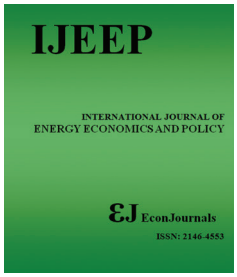

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The Impact of Renewable Energy on Economic Well-Being of Malaysia: Fresh Evidence from Auto Regressive Distributed Lag Bound Testing Approach

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ABSTRACT

This present study examines the role of renewable energy in influencing economic well-being in Malaysia. We used annual data over the period of 1980–2016 in order to apply recent econometrics. The study used renewable energy and economic growth as a proxy of economic well-being to examine the long run connection between renewable energy and economic well-being. The results of auto regressive distributed bound testing approach confirm the valid long-term connection among renewable energy and economic well-being in Malaysia. Furthermore, the results indicate that renewable energy have significant and positive impact on economic well-being in short and long run. It is therefore recommended that the policymakers are required to focus on the green energy generation sector by increasing renewable energy production from the existing sources.

Keywords: Renewable Energy, Economic Well-being, Auto Regressive Distributed Bound Testing, Malaysia
JEL Classifications: I31, Q22, Q52

1. INTRODUCTION

The world at present is entangled with the hostile environmental changes and climate conditions that pose great threat to the wellbeing of future mankind. In addition, the diminishing resources that are the crucial part of today's economy and businesses, all around the world, also constitute a major threat to long term sustainability. In the present business, the utilization of energy is thought as a crucial driver of output, and it is assumed as a basic catalyst of economic improvement. The contribution of energy in progressing a country's economy is known to play a crucial part in financial development either straightforwardly or as a supplement to different variables of production. The conventional Neo-classical growth model contemplates energy as an intermediary inputs. And stresses land and labor to be the substantial factors of production. Furthermore, according to the renowned biophysical and ecological aspect, energy is fundamental motivator of income creation. Hence, the economies vigorously reliant on energy utilization and therefore are greatly influenced by changes in energy utilization (Yuan et al., 2008; Farhani, 2013, Kobayashi et al., 2013; Cuevas-Rodriguez and Cabello-Medina, 2014; Ekong and Akpan, 2014; Oyaromade et al., 2014; Anowor et al., 2014; Asyraf, 2014; Behera, 2015; Vafaeirad et al., 2015; Anwana and Akpan, 2016; Kimuli et al., 2017; Bayat et al., 2017; Hasan, 2017).

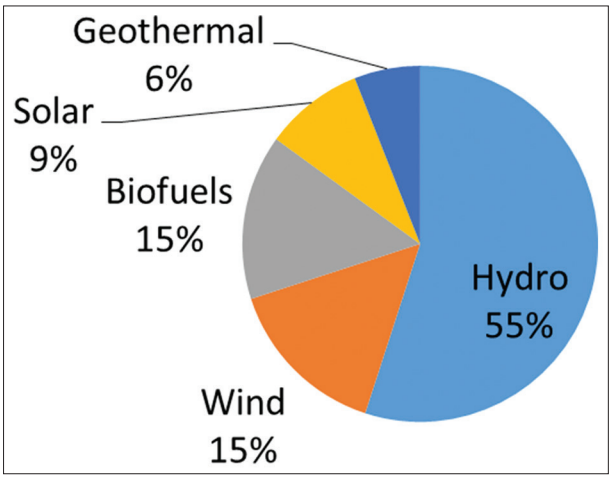
Keeping in mind the rising environmental deterioration and adverse climate effects, the extensive energy dependent economies are considered as the most potential victim of the deteriorating atmosphere and thus vanguard the risk of futuristic economic

setbacks. In compliance, the role of renewable sources of energy are debated for being the sanctification that endures the ability to fulfil economic needs and at the same time exert minimal or no damage to the environment. Acknowledgement of this facet is followed by the continuous rise in the usage and production of renewable energy globally. In this context, the primary production of renewable energy is witnessed to increase by an average growth rate of 4.3% and it is increased by 174% from 1990 to 2015. In the year 2011, the essential generation of renewable power source dropped by 2.2%; this was predominantly because of the yearly growth in hydropower creation and abatement in the burning of solid biomass. This was just the second lessening recorded since 1990; the first in 2002 (−1.6%) was also due to the hydropower fluctuation. Likewise, total electricity production from renewable sources increased by 4.9% in 2014 as compare to 2013 and it increased by 191% from 1990 to 2015. In 2015, renewable elasticity production accounted 28% of total gross electricity production, however, it varies depending on the energy sources. The renewable energy as a share of total primary energy from the different sources is presented in the Figure 1. It shows that hydro ranked first, with the equal share wind and biofuels ranked second, solar ranked third and geothermal remained at fourth in the year 2015 (International Energy Agency, 2015).

Moreover, contribution in the world renewable energy is come from the various countries but China and the US are pioneers in clean energy. Although China ranked first in the renewable energy production but it is only 19% of its total electricity. Similarly, the US remained second in renewable energy generation but it is only 15% of the total electricity consumption. The top ten countries that generate the most electricity from renewable resources are presented in the Table 1. It shows that among top ten countries most of them are high income countries like the US, Canada, Russia, Germany, Norway, Japan and Spain.

The benefits of renewable energy are not only limited to a single domain but extended to support the numerous sectors of the country's well-being. In this context, the contribution of renewable in job creation is notable. An expected 5.7 million individuals overall work in the renewable power sector. China is the world pioneer to create 1.75 million jobs in the renewable power source division. The second highly job creation in renewable sector is in the countries of European Union that employed 1.2 million workforce. And thirdly, Brazil initiated 0.8 million of the job for its people in renewable energy sector (Bergstrom and Randall, 2016). Hence the role of renewable energy is predominant in influencing not only economic and financial wellbeing but also to augment the social well-being of the country by creating jobs, increasing household income and improving quality of life of the people.

Figure 1: Renewable energy generation from the different sources in 2015



Source: International Energy Agency, 2015

2. RENEWABLE ENERGY STATUS IN MALAYSIA

Malaysia, as different nations around the globe, critically relies upon non-renewable sources of energy generation (Ong et al., 2011). In recent years, this enormous dependence and importance of renewable in influencing economic and social well-being has expanded the concerns of policymakers in structuring, sustaining and enhancing the sources of renewables and at the same time, innovating numerous measures to preserve alternate sources of energy creation. It is noteworthy to consider that the total energy demand in Malaysia is rising at a mean yearly growth of 6.6% from 1980 to 2010. It is also significant to recognize that renewable energy plays the vital part in the achievement of the country's growth objectives. In the regional countries, Malaysia is foremost in the potential per capita renewables. A comparison renewable energy potential between Malaysia and Association of South East Asian Council (ASEAN) countries is presented in Table 2. It shows that Malaysian ranked first, Vietnam second, Thailand third, Indonesia fourth and Singapore remained at fifth in ASEAN countries.

The main indigenous renewable sources in Malaysia include; palm oil biomass wastage, "hydropower, solar power, solid waste and landfill gas, wind energy. Among these resources, hydropower is suitable for both small and large scale applications, solar photo voltaic power is suitable for use in small - scale applications and at the household level. Biomass development have been established and proven cost-effective, particularly at large scales and in industrial applications (Malek et al., 2010). In addition, Malaysia's domestic oil production occurs offshore, primarily near the Peninsular Malaysia. At the end of 2015, Malaysia's crude oil reserve, including condensate, was 5.5 billion barrels of equivalent. Malaysia also has an abundant natural gas reserve. At the end of 2015, Malaysia's proven natural gas reserves were 14.66 billion barrels of equivalent. Malaysia's hydropower potential is assessed at 29 000 megawatts; 85% of potential sites are located in East Malaysia. Biomass resources are mainly from palm oil, wood and agro-industries" (Kardooni et al., 2016). Thus, exploring and promoting renewable energy is undeniable vital for achieving sustainable development. It is accepted by the Government of Malaysia and mentioned in the 11th Malaysian plan.

Promoting renewable energy will not only help in green growth, but the approach will lead to improved level of growth, increase food, reduce environmental risks, and eventually will improve social, financial and economic welfare of the country. The

Table 1: Electricity generation from the renewable resources

Countries	Electricity generation from renewable resources (bkwt)	Countries	Electricity generation from renewable resources (bkwt)
China	800	India	160
United States	527	Germany	126
Brazil	459	Norway	121
Canada	398	Japan	116
Russia	168	Spain	87

Source: International Energy Agency, 2015

Table 2: Renewable potential per capita of ASEAN countries

Country	Renewable energy potential per capita
Malaysia	4.73
Vietnam	2.18
Thailand	1.85
Indonesia	1.57
Singapore	0.73

Source: Ölz and Beerepoot (2010)

objective of present study is to investigate the role of renewable energy in enhancing the three predominant aspects of economic, financial and social well-being of Malaysia. We trust that the results achieve from the present study will deliver a comprehensive description of the vital renewable energy and wellbeing nexus through the refined auto regressive distributed lag (ARDL) bound testing approach, which could not otherwise be conceivable by utilizing the simple and traditional econometrics.

3. LITERATURE REVIEW

Many studies in the past has examined the association of renewable energy with crucial factors of carbon emission, economic growth and financial development. The overview of the empirical findings, however, have established mixed results and in this way given rise to ambiguities and uncertainties in establishing the specific connection of renewable energy consumption with well-being of the country.

Among those studies, emphasizing on the role of renewable in creating employment opportunities, Dvořák et al. (2017) investigated the contribution of renewable investment and job generation of Czech Republic. The study utilized the data from the period of 2008 to 2013 to investigate the impact of renewable energy sector in green job generation of the country. The findings of the study establish that renewable energy sector is crucial to create greater job opportunities. The findings also suggested the resilient dependence of employment enhancement with the investment in the renewable industry of Czech Republic.

In Pakistan, Shahbaz et al. (2015) investigated the role of renewable energy consumption in enhancing financial well-being. The study utilized the sample of quarterly observation from the time frame of 1972 to 2011. By applying ARDLs methodology, the outcomes of the study established that renewable energy consumption is significant to influence financial advancements of Pakistan in long run. In order to check the causal connection between the variables, the study also applied VECM Granger causality. The outcomes of the analysis revealed that there exist a feedback causal effect between renewable energy consumption and financial well-being of the country.

More recently, In United States, Troster et al. (2018) investigated the connection between green energy, economic well-being and oil prices. The sample used in the study consist of 28 years i.e., from 1989 to 2016. The study applied the recent econometrics of granger causality in quantiles to check the causal effect among the studied variables. The results of the empirical analysis confirms the presence of the feedback causal among the variables.

In Germany, Lehr et al. (2008) studied the status of employment in respect to the rise in the popularity of renewable energy industry. The study applied input-output approach to investigate the situation of employment in the process of converting German economy from brown carbon- dependent economy from green renewable-dependent economy. The findings of the study conclude that by the end of 2020, the domestic installation in Germany is likely to offer only 4% to the global economy as the rate of renewable adoption in the world is greater than the adoption rate in Germany. Hence, the study establish that employment rate in the country is substantially dependent on expansion of exports. The study further estimated that given the current economic and renewable sector progress, employment in renewable sector is likely to create 400,000 jobs by 2030. Thus, the net effect of renewable energy sector on the employment of the German economy is positive.

Apergis et al. (2010) investigate the long-run dependence among environmental degradation and renewable consumption. The study utilized data from the period of 1984 to 2007 and applied panel vector error correction model to study investigate the association in nineteen emerging economies. The findings of the study establish that renewable energy is substantial to decrease carbon emission in long run. The findings of the study however failed to find significance of renewable in influencing carbon emission in short run. The similar studies of Azlina et al. (2014) and Azlina and Mustapha, (2012) also studied the likewise association in Malaysia. The results of these studies revealed the dependence of renewables on environmental degradation and suggest the uni-directional link between the variable stating that increase in renewable is likely to decline environmental deterioration in the form of carbon emission.

Similarly, Rafindadi and Ozturk (2017) examine the role of renewable energy consumption in improving the economic well-being of Germany. The study utilized the sample from 1971 to 2013 constituting of quarterly observations. The results of the

study suggested that one percent enhancement in the consumption of renewable sources of energy is likely to augment economic well-being of Germany by 0.22%. On the other hand, Fang (2011) analyzed the contribution of renewable energy utilization in improving the financial well-being of China. The study used the data from the period of 1978 to 2008. The study perform the statistical investigation through multivariate ordinary least square method. The results of the study confirms the positive connection between renewable energy with financial well-being of China. Similar results are found in the study of Alper and Oguz (2016) that investigated the link of renewable energy in enhancing financial development in new EU countries from 1990 to 2009.

Likewise, Menegaki (2011) also investigated the causal relationship between renewable energy consumption and financial development. The study analyzed twenty seven European nations from the period of 1997 to 2007. Contrarily to Fang (2011), the results of the study failed to find any causal connection between renewable energy and financial development of the five (Estonia, Poland Hungary, Cyprus and Slovenia) out of six sampled countries.

4. METHODOLOGY AND DATA

By focusing on above literature, the current study scrutinizes the connection between economic well-being and renewable energy is established by using Cobb-Douglas production function and the framework is given below:

$$GDP_t=\beta_0+\beta_1 RENE_t+\beta_2 GFCF_t+\beta_3 LF_t+\varepsilon_t$$

Where, ε_t is the error term, *RENE* is the renewable energy consumption which is explained by portion of renewable energy consumption out of total energy consumption (in Local Currency Unit, LCU), *GDP* is real gross domestic product which is calculated by the total finished goods and services (in LCU). GDP is used as a proxy of economic well-being of Malaysia. *GFCF* is total gross fixed capital formation (in LCU) and *LF* is a total labor force which is measured by the sum of number of employed and unemployed person. All data are collected from World Development Indicators (World Bank).

4.1. Stationarity Approaches

In order to check the stationary features for long-term linking of considered time series data, the current study apply augmented Dickey-Fuller (*ADF)* and *PP* unit root tests. We examine the data initially on level and then on first differential series.

4.2. Long Run Co-integration Analysis

In order to inspect the long-term connection among social Islamic finance and economic progression in Malaysia, we consider the ARDL technique of long run relationship which was proposed by Pesaran et al. (2001; 2000), Pesaran and Shin (1999), Pesaran and Pesaran (1997) is utilized with the support of unobstructed vector error correction framework to examine the long-term association among social Islamic finance and economic development. The ARDL method has several benefits on former long run relationship analyses (like J.J Cointegration and others). The ARDL method could be useful nevertheless of whether considered series are completely *I (0)*, *I (1)* or equally co-integrated.[1] The ARDL framework is proposed for above examination is as follow:

$$\Delta GDP = \varphi_0 + \varphi_1 \sum_{i=1}^{p} \Delta GDP_{t-1} + \varphi_2 \sum_{i=1}^{p} \Delta GFCF_{t-1} + \varphi_3 \sum_{i=1}^{p} \Delta LF_{t-1} + \varphi_1 \sum_{i=1}^{p} \Delta RENE_{t-1} + \lambda_1 GDP_{t-1} + \lambda_2 GFCF_{t-1} + \lambda_3 LF_{t-1} + \lambda_5 RENE_{t-1} + \mu_t$$

Where, φ_0 is constant term and μ_t is white noise error term, the error correction boundary is represented by the sign of summation whereas the other measure of the equation relates to long-term connection. The Schwarz Bayesian Criteria (SBC) is utilized to examine the maximum lag length selection for each variable. In ARDL method, initially the current study calculate the *F*-statistics significance by applying the suitable ARDL frameworks. Next, the Wald (*F*-stats) test is applied to study the long-term association among the variables. If long-term bonding between renewable energy and economic well-being is established, then the present study calculated the long-term parameter measurements.

5. DATA ANALYSIS AND DISCUSSION

This section explains the data analysis and discuss the results. Initially we applied stationary test to confirm the stationary property of the considered variables. The results of unit root test present in Table 3. We utilized two unit root tests namely ADF and Philip Perron (PP) test to check the stationary properties of the variables. The findings confirm that renewable energy consumption, gross fixed capital formation, economic growth and labor force initially are not stationary at level and becomes stationary at first differential series. In other words, from the outcomes of unit root test, we can apprehend that series of all the variables reflect the stationary properties and allow for proceeding towards the long run estimations.

Moreover, to inspect the long run relationship between economic well-being and renewable energy in Malaysia, the current study has applied the technique of Autoregressive distributed lag method of cointegration (ARDL). In doing so, the first stage is to identify the optimum lag-length of the all the variables. The sequence of this optimum lag-length is chosen by taking criteria of SBC. Therefore, the outcome of the ARDL long-term relationship results are displayed in Table 4.

The outcomes confirm the null hypothesis claiming that not cointegration between the variables is rejected. This is due to the coefficient of the *F*-stats is larger than UBC coefficient at 1% significance level. Therefore, it is in indulgence of the alternative hypothesis which suggest that there is a effective long-term connection occur among renewable energy and economic well-being in Malaysia (Table 5).

1 Pesaran and Shin (1999).

Table 3: Results of Unit root test

Variables	ADF unit root test				PP unit root test			
	I (0)		I (1)		I (0)		I (1)	
	C	C and T	C	C and T	C	C and T	C	C and T
GDP	2.20	2.36	−5.84	−5.87	2.97	2.50	−5.82	−5.16
GFCF	−0.34	−0.26	−6.32	−6.10	−0.17	−0.03	−6.19	−6.30
LF	−1.21	−1.29	−5.16	−5.35	−1.18	−1.20	−5.45	−5.48
RENE	−1.32	−1.22	−5.15	−5.10	−1.29	−1.28	−5.13	−5.10

The critical values for ADF and PP tests with constant (c) and with constant and trend (C and T) 1%, 5% and 10% level of significance are−3.711, −2.981 and−4.394, −3.612, −3.243 respectively. Source: Authors; estimation

Table 4: Results of bound testing for cointegration

Lags order	AIC	HQ	SBC	F-test statistics
0	−4.311	−4.050	−4.872	
1	−5.236	−5.274	−5.637	32.221*
2	−7.985*	−7.457*	−7.762*	

*1% level of significant. Source: Authors' estimation. SBC: Schwarz Bayesian criteria

Table 5: Results of Lag Length Selection

Lag	0	1	2	Nominated lags
	SBC	SBC	SBC	SBC
GDP	2.451	−2.685*	−1.991	1
GFCF	2.478	−3.820*	−2.409	1
LF	1.441	−3.331*	−2.187	1
RENE	0.250	−4.647*	−3.477	1

*Indicate minimum SBC values. Source: Authors' estimation. SBC: Schwarz Bayesian criteria

Outcomes of ARDL bound testing cointegration test, therefore, establish the robustness of estimated findings. It is indicated that a significant long-term association presents among economic well-being and renewable energy consumption in Malaysia. Moreover, after confirming the evidence of long-term connection between renewable energy and economic well-being, the further step of the examination is to apply the ARDL method with the aim of finding the beta value of long-short run time. In doing so, the present study measures the lag length order of the both economic well-being and renewable energy consumption through the minimum value of SBC.

The long run results of ARDL method of estimation is displayed in Table 6. The findings therefore establish that gross fixed capital formation, renewable energy consumption and labor force are valid determinants of economic well-being in Malaysia. Also, the results of renewable energy consumption is positive effect of economic well-being in Malaysia. Consequently, it can be argued that all variables including gross fixed capital formation, renewable energy consumption and labor force play a significant role to enhance economic well-being in Malaysia. The renewable energy consumption enhances the energy efficiency and encourages growth through upgraded technology transfer & resource distribution. It is revealed that renewable energy consumption allows an increase in mobilization of deposits and also increases the size of domestic investment.

The short run results of ARDL method of estimation is displayed in Table 7. The findings displayed a valid short run relationship between renewable energy and economic well-being in Malaysia. The coefficient of error term is displaying the value of around

Table 6: Results using ARDL Approach (Long Run)

Variables	Coeff.	t-stats	Prob.
C	0.224	2.957	0.000
GDP (−1)	0.150	4.909	0.000
GFCF	0.335	5.321	0.000
GFCF (−1)	0.247	3.529	0.000
LF	0.512	5.505	0.000
LF (−1)	0.255	12.638	0.000
RENE	0.535	7.679	0.000
RENE (−1)	0.369	2.369	0.019
Adj. R^2		0.931	
D.W stats		2.079	
F-stats (Prob.)		835.881 (0.000)	

Source: Authors' estimation

Table 7: Results using ARDL Approach (Short Run)

Variables	Coeff.	t-stats	Prob.
C	0.321	4.346	0.000
GDP (−1)	0.534	6.069	0.000
GFCF	0.249	6.172	0.000
GFCF (−1)	0.356	1.519	0.131
LF	0.263	3.633	0.000
LF (−1)	0.789	0.975	0.331
RENE	0.583	2.279	0.024
RENE (−1)	0.125	0.882	0.379
ECM (−1)	−0.218	−3.304	0.001
Adj. R^2		0.836	
D.W stats		1.928	
F-stats (Prob.)		401.457 (0.000)	

Source: Authors' estimation

−0.21 propose that around 21% of instability is adjusted in the present year. Furthermore, the findings also confirm the significant positive impact of gross fixed capital formation, renewable energy consumption and labor force on the economic well-being in Malaysia in short run as well.

6. CONCLUSION AND RECOMMENDATION

This current paper investigates the role of renewable energy consumption in effecting economic well-being of Malaysia by using the annual data over the time from 1980 to 2016. The study uses renewable energy consumption (% of renewable energy consumption to total energy consumption) and economic growth as a proxy of economic well-being to inspect the long-run connection among renewable energy consumption and economic well-being. We applied the advance econometrics to serve the purpose of investigation and therefore used the ARDLs bound testing approach for assessing the presence of long-run relationship between the variables. Utilizing the framework of Cobb-Douglas,

the results of ARDL bound testing approach confirm the valid long run relationship between renewable energy consumption and economic well-being in Malaysia. The empirical results indicate that renewable energy consumption have significant and an encouraging impact on economic well-being in short and long run.

These outcome highlight the importance of renewable energy consumption on economic well-being, economic development, and welfare of Malaysia. Therefore, the current energy policies and the renewable energy sectors' future reformation process should be designed with this understanding in mind. Thus, conservation policies should be restricted, but at the same time the unproductive and over-dependence on non-renewable energy should also be curtailed. In addition, the governments of these countries should adopt policies aiming at increasing the investment in the green energy generation sector by increasing renewable energy production from the existing sources.

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