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Environmental Impact of Biomass Energy Consumption on Sustainable Development: Evidence from ARDL Bound Testing Approach

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Abstract

This present study examines the environmental impact of biomass energy consumption as a bioenergy resource in predicting economic growth in Indonesia in the presence of Cobb-Douglas production function. Biomass is considered a sustainable, potentially environmentally sound and a replenishable resource .The present study takes annual time series data over the time period of 1980 to 2017. The study used biomass energy consumption to examine the long run relationship between environment, economic development, capital, labor, exports of goods and services and biomass energy consumption in Indonesia. The author applied the advance econometrics to serve the purpose of environmental investigation and therefore used the ARDL bound testing cointegration for assessing the presence of long-run relationship between the variables. Utilizing the framework of production function, the results of ARDL method confirm the valid long run relationship between biomass energy consumption and economic development in Indonesia. The environmental analysis indicates that biomass energy consumption has positive and significant impact on economic growth in long and short run. Therefore, the findings of the study recommended that biomass energy consumption does not only benefit for the economic development but also helps to improve environmental development in Indonesia.

Keywords: biomass energy consumption, environmental impact, sustainable development, economic growth, Cobb-Douglas

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INTRODUCTION

Organic matter, particularly cellulosic or ligno-cellulosic matter is available on a renewable or recurring basis, including dedicated energy crops and trees, wood and wood residues, plants and associated residues, agricultural food and feed crop residues, plant fiber, aquatic plants, animal wastes, specific industrial waste, the paper component of municipal solid waste, other waste materials, all of them being well-known as biomass. In the same context, the term biobased product is used to designate any commercial or industrial product (either from food or feed) that utilizes biological products or renewable domestic agricultural (plant, animal, or marine) or forestry materials (ABB 2003, Industry Report 2008, OCAPP 2007). Both in the application in chemistry and in transport and the generation of energy, biomass offers great opportunities for the conservation of energy management (IPM 2007). At some stage in human history, biomass in all its forms has been the most important source of various basic needs: food, feed, fuel, feedstock, fibers, fertilizers (Rosillo-Calle 2007). Nowadays, biomass continues to be a subject of growing significance worldwide, in particular due to its suitability as source of bioenergy, as a result of global increase in the demand for energy, the constant rise in the price of fossil fuels and the need to reduce greenhouse gas emissions (Perlack et al. 2005, Thornley and Cooper 2008, Thornley et al. 2008, Yuan et al. 2008).

The state of people's régime and way they live are largely shaped by surrounding environment. The environment around mankind comprises of numerous elements of prevailing life styles, educational development, economic demeanors and the manners in

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which businesses operate in a society (Apergis and Payne 2015). The growing advancements in organizational practices and the immense market competition at both national and international level, in second industrial revolution era, resulted in introducing the extensive energy dependence economies. The development process of many industrialized nations is an outcome of massive power consumption and energy driven. This is the era of the renowned contentious debate of the literature among the adherents of Neo-classical viewpoint and the biophysical & ecological approach. The orthodox systems and beliefs of Neo-classical ideals defines the contribution of energy as a transitional input. The theory gave more emphasis to the other factors of production such as land & labour. On the other hand, the adherents of biophysical & ecological school of thought stress on the role of energy as an essential driver of income generation. Many studies in this regard rebels the neo-classical view and conclude energy as the main influencer of economic development.

However, such extreme utilization of energy in the present globalized world has also brought severe adverse effects to the natural habitat. It does not only hurt the health, security and future stability of the atmosphere but also results in diminishing the natural reserves that form the major constituent of several economies (Sharif et al. 2017a, 2017b). In addition, the adorned usage of energy and its negative impact on the environment created the severe uncertainty related to future human development and the embedded quality of life (Boyi et al. 2017, Dölek and Günes 2016, Jebli and Youssef 2015, Ozturk and Ozturk 2018a, 2018b, Pérez-Luna et al. 2018, Rahman et al. 2017, Tshepo et al. 2017). Adjusting with the economic need. The evolution of third industrial revolution emphasized greatly on the energy consumption. Despite on the conventional fuel-based power utilization, the horizon of third industrial revolution extensively revolves around the paradigm change from the traditional sources of energy to the alternative energy-based economies (Lee et al. 2018). In this way, the importance of renewable sources of energy are being appreciated to ensure the balance between economic need for power consumption and environmental sustainability (Haseeb et al. 2017, Suryanto et al. 2018).

By definition, renewable energy is the power obtained from all such sources in the natural habitat that poses minimum harm to the environment (Apergis and Payne 2014). In this context, the concept of renewable energy consumption makes certain that the prospect of sustainability is protected. The concept of sustainable development enlightens that the mode of bringing ease, efficiency and development in the human life should be allowed in a way that does not stop the future generation to avail the similar advancements in their daily lives (Rayner and Morgan 2018, Abd El-Kader and Al-Jiffri 2018). The contribution of renewable energy is therefore vital to fulfill the objective of sustainable green economies. The utilization of traditional sources of energy in countries for fulfilling economic needs of businesses and human development are defined as the brown economies. On the other hand, green economies are such nations that consume eco-friendly sources of energy and thereby brings technological efficiency by ensuring the prospects of sustainable development. In this way. Green economies are considered to have greater success in applying the visionary paradigms of future development.

There exist several sources of renewable energy, however, the utilization of biomass is famous in fulfilling the cost-efficient needs of the economy by covering multiple aspects of environmental well-being (Adewuyi and Awodumi 2017). The accessibility of biomass energy is achieved from the organic materials. These include wood, agriculture, waste and garbage, alcohol fuels, etc. (Bildirici 2014). Among the benefits of biomass energy, the general acceptance and the ease in production are the most vital factors that attract countries in the process of optimum renewable utilization of energies. The usage of biomass energy is not only limited to single segment but the usefulness of this renewable source of energy is stretched across the needs of household, commercial and industrial sectors (Ahmed et al. 2016). The consumption of biomass energy involves multiple tasks of cooking, electricity generation, space heating and commercial procedures (Jabarullah et al. 2014, Shahbaz et al. 2016).

Keeping in mind the importance of biomass energy in the economic development of energy dependent economies, the present study aims to identify the dependence structure of biomass energy consumption with economic growth of Indonesia. Several studies of the past examine the association of biomass energy with economic development (Adewuyi and Awodumi 2017, Ahmed et al. 2016, Bildirici 2014, Dogan and Inglesi-Lotz 2017, Shahbaz et al. 2016), however, the focus of ample of such investigations are leaned towards panel estimation. Filling the identified gap of the literature, the current study is motivated to perform the all-embracing time series inspection of Indonesian economy to highlights the explicit need of the country

in identifying the significant contribution of biomass energy in the economic progress. Furthermore, the present study is determined to perform the rigorous statistical analysis that can assure the reliability of the outcomes resulted from the use of advanced econometrics. The findings obtained from such vigilant approach would help in attaining useful understanding of the imperative relationship not only for businesses but also for the policymakers in the process of articulating environmental policies (Jabarullah et al. 2015).

The rest of the paper is structured as following. Section two of the study provides detailed literature review in identifying the theoretical connection between economic growth and renewable energy in general and biomass energy in particular. Section three of the present study comprises the details of the applied methods and the information regarding the data collections process. It is followed by chapter four that presents the findings of the statistical analysis and the interpretation of the results. Finally, section five concludes the study and provide policy implications.

LITERATURE REVIEW

Many studies in the existing literature examined the environmental role of energy consumption on economic growth. Several studies found energy to be a significant contributor of economic development, whereas, few concluded energy to be irrelevant for a country's growth process. The advent of third industrial revolution calls for the need of utilizing alternate sources of the energy, the objective of which were more clearly emphasized in the emerging fourth industrial revolution that considers environment to be critical factor of technological evolution (Jabarullah et al. 2016, Lee et al. 2018). This prominence leaded to extensive literary investigations on the contribution of renewable energy utilization on economic growth. However, very few studies examined the contribution of biomass energy consumption in the process of economic expansion (Adewuyi and Awodumi 2017, Jabarullah et al. 2017).

The general effect of energy-growth nexus can be resulted in four possible outcomes. It either lead to validate growth hypothesis that suggests that economic growth leads to higher energy consumption or it can result the opposite hypothesis, also famous as conservative hypothesis that suggest that energy consumption leads to economic development (Jabarullah and Hussain 2018). On the other hand, the relationship can also form a feedback effect where both energy consumption and economic growth correspond to each other simultaneously. And lastly the energy-growth nexus can fall into the category of neutrality effect that concludes no interdependence among the both variable (Jabarullah and Othman 2018). In identifying the relationship between renewable energy, emissions and economic growth, Apergis, Payne, Menyah and Wolde-Rufael (2010) performed the examination of the long run association and causality connections among the variable in nineteen economies. Utilizing the data from the period of 1984 to 2007, the empirical findings concluded that long-run associations exists among economic development, carbon emissions and renewable energy. Furthermore, the results of causal connections established the presence of bi-directional causality between economic development and renewable energy consumption for the panel of nineteen developed and developing economies. Similarly, also analyzed the panel of eleven west African countries for the investigation of renewable energy and growth link. Utilizing the measure of biomass energy, the study examined the sampled nations over the period of 1980 to 2010. The results of the study elaborated the high interactive significance and the presence of feedback association among biomass energy consumption, economic growth and emission in the five economies of Mali, Burkina Faso, Togo, Nigeria and Gambia. For the rest of the six west African countries, the study concluded the presence of partial significance of the studied variables.

In another panel examination, Shahbaz et al. (2016) study the relationship between biomass energy consumption and economic development in BRICS economies. The study utilized the data from the period of 1991 to 2015. The results of the study validated the existence of long run association among the variables. In addition, the results suggested that the usage of biomass encourages economic development. The outcomes of causality effects concluded the presence of bi-directional association among biomass utilization and economic prosperity in BRICCS nations. On the other hand, Dogan and Lotz (2017) identified the connection of environment degradation with biomass energy and economic growth. Utilizing the data from the period of 1985 to 2012, the authors found evidence of significant negative association between biomass energy consumption and emissions in a panel of twenty two developed and developing countries. Furthermore, the findings of the study also concluded the validity of EKC framework in assessing the relationship of economic growth and biomass energy with

environment degradation (Abidin et al. 2015a, 2015b; Azam et al. 2016a, 2016b).

Among the scarce time series literature, Payne (2009) analyzed the causal link between aggregate renewable energy and output growth of United States. The findings of the study failed to establish the significant contribution of renewable energy consumption in influencing US's economic progression. On the other hand, Bowden and Payne (2010) analyzed the relationship between disaggregate renewable energy consumption and output growth of USA. The results of the study supported the conclusion of Payne (2009) for industrial & commercial sectors. However, for residential renewable energy consumption, the outcomes of the investigation established the uni-directional causal connection among the variables. The study summarized that residential renewable energy consumption augmented the real GDP of United States. Similarly, Payne (2011) also analyzed the causal association of biomass energy with economic development of United States. The study utilized the data from the period of 1949 to 2007. In order to detect causal link between both variables, the author applied the statistical method of Toda-Yamamoto causality. Unlike Apergis et al. (2010), the results of the analysis supported the existence of Growth hypothesis. It is therefore concluded that greater growth in economic activities lead to enhance the consumption of biomass energy in USA economy.

In another panel examination of twenty OECD economies, Apergis and Payne (2010) explored the association between renewable energy and economic development. The study used the data from the period of 1985 to 2005. The results of the study applying ECM methods established the existence of bi-directional association between both variables.

Bhattacharya, Paramati, Ozturk and Bhattacharya (2016) also explored the relationship between renewables and output growth. Utilizing the heterogeneous sample of thirty-eight economies, the study aimed to investigate the potential link between consumption of renewables and economic development (Salem et al. 2016). The study used the data from the period of 1991 to 2012 and established that long run relationship exists between the variables. The outcomes further elaborated that for fifty seven percent of the utilized economies, the impact of renewable consumption of significant to bring positive shocks to development (Salem et al. 2018). For the cluster of G-7 countries, Tugcu, Ozturk and Aslan (2012) examined the link of renewable and non-renewable energy utilization and output development. For that, the study used the data from the period of 1980 to 2009. The outcomes of the investigation supported the view of significant long-run connections between both types of power consumption to augment production function of the economies. Furthermore, the study concluded that in the classical production model, the causal connection among the variables supported the presence of feedback effect in between renewable-output association and also for non-renewable-output relationship.

METHODOLOGY

As discussed in earlier studies that energy consumption provides a significant and positive impact on economic growth therefore, the current study scrutinizes the connection between biomass energy consumption and economic growth by using Cobb-Douglas production function and the framework is given below:

$$Y = \beta_0 + \beta_1(K) + \beta_2(L) + \beta_3(EXP) + \beta_4(BIO) + \varepsilon_t$$

Where, $\varepsilon_t$is the error term, *BIO* is the biomass energy consumption which is explained by portion of biomass energy consumption out of total energy consumption (in Local Currency Unit, LCU), *Y* is real gross domestic product which is calculated by the total finished goods and services (in LCU). *K* is the total gross fixed capital formation (in LCU) and *L* is a total labor force which is measured by the sum of number of employed and unemployed person and *EXP* is the exports of goods and service and measure in (LCU). All data are collected from World Development Indicators (World Bank). The time period for the collected sample is from 1981 to 2017. The current study uses all data in natural logarithmic forms as suggested by (Afshan et al. 2018, Raza et al. 2017, Sharif et al. 2017, 2018, Sharif and Afshan 2018). The expected sign of capital, labor and exports of goods and services is positive whereas, the sign of biomass energy consumption will be revealed by the current research.

To investigate the presence of long-run or cointegrating relation between economic growth, capital, labor, exports of good and services and biomass energy consumption in Indonesia, the current research apply Autoregressive Distributed Lag (ARDL) Model (Pesaran and Shin 1999, Pesaran et al. 2001) Bounds Cointegration tests. ARDL Model does not need the variables to be integrated of order 1 i.e. I(1) or the variables to be mutually cointegrated (Pesaran and Shin

Table 1. Results of Descriptive Statistics

	Mean	Minimum	Maximum	Std. Dev.	Jarque-Bera	Correlation
Y	304.061	205.052	408.069	107.052	24.346***	
K	280.238	220.451	420.234	121.052	29.491***	0.925***
L	140.475	90.921	190.213	70.329	17.915***	0.907***
EXP	183.897	127.438	224.445	785.29	25.323***	0.902***
BIO	528.994	212.049	703.932	191.01	65.948***	0.771***

Note: *** represents the values are significant at 1%.
Source: Authors Estimation

1999). The ARDL Bounds Testing Approach is more advantageous to be useful for small data size (Haug 2002) and is relatively easier to estimate the cointegrating relations. The ARDL model for examining the cointegrating association among the variables under study is outlined as follows:

$$\begin{aligned}\Delta\, ln(Y) = {} & \beta_0 + \sum_{i=1}^{n} \delta_1 \Delta ln(Y)_{t-i} \\ & + \sum_{i=1}^{n} \delta_2 \Delta ln(K)_{t-i} + \sum_{i=1}^{n} \delta_3 \Delta ln(L)_{t-i} \\ & + \sum_{i=1}^{n} \delta_4 \Delta ln(EXP)_{t-i} + \beta_1\, ln(Y)_{t-i} \\ & + \beta_2\, ln(K)_{t-i} + \beta_3\, ln(L)_{t-i} \\ & \beta_4\, ln(EXP)_{t-i} + {} + \beta_5\, ln(BIO)_{t-i} + \varepsilon_t\end{aligned} \quad (1)$$

In denotes the logarithmic series of the variables of economic growth (Y), capital (K), labor force (L), exports of good and services (EXP) and biomass energy consumption (BIO). Δ represents the first difference operator and the intercepts are explained by β_0. The long-run coefficients are represented by $\beta_1, \beta_2, \ldots, \beta_4$ and $\delta_1, \delta_2, \ldots, \delta_4$ represent the short-run dynamics. ε_t denotes the residuals or white noise error term.

The framed ARDL framework estimates the Equation (1) with ordinary least square framework. The ARDL framework investigates the long run relationship among the given variables by testing the null hypothesis of $H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ against the alternate hypothesis $H_1 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$ by calculating F-Test developed by Pesaran and Shin, and Smith (2001) and altered by Narayan (2005). The calculated F-Statistic is compared with upper and lower critical values given by Pesaran et al. (2001). When the calculated F-Statistic is greater than upper critical value, the null hypothesis of no cointegration is rejected and is accepted in case the F-Statistic is lower than the lower critical value at a given significance level. When the calculated F-Statistic falls within the lower and upper critical values the inference becomes inconclusive.

In order to identify the causal linkages between the specified variables, the present study intended to apply the Granger causality technique. The method of Granger causality entails numerous benefits in contrast to other causal estimation particularly in the time-series estimations. This endorses that the decision of applying the said analysis for identifying the causal connection between economic growth, capital, labor, exports of goods and services and biomass energy consumption in Indonesian economy are trustworthy and more dependable in comparison to the earlier studies.

DATA ANALYSIS AND DISCUSSION

The primary focus of the present research is to apply the Cobb-Douglas framework in Indonesia (Hussain et al. 2018). **Table 1** explains the outcomes of the descriptive statistics of economic growth, capital, labor, exports of good and services and biomass energy consumption. The mean values for all the considered variables are positive.

Economic growth mean value of (304.061) which varies from 205.052 to 408.069. Capital has an average value of (280.238) which fluctuates from 220.451 to 420.234, labor force has a mean value of 14.475 which varies from 90.921 to 190.213, exports of goods and services has a mean value of 183.897 which differs from 2273 to 16454, biomass energy utilization has a mean value of 528.994 which fluctuates from 212.049 to 703.932. Moreover, the outcomes of the Jarque-Bera test are significant at the 1% level, which shows that economic growth, capital, labor, exports of good and services and biomass energy consumption are not normally distributed in the case of Indonesia. Also, the coefficient of correlation is also positive and strong for all the variables. The maximum correlation is found between capital and economic growth with the coefficient value of 0.925. However, the correlation between transportation energy utilization and economic growth is also positive and high with the coefficient value of 0.921. Whereas, the lowest coefficient or correlation is found in the case of biomass energy consumption and economic growth which is 0.771. The coefficient of correlation between labor force and economic growth is also high with the value of 0.907. Moreover, the coefficient of correlation between exports of goods and services and economic growth is also positive with the value of 0.902. The p-values of the

Table 2. Results of Unit root test

Variables	ADF Unit root test				PP unit root test			
	I(0)		I(1)		I(0)		I(1)	
	C	C&T	C	C&T	C	C&T	C	C&T
Y	1.473	1.482	-4.385	-4.573	1.346	1.453	-4.483	-4.492
K	0.483	0.429	-.3687	-3.683	0.472	0.385	-4.693	-4.584
L	-1.381	-1.385	-5.402	-5.492	-1.129	-1.012	-5.586	-4.582
EXP	-1.375	-1.395	-5.058	-5.025	-1.381	-1.392	-5.291	-5.019
BIO	0.390	0.401	-4.595	-4.684	0.561	0.472	-4.493	-4.592

Note: The critical values for ADF and PP tests with constant (c) and with constant & trend (C&T) 1%, 5% and 10% level of significance are -3.711, -2.9181, -2.629 and -4.394, -3.612, -3.243 respectively.
Source: Authors' estimation

Table 3. Results of Bound Testing for Cointegration

Lags Order	AIC	HQ	SBC	F-test Statistics
0	-2.893	-2.982	-3.029	48.284⋆
1	-5.473⋆	-5.320⋆	-5.129⋆	
2	-3.385	-3.301	-3.479	
3	-3.465	-3.128	-3.485	

⋆ 1% level of significant.
Source: Authors' estimation.

Table 4. Results of Lag Length Selection

Lag	0	1	2	Nominated Lags
	SBC	SBC	SBC	SBC
K	-1.323	-2.003⋆	-1.573	1
L	-1.647	-2.382⋆	-2.042	1
EXP	-1.843⋆	-1.584	-1.372	0
BIO	-2.018⋆	-1.577	-1.743	0

⋆ indicate minimum SBC values.
Source: Authors' estimation.

correlation coefficients are highly significant as those values are statistically significant at the 1% level.

Table 2 represents the results of stationary test employed in the current study. For fulfilling the persistence of ensuring the data stationarity, the current study have applied the tests of Augmented Dickey Fuller (*ADF*) & Phillip Perron (*PP*) tests (Johari et al. 2018). The tests of unit root therefore reflect the results primarily at level of variables but later on apply the tests on their first difference.

The results of **Table 2** confirm that economic growth, capital, labor, exports of goods and services and biomass energy consumption are stationary & integrated at their first differential series. The results of ADF and PP test confirm the robustness of results suggesting that all variables are co-integrated at I(1) and we can use these variables for further long run estimation procedures. In other words, from the outcomes of unit root test, we can apprehend that series of both the variables reflect the stationary properties and allow for proceeding towards the long run estimations (Abdul Hadi et al. 2018). Furthermore, in order to find the long run relationship between biomass energy consumption and economic growth, we have applied the technique of ARDL bound testing cointegration. Therefore, the outcomes of the ARDL bound testing cointegration are displayed in **Table 3**.

The results of **Table 3** confirm the null hypothesis claiming that not cointegration between the variables is rejected. This is because to the value of the *F*-statistics which is higher than UBC value at 1% significance level. So, it is checked that there is a long-term relationship occur among economic growth, capital, labor, biomass energy consumption in Indonesia.

The results of ARDL bound testing cointegration test, however check the robustness of investigated results. Therefore, it is confirmed that a significant long-term relationship presents among economic growth, labor force, capital, exports of goods and services and biomass energy consumption in Indonesia. Furthermore, after concluding the results of long-term relationship between the considered variables, the next procedure is to examination of ARDL method with the aim of calculating the beta value of long-short run time (Zainal Arifin et al. 2018). In doing so, the current research calculates the lag length order of all variables through the minimum value of SBC.

The long-run outcomes of ARDL model is shown in **Table 5**. The results of ARDL suggest that capital, labor, exports of goods and services and biomass energy consumption are strong determinant of economic growth in Indonesia. Likewise, the outcomes confirm that biomass energy consumption has a positive outcome on economic growth in Indonesia which implies that the nation energy utilization from renewable energy sectors increase the economic growth in Indonesia. The consequences of Cobb-Douglas function in the presence of biomass energy utilization confirm the enhancement of economic growth in Indonesia. The findings confirm a valid long-run relationship so now we further move to the short-run estimations of ARDL test (Ya'acob et al. 2018).

Table 5. Results using ARDL Approach (Long Run)

Variables	Coeff.	t-stats	Prob.
C	-0.274	-3.783	0.000
Y (-1)	0.289	2.983	0.000
K	0.310	4.473	0.000
K (-1)	0.002	0.879	0.391
LF	0.237	3.574	0.000
LF (-1)	-0.034	-0.936	0.350
EXP	0.204	3.432	0.000
BIO	0.382	4.021	0.000
Adj. R^2	0.946		
D.W stats	2.048		
F-stats (Prob.)	1839.987 (0.000)		

Source: Authors' estimation.

Table 6. Results using ARDL Approach (Short Run)

Variables	Coeff.	t-stats	Prob.
C	-0.135	-3.485	0.000
ΔY (-1)	0.185	3.983	0.000
ΔK	0.170	2.486	0.022
ΔK (-1)	0.002	1.148	0.264
ΔLF	0.234	3.675	0.000
ΔLF (-1)	-0.117	-0.811	0.426
ΔEXP	0.284	4.210	0.000
ΔBIO	0.301	5.960	0.000
ECM (1)	-0.341	-3.586	0.000
Adj. R^2	0.93		
D.W stats	1.956		
F-stats (Prob.)	893.381 (0.000)		

Source: Authors' estimation.

The short-run results of ARDL method represent in **Table 6**. The results described a short run relationship between economic growth, capital, labor, exports of goods and services and biomass energy utilization in Indonesia. The coefficient of error correction model is describing the value of around -0.341 suggest that around 34% of volatility is adjusted in the recent year. Though, the results also confirm the significant impact of capital, labor force, exports of goods and services and biomass energy consumption on on economic development in Indonesia in short run as well.

The results of Granger-causality show in **Table 7**. The results explain that there a causal relationship among all the variables with economic growth. The findings confirm that capital, labor force, exports of goods and services and biomass energy consumption have a bi-directional causal relationship with economic growth which means causality is running in both directions.

Table 7. Results of Granger-Causality Test

Null Hypothesis:	F-Statistic	Prob.
Y does not Granger Cause K	4.583	0.000
K does not Granger Cause Y	12.059	0.000
Y does not Granger Cause LF	10.473	0.000
K does not Granger Cause Y	7.176	0.000
Y does not Granger Cause EXP	8.382	0.000
EXP does not Granger Cause Y	6.783	0.000
Y does not Granger Cause BIO	9.240	0.000
BIO does not Granger Cause Y	14.329	0.009

Source: Author's Estimation

CONCLUSION

The present research examines the environmental effect of biomass energy consumption on economic growth in the presence of Cobb-Douglas function in Indonesia by using the annual time series data over the period from 1981 to 2017. The study uses biomass energy consumption which is also a proxy of renewable energy consumption. We applied the advance econometrics to serve the purpose of investigation and therefore used the Auto Regressive Distributed Lags bound testing approach for investigating the presence of long-run relationship between the variables. Utilizing the framework of Cobb-Douglas, the results of ARDL bound testing approach ascertain the valid long run relationship between economic growth, capital, labor, biomass energy consumption in Indonesia. The final outcomes confirm that biomass energy consumption, capital, exports of goods and services and labor force have a positive and significant impact on economic growth. Furthermore, results of Granger-causality also confirm the existence of bi-directional causal relationship between biomass energy consumption, capital, labor force, exports of goods and services and economic growth in Indonesia.

REFERENCES

Abd El-Kader, S. M., Al-Jiffri, O. H (2018) Coagulation, fibrinolytic and cytokines parameters response to weight reduction in obese subjects. European Journal of General Medicine, 15(1), 27-32. https://doi.org/10.29333/ejgm/81730

Abdul Hadi AR, Zafar S, Iqbal T, Zafar Z, Hussain HI (2018) Analyzing Sectorial Level Determinants of Foreign Direct Investment (FDI) in ASEAN, Polish Journal of Management Studies, 17(2): 7–17.

Abidin ISZ, Bakar NA, Haseeb M (2015a) Exploring trade relationship between Malaysia and the OIC member countries: A panel cointegration approach (1995-2012). Asian Journal of Scientific Research, 8(1): 107.

Abidin ISZ, Haseeb M, Azam M, Islam R (2015b) Foreign direct investment, financial Development, international trade and energy consumption: Panel data evidence from selected ASEAN Countries. International Journal of Energy Economics and Policy, 5(3): 841-850.

Adewuyi AO, Awodumi OB (2017) Biomass energy consumption, economic growth and carbon emissions: Fresh evidence from West Africa using a simultaneous equation model. Energy, 119: 453-471.

Afshan S, Sharif A, Loganathan N, Jammazi R (2018) Time–frequency causality between stock prices and exchange rates: Further evidences from cointegration and wavelet analysis. Physica A: Statistical Mechanics and its Applications, 495: 225-244.

Ahmed A, Uddin GS, Sohag K (2016) Biomass energy, technological progress and the environmental Kuznets curve: Evidence from selected European countries. Biomass and Bioenergy, 90: 202-208.

Apergis N, Payne JE (2014) The causal dynamics between renewable energy, real GDP, emissions and oil prices: evidence from OECD countries. Applied Economics, 46(36): 4519-4525.

Apergis N, Payne JE (2015) Renewable energy, output, carbon dioxide emissions, and oil prices: evidence from South America. Energy Sources, Part B: Economics, Planning, and Policy, 10(3): 281-287.

Apergis N, Payne JE, Menyah K, Wolde-Rufael Y (2010) On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. Ecological Economics, 69(11): 2255-2260.

Azam M, Haseeb M, binti Samsi A, Raji JO (2016a) Stock market development and economic growth: Evidences from Asia-4 Countries. International Journal of Economics and Financial Issues, 6(3): 1200-1208.

Azam M, Haseeb M, Samsudin S (2016b) The impact of foreign remittances on poverty alleviation: Global evidence. Economics & Sociology, 9(1): 264.

Ben Jebli M, Ben Youssef S, Ozturk I (2015) The Role of Renewable Energy Consumption and Trade: Environmental Kuznets Curve Analysis for Sub-Saharan Africa Countries. African Development Review, 27(3): 288-300.

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

Bildirici ME (2014) Relationship between biomass energy and economic growth in transition countries: panel ARDL approach. Gcb Bioenergy, 6(6): 717-726.

Bowden N, Payne JE (2010) Sectoral analysis of the causal relationship between renewable and non-renewable energy consumption and real output in the US. Energy Sources, Part B: Economics, Planning, and Policy, 5(4): 400-408.

Boyi I, Chidozie C, Okonkwo I (2017) Nutrient Compositions of Different Grains for Use in the Formulation of Bacteriological Media. The International Journal of Biotechnology, 6(1): 1-10.

Dogan E, Inglesi-Lotz R (2017) Analyzing the effects of real income and biomass energy consumption on carbon dioxide (CO2) emissions: Empirical evidence from the panel of biomass-consuming countries. Energy, 138: 721-727.

Dölek Ü, Günes M (2016) Fruit Growth Characteristics of Rose Hips (Rosa sp). Agriculture and Food Sciences Research, 3(2): 75-79.

Haseeb M, Hassan S, Azam M (2017) Rural–urban transformation, energy consumption, economic growth, and CO2 emissions using STRIPAT model for BRICS countries. Environmental Progress & Sustainable Energy, 36(2): 523-531.

Haug AA (2002) Temporal aggregation and the power of cointegration tests: a Monte Carlo study. Oxford Bulletin of Economics and statistics, 64(4): 399-412.

Hussain HI, Sallehuddin S, Shamsudin MF, Jabarullah NH (2018) Debt Maturity Structure and Shari'ah Compliance: Evidence from Malaysia, European Research Studies Journal, 21(1): 179–189.

Jabarullah NH, Hussain HI (2018) Comparison of Higher TVET Education and 'Normal' Academic Education: The Determinants of Electrical Engineering Students' Performance, International Journal of Engineering & Technology, 7 (4.29): 82-85.

Jabarullah NH, Mauldin C, Navarro LA, Golden J, Madianos L, Kemp NT (2017) Modelling and Simulation Analysis for the Prediction of the Performance of Intrinsic Conducting Polymer Current Limiting Device. Advanced Science Letters, 23(6): 5117-5120.

Jabarullah NH, Othman R (2018) Steam reforming of shale gas over Al2O3 supported Ni-Cu nano-catalysts, Petroleum Science and Technology. https://doi.org/10.1080/10916466.2018.1547759

Jabarullah NH, Verrelli E, Gee A, Mauldin C, Navarro LA, Golden JH, Kemp NT (2016) Large dopant dependence of the current limiting properties of intrinsic conducting polymer surge protection devices. RSC Advances, 6(89): 85710-85717.

Jabarullah NH, Verrelli E, Mauldin C, Navarro LA, Golden J, Madianos L, ... Kemp NT (2014) Novel conducting polymer current limiting devices for low cost surge protection applications. Journal of Applied Physics, 116(16): 164501.

Jabarullah NH, Verrelli E, Mauldin C, Navarro LA, Golden JH, Madianos LM, Kemp NT (2015) Superhydrophobic SAM Modified Electrodes for Enhanced Current Limiting Properties in Intrinsic Conducting Polymer Surge Protection Devices. Langmuir, 31(22): 6253-6264.

Jebli MB, Youssef SB (2015) The environmental Kuznets curve, economic growth, renewable and non-renewable energy, and trade in Tunisia. Renewable and Sustainable Energy Reviews, 47: 173-185.

Johari M, Jalil M, Mohd Shariff M (2018) Comparison of horizontal axis wind turbine (HAWT) and vertical axis wind turbine (VAWT). International Journal of Engineering and Technology, 7(4.13): 74-80.

Lee M, Yun J, Pyka A, Won D, Kodama F, Schiuma G, ... Yan MR (2018) How to respond to the Fourth Industrial Revolution, or the Second Information Technology Revolution? Dynamic new combinations between technology, market, and society through open innovation. Journal of Open Innovation: Technology, Market, and Complexity, 4(3): 21.

Mitra I, Biswas GR, Majee SB (2014) Effect of Filler Hydrophilicity on Superdisintegrant Performance and Release Kinetics From Solid Dispersion Tablets of A Model BCS Class II Drug. International Journal of Pharmacy Research & Technology 4: 28-33.

Narayan PK (2005) The saving and investment nexus for China: evidence from cointegration tests. Applied economics, 37(17): 1979-1990.

Ozturk F, Ozturk S (2018a) Exploring the Nexus of Coal Consumption, Economic Growth, Energy Prices and Technological Innovation in Turkey. Asian Economic and Financial Review, 8(12): 1406-1414.

Ozturk S, Ozturk F (2018b) Forecasting Energy Consumption of Turkey by Arima Model. Journal of Asian Scientific Research, 8(2): 52-60.

Payne JE (2009) On the dynamics of energy consumption and output in the US. Applied Energy, 86(4): 575-577.

Pérez-Luna YC, Sánchez-Roque Y, Berrones Hernández R (2018) Physicochemical Characterization of Compost Mixtures Enriched with Agroindustrial Waste. Canadian Journal of Agriculture and Crops, 3(1): 33-41.

Pesaran MH, Pesaran B (1997) Working with Microfit 4.0: interactive econometric analysis. Oxford University Press, Oxford.

Pesaran MH, Shin Y (1998) Generalized impulse response analysis in linear multivariate models. Economic Letters 58(1): 17–29.

Pesaran MH, Shin Y (1999) An autoregressive distributed lag modeling approach to co-integration analysis. In Strom S (ed.) Econometrics and economic theory in the 20th century: the Ragnar Frisch centennial symposium. Cambridge University Press, Cambridge.

Pesaran MH, Shin Y, Smith RJ (2000) Structural analysis of vector error correction models with exogenous I(1) variables. Journal of Econometrics 97: 293–343.

Pesaran MH, Shin Y, Smith RJ (2001) Bounds testing approaches to the analysis of level relationships. Journal of Applied Economics, 16: 289–326.

Rahman KA, Guozhou F, Zhang D (2017) Agricultural Consumption Culture and Ecological Transformation: Bangladesh Perspective. Asian Development Policy Review, 5(4): 243-252.

Rayner J, Morgan D (2018) An empirical study of 'green' workplace behaviours: ability, motivation and opportunity. Asia Pacific Journal of Human Resources, 56(1): 56-78.

Raza SA, Sharif A, Wong WK, Karim MZA (2017) Tourism development and environmental degradation in the United States: Evidence from wavelet-based analysis. Current Issues in Tourism, 20(16): 1768-1790.

Salem M, Shawtari F, Shamsudin M, Hussain HI (2018) The Consequences of Integrating Stakeholders' Engagement on Sustainable Development (Environmental Perspectives), Sustainable Development, 26(3): 255–268.

Salem MA, Shawtari FA, Shamsudin MF, Hussain HI (2016) The relation between stakeholders' integration and environmental competitiveness. Social Responsibility Journal, 12(4): 755-769.

Shahbaz M, Balsalobre D, Shahzad SJH (2018) The Influencing Factors of CO 2 Emissions and the Role of Biomass Energy Consumption: Statistical Experience from G-7 Countries. Environmental Modeling & Assessment: 1-19.

Shahbaz M, Rasool G, Ahmed K, Mahalik MK (2016) Considering the effect of biomass energy consumption on economic growth: fresh evidence from BRICS region. Renewable and Sustainable Energy Reviews, 60: 1442-1450.

Sharif A, Afshan S (2018) Does Military Spending Impede Income Inequality? A Comparative Study of Pakistan and India. Global Business Review, 19(2): 257-279.

Sharif A, Afshan S, Khan BS (2018) Does democracy embolden economic growth in Pakistan? Evidence from ARDL bound testing and rolling window analysis. International Journal of Economics and Business Research, 15(2): 180-203.

Sharif A, Afshan S, Nisha N (2017) Impact of tourism on CO2 emission: evidence from Pakistan. Asia Pacific Journal of Tourism Research, 22(4): 408-421.

Sharif A, Saha S, Loganathan N (2017) Does Tourism Sustain Economic Growth? Wavelet-Based Evidence from the United States. Tourism Analysis, 22(4): 467-482.

Suryanto T, Haseeb M, Hartani NH (2018) The Correlates of Developing Green Supply Chain Management Practices: Firms Level Analysis in Malaysia. Int. J Sup. Chain. Mgt Vol, 7(5): 316.

Tshepo K, Tafesse NT, Chaoka RT, Alemaw BF, Laletsang K (2017) Impacts of Treated Wastewater on the Surface Water and Groundwater Quality: A Case Study in North East Gaborone, Botswana. Asian Review of Environmental and Earth Sciences, 4(1): 36-45.

Tugcu CT, Ozturk I, Aslan A (2012) Renewable and non-renewable energy consumption and economic growth relationship revisited: evidence from G7 countries. Energy economics, 34(6): 1942-1950.

Ya'acob A, Mohd Razali M, Anwar U, Mohd Radhi M, Ishak M, Minhat M, . . . The C (2018) Investigation of closed compartment moulding for pull-winding process. International Journal of Engineering and Technology, 7 (4.13): 107-111.

Yuan JH, Kang JG, Zhao CH, Hu ZG (2008) Energy consumption and economic growth: evidence from China at both aggregated and disaggregated levels. Energy Economics, 30(6): 3077-3094.

Zainal Ariffin M, Johari M, Ibrahim H (2018) The needs of aircraft avionics' radio line replaceable unit repair center at UniKL MIAT. International Journal of Engineering and Technology, 7(4.13): 86-88.