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The Causal Relationship between Energy Consumption and GDP in Oman

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Abstract. This paper aimed to examine the relationship between Energy Consumption and Gross domestic product "GDP" in Oman, using annual logarithm data during the period 1971-2014, the results of Augmented Dickey Fuller "ADF", and Phillips, Perron "PP" stationarity tests showed that both Energy Consumption per capita and GDP per capita were stationary at the first order. Autoregressive-Distributed Lag "ARDL" model and Pairwise granger causality test, were applied, the results indicated that there's bidirectional long run causality between energy consumption and GDP, and unidirectional short run causality running from GDP to energy consumption. Bidirectional long run causality indicates that increasing of GDP leads to a raise in energy consumption, and vice versa. this finding can help policy makers to develop appropriate policy related to energy consumption and GDP in Oman which has large amount of Oil, and natural gas reserves.

Keywords: Energy consumption, GDP, causality, ARDL bound test, Oman.

1.Introduction

The continues increasing of oil prices following the oil shock in the 1970s, the instability of prices of oil up to now, and the increasing of energy consumption cast a shadow over the importance of studying energy and its impact on economic output and economic development in general, along with the critical role of energy in the various economic activities. The international influence, environmental effects of energy and the presence of energy sources in some countries and their absence in others have added a new dimension to the importance of the study of energy. Consequently, countries have been divided into energy exporting and importing countries. The causal relationship between GDP and energy consumption has been studied widely during last decades for many countries separately or as groups to detect the presence of this relation and to determine its direction. This paper investigates the long run relationship and causality between energy consumption and GDP in Oman using ARDL bounds testing procedure which has been developed by Pesaran and Shin (1999), and Pesaran et al. (2001), and Granger causality test to examine the short run causality.

2.Literature review

After the major work of Kraft and Kraft (1978), which found that the causality between energy and gross national product in the USA was unidirectional; only running from GNP to energy for the period following the war and no observed causality from energy to GNP, Empirical studies of the relationship between energy consumption and GDP were conducted for both separate or combined countries. The Empirical studies dealt with the relationship according to four hypotheses: first, there is a causal relationship going from GDP to energy consumption, second there's a causal relationship coming from energy consumption to GDP, third there are two-way causal relationship between energy consumption and GDP, and the fourth is absence the relationship between them.

A paper by Shahateet (2014), examined the relationship between real economic growth and energy consumption in 17 Arab countries: Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates, Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, and Yemen. Using ARDL model and granger causality test, the results supported the neutrality hypothesis in all countries except the state of Kuwait, this finding contradict with Al-Iriani (2006), which supported the unidirectional causality coming from GDP to energy consumption in the countries of the Gulf Cooperation Council (GCC) including Oman, the results were obtained using the panel Cointegration and causality techniques. Further, Bouoiyour and Selmi (2013), studied the nexus between electricity consumption and economic growth in 12 of MENA countries using panel cointegration methods and panel causality test over the period 1975–2010. They classified those countries as energy exporters and energy importers countries, the research indicates that in Oman as an energy export country, the causal

relationship comes from economic growth to energy consumption. While the majority of other countries supporting the bi-directional causal relationship hypothesis. Hossein,Yazdan and Hasan(2012), examined the relationship between the energy consumption and economic growth for OPEC countries using error-correction models and the Granger causality test; they revealed that there was a Granger causality short run causal relationship in Iran, Iraq, Qatar, United Arab Emirates and Saudi Arabia comes from income to energy consumption, and there was a Granger causality runs from energy consumption to income in rest of other OPEC countries. while there was no long run causal relationship in all OPIC countries.

Another paper of Ozturk and Acaravci (2011), investigated the short and long run nexus between energy consumption and real GDP in the selected 11 Middle East and North Africa (MENA) countries using ARDL approach with annual data covering the period from 1971 to 2006. The results generally indicated that no relationship between the electricity consumption and real GDP in the most of the MENA countries, however only in Oman the one-way both long-run and strong Granger causalities from electricity consumption to real GDP was existed. In addition to presence of short run one-way Granger causality from real GDP to electricity. Souhila and Kourbali (2012), examined the energy consumption-growth relation in Algeria using threshold Cointegration and Granger causality tests, they used logarithm per capita data for the 1965 -2008 time period, they found a unidirectional causality running from the GDP to energy consumption. Yazdan and Hossein (2012), applied the ARDL model and Granger causality test to investigate the relationship between oil consumption and economic growth in Iran, the results showed the short run relationship running from GDP to oil consumption, and there was no long run relationship between them. Halis and Korap (2015), studied the relationship between electricity consumption and income using ARDL bounds testing, they found a unidirectional long run running from electricity energy consumption to income.

The nexus relationship between energy consumption (both renewable and nonrenewable) and economic growth in Pakistan had examined by Shahbaz, Zeshan, and Afza (2012), using the ARDL bounds testing and Gregory and Hansen (1990) structural break Cointegration approaches for long run, they proved the presence of Cointegration between the economic growth and renewable and non-renewable energy consumption, also the two-way causal relationship was existed. Binh (2011), investigated the relationship between Energy Consumption and Economic Growth in Vietnam by using the threshold Cointegration and vector error correction models for Granger causality tests, the results confirmed the long run relationship running from GDP to energy consumption, his date was in logarithm during the 1976-2010 period. In the case of Turkey, Kaplan, Ozturk, and Kalyoncu (2011), modelled two multivariate models, demand model and production model, based on vector error correction model. They detected the two-way causal relationship between energy consumption and economic growth. Also, the long run bidirectional relationship was existed. In the case of Korea according to the work of Oh and Lee (2004), which as well indicates to short run unidirectional causality running from energy consumption to GDP.

Using vector error correction model (VECM) the work of Belloumi (2009), found that the long run causal relationship between the Energy consumption and GDP in Tunisia was bi-directional, and the short run causal relationship was unidirectional from energy consumption to GDP. finally, the work of Rezitis and Ahammad (2016), confirmed the unidirectional causality relationship runs from energy consumption to economic growth in the South and Southeast Asian Countries (i.e., Bangladesh, Brunei Darussalam, India, Indonesia, Malaysia, Pakistan, the Philippines, Sri Lanka, and Thailand) A Panel Vector Autoregression Approach and Causality Analysis, were used and impulse response functions (IRFs), which empower the effect of shocks to be analyzed between real gross domestic product, energy consumption, real gross fixed capital formation, and total labor force.

3.Model Specification And Data

To investigate the relationship between the energy consumption and GDP we used annual data during 1971-2014 period, the source of data was the World bank: Development indicators for Oman, the data was in per capita form for both energy use (kg of oil equivalent per capita) and GDP, also we transformed the data into logarithm. Figure (1) shows the data where (LENC) is the energy use per capita in logarithm, and (LGDP) is the gross domestic product per capita in logarithm.

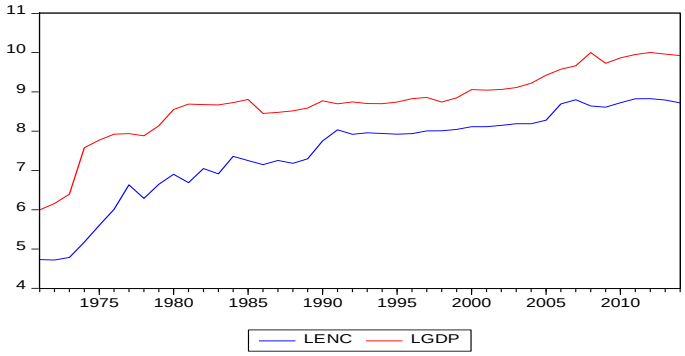

FIG (1). Energy use per capita and GDP per capita in Oman.

Nelson and Plosser (1982), argued that almost all macroeconomic time series are not stationary at level (have unit root) so, series will be examined using Augmented Dickey Fuller (ADF) and Phillips, Perron tests. Autoregressive Distributed Lag (ARDL)-Bounds testing approach which was primarily introduced by Pesaran and Shin (1999), then has extend by Pesaran et al. (2001), used to investigate the presence of Cointegration between the two series, unlike Johansson Joint Cointegration Test, ARDL does not require the integration of time series at the same order. so, it can be applied using either I (0) or I (1) series, or both I (0) and I (1), but if there's I (2) series Methodology cannot be used according to Pesaran et al. (2001), where I(.) indicates the degree of integration for the

series. F- test value in the boundary test is compared to the values developed by Pesaran et al. (2001), the null hypothesis is: there's no long run Cointegration between the variables, while the alternative hypothesis indicates that there's a Cointegration, If the value of F-test is higher than the upper limit, the null hypothesis can be rejected, In case it is less than the lower limit, this indicates to the absence of the Cointegration between the variables, If the value of F-test is between the upper and lower limits no decision can be taken. Then error correction term obtained from ARDL model will be examined to show the speed of adjustment at which the model reverts to long-term after the shocks happened in short run. The model will be applied twice. First, while LENC is a dependent variable as follow:

$$\triangle LENC = B_0 + \sum_{i=1}^{p} B_i \triangle LENC_{t-i} + \sum_{i=0}^{q} \alpha_i \triangle LGDP_{t-i} + \phi_0 \triangle LENC_{t-1} + \phi_1 \triangle LGDP_{t-1} + \varepsilon_t$$

Where ϕ_0 , ϕ_1 show the coefficients of long-run relationship between the series; αi and βi show the coefficients of short-run relationship between the series. Δ is defined as first difference operator. Null hypothesis Ho : $\phi_0 = \phi_1 = 0$, alternative hypothesis H1: $\phi_0 \neq \phi_1 \neq 0$

"p" impersonates the lag length of LENC and "q" impersonates the lag length of LGDP series.

Second, LGDP is a dependent variable as follow:

$$\triangle LGDP = B_0 + \sum_{i=1}^{p} B_i \triangle LGDP_{t-i} + \sum_{i=0}^{q} \alpha_i \triangle LENC_{t-i} + \phi_0 \triangle LGDP_{t-1} + \phi_1 \triangle LENC_{t-1} + \varepsilon_t$$

Where ϕ_0 , ϕ_1 show the coefficients of long-run relationship between the series; αi and βi show the coefficients of short-run relationship between the series. Δ is defined as first difference operator. Null hypothesis Ho : $\phi_0 = \phi_1 = 0$, alternative hypothesis H1: $\phi_0 \neq \phi_1 \neq 0$.

"p" impersonates the lag length of LENC and "q" impersonates the lag length of LGDP series. The error correction model has been established as follow Respectively:

$$\triangle LENC = B_0 + \sum_{i=1}^{p} B_i \triangle LENC_{t-i} + \sum_{i=0}^{q} \alpha_i \triangle LGDP_{t-i} + \omega ECM_{t-1} + \varepsilon_t$$

$$\triangle LGDP = B_0 + \sum_{i=1}^{p} B_i \triangle LGDP_{t-i} + \sum_{i=0}^{q} \alpha_i \triangle LENC_{t-i} + \omega ECM_{t-1} + \varepsilon_t$$

While ECM is the error correction term, and (ω) represents the speed of adjustment at which the model reverts to long-term after the shocks happened in short run.

4.Empirical results

ADF, PP tests were used to investigate the stationarity of series, null hypothesis claims that series contain a unit root (non – stationary) the result is summarised in the table (1) for LGDP.

Table (1). PDF, PP Stationary Test Results for LGDP.

Augmented Dickey Fuller (ADF) results				
At level			**At first difference**	
	t-Statistic	***Prob.***	**t-Statistic**	***Prob.***
With constant	-3.4451	*0.0146**	-5.3228	*0.0001***
With constant& trend	-3.6167	*0.0401**	-5.6600	*0.0002***
none	2.3538	*0.9948*	-4.7708	*0.0000***
Phillips, Perron, test results				
At level			**At first difference**	
	t-Statistic	***Prob.***	t-Statistic	***Prob.***
With constant	-3.5297	***0.0118****	-5.3169	***0.0001****
With constant& trend	-3.7361	***0.0304****	-5.6610	***0.0002****
none	2.0344	***0.9888***	-4.7362	***0.0000****

**Significant at 5%, **significant at 1%*

The results indicate that (LGDP) is not stationary at level, but after taking the first difference it became stationary at 1%. Table (2) summarised the results of ADF, PP tests for (LENC)

Table (2). PDF, PP Stationary Test Results for LENC.

Augmented Dickey Fuller (ADF) results				
At level			**At first difference**	
	t-Statistic	***Prob.***	**t-Statistic**	***Prob.***
With constant	-2.7163	*0.0795*	-6.6391	*0.0000***
With constant& trend	-2.2217	*0.4660*	-7.4113	*0.0000***
None	2.4168	*0.9955*	-5.6070	*0.0000***
Phillips, Perron, test results				
At level			**At first difference**	
	t-Statistic	*Prob.*	t-Statistic	*Prob.*
With constant	-3.4283	*0.0153**	-6.6436	*0.0000***
With constant& trend	-2.0869	*0.5382*	-7.4317	*0.0000***
None	2.2372	*0.9931*	-5.7783	*0.0000***

**Significant at 5%, **significant at 1%*

It's clear that (LENC) series is not stationary at level, but became stationary with the first difference at 1%. According to the results above LGDP, LENC are integrated at the first order I (1). Since the variables are integrated at first level, and none of them is I (2), then we can apply ARDL as follow:

4.1 ARDL model

Since both LENC and LGDP are I (1) we applied tow ARDL models with considering LENC as dependent variable in the first model, and LGDP as dependent variable in the second one.

Table (3) represents the ARDL bound testing outcome while LENC is dependent variable model 1, the Selected Model was: ARDL (2, 0), figure (4)

Table (3). F-Bounds Test, long run coefficient, and error correction term. model 1.

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LGDP	1.020458	0.161600	6.314725	0.0000
C	-1.084645	1.488233	-0.728814	0.4706
c				
F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
			Asymptotic: n=1000	
F-statistic	10.95384	10%	3.02	3.51
k	1	5%	3.62	4.16
		2.5%	4.18	4.79
		1%	4.94	5.58
ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LENC(-1))	-0.162412	0.125271	-1.296487	0.2026
CointEq(-1)*	-0.263722	0.044840	-5.881416	0.0000

* significant at 1%

The value of F-test is strongly higher than upper limit at all significance levels. This indicates to presence of long run Cointegration between the GDP and energy consumption, the long run coefficient of LGDP is statistically significant, the error correction term is negative and statistically significant, (- 0.263722) is the coefficient of ECM which indicates the speed of LENC to come back to long run relationship with LGDP.

Table (4) represents the F-Bounds Test long run coefficients, and error correction term, model 2 while LGDP is the dependent variable, Selected Model: ARDL (1, 1), figure (5).

Table (4). F-Bounds Test, long run coefficient, and error correction term. model 2.

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LENC	0.503448	0.180301	2.792263	0.0081
C	5.193592	1.474423	3.522457	0.0011
EC = LGDP - (0.5034*LENC + 5.1936)				
F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	4.661677	10%	3.02	3.51
K	1	5%	3.62	4.16
		2.5%	4.18	4.79
		1%	4.94	5.58
ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LENC)	0.341071	0.127714	2.670592	0.0110
CointEq(-1)*	-0.228969	0.059715	-3.834346	0.0004

*significant at 1%

The finding revealed similar results at whole, F-test is higher than upper limit at 5%, the long run coefficient is statistically significant, and error correction term is negative and significant at 1%, (-0.228969) is the coefficient of ECM which indicates the speed of LGDP to come back to long run relationship with LENC.

In order to detect the causal relationship in short run we have used the Pairwise Granger Causality Tests, the results of pairwise granger causality test showed that we can except the null hypothesis which indicates that DLENC does not Granger Cause DLGDP because the probability was more than 0.05, in contrast we can't accept the null hypothesis which indicates that DLGDP does not Granger Cause DLENC because the probability was less than 0.05, the we can conclude that there's only short run causality running from LGDP to LENC.

Table (5). Pairwise Granger Causality Tests.

Pairwise Granger Causality Tests			
Sample: 1971 2014			
Lags: 2			
Null Hypothesis:	Obs	F-Statistic	Prob.
DLGDP does not Granger Cause DLENC	41	3.58162	0.0381
DLENC does not Granger Cause DLGDP		0.67994	0.5130

4.2 Residuals tests

For the purpose of studying model's quality, we examined the Serial Correlation, Heteroscedasticity, and stability of relationship in the long run, the results showed that there's no Serial Correlation in both 2 models the probability of F in Breusch-Godfrey Serial Correlation LM Test was greater than 0.05. so, we cannot accept the null hypothesis of Breusch-Godfrey Serial Correlation LM Test which indicates the presence of serial correlation. in the other hand the results indicated the absence of Heteroscedasticity in both models. The probability of F in ARCH test was above 0.05.so, we cannot accept the null hypothesis.

In order to study the stability in long run the CUSUM and CUSUM of squares tests have been applied, the results were slightly different, the results of recursive residuals CUSUM test for both the first and second model indicate to the stability, in contrast the results of CUSUM of squares especially for second model have some deviations which indicate to the parameter instability. However, the cointegration and presence of long run can Emphasizes the stability of the parameters of our models.

Results of Breusch-Godfrey Serial Correlation LM Test, and ARACH test for model (1) and model (2) respectively in the appendix have showed in the table (6), and table (7). While figure (2) and figure (3) in the appendix summarized the results of CUSUM and CUSUM of squares tests for both first and second model.

5. Conclusion

The relationship between GDP and energy consumption has been studied in different countries using different econometrics' methodologies in view of the importance of energy for economics and the emergence of several hypotheses to interpret it. this work aimed to examine the causality relationship between GDP and energy consumption in Oman from 1971 to 2014, using ARDL model, and granger causality test. ADF, PP tests were used to investigate the stationarity of series. The results indicated that LENC and LGDP were integrated at the first order. Also, there was a bidirectional long run causality relationship between GDP and energy consumption in addition to existence of a unidirectional short run causality relationship coming from GDP to energy consumption. In order to verify the validity of the results the tests of serial correlation, heteroscedasticity, and stability for the residuals have been applied and showed that our results were reliable. Bidirectional long run causality indicated that increasing of GDP will lead to a raise in energy consumption, and vice versa.

Energy plays an important role in Oman as oil-exporting country, which relies mainly on fossil fuels as an energy source. But no separate studies were mad for the causal relationship between GDP and energy consumption in Oman. So, our findings may help the government to make a policy which can Stimulate GDP growth and optimize energy consumption.

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Appendix

Table (6). Serial Correlation, and Heteroscedasticity for model (1).

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.043553	Prob. F(2,36)	0.9574
Obs*R-squared	0.101379	Prob. Chi-Square(2)	0.9506
Heteroskedasticity Test: ARCH			
F-statistic	0.860960	Prob. F(1,39)	0.3592
Obs*R-squared	0.885563	Prob. Chi-Square(1)	0.3467

Table (7). Serial Correlation, and Heteroscedasticity for model (2).

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.043243	Prob. F(2,37)	0.9577
Obs*R-squared	0.100277	Prob. Chi-Square(2)	0.9511
Heteroskedasticity Test: ARCH			
F-statistic	0.211205	Prob. F(1,40)	0.6483
Obs*R-squared	0.220600	Prob. Chi-Square(1)	0.6386

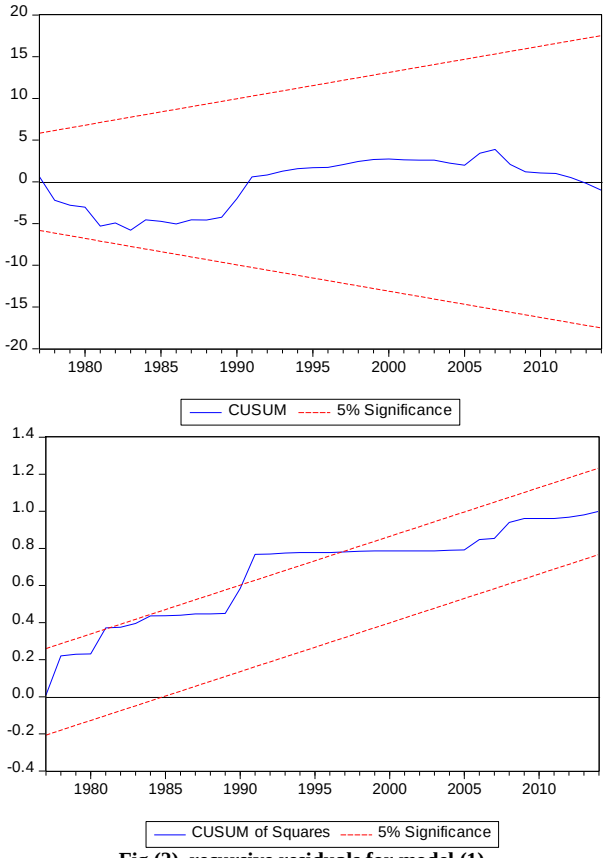

Fig (2). recursive residuals for model (1).

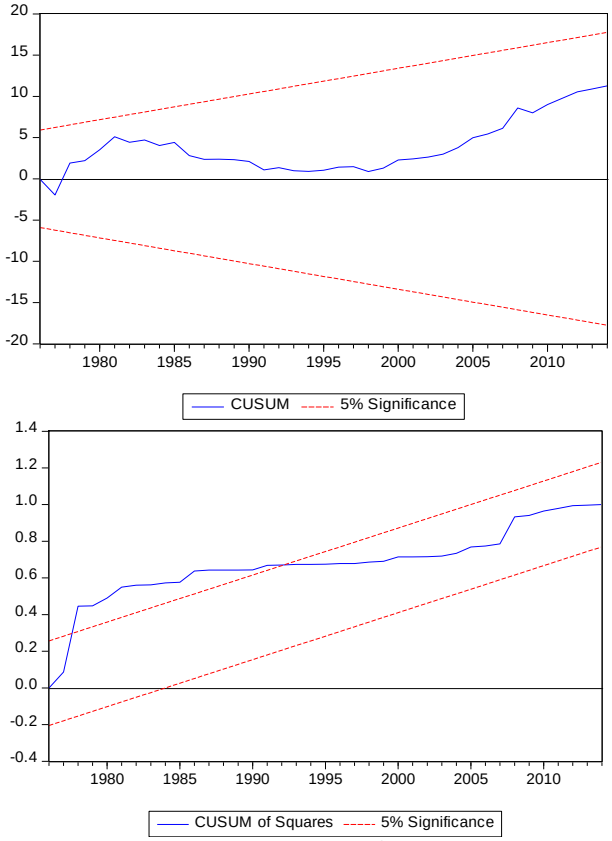

Fig (3). recursive residuals for model (2).

Akaike Information Criteria

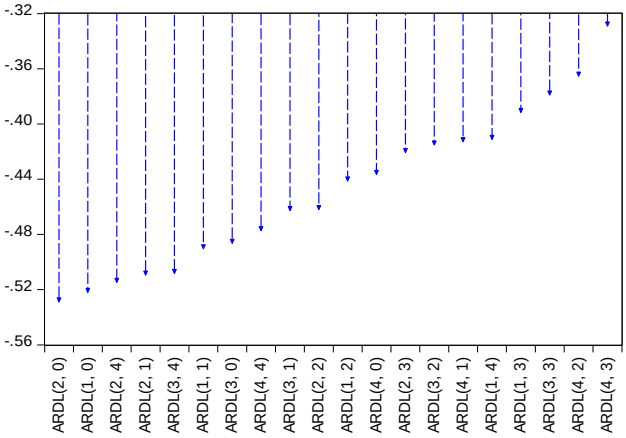

Fig (4). Figure 1 Akaike Information Criteria (top 20 models) for Model 1.

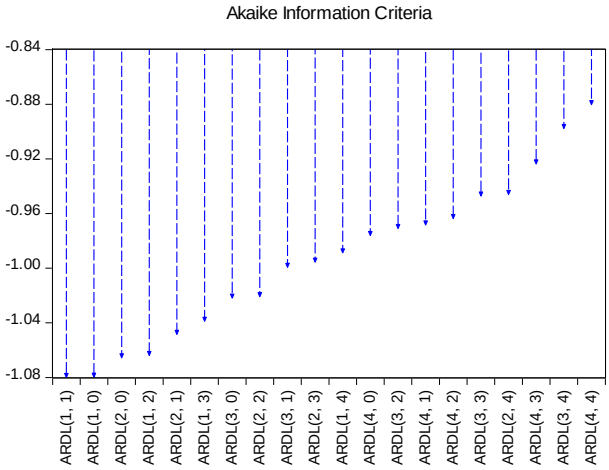

Fig (5). Figure 1 Akaike Information Criteria (top 20 models) for Model 2.

العلاقة السببية بين استهلاك الطاقة والناتج المحلي الإجمالي في عمان

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ملخص البحث. هدفت هذه الدراسة إلى اختبار العلاقة السببية بين استهلاك الطاقة ,والناتج المحلي الإجمالي GDP في دولة عمان، باستخدام بيانات سنوية لوغاريتمية للفترة من ١٩٧١ وحتى ٢٠١٤، وأشارت نتيجة اختباري السكون ADF,PP إلى أن استهلاك الطاقة للفرد وكذلك الناتج المحلي للفرد مستقران عند الفروق الأولى، وقد تم استخدام نموذج الانحدار الذاتي ذو الفترات الزمنية الموزعة "ARDL " واختبار سببية جرانجر، وقد أظهرت النتائج ,وجود علاقة سببية ثنائية الاتجاه بين استهلاك الطاقة والناتج المحلي الإجمالي GDP في الأجل الطويل، وعلاقة سببية تتجه من الناتج المحلي الإجمالي GDP باتجاه استهلاك الطاقة في الأجل القصير، وتشير العلاقة الثنائية أن الزيادة في الناتج المحلي الإجمالي قد يقود إلى زيادة استهلاك الطاقة والعكس بالعكس. ويمكن لهذه النتائج أن تساعد صانعي السياسات في تطوير سياسات ملائمة فيما يتعلق باستهلاك الطاقة والناتج المحلي الإجمالي في عمان التي تمتلك احتياطيات كبيرة من النفط والغاز الطبيعي.

الكلمات الافتتاحية: استهلاك الطاقة، الناتج المحلي الإجمالي،GDP ، السببية، اختبار الحدود ARDL، عمان