55.835902	0.0000
C	0.253346	0.183580	1.380033	0.1756
CointEq(-1)	-0.046643	0.034547	-1.350116	0.1850

Cointeq = LFES - (0.0422*LVAS + 1.0138*LCOS)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LVAS	0.042219	0.136465	0.309378	0.7587
LCOS	1.013758	0.136091	7.449104	0.0000

Dependent Variable: D(LFES)
Method: Least Squares
Date: 07/11/17 Time: 03:21
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LVAS)	0.000121	0.014894	0.008099	0.9936
D(LCOS)	0.957473	0.017148	55.83590	0.0000
C	0.253346	0.183580	1.380033	0.1754
ECT(-1)	-0.046643	0.034547	-1.350116	0.1848

R-squared	0.989993	Mean dependent var	0.067768
Adjusted R-squared	0.989224	S.D. dependent var	0.044421
S.E. of regression	0.004611	Akaike info criterion	-7.832206
Sum squared resid	0.000829	Schwarz criterion	-7.668374
Log likelihood	172.3924	Hannan-Quinn criter.	-7.771790
F-statistic	1286.153	Durbin-Watson stat	2.230821
Prob(F-statistic)	0.000000		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	0.008099	39	0.9936
F-statistic	6.56E-05	(1, 39)	0.9936
Chi-square	6.56E-05	1	0.9935

Null Hypothesis: C(1)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.000121	0.014894

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	55.83590	39	0.0000
F-statistic	3117.648	(1, 39)	0.0000
Chi-square	3117.648	1	0.0000

Null Hypothesis: C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	0.957473	0.017148

Appendix N

Estimation Model 5c

Dependent Variable: LVAS
Method: ARDL
Date: 07/09/17 Time: 19:51
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LCOS LFES
Fixed regressors: C
Number of models evaluated: 18
Selected Model: ARDL(1, 1, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LVAS(-1)	0.904282	0.074904	12.07261	0.0000
LCOS	-0.409854	0.619161	-0.661951	0.5120
LCOS(-1)	-0.502590	0.167929	-2.992881	0.0048
LFES	0.966975	0.608789	1.588359	0.1205
C	-4.730878	3.352434	-1.411177	0.1663

R-squared	0.996344	Mean dependent var	11.63396
Adjusted R-squared	0.995959	S.D. dependent var	0.775720
S.E. of regression	0.049310	Akaike info criterion	-3.072437
Sum squared resid	0.092396	Schwarz criterion	-2.867646
Log likelihood	71.05740	Hannan-Quinn criter.	-2.996917
F-statistic	2589.046	Durbin-Watson stat	1.797765
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 10:36
Sample: 1972 2014
Included observations: 43
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	1.284256	2

Critical Value Bounds

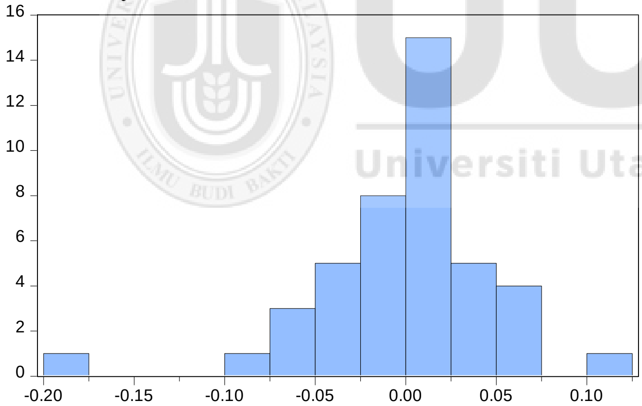
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LVAS)
Method: Least Squares
Date: 08/06/17 Time: 10:36
Sample: 1972 2014
Included observations: 43

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOS)	0.513485	0.176282	2.912858	0.0060
C	-5.199023	3.404426	-1.527136	0.1350
LCOS(-1)	-0.997342	0.619227	-1.610625	0.1155
LFES(-1)	1.052876	0.618370	1.702662	0.0968
LVAS(-1)	-0.098651	0.074631	-1.321850	0.1941

R-squared	0.264100	Mean dependent var	0.064541
Adjusted R-squared	0.186637	S.D. dependent var	0.054423
S.E. of regression	0.049083	Akaike info criterion	-3.081677
Sum squared resid	0.091546	Schwarz criterion	-2.876887
Log likelihood	71.25606	Hannan-Quinn criter.	-3.006157
F-statistic	3.409365	Durbin-Watson stat	1.717798
Prob(F-statistic)	0.017742		

Normality test:



Series: Residuals	
Sample 1972 2014	
Observations 43	
Mean	1.87e-17
Median	0.006152
Maximum	0.121835
Minimum	-0.177808
Std. Dev.	0.046903
Skewness	-0.995655
Kurtosis	6.839011
Jarque-Bera	33.51011
Probability	0.000000

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.346596	Prob. F(1,37)	0.5596
Obs*R-squared	0.399062	Prob. Chi-Square(1)	0.5276

Heteroskedasticity Test: ARCH

F-statistic	0.027522	Prob. F(1,40)	0.8691
Obs*R-squared	0.028879	Prob. Chi-Square(1)	0.8651

Ramsey RESET Test
Equation: UNTITLED
Specification: LVAS LVAS(-1) LCOS LCOS(-1) LFES C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.914263	37	0.0633
F-statistic	3.664403	(1, 37)	0.0633

Chow Forecast Test
Equation: UNTITLED
Specification: LVAS LVAS(-1) LCOS LCOS(-1) LFES C
Test predictions for observations from 1982 to 2014

	Value	df	Probability
F-statistic	2.617467	(33, 5)	0.1426
Likelihood ratio	124.9386	33	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LVAS
Selected Model: ARDL(1, 1, 0)
Date: 07/09/17 Time: 19:57
Sample: 1971 2014
Included observations: 43

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOS)	0.469194	1.595976	0.293985	0.7704
D(LFES)	0.044264	1.666782	0.026557	0.9790
C	-4.935363	2.537799	-1.944741	0.0592
CointEq(-1)	-0.099933	0.051036	-1.958091	0.0576

Cointeq = LVAS - (-9.5326*LCOS + 10.1023*LFES)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCOS	-9.532591	8.728757	-1.092090	0.2817
LFES	10.102288	8.415388	1.200454	0.2374

Dependent Variable: D(LVAS)
Method: Least Squares
Date: 07/11/17 Time: 03:26
Sample (adjusted): 1972 2014
Included observations: 43 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOS)	0.469194	1.595976	0.293985	0.7703
D(LFES)	0.044264	1.666782	0.026557	0.9789
C	-4.935363	2.537799	-1.944741	0.0590
ECT(-1)	-0.099933	0.051036	-1.958091	0.0574

R-squared	0.263654	Mean dependent var	0.064541
Adjusted R-squared	0.207012	S.D. dependent var	0.054423
S.E. of regression	0.048464	Akaike info criterion	-3.127582
Sum squared resid	0.091602	Schwarz criterion	-2.963750
Log likelihood	71.24302	Hannan-Quinn criter.	-3.067166
F-statistic	4.654735	Durbin-Watson stat	1.720242
Prob(F-statistic)	0.007102		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	0.293985	39	0.7703
F-statistic	0.086427	(1, 39)	0.7703
Chi-square	0.086427	1	0.7688

Null Hypothesis: C(1)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.469194	1.595976

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	0.026557	39	0.9789
F-statistic	0.000705	(1, 39)	0.9789
Chi-square	0.000705	1	0.9788

Null Hypothesis: C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	0.044264	1.666782

Appendix O

Estimation Model 6a

Dependent Variable: LCOR
Method: ARDL
Date: 07/09/17 Time: 20:05
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): LFER LGRP
Fixed regressors: C
Number of models evaluated: 18
Selected Model: ARDL(2, 1, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LCOR(-1)	1.226332	0.110837	11.06433	0.0000
LCOR(-2)	-0.261169	0.109154	-2.392670	0.0224
LFER	2.780000	0.584267	4.758096	0.0000
LFER(-1)	-2.889814	0.560213	-5.158418	0.0000
LGRP	0.040054	0.181635	0.220519	0.8268
LGRP(-1)	-0.380580	0.281118	-1.353807	0.1847
LGRP(-2)	0.371731	0.197101	1.885995	0.0679
C	1.016351	1.181776	0.860020	0.3958

R-squared	0.988799	Mean dependent var	2.905742
Adjusted R-squared	0.986493	S.D. dependent var	0.321460
S.E. of regression	0.037360	Akaike info criterion	-3.566809
Sum squared resid	0.047455	Schwarz criterion	-3.235825
Log likelihood	82.90300	Hannan-Quinn criter.	-3.445490
F-statistic	428.7890	Durbin-Watson stat	2.183222
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 10:39
Sample: 1973 2014
Included observations: 42
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	3.632707	2

Critical Value Bounds

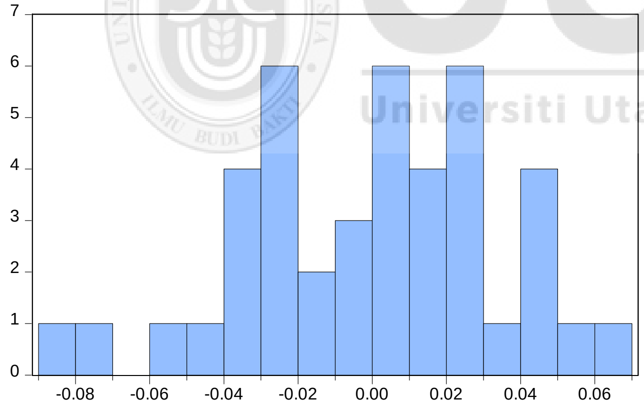
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LCOR)
Method: Least Squares
Date: 08/06/17 Time: 10:39
Sample: 1973 2014
Included observations: 42

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOR(-1))	0.261169	0.109154	2.392670	0.0224
D(LFER)	2.780000	0.584267	4.758096	0.0000
D(LGRP)	0.040054	0.181635	0.220519	0.8268
D(LGRP(-1))	-0.371731	0.197101	-1.885995	0.0679
C	1.016351	1.181776	0.860020	0.3958
LFER(-1)	-0.109813	0.167237	-0.656633	0.5158
LGRP(-1)	0.031205	0.081063	0.384951	0.7027
LCOR(-1)	-0.034836	0.031988	-1.089057	0.2838

R-squared	0.781347	Mean dependent var	0.025368
Adjusted R-squared	0.736330	S.D. dependent var	0.072757
S.E. of regression	0.037360	Akaike info criterion	-3.566809
Sum squared resid	0.047455	Schwarz criterion	-3.235825
Log likelihood	82.90300	Hannan-Quinn criter.	-3.445490
F-statistic	17.35678	Durbin-Watson stat	2.183222
Prob(F-statistic)	0.000000		

Normality test:



Series: Residuals	
Sample 1973 2014	
Observations 42	
Mean	9.99e-15
Median	0.003076
Maximum	0.063978
Minimum	-0.082140
Std. Dev.	0.034021
Skewness	-0.330159
Kurtosis	2.655743
Jarque-Bera	0.970432
Probability	0.615564

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.745338	Prob. F(2,32)	0.4826
Obs*R-squared	1.869428	Prob. Chi-Square(2)	0.3927

Heteroskedasticity Test: ARCH

F-statistic	0.097461	Prob. F(2,37)	0.9074
Obs*R-squared	0.209622	Prob. Chi-Square(2)	0.9005

Ramsey RESET Test
Equation: UNTITLED
Specification: LCOR LCOR(-1) LCOR(-2) LFER LFER(-1) LGRP LGRP(-1) LGRP(-2) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.013964	33	0.3180
F-statistic	1.028123	(1, 33)	0.3180

Chow Forecast Test
Equation: UNTITLED
Specification: LCOR LCOR(-1) LCOR(-2) LFER LFER(-1) LGRP LGRP(-1) LGRP(-2) C
Test predictions for observations from 1984 to 2014

	Value	df	Probability
F-statistic	4.749528	(31, 3)	0.1117
Likelihood ratio	164.3708	31	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LCOR
Selected Model: ARDL(2, 1, 2)
Date: 07/09/17 Time: 20:17
Sample: 1971 2014
Included observations: 42

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOR(-1))	0.261169	0.094541	2.762503	0.0092
D(LFER)	2.780000	0.500603	5.553307	0.0000
D(LGRP)	0.040054	0.168052	0.238343	0.8130
D(LGRP(-1))	-0.371731	0.175609	-2.116815	0.0417
C	1.016351	0.311511	3.262650	0.0025
CointEq(-1)	-0.034836	0.010255	-3.396938	0.0018

Cointeq = LCOR - (-3.1523*LFER + 0.8958*LGRP)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LFER	-3.152261	6.531598	-0.482617	0.6325
LGRP	0.895767	2.609914	0.343217	0.7335

Dependent Variable: D(LCOR)
Method: Least Squares
Date: 07/11/17 Time: 03:32
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCOR(-1))	0.261169	0.094541	2.762503	0.0090
D(LFER)	2.780000	0.500603	5.553307	0.0000
D(LGRP)	0.040054	0.168052	0.238343	0.8130
D(LGRP(-1))	-0.371731	0.175609	-2.116815	0.0413
C	1.016351	0.311511	3.262650	0.0024
ECT(-1)	-0.034836	0.010255	-3.396938	0.0017

R-squared	0.781347	Mean dependent var	0.025368
Adjusted R-squared	0.750978	S.D. dependent var	0.072757
S.E. of regression	0.036307	Akaike info criterion	-3.662048
Sum squared resid	0.047455	Schwarz criterion	-3.413809
Log likelihood	82.90300	Hannan-Quinn criter.	-3.571058
F-statistic	25.72887	Durbin-Watson stat	2.183222
Prob(F-statistic)	0.000000		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	5.553307	36	0.0000
F-statistic	30.83922	(1, 36)	0.0000
Chi-square	30.83922	1	0.0000

Null Hypothesis: C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	2.780000	0.500603

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2.274653	(2, 36)	0.1174
Chi-square	4.549306	2	0.1028

Null Hypothesis: C(3)=C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	0.040054	0.168052
C(4)	-0.371731	0.175609

Appendix P

Estimation Model 6b

Dependent Variable: LFER
Method: ARDL
Date: 07/09/17 Time: 20:18
Sample (adjusted): 1975 2014
Included observations: 40 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LGRP LCOR
Fixed regressors: C
Number of models evalulated: 100
Selected Model: ARDL(4, 0, 4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LFER(-1)	0.986268	0.164210	6.006147	0.0000
LFER(-2)	-0.294476	0.245482	-1.199581	0.2400
LFER(-3)	0.738341	0.328756	2.245868	0.0325
LFER(-4)	-0.418715	0.232893	-1.797884	0.0826
LGRP	0.004152	0.015384	0.269892	0.7892
LCOR	0.164677	0.025343	6.497851	0.0000
LCOR(-1)	-0.139522	0.045741	-3.050254	0.0048
LCOR(-2)	0.005902	0.051957	0.113585	0.9103
LCOR(-3)	-0.143563	0.060119	-2.387992	0.0237
LCOR(-4)	0.102171	0.039144	2.610130	0.0142
C	-0.106919	0.246156	-0.434352	0.6672

R-squared	0.999116	Mean dependent var	10.71678
Adjusted R-squared	0.998811	S.D. dependent var	0.217847
S.E. of regression	0.007510	Akaike info criterion	-6.716645
Sum squared resid	0.001636	Schwarz criterion	-6.252203
Log likelihood	145.3329	Hannan-Quinn criter.	-6.548717
F-statistic	3278.375	Durbin-Watson stat	1.944883
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 10:54
Sample: 1975 2014
Included observations: 40
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	0.715769	2

Critical Value Bounds

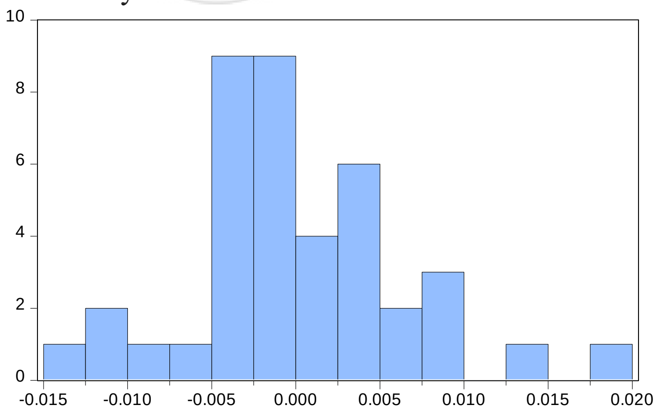
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LFER)
Method: Least Squares
Date: 08/06/17   Time: 10:54
Sample: 1975 2014
Included observations: 40

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFER(-1))	-0.027246	0.167521	-0.162643	0.8719
D(LFER(-2))	-0.315090	0.172264	-1.829115	0.0777
D(LFER(-3))	0.418281	0.232383	1.799965	0.0823
D(LCOR)	0.163828	0.025324	6.469207	0.0000
D(LCOR(-1))	0.036283	0.034660	1.046819	0.3038
D(LCOR(-2))	0.040726	0.037546	1.084686	0.2870
D(LCOR(-3))	-0.101709	0.038889	-2.615333	0.0140
C	-0.072519	0.246833	-0.293795	0.7710
LGRP(-1)	0.006622	0.015156	0.436934	0.6654
LCOR(-1)	-0.010133	0.008550	-1.185197	0.2456
LFER(-1)	0.006431	0.033664	0.191041	0.8498

R-squared	0.773813	Mean dependent var	0.019664
Adjusted R-squared	0.695817	S.D. dependent var	0.013590
S.E. of regression	0.007495	Akaike info criterion	-6.720698
Sum squared resid	0.001629	Schwarz criterion	-6.256256
Log likelihood	145.4140	Hannan-Quinn criter.	-6.552770
F-statistic	9.921231	Durbin-Watson stat	1.949501
Prob(F-statistic)	0.000001		

Normality test:



Series: Residuals	
Sample 1975 2014	
Observations 40	
Mean	-2.38e-15
Median	-0.001247
Maximum	0.019120
Minimum	-0.013735
Std. Dev.	0.006476
Skewness	0.498738
Kurtosis	3.988623
Jarque-Bera	3.287221
Probability	0.193281

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.577567	Prob. F(4,25)	0.6816
Obs*R-squared	3.383737	Prob. Chi-Square(4)	0.4958

Heteroskedasticity Test: ARCH

F-statistic	1.259508	Prob. F(4,31)	0.3069
Obs*R-squared	5.032717	Prob. Chi-Square(4)	0.2840

Ramsey RESET Test
Equation: UNTITLED
Specification: LFER LFER(-1) LFER(-2) LFER(-3) LFER(-4) LGRP LCOR LCOR(-1) LCOR(-2) LCOR(-3) LCOR(-4) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.184301	28	0.8551
F-statistic	0.033967	(1, 28)	0.8551

Chow Forecast Test
Equation: UNTITLED
Specification: LFER LFER(-1) LFER(-2) LFER(-3) LFER(-4) LGRP LCOR LCOR(-1) LCOR(-2) LCOR(-3) LCOR(-4) C
Test predictions for observations from 1988 to 2014

	Value	df	Probability
F-statistic	29.81209	(27, 2)	0.0329
Likelihood ratio	240.0034	27	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LFER
Selected Model: ARDL(4, 0, 4)
Date: 07/09/17 Time: 20:23
Sample: 1971 2014
Included observations: 40

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFER(-1))	-0.044601	0.162531	-0.274413	0.7857
D(LFER(-2))	-0.314913	0.163541	-1.925595	0.0640
D(LFER(-3))	0.410311	0.216982	1.890989	0.0687
D(LGRP)	-0.011192	0.034261	-0.326679	0.7463
D(LCOR)	0.165045	0.023257	7.096559	0.0000
D(LCOR(-1))	0.038998	0.033736	1.155969	0.2571
D(LCOR(-2))	0.040812	0.035547	1.148106	0.2603
D(LCOR(-3))	-0.102172	0.035823	-2.852115	0.0079
C	-0.108327	0.084583	-1.280721	0.2104
CointEq(-1)	0.011638	0.007885	1.475930	0.1507

Cointeq = LFER - (-0.3636*LGRP + 0.9051*LCOR)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGRP	-0.363618	2.365577	-0.153712	0.8789
LCOR	0.905110	2.350514	0.385069	0.7030

Dependent Variable: D(LFER)
Method: Least Squares
Date: 07/11/17 Time: 03:38
Sample (adjusted): 1975 2014
Included observations: 40 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFER(-1))	-0.044601	0.162531	-0.274413	0.7856
D(LFER(-2))	-0.314913	0.163541	-1.925595	0.0637
D(LFER(-3))	0.410311	0.216982	1.890989	0.0683
D(LGRP)	-0.011192	0.034261	-0.326679	0.7462
D(LCOR)	0.165045	0.023257	7.096559	0.0000
D(LCOR(-1))	0.038998	0.033736	1.155969	0.2568
D(LCOR(-2))	0.040812	0.035547	1.148106	0.2600
D(LCOR(-3))	-0.102172	0.035823	-2.852115	0.0078
C	-0.108327	0.084583	-1.280721	0.2101
ECT(-1)	0.011638	0.007885	1.475930	0.1504

R-squared	0.774413	Mean dependent var	0.019664
Adjusted R-squared	0.706737	S.D. dependent var	0.013590
S.E. of regression	0.007359	Akaike info criterion	-6.773356
Sum squared resid	0.001625	Schwarz criterion	-6.351136
Log likelihood	145.4671	Hannan-Quinn criter.	-6.620694
F-statistic	11.44293	Durbin-Watson stat	1.965657
Prob(F-statistic)	0.000000		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-0.326679	30	0.7462
F-statistic	0.106719	(1, 30)	0.7462
Chi-square	0.106719	1	0.7439

Null Hypothesis: C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-0.011192	0.034261

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	16.14587	(4, 30)	0.0000
Chi-square	64.58347	4	0.0000

Null Hypothesis: C(5)=C(6)=C(7)=C(8)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5)	0.165045	0.023257
C(6)	0.038998	0.033736
C(7)	0.040812	0.035547
C(8)	-0.102172	0.035823

Appendix Q

Estimation Model 6c

Dependent Variable: LGRP
Method: ARDL
Date: 07/09/17 Time: 20:30
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LCOR LFER
Fixed regressors: C
Number of models evaluated: 100
Selected Model: ARDL(2, 0, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LGRP(-1)	1.182659	0.158972	7.439400	0.0000
LGRP(-2)	-0.297926	0.165412	-1.801113	0.0798
LCOR	-0.033893	0.028352	-1.195443	0.2395
LFER	0.241993	0.143748	1.683452	0.1007
C	-1.604827	1.021484	-1.571074	0.1247

R-squared	0.994897	Mean dependent var	7.480499
Adjusted R-squared	0.994345	S.D. dependent var	0.451482
S.E. of regression	0.033950	Akaike info criterion	-3.816491
Sum squared resid	0.042647	Schwarz criterion	-3.609626
Log likelihood	85.14632	Hannan-Quinn criter.	-3.740667
F-statistic	1803.409	Durbin-Watson stat	1.984141
Prob(F-statistic)	0.000000		

ARDL Bounds Test
Date: 08/06/17 Time: 10:57
Sample: 1973 2014
Included observations: 42
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	1.408752	2

Critical Value Bounds

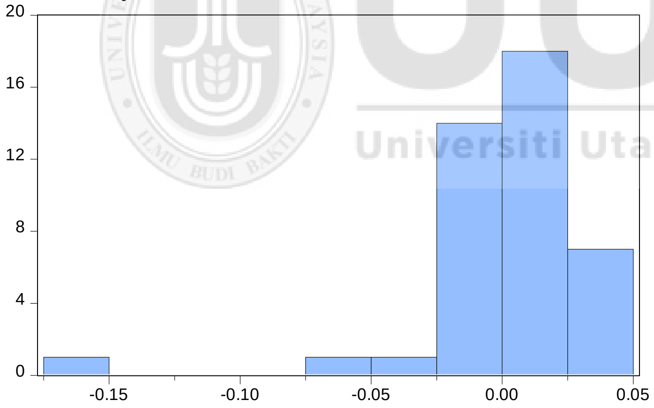
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Test Equation:
Dependent Variable: D(LGRP)
Method: Least Squares
Date: 08/06/17 Time: 10:57
Sample: 1973 2014
Included observations: 42

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGRP(-1))	0.289701	0.159178	1.819979	0.0769
C	-1.560453	1.002094	-1.557191	0.1279
LCOR(-1)	-0.036523	0.027639	-1.321452	0.1945
LFER(-1)	0.233965	0.140656	1.663376	0.1047
LGRP(-1)	-0.108121	0.065493	-1.650869	0.1072

R-squared	0.170233	Mean dependent var	0.038908
Adjusted R-squared	0.080528	S.D. dependent var	0.035431
S.E. of regression	0.033974	Akaike info criterion	-3.815092
Sum squared resid	0.042707	Schwarz criterion	-3.608226
Log likelihood	85.11693	Hannan-Quinn criter.	-3.739268
F-statistic	1.897703	Durbin-Watson stat	1.996149
Prob(F-statistic)	0.131422		

Normality test:



Series: Residuals	
Sample 1973 2014	
Observations 42	
Mean	-1.46e-15
Median	0.004272
Maximum	0.040864
Minimum	-0.166369
Std. Dev.	0.032252
Skewness	-3.353943
Kurtosis	18.14090
Jarque-Bera	479.9245
Probability	0.000000

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.325388	Prob. F(2,35)	0.7244
Obs*R-squared	0.766677	Prob. Chi-Square(2)	0.6816

Heteroskedasticity Test: ARCH

F-statistic	0.021159	Prob. F(2,37)	0.9791
Obs*R-squared	0.045697	Prob. Chi-Square(2)	0.9774

Ramsey RESET Test
Equation: UNTITLED
Specification: LGRP LGRP(-1) LGRP(-2) LCOR LFER C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.851373	36	0.0723
F-statistic	3.427583	(1, 36)	0.0723

Chow Forecast Test
Equation: UNTITLED
Specification: LGRP LGRP(-1) LGRP(-2) LCOR LFER C
Test predictions for observations from 1984 to 2014

	Value	df	Probability
F-statistic	5.623917	(31, 6)	0.0191
Likelihood ratio	142.9299	31	0.0000

ARDL Cointegrating And Long Run Form
Dependent Variable: LGRP
Selected Model: ARDL(2, 0, 0)
Date: 07/09/17   Time: 20:33
Sample: 1971 2014
Included observations: 42

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGRP(-1))	0.302099	0.151608	1.992632	0.0537
D(LCOR)	-0.008246	0.119971	-0.068736	0.9456
D(LFER)	0.185719	0.639843	0.290257	0.7732
C	-1.554641	0.814185	-1.909446	0.0640
CointEq(-1)	-0.111735	0.057450	-1.944923	0.0594

Cointeq = LGRP - (-0.2940*LCOR + 2.0994*LFER)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCOR	-0.294039	0.272530	-1.078921	0.2876
LFER	2.099413	0.324957	6.460590	0.0000

Dependent Variable: D(LGRP)
Method: Least Squares
Date: 07/11/17 Time: 03:43
Sample (adjusted): 1973 2014
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LGRP(-1))	0.302099	0.151608	1.992632	0.0537
D(LCOR)	-0.008246	0.119971	-0.068736	0.9456
D(LFER)	0.185719	0.639843	0.290257	0.7732
C	-1.554641	0.814185	-1.909446	0.0640
ECT(-1)	-0.111735	0.057450	-1.944923	0.0594

R-squared	0.172759	Mean dependent var	0.038908
Adjusted R-squared	0.083328	S.D. dependent var	0.035431
S.E. of regression	0.033922	Akaike info criterion	-3.818142
Sum squared resid	0.042577	Schwarz criterion	-3.611276
Log likelihood	85.18097	Hannan-Quinn criter.	-3.742317
F-statistic	1.931751	Durbin-Watson stat	1.978339
Prob(F-statistic)	0.125612		

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-0.068736	37	0.9456
F-statistic	0.004725	(1, 37)	0.9456
Chi-square	0.004725	1	0.9452

Null Hypothesis: C(2)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	-0.008246	0.119971

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	0.290257	37	0.7732
F-statistic	0.084249	(1, 37)	0.7732
Chi-square	0.084249	1	0.7716

Null Hypothesis: C(3)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	0.185719	0.639843