The Energy-Economic Growth Nexus in Indonesia

Andhyka Tyaz Nugraha*, Nor Hasni Osman
School of Technology Management and Logistics, College of Business, Universiti Utara Malaysia, Sintok, Kedah, Malaysia

Abstract

The aim of this study is to investigate the causal relationship between final energy consumption and economic growth for three main development sectors in Indonesia. In this study, we consider final energy consumption as energy indicator and the value added of development sectors as economic indicator. We use annual data from 1971 to 2014 and collected data from international energy agency and the world development indicator. We use Autoregressive distributed lag (ARDL) technique for cointegration and granger causality approach to explore direction of causality between the variables. We found a bidirectional relationship between energy and economic growth in the industrial sector in the long-run and in services sector in the short-run. Furthermore, we found a unidirectional relationship from economic growth to energy consumption in the services sector in the long-term and in the agriculture sector in the short and long terms. Based on these results, we concluded that economic growth is significantly influenced by final energy consumption on three development sectors in Indonesia, especially in the long-term. However, this study only focus on exploring energy-economic growth nexus on three development sectors in Indonesia and provide specific information for the policy makers on the three sectors in Indonesia. This study provides a new approach in terms of exploring energy-economic growth nexus in a single country and assess that energy-economic growth nexus in a single country should consider situations and conditions in each development sector.

Keywords: ARDL bounds, granger causality, final energy consumption, economic growth, development sector, Indonesia

1.0 Introduction

Energy is one of the major building blocks of society and has become an integral part of human life for almost every activity and pervades all sectors of society, such as trade, labor, environment, international relations, food, health, transportation, etc (Tiwari and Mishra, 2011; Hinrichs and. Kleinbach, 2012). Energy is vital for economic activities because all production and consumption activities are directly related to energy consumption (Yazdi and Shakouri, 2014; Javid and Sharif, 2016). The substitution of

* Corresponding Author
E-mail Address: dhyka_sriwijaya@yahoo.co.id

human power with energy through innovative technology on agriculture, industry and services has indirectly contributed to economic development. The increased availability of energy stimulates economic activities in terms of ability of society to access energy in new forms which are adaptable to a range of needs based on social and cultural characteristic of a society (Reddy and Assenza, 2009).

Every country has several characteristics which distinguish them from other countries, such as the potential domestic energy resources, the quantity of supply and demand of energy, the level and structure of economic development, lifestyles and the level of social welfare, etc. Moreover, developed and developing countries also have the diversity of energy users which certainly have differences in terms of activities, ways and dependence to energy resources. The economic growth in developing and developed countries involves several development sectors which contribute value to national income. Any development sector consists of one or more categories of energy users, which contribute value-added to national income of a country. In general, development sectors in a country can grouped into three, i.e. industry, agriculture, and services (include finance, commercial and public services, transport, etc).

The topic of causal relationship between energy consumption and economic growth in developed and developing countries that have diversity of the structure and level of economic development have been widely studied by many scientists (Chiou-wei et al., 2008). Most of the previous studies that investigate the relationship between energy consumption and economic growth commonly employed total primary energy consumption as energy consumption indicator and real Gross domestic product (GDP) as economic growth indicator (see, Yildirim et al, 2014; Azam et al, 2015b; Talbi, 2015, Tang et al, 2016). In general, those studies made empirical findings under four hypotheses i.e. Growth hypothesis, conservation hypothesis, feedback hypothesis, and neutrality hypothesis (Alshehry and Belloumi, 2014; Bhattacharya et al, 2016).

The growth hypothesis proposes a unidirectional relationship from energy consumption to economic growth. This hypothesis suggests that energy has significant contribution to economic development or income in a country and implies that energy consumption potentially encourage sustainable economic development, but not vice versa. In this situation, the application of energy conservation policies probably has a detrimental impact on economic development process. The conservation hypothesis assert that advancement economic development potentially causes an increase of energy consumption, but not vice versa. This hypothesis asserts that energy conservation policies that are aimed at reducing CO_2 emissions, efficiency improvement and waste management do not necessarily reduce GDP. Therefore, in this situation, energy reduction policies would not have adverse effect on economic growth because economic growth of the country does not seem to be dependent on energy.

The feedback hypothesis implies the interdependent relationship between economic development and energy consumption, where each component may act as a complement to each other. In this situation, any change in energy consumption directly will have significant impact on economic growth and also vice versa. In general, this hypothesis postulates that energy conservation policy can potentially adversely affect economic development, while an increase in the economic growth will directly cause an increase in the amount of energy consumption in a country. Meanwhile, the neutrality hypothesis implies that energy consumption and economic growth do not have any causal relationship, are independent and do not influence each other (Shahbaz et al, 2013b; Bhattacharya et al, 2016). In such situations, applying conservation and exploration energy policies will not have a favorable effect on economic development.

Indonesia is a non-OECD country which previously was an oil exporting country and a member of the Organization of the Petroleum Exporting Countries (OPEC), but later withdrew from OPEC since 2004 in order to struggle to attract sufficient investment to improve productivity of domestic energy supply which currently face some challenges such as inadequate infrastructure and a complex environmental regulations as well as the limitation of domestic petroleum reserves. Nevertheless, Indonesia is the world's fourth-largest producer of coal and a top coal exporter. Indonesia is also Southeast Asia's biggest gas supplier, with exports accounting for roughly 45% of its production. Globally, Indonesia is the tenth-largest gas producer and the seventh-largest exporter of liquefied natural gas (LNG). In terms of renewable energy, Indonesia is the largest producer of biofuels in the world, and is increasingly scaling up efforts to exploit its extensive renewable energy potential, particularly in geothermal power. (EIA, 2016).

According to the International Energy Agency (2016) during the period of 2000-2014 Indonesia's final energy consumption (excluding non-use energy category) was increased by approximately 42.7 percent and mostly dominated by final energy products that were generated from fossil resources such as petroleum, coal, and natural gas. Dependence of Indonesia on energy users against some type of final energy products that generated from fossil resources gradually affect to domestic fossil energy reserves in Indonesia and certainly will threaten the sustainability of energy security, economic development and the stability of social condition in Indonesia. These phenomena certainly are a main concern for the Indonesian government, particularly the policy makers that are involved in implementation of energy policy in the country.

The economic growth of Indonesia was quite stable during recent years since the country faced monetary crisis in 1998. Nevertheless, Indonesian economic development has still remained vulnerable due to structural reforms that have not proceeded as planned by policy makers. Unexpected global economic dynamics give pressure on the domestic economy in Indonesia throughout the past five years. Weak global demand and low international commodity prices undermined Indonesia export performance. The structure of Indonesia's exports still relies on natural resource-based commodities along with other developing countries as the main export destination country. According to the annual data of world development indicator (WDI, 2016), during the period of 2005-2014, the GDP of Indonesia at constant prices increased by an average of 5.7 percent annually.

According to annual data of World Development Indicator (World Bank, 2016), the industrial sector is the largest contributor of value to the national incomes of Indonesia. As the main development sector that drives economic growth of Indonesia, this sector provides vast employment opportunities for Indonesian people. Inflation and decreased Indonesia's economic performance in the two recent decades affected the activity of industrial sector (Agency for The Assessment and Application of Technology, 2016). The weakening of the domestic currency against foreign currencies indirectly causes expenditure for raw material, energy consumption (fuel and electricity) and labor forces in Industrial sector also significantly increased.

Since three decades ago the contribution of agriculture sector to national income of Indonesia has gradually decreased and even currently Indonesia has been an import dependent country for some commodities of agriculture products (Statistics Indonesia, 2015). Most of the energy users in this sector are rural communities that earn income from agriculture, forestry and logging, fishery, plantation and livestock. Technology innovation and utilization of modern agricultural machinery and equipment have been widely applied in Indonesia, which certainly require various types of final energy products as energy source (Prastowo, 2007; Asmara and Handoyo, 2015). Although currently, this sector is the lowest final energy consumer in Indonesia, energy consumption in this sector potentially increase in line with the application of modern technology on agricultural machineries and equipment by energy users in this sector.

Meanwhile, the service sector consists of several sub-sectors that are not included in the criteria of industrial or agricultural sector. This sector has been contributing value-added of more than a third of annual national income of Indonesia during the last two decades (WDI, 2016). This sector is obtaining income from economic activities such as trade, distribution, transportation, commercial and public services. The performance of this sector is very sensitive against any changes in domestic economic situation because almost all the activities in this sector are dependent on stability of the prices of domestic goods and services. Dependence of energy users on transport category against type of fossil fuels and limited capacity of domestic electricity supply are the major problems currently faced by this sector. The rapid growth in the number of motor vehicles and increased commercial and service activities in Indonesia indirectly being great challenge for this sector (Agency for the Assessment and Application of Technology, 2016).

During the past two decades, many experts have examined the relationship between energy consumption and economic growth in Indonesia. However, some of their studies found different results from each other which certainly cannot be used as an appropriate reference for policy makers in Indonesia. The evidence of growth hypothesis was found by Asafu-adjaye (2000), Wahid et al (2013), Chandran and Tang (2013), and Soares et al. (2014). The empirical evidence for conservation hypothesis was found by Hwang and Yoo (2012) and Azam et al (2015a). The empirical evidence for feedback hypothesis was discovered by Chiou et al (2008) and Mahadevan and Asafu-adjaye (2007). While, the empirical evidence for neutral hypothesis had been found by some researchers such as Soytas and Sari (2003), Fatai et al (2004), Shahbaz et al (2013), Saboori and Sulaiman (2013b), Yildirim et al (2014), and Azam et al (2015b).

Overall, the previous studies assumed the nature of temporal causality, both in short-term and long-term, between energy consumption and economic growth in Indonesia. Moreover, those previous studies did not examine the relationship between energy consumption and economic development on three main development sectors. In order to obtain complex and useful information for sustainable development in Indonesia, the observation and investigation that considering a diversity of the category of energy users as a part of development sectors should be applied. Therefore, empirical exploration with the comparative consideration among development sectors is indispensable in order to verify the linkage and to understand the energy-economic growth nexus in Indonesia, especially in order to determine appropriate energy-economic policy which indirectly encourages sustainable economic development in Indonesia.

Based on this issue, we then decided to investigate the causal relationship between final energy consumption and economic growth for three development sectors in Indonesia. This study is expected to provide specific information which can be used as a reference in the determination of energy conservation and economic development policies in Indonesia. We assumed that energy-economic growth nexus on three development sectors in Indonesia certainly is different each other and hence needs appropriate decision and act in order to face a challenge in future. Furthermore, the remainder of this paper consists of four sections. Section two presents data and specification model. Section three discusses the procedure and analysis methods. The empirical results were presented in Section four. The last section provides conclusions and policy implications.

2.0 Data and Model Specifications

The annual data for Indonesia over the period of 1971–2014 was employed for this study. These data were then divided into three categories, i.e. Industry sector, Agriculture sector, and Service sector. Data of the share of value-added by the three development sectors to real GDP of Indonesia were obtained from the World Development Indicators, World Bank. While, data of final energy consumption by energy users on three development sectors, respectively, were collected from The International Energy Agency (IEA). In this study we apply the standard log-linear functional specification in order to investigates the linkage between final energy consumption and value-added for three main development sectors in Indonesia which can be written as follows:

$$\ln VA_t = \alpha_1 + \beta_1 lnFE_t + \varepsilon_{1t}VA_t = \alpha_1 + \beta_1 lnFE_t + \varepsilon_{1t} \quad (1)$$

$$\ln FE_t = \alpha_2 + \beta_2 lnVA_t + \varepsilon_{2t}FE_t = \alpha_2 + \beta_2 lnVA_t + \varepsilon_{2t} \quad (2)$$

where α_1 and α_2 are intercept, β_1 and β_2 are coefficient of independent variable, ε_{1t} and ε_{2t} are error terms, VA_t is the share value added by development sector to real GDP (constant 2010 price in Indonesian rupiahs) and FE_t is final energy consumptions by energy users in each development sectors in Indonesia (thousand tonnes of oil equivalent).

Table 1

Definition and Classification of Data

Development Sector	Final Energy Consumption[a]	Economic Growth[b]
Industry	Total final energy consumptions by final energy users in the category of industry.	The share of value added to real GDP of Indonesia by Industrial sector.
Agriculture	Total final energy consumptions by final energy users in the category of agriculture/forestry and fishery.	The share of value added to real GDP of Indonesia by Agricultural sector
Service	Total final energy consumption by energy users in the category of transportation, commercial and public services, and non specified energy users.	The share of value added to real GDP of Indonesia by Service sector

Note : [a] Based on the classification of energy users by the International Energy Agency (IEA).
[b] Based on the classification of development sectors by World Development Indicator, World Bank.

3.0 Methodology

In this study, we apply the Engle-Granger two steps approach which was proposed by Engle and Granger (1987). In the first step, we check the existence of cointegration between the variables using ARDL bound test proposed by Pesaran (1997), Pesaran and Shin (1999) and Pesaran et al (2001). In the second step, we examine the direction of causal relationships between the variables using granger causality test.

3.1 Autoregressive Distributed Lag (ARDL) Cointegration Analysis

The autoregressive distributed lag (ARDL) bounds testing approach has been extensively used in empirical modelling and has numerous advantages in comparison with other cointegration methods. The ARDL bounds testing approach can be applicable irrespective of whether variables are I(0) and/or I(1) but none of the series are I(2). Therefore, it is necessary to test unit root in order to ensure that all series only stationary at I(0) or I(1) before proceeding to the estimation stage. In this study, we employing augmented Dickey–Fuller (ADF) unit root test which developed by Dickey and Fuller (1979) and Philips–Perron (PP) unit root test developed by Philips and Perron (1988) for checking stationary of data series. Furthermore, a dynamic unrestricted error correction model (UECM) can be derived from the ARDL bounds testing through a simple linear transformation. The UECM integrates the short run dynamics with the long run equilibrium without losing any long run information. The UECM can be expressed as follows:

$$\Delta lnY_t = \alpha + \sum_{i=1}^{a} \phi_i \Delta lnY_{t-i} + \sum_{j=0}^{b} \beta_j \Delta lnX_{t-j} + \lambda_1 lnX_{t-1} + \lambda_2 lnY_{t-1} + \varepsilon_t \quad (3)$$

Where α is intercept, Δ is the first difference operator and ε_t is error term assumed to be independently and identically distributed, Y is a dependent variable, and X is Independent variable. In this study, the optimal lag structure is selected by Akaike information criterion (AIC) which proposed by Akaike (1974). Moreover, we use two set of critical values for smaller and finite samples (30 observations to 80 observations) were developed by Narayan (2005). The critical values of Narayan (2005), were used for purely level variables I(0), purely differenced variables I(1) and a combination of both. The bounds testing procedure is based on the joint F-statistic or Wald statistic which tested the null hypothesis of no cointegration, $H_0: \lambda_r = 0$, against the alternative of $H_1: \lambda_r \neq 0 H_1: \lambda_r \neq 0$, r = 1, 2. We reject the null hypothesis and concluded existence a cointegration relationship if the value of F-statistic exceeds the upper critical value. We can accept the null hypothesis of no cointegration if the value of F-statistic falls below the lower critical bound. However, if the F-statistic lies between the lower and upper critical bounds, it means inference would be inconclusive. In this situation, we should rely on the estimation of the lagged error correction term (ECT) to investigate the long-run relationship between the variables. Furthermore, the long-run model and the short-run dynamics of ARDL model can be written as follows:

$$lnY_t = \alpha + \sum_{i=1}^{c} \phi_i lnY_{t-i} + \sum_{j=0}^{d} \beta_j lnX_{t-j} + \varepsilon_t \quad (4)$$

$$\Delta lnY_t = \alpha + \sum_{i=1}^{e} \phi_i \Delta lnY_{t-i} + \sum_{j=0}^{f} \beta_j \Delta lnX_{t-j} + \psi ECT_{t-1} + \varepsilon_t \quad (5)$$

where ψ is the coefficient of error correction term. The coefficients of the ECT's represent how fast deviations from the long run equilibrium are eliminated following changes in each variable. The long-run causalities are examined through the t-test or Wald test for the significance of the relavant ψ coefficients on the lagged error correction term.

3.2 Granger Causality Test

The ARDL bound tests only examines whether a cointegration or long-run relationship exists between final energy consumption and value-added on three development sector in Indonesia and it does not indicate the direction of causality between both variables.

Therefore, after estimate bound tests, we then estimate the short-run dynamics and error correction term that is given in Eq (5) using granger causality test procedure. Having Eqs. (5) as a reference estimation, Granger causality can be examined in three ways. First, we estimate the significance of $ECT_{t-1}ECT_{t-1}$ in eq. (5) in order to examine existence the long-run causality between the variables. We conclude that there is a long relationship if t-statistics of $ECT_{t-1}ECT_{t-1}$ has negative sign and statistically significant at 5% level. Second, we explore the direction of short-run relationship between the variables which determined by testing the null hypothesis of no granger causality, H_0: $\beta_j = 0$ for all *j* in Eqs. (5). Third, we test the joint significance of the error correction term and the short-run dynamics of ARDL model (strong Granger) which can be detected by testing the null hypothesis of no strong granger causality, H_0: $\beta_j = \psi_1 = 0$ for all *j* in Eqs. (5). However, we only estimate strong granger causality when there is a cointegration or long-run relationship between the variables on our models. The short-run and strong granger causality are determined by the F-statistic of Wald test.

3.3 Empirical Results

The results of ADF and PP unit root tests reported in Table 2. The result of ADF unit root test indicated the series of lnVA and lnFE for Industry sector and agriculture sector are stationary at I(0) and/or I(1), while the series of lnVA and lnFE for service sector is only stationary at I(1). Meanwhile, the result of Phillips-Perron test shows that all series are only stationary at I(1) for three development sectors. Based on these results, we conclude that neither of series are stationary at I(2) and hence we can apply the ARDL bound test in order to examines cointegration relationship between lnVA and lnFE on three development sectors, respectively.

Table 2

ADF and PP Unit Root Tests Result

Sector	Variables	ADF unit root test		PP unit root test	
		Constant	Constant with Trend	Constant	Constant with Trend
Industry	lnFE	-2.579	-0.923	-2.965**	-0.669
	lnVA	-3.231**	-2.416	-3.231**	-2.399
	ΔlnFE	-6.803***	-7.912***	-6.796***	-8.163***
	ΔlnVA	-4.692***	-5.116***	-4.689***	-5.130***
Agriculture	lnFE	-2.695*	0.541	-2.695*	0.571
	lnVA	-0.135	-1.446	-0.134	-1.555
	ΔlnFE	-4.046***	-4.658***	-4.126***	-4.484***
	ΔlnVA	-6.288***	-6.214***	-6.289***	-6.216***

(*continued*)

Sector	Variables	ADF unit root test		PP unit root test	
		Constant	Constant with Trend	Constant	Constant with Trend
Service	lnFE	-1.076	-2.427	-1.164	-1.934
	lnVA	-1.104	-2.275	-1.421	-2.197
	ΔlnFE	-3.735***	-3.792**	-3.805***	-3.862**
	ΔlnVA	-4.385***	-4.423***	-4.382***	-4.428***

Note : ln is symbol of natural logarithm form. Δ is symbol of first difference values. *, **, and *** denotes significance level at 1%, 5%, and 10%, respectively.

The result of ARDL bounds test can be seen in Table 3. In Industry sector, the result of bound test shows that the value of F-statistics has lies between lower and upper critical bounds when final energy consumption determined as dependent variable and upper than the value of upper critical bound at 10% significance level when the value added of Industry sector determined as dependent variable. This result implied possibility existence of bidirectional cointegration relationship between economic growth and final energy consumption in Industry sector or at least, there is one cointegration relationship between economic growth and final energy consumption in Industry sector.

Table 3

ARDL Bound Test Results

Sector	DV	Lags	F- Stat	Decision
Industry	lnFE	1,0	4.132	inconclusive
	lnVA	1,0	5.158*	cointegrated
Agriculture	lnFE	3,3	4.971	inconclusive
	lnVA	1,0	0.363	not cointegrated
Service	lnFE	2,3	4.304	inconclusive
	lnVA	3,2	0.976	not cointegrated

Significance Level	**Critical Bound**		
	1%	5%	**10%**
Lower bound, I(0)	7.740	5.235	4.225
Upper bound, I(1)	8.650	6.135	5.020

Note : ***,**,* denotes significance at 1%, 5%, and 10% levels, respectively. The critical values for the lower I(0) and upper I(1) bounds are taken from Narayan (2005) case III: unrestricted contant without trend, k=45.

Meanwhile, in the agriculture sector and the services sector, the result of ARDL bound test shows that the value of F-statistics stands between the lower and upper critical bound values when final energy consumption as determined as dependent variable and lies below the lower critical bound when the value added of each development sectors was determined as dependent variable. These results indicate a possibility that there is one-way cointegration or long-run relationship running from economic growth to final energy consumption in both development sectors, but not vice versa.

Table 4 shows the result of granger causality tests based selected ARDL models for three development sectors in Indonesia. In Industrial sector, granger causality test discovered a strong bidirectional causality between economic growth and final energy consumption which statistically significant at 1% and 5% levels. However, this relationship specifically only discovered long-term, not short-term. This finding implies that empirical evidence for feedback hypothesis is acceptable for the Industrial sector. Previously, Chiou et al. (2008) and Mahadevan and Asafu-adjaye (2007) also found support for this hypothesis for Indonesia, unfortunately their study did not specifically investigate the case of Industry sector.

Table 4

Granger Causality Based Selected ARDL Models

The null hypotheses	Industry	Agriculture	Service
Short-run (F-statistics)			
$\Delta lnVA \Rightarrow \Delta lnFE\ (H_0: \beta_j = 0)$	0.603	3.188**	6.948***
$\Delta lnFE \Rightarrow \Delta lnVA\ (H_0: \phi_j = 0)$	0.664	0.151	8.190***
Long-run (t-statistics)			
$ECT \Rightarrow \Delta lnFE\ (H_0: \psi_j = 0)$	-2.493**	-3.200***	-2.977***
$ECT \Rightarrow \Delta lnVA\ (H_0: \psi_j = 0)$	-2.857***	0.868	-1.418
Strong Granger (F-statistics)			
$\Delta \ln VA, ECT \Rightarrow \Delta lnFE\ (H_0: \beta_j = \psi_j = 0)$	4.456**	4.275***	7.170***
$\Delta \ln FE, ECT \Rightarrow \Delta lnVA\ (H_0: \phi_j = \psi_j = 0)$	5.487***	-	-

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

In Agriculture sector, granger causality test suggests that there is a strong unidirectional causality relationship from value-added to final energy consumption. This empirical evidence also significant and clearly appear in short and long terms. Therefore, we determine that conservation hypothesis is acceptable for the case of the Agriculture sector. Previously, this hypothesis also had been supported by Hwang and Yoo (2012) and Azam et al. (2015a) for Indonesia. However, their studies did not specifically analysis for case in each development sectors in Indonesia.

In services sector, Granger causality test revealed an existence of a two-way causal relationship between the variables in short-run and a one-way relationship from value-added to final energy consumption in the long-run. These findings indirectly imply an empirical evidence for the feedback hypothesis in the short-term and empirical evidence for conservation hypothesis in the long-term for the case of the Agriculture sector. However, although value-added and final energy consumption is interdependent in the short-term, but the growth of value-added of the service sector potentially control final energy consumption in the long-term. Therefore, we conclude that conservation hypothesis more acceptable for this sector than feedback hypothesis.

4.0 Conclusion

This paper investigates the energy-economic growth nexus in Indonesia using annual data from 1971 to 2014 for three main development sectors, i.e. Industry, Agriculture, and Services. We assume that the energy-economic growth nexus in each development sectors probably are different from each other and hence need specific study in order to provide useful information for the policy makers in Indonesia. In this study we determined final energy consumption as the indicator of energy consumption and the share of value added to real GDP by development sector as the indicator of economic growth. In the first step, we use the ARDL bound test in order to examine the existence of cointegration relationship between final energy consumption and economic growth for three development sectors in Indonesia, respectively. In the second step, we explore the short-run and long-run effects as well as strong causality relationships between final energy consumption and economic growth using Granger causality test approach.

In the industry sector, our study shows that economic development has a significant effect on final energy consumption, and vice versa. This evidence also indicate that the industry sector is an energy-dependent sector in Indonesia and hence energy conservation policies unaccompanied by useful technology innovation and the development of new and renewable energy will be detrimental to sustainable economic development in the industrial sector. Moreover, this situation also suggests that energy conservation policy can adversely affect economic development, while an increase economic performance in this sector will directly cause increase in the amount of final energy consumption in the long-term. Therefore, in order to make these policies more effective and sustainable, government as a policy maker, should encourage the development of technology innovation of green energy and implementing new and renewable energy in this sector.

In the Agriculture sector, our findings imply that economic development has significant affect to final energy consumption in this sector. Therefore, we consider that energy conservation policies have a positive influence on sustainable economic development in this sector. In addition, this sector generates large value-added on national income of Indonesia from biofuels production in future. Therefore, the policy makers should give special attention and support for sustainable economic development in this sector, especially in terms of development of new and renewable energy from agricultural commodities in Indonesia. This is deemed necessary as it relates to sustainable strategy of facing the challenges of increasing energy demand and limitation of conventional energy resources in the future.

In the services sector, our finding implies that initially economic development and final energy consumption in this sector are interdependent in the short-run period, but then economic development is gradually dominating and influencing final energy consumption in this sector for the long-run period. It indicates that the economic performance of this sector is controlling the growth of final energy consumption by energy users in the long-term. In this situation, energy conservation policies implemented by policy makers may cause little adverse impacts on economic development in the short-term. Therefore, energy conservation policies should be implemented gradually so as not to impede and influence short-term economic development in this sector.

Overall, our study concludes that the relationship between final energy consumption and economic growth on three development sectors in Indonesia specifically are different from each other and are the opposite of some conclusions from previous studies. This result supports our earlier assumption that energy economic policies in Indonesia should be applied differently for each development sector. In this study the feedback hypothesis is applicable in the Industrial sector and the conservation hypothesis is applicable in the Agriculture and Services sectors. Therefore, we advise that Indonesian policymakers should establish appropriate energy and economic policies appropriate for the situation and conditions of each development sector in Indonesia, both in short-term and long-term. The implementation of the same policy in all sectors of development will certainly have a negative impact because it may not be in accordance with the conditions and situations faced by each sector of development.

In addition, this study provides an illustration that the application of energy and economic policies in a country should involve and consider the conditions that occur in each energy user group that is part of the development sector in a country. Therefore, it is hoped that future research can take advantage of the issues and challenges faced by each development sector in a country to provide appropriate inputs for sustainable development. Moreover, this study does not consider final energy users on residential category as part of the development sector, hence expected future studies can explore the causal relationship between income and final energy consumption for the category of final energy users in a country.

References

Agency for The Assessment and Application of Technology. (2016). *Indonesia Energy Outlook 2016: Energy Development in Supporting Green Industry. Agency for The Assessment and Application of Technology*, Ministry of Energy and Mineral Resources of Indonesia.

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.

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.

Asmara, A, Y., & Handoyo, S. (2015). *Evidence-Based Policy Making: Study on Policy Making Process for Standardization of the Agriculture Tools and Machinery in Indonesia*. Warta KIML Vol. 13. No.1, 2015. The Research Development Center of Sciences and Technology, Institute Sciences of Indonesia.

Azam, M., Khan, A. Q., Bakhtyar, B., & Emirullah, C. (2015b). The causal relationship between energy consumption and economic growth in the ASEAN-5 countries. *Renewable and Sustainable Energy Reviews*, *47*, 732-745.

Azam, M., Khan, A. Q., Zaman, K., & Ahmad, M. (2015a). Factors determining energy consumption: Evidence from Indonesia, Malaysia and Thailand. *Renewable and Sustainable Energy Reviews*, *42*, 1123-1131.

Bhattacharya, M., Paramati, S. R., Ozturk, I., & Bhattacharya, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied Energy*, *162*, 733-741.

Chandran, V. G. R., & Tang, C. F. (2013). The impacts of transport energy consumption, foreign direct investment and income on CO 2 emissions in ASEAN-5 economies. *Renewable and Sustainable Energy Reviews*, *24*, 445-453.

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.

Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica: Journal of the Econometric Society*, 1057-1072.

Energy Information Administration, US. (2014). *International energy data and analysis: Indonesia*. U.S. Departement of Energy, Washington, DC. Retrieved May 23, 2016 from http://www.eia.gov/beta/international/analysis.cfm?iso=IDN#note.

Engle, R.F., & Granger, C.W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, 251-276..

Fatai, K., Oxley, L., & Scrimgeour, F.G. (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*, 431-445.

Hinrichs, R., & Kleinbach, M. (2012). *Energy: Its use and the environment*. Cengage Learning.

Hwang, J. H., & Yoo, S. H. (2014). Energy consumption, CO2 emissions, and economic growth: Evidence from Indonesia. *Quality and Quantity*, *48*(1), 63-73.

International Energy Agency. (2016). *Indonesia (Association country)*. Retrieved May 20, 2016 from https://www.iea.org/countries/non-membercountries/indonesia/

Javid, M., & Sharif, F. (2016). Environmental Kuznets curve and financial development in Pakistan. *Renewable and Sustainable Energy Reviews*, *54*, 406-414.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12*(2-3), 231-254.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, *52*(2), 169-210.

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.

Narayan, P. K. (2005). The saving and investment nexus for China: Evidence from cointegration tests. *Applied Economics*, *37*(17), 1979-1990.

Pesaran, M. H. (1997). The role of economic theory in modelling the long run. *The Economic Journal*, *107*(440), 178-191.

Pesaran, M. H., & Shin, Y. (1998). An autoregressive distributed-lag modelling approach to cointegration analysis. *Econometric Society Monographs*, *31*, 371-413.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289-326.

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*(2), 335-346.

Prastowo, B. (2008). *Inovasi teknologi pertanian mendukung pengembangan bahan bakar nabati*. A Proceeding Papers on Seminar National of Agricultural Engineering 2008. Department of Agricultural Engineering, Faculty of Agricultural Technology, Gajah Mada University, Yogyakarta, 18-19 November 2008.

Reddy, B. S., and Assenza, G. B. (2009). Climate change–a developing country perspective. Current Science, *97(*1), 50-62.

Saboori, B., & Sulaiman, J. (2013). CO 2 emissions, energy consumption and economic growth in Association of Southeast Asian Nations (ASEAN) countries: A Cointegration Approach. *Energy*, *55*, 813-822.

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., & Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. *Renewable and Sustainable Energy Reviews*, *25*, 109-121.

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.

Soytas, U., & Sari, R. (2003). Energy consumption and GDP: Causality relationship in G-7 and emerging markets. *Energy Economics*, *25*, 33-37.

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, B. W., & Ozturk, I. (2016). Energy consumption and economic growth in Vietnam. *Renewable and Sustainable Energy Reviews*, volume *54*, February 2016, Pages 1506-1514.

Tiwari, G. N., & Mishra, R. K. (2011). Advanced renewable energy sources. *Royal Society of Chemistry*.

Wahid, I. N., Aziz, A. A., & Mustapha, N. H. N. (2013), June. Energy consumption, economic growth and CO2 emissions in selected ASEAN countries. In Proceedings of the Malaysian National Economic Conference (PERKEM) VIII-*Public Policy in the Era of Economic Transformation: Challenges and Future Directions*, 758-765.

World Development Indicators, World Bank. Online Database. World Bank; 2016.

Yazdi, S.K., & 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), 1293-1300.

Yildirim, E., Kuruoglu, 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.