Investigating the linkage between Renewable Energy Consumption and Economic Growth: The case of Turkey

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ABSTRACT

The study purposes to investigate the relationship between renewable energy consumption and economic growth in Turkey using annual data covering the period 1990–2014. The Autoregressive Distributed Lag (ARDL) model is applied and the findings suggest existence of a long run relationship among the variables. The ARDL long run estimation results discovered that renewable energy consumption has a positive and significant effect on economic growth. The results from the Vector Error Correction Model (VECM) reveals that there is a unidirectional causality flowing from economic growth to renewable energy consumption without feedback. These findings bring a fresh perspective for policy makers for long run and sustainable economic development in Turkey.

Keywords: Renewable energy consumption, Economic growth, Causality, Turkey

JEL codes: C32, D04, Q47, Q42, Q01

1. INTRODUCTION

The failure of most countries in meeting the minimum requirements of the greenhouse gas emissions in the last decade in most economies, particularly developing countries, has heightened the debate on the role that renewable energy consumption plays in addressing demand deficiencies and economic growth. This growing concern got most energy economist looking for ways to come up policy implications that will promote provision of clean and sustainable energy which will boost the world's economic growth (Sebri and Ben-Salha 2014; Ocal and Aslan 2013 and Apergies and Payne, 2011). However, the importance of energy consumption on economic growth based on conservation policies still remain varied across both empirical and theoretical literature. Keynes' view on environment issues was that environmental degradation seems fit to incorporate among the outstanding faults of the economic system.

To explore whether such a synthesis might be possible, many studies have investigated the linkage between renewable energy consumption and economic growth using different models and focusing on different countries. The purpose of this study is to examine empirically the relationship between renewable energy consumption and economic growth under a multivariable framework. For this purpose, trade openness, employment and capital formation will be included as additional variables. The time series data for Turkey will be used covering the period between 1990 and 2014. The Autoregressive distributed lag (ARDL) estimation is applied to capture the relationship between economic growth, renewable energy consumption, trade openness, employment and capital.

Before proceeding, it is worth clarifying the choice of Turkey in this study. Turkey has become one of the world's fastest growing energy market. The country had an initiative in 2002 to privatise most of its industry and has been successful in that regard and these sectors include the energy market (IEA 2015). The national renewable energy strategic plan includes generating 30% of the total electricity from renewable source by 2013. The 2015-2019 strategic plan includes diversifying its energy supply to ensure security of supply at the same time protecting its environment by providing renewable, clean and low carbon technologies. It is therefore important to explore whether or not these initiatives will boost economic growth in Turkey using the conservation policies.

This study is divided into five sections: Section two reviews other studies' literature on economic growth and renewable energy consumption. Section three presents data and methodology employed in this study. The finding and interpretation of the results are presented in Section four. Finally, section five concludes and provide policy recommendations based on the study's findings.

2. LITERATURE REVIEW

The analysis of the relationship between energy consumption and economic growth can be categorised into four hypotheses. The *feedback hypotheses* which implies that there is a two-way relationship between energy consumption and economic growth. This hypothesis reveals that a change in energy consumption will have an effect on economic growth and the opposite is true. The *growth hypothesis*, indicates that economic growth depends on energy consumption such that a change in energy consumption will have an effect on economic growth. In this case, there is a one way causality running from energy consumption to economic growth. Under growth hypothesis, energy conservation policies are not applicable as they will adversely affect economic growth. The *conservation hypothesis*, shows that there is a unidirectional causality flowing from economic growth to energy consumption. In this case, energy consumption is dependent on economic growth but not the other way around. As a result, energy conservation policies will not have an adverse effect on economic growth. The *neutrality hypothesis*, purports that there is no causal relationship flowing between economic growth and energy consumption. Voluminous literate has focused on energy consumption and growth without specifically focusing on the renewable energy. To fill in the gap, our study investigates the relationship between renewable energy consumption and economic growth.

The scant literature on renewable energy consumption in practice has been varied and so are the respective empirical findings, suggesting mixed results on the effect of renewable energy consumption on economic growth. Sebri an Ben-Salha (2014) established a bidirectional causality flowing between renewable energy consumption and economic growth in Brics countries using the vector error correction model. Their results also evidenced existence of a long run relationship between these variables. A one-way directional causality flowing from economic growth to renewable energy consumption was found by Ocal and Aslan (2013) who focused on Turkey using the autoregressive distributed lag (ARDL) model. Apergis and Payne's (2012) study suggested a feedback hypothesis between renewable energy consumption and economic growth for 80 countries they studied using the panel error correction model.

Apergis and Payne (2011) applied the panel error correction model for 6 Central American countries covering the period between 1980 and 2006 in investigating the linkage between economic growth and renewable energy consumption. Their study revealed a feedback hypothesis. Focusing on 13 countries within Eurasia, Apergis and Payne (2010) found that renewable energy consumption and economic growth Granger-cause each other. Apergis and Payne (2010a) undertook another panel of 20 OECD countries to investigate the relationship between economic growth and renewable energy consumption and established a bidirectional causality flowing between the variables.

Sadorsky (2009) investigated the relationship between renewable energy consumption and economic growth in the emerging countries. Panel co-integration tests affirmed that real GDP per capita has a positive impact on renewable energy consumption such that a 1% increase in real GDP per capita boosts the renewable energy consumption by 3.5%. Sadorsky (2009a) focused on the G7 countries and found that real GDP per capita has a positive effect on renewable energy consumption.

Bowden and Payne (2010) served to examine the linkage between sectorial renewable energy consumption and economic growth. The results from Toda-Yamamoto revealed a unidirectional causality flowing from residential renewable energy consumption to economic but failed to establish causality between commercial renewable energy consumption and economic growth. Another study that failed to find the long run relationship between renewable energy consumption and economic growth was done by Tiwari (2011) which employed the structural VAR and Johansen-Juselius (1990).

3. METHODOLOGY

In exploring the link between economic growth and renewable energy consumption, the study proposes a simple production function, where along the traditional inputs, it incorporates renewable energy consumption and trade openness. The conventional neo-classical one-sector aggregate production technology is applied, where labour, capital, trade openness and renewable energy consumption are considered as separate inputs.

$$GDP_t = f(RE_t; TR_t; EM_t; K_t)$$

Where subscript *t* represents time period. GDP stands for real GDP in constant 2010 US dollars and is employed in this study as a proxy for economic growth. TR is trade openness and is measured by combining together imports and exports. K represents the growth in capital stock and is measured by real gross fixed capital formation in constant 2010 US dollars. Lastly, EM denotes employment which is measured as persons employed in thousands of persons. These data was collected from different sources. Data for GDP, K and EM was sourced from the World

Development Inidcators (WDI) published by the World Bank (2016). Data on renewable energy consumption was collected from the US Energy Information Administration (IEA).

The standard log-linear functional specification of the relationship between economic growth, renewable energy consumption, trade openness, employment and capital can be molded as follows:

$$GDP_t = \alpha_1 + \alpha_{RE}RE_t + \alpha_{TR}TR_t + \alpha_{EM}EM_t + \alpha_K K_t + \varepsilon_t \quad (1)$$

To avoid the problems associated with dynamic properties of the data series, all series are transformed into natural logarithms. The empirical equation is molded as follows:

$$lnGDP_t = \alpha_1 + \alpha_{RE}lnRE_t + \alpha_{TR}lnTR_t + \alpha_{EM}lnEM_t + \alpha_K lnK_t + \varepsilon_t \quad (2)$$

Where $\alpha_{RE}, \alpha_{TR}, \alpha_{EM}, \alpha_K,$ are elasticities of economic growth with respect to renewable energy consumption, trade openness, employment and capital, respectively. ε is the error term.

To investigate the long run relationship between the renewable energy consumption and economic growth, this study applies the Autoregressive Distributed Lag (ARDL) bounds test of co-integration developed by Pesaran and Shin (1998) and refined later by Pesaran et.al (2001). This approach is preferred over other techniques because it does not require pretests of the unit roots. ARDL cointegration technique is also preferable when the underlying variables are integrated to different order, I(0), I(1) or the combination of both. It also provides robust results when there is a single long run relationship between the variables of interest in a small sample.

The application of the ARDL technique in examining the long run relationship between renewable energy consumption and economic growth involves estimation of an unrestricted error correction model (UECM) in the first difference form (Khobai *et.al* 2016). The modified model used in this paper is presented in an ARDL representation as follows:

$$\Delta lnDGP_t = \alpha_1 + \alpha_T T + \alpha_{GDP}lnGDP_{t-1} + \alpha_{RE}lnRE_{t-1} + \alpha_{TR}lnTR_{t-1} + \alpha_{EM}lnEM_{t-1} + \alpha_K lnK_{t-1} + \sum_{i=1}^{p}\alpha_i \Delta lnGDP_{t-i} + \sum_{j=0}^{q}\alpha_j \Delta lnRE_{t-j} + \sum_{k=0}^{r}\alpha_k \Delta lnTR_{t-k} + \sum_{l=0}^{s}\alpha_l \Delta lnEM_{t-l} + \sum_{m}^{t}\alpha_{m=0}\Delta lnK_{t-m} + \varepsilon_{1i} \quad (3)$$

$$\Delta lnRE_t = \alpha_1 + \alpha_T T + \alpha_{GDP} lnGDP_{t-1} + \alpha_{RE} lnRE_{t-1} + \alpha_{TR} lnTR_{t-1} + \alpha_{EM} lnEM_{t-1} + \alpha_K lnK_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta lnGDP_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta lnRE_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta lnTR_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta lnEM_{t-l} + \sum_{m}^{t} \alpha_{m=0} \Delta lnK_{t-m} + \varepsilon_{2i} \quad (4)$$

$$\Delta lnTR_t = \alpha_1 + \alpha_T T + \alpha_{GDP} lnGDP_{t-1} + \alpha_{RE} lnRE_{t-1} + \alpha_{TR} lnTR_{t-1} + \alpha_{EM} lnEM_{t-1} + \alpha_K lnK_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta lnGDP_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta lnRE_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta lnTR_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta lnEM_{t-l} + \sum_{m}^{t} \alpha_{m=0} \Delta lnK_{t-m} + \varepsilon_{3i} \quad (5)$$

$$\Delta lnK_t = \alpha_1 + \alpha_T T + \alpha_{GDP} lnGDP_{t-1} + \alpha_{RE} lnRE_{t-1} + \alpha_{TR} lnTR_{t-1} + \alpha_{EM} lnEM_{t-1} + \alpha_K lnK_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta lnGDP_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta lnRE_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta lnTR_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta lnEM_{t-l} + \sum_{m}^{t} \alpha_{m=0} \Delta lnK_{t-m} + \varepsilon_{4i} \quad (6)$$

$$\Delta lnEM_t = \alpha_1 + \alpha_T T + \alpha_{GDP} lnGDP_{t-1} + \alpha_{RE} lnRE_{t-1} + \alpha_{TR} lnTR_{t-1} + \alpha_{EM} lnEM_{t-1} + \alpha_K lnK_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta lnGDP_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta lnRE_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta lnTR_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta lnEM_{t-l} + \sum_{m}^{t} \alpha_{m=0} \Delta lnK_{t-m} + \varepsilon_{5i} \quad (7)$$

Where Δ is the first difference operator, *T* is the time trend. The dependent variable, *ln*GDP is the natural logarithm of real gross domestic product and is used as a proxy for economic growth. The first control variable RE represents renewable energy consumption. The other three control variables TR, EM and K denote trade openness, employment and capital, respectively. *p, q, r, s,* are the maximum number of lags in the model.

Renewable energy is the energy that is collected from renewable sources. One of its characteristics is that it is sustainable which means it never runs out. In this case, the usage of renewable energy guarantees availability of the source of power. It is expected that it will have a positive effect on economic growth (Apergis and Payne 2011). Renewable energy is measured as a % of total final energy consumption.

Trade openness is measured as the addition of both the exports and imports. Trade openness is considered as an engine of growth (Khobai et.al 2018 and Olufemi and Olufemi 2004). Therefore, it is expected to have a positive effect on economic growth.

A wage-led growth is possible only through employment creation, more especially in the developing countries. Therefore it would boost growth through expanding consumption demand in the local market. It is therefore anticipated that employment will have a positive effect on economic growth. Capital stock is measured by the gross fixed capital formation. It is also expected to have a positive and significant effect on economic growth.

The bounce test technique is carried out by employing the F-test for the joint significance of coefficients of the lagged variables. The null hypothesis of no co-integration is estimated against the alternative hypothesis of co-integration in Equation (3). To find whether there is existence of co-integration or not, the computed F-statistics are compared with the critical values constructed by Pesaran et.al (2001). Pesaran et.al's (2001) critical values comprises to two sets, the lower-bounds critical values and the upper-bounds critical values. The following results can be derived from the hypothesis: the null hypothesis of no co-integration among the variables cannot be rejected if the calculated F-statistics falls below the lower-bound values. The null hypothesis of no co-integration can be rejected if the calculated F-statistics is greater than the upper-bounds values. However, if the calculated F-statistics falls between the lower and the upper bounds, the results are inconclusive.

The presence of a long run relationship between economic growth and renewable energy consumption indicates that there is Granger-causality at least in one direction. Therefore, to determine the direction of causality between the underlying variables, the study applies the F-statistics and the lagged error-correction term. The long run relationship in shown by the t-statistic on the coefficient of the lagged error-term while the short run relationship is shown by the F-statistic on the explanatory variables (Khobai et.al 2016). The VECM is moulded by Eq. (8) – Eq.(12). In each equation, the dependent variable is explained by itself, the independent variables and the error correction term

$$\Delta lnGDP_t = \gamma_0 + \sum_{i=1}^{p} \gamma_1 \Delta\, lnGDP_{t-i} + \sum_{i=0}^{p} \gamma_2 \Delta lnRE_{t-i} + \sum_{i=0}^{p} \gamma_3 \Delta lnTR_{t-i} + \sum_{i=0}^{p} \gamma_4 \Delta lnEM_{t-i} + \sum_{i=0}^{p} \gamma_5 \Delta lnK_{t-i} + \delta ECT_{t-1} + \mu_t \quad (8)$$

$$\Delta lnRE_t = \alpha_0 + \sum_{i=1}^{p} \gamma_1 \Delta\, lnGDP_{t-i} + \sum_{i=0}^{p} \alpha_2 \Delta lnRE_{t-i} + \sum_{i=0}^{p} \alpha_3 \Delta lnTR_{t-i} + \sum_{i=0}^{p} \alpha_4 \Delta lnEM_{t-i} + \sum_{i=0}^{p} \alpha_5 \Delta lnK_{t-i} + \delta ECT_{t-1} + \mu_t \quad (9)$$

$$\Delta lnTR_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta\, lnGDP_{t-i} + \sum_{i=0}^{p} \beta_2 \Delta lnRE_{t-i} + \sum_{i=0}^{p} \beta_3 \Delta lnTR_{t-i} + \sum_{i=0}^{p} \beta_4 \Delta lnEM_{t-i} + \sum_{i=0}^{p} \beta_5 \Delta lnK_{t-i} + \delta ECT_{t-1} + \mu_t \quad (10)$$

$$\Delta lnK_t = \theta_0 + \sum_{i=1}^{p} \theta_1 \Delta\, lnGDP_{t-i} + \sum_{i=0}^{p} \theta_2 \Delta lnRE_{t-i} + \sum_{i=0}^{p} \theta_3 \Delta lnTR_{t-i} + \sum_{i=0}^{p} \theta_4 \Delta lnEM_{t-i} + \sum_{i=0}^{p} \theta_5 \Delta lnK_{t-i} + \delta ECT_{t-1} + \mu_t \quad (11)$$

$$\Delta lnEM_t = \varphi_0 + \sum_{i=1}^{p} \varphi_1 \Delta\, lnGDP_{t-i} + \sum_{i=0}^{p} \varphi_2 \Delta lnRE_{t-i} + \sum_{i=0}^{p} \varphi_3 \Delta lnTR_{t-i} + \sum_{i=0}^{p} \varphi_4 \Delta lnEM_{t-i} + \sum_{i=0}^{p} \varphi_5 \Delta lnK_{t-i} + \delta ECT_{t-1} + \mu_t \quad (12)$$

Δ denotes the difference operator, $\gamma, \alpha, \beta, \theta, \varphi$ are the constant terms and ECT represents the error correction term derived from the long run co-integrating relationships. The *t*-statistics is employed to test the significance of the speed of adjustment in ECT terms. The statistical significance of ECT_{t-1} with a negative sign validates the existence of a long run causality flowing among the variables. To investigate the short run causality, the Wald test is applied on differenced and lagged differenced terms of the independent variables.

4. FINDINGS OF THE STUDY

4.1 Unit root tests

Table 1 shows the results of the three unit root tests, Augmented Dickey Fuller, Phillips and Perron and Dickey-Fuller Generalised Least Squares (DF-GLS) unit root tests. The test interpretation for these tests is $H_0 =$ there is unit root for the series and $H_1 =$no unit root for the series (meaning the series is stationary). Performed first at levels, the results validated that the null hypothesis is not rejected at conventional critical values for the series in levels. This implies that the variables are non-stationary at levels. Transformed into first differences, the results posit that the null hypothesis is rejected. Therefore, we conclude that economic growth, renewable energy consumption, trade openness, employment and capital are stationary and hence integrated of first order, *I*(1).

Table 1: Unit root tests

	Levels			**First difference**		
Variable	**ADF**	**PP**	**DF-GLS**	**ADF**	**PP**	**DF-GLS**
LGDP	0.1625	0.6727	1.1345	-2.8540***	-5.3503*	-1.5128***
LRE	0.1545	-0.0355	1.5867	-5.2599*	-4.2808*	-5.2733*
LTR	-1.7256	-0.8831	-0.4635	-3.1344**	-5.6165*	-1.2906***
LEM	1.5820	1.1425	1.8711	-1.4573***	-4.6429*	-1.6656***
LK	0.7866	-0.6744	0.0722	-3.1351**	-6.0531*	-1.1894***

Source: Own calculation

The suitable ARDL model is chosen by using the Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Info Criterion (AIC) and Schwarz Bayesian Criterion (SBC), Hannan-Quinn (HQ). To select the suitable model, several lag models were fitted. Among the models the preferred models to explain the long run relationship were AIC and SB. Following from Table 2, this two models selected the lag 2 as the best model.

Table 2 Selection order criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	859.94	NA	5.98e-15	-18.5612	-18.4277	-18.5072
1	1805.09	1704.66	5.99e-23	-36.9811	-32.1797	-36.6572
2	1932.94	226.39*	7.06e-24*	-39.1236*	-37.6545*	-38.5298*
3	1945.69	21.2514	9.21e-24	-38.8685	-36.7315	-38.0047
4	1951.56	9.1815	1.40e-23	-38.4700	-35.6653	-37.3363

Source: own calculation

4.2 Bounds test to Co-integration

The next step is to explore the presence of the long run relationship between economic growth, renewable energy, trade openness, capital and employment in equations (3-7). The study applies the bounds F-test and presents the findings in Table 3.

Table 3 ARDL Co-Integration Test

Critical value bound of the F-statistic						
K	90% level		95% level		99% level	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
3	2.022	3.112	2.459	3.625	3.372	4.797
4	1.919	3.016	2.282	3.340	3.061	4.486

Calculated F-statistics

F_{GDP}(GDP/RE, TR, K, EM) = 13.27

F_{RE}(RE/GDP, TR, K, EM) = 3.706

F_{TR}(TR/GDP, RE, K, EM) = 1.769

F_{K}(K/GDP, RE, TR, EM) = 3.86

F_{EM}(EM/GDP, RE, TR, K) = 2.10

………………………………………………

Note: The critical bound values were taken from Narayam and Smyth (2005: 470)

The findings of the bounds test approach to co-integration of equations (3-7) suggest, based on the F-statistics, that co-integration exists only for equations (3, 4 and 6) when economic growth, renewable energy consumption and capital are used as dependent variables. This is because the F-statistics (13.27, 3.706 and 3.86) for equations (3, 4 and 6) respectively, are greater than the upper bound critical values at 5% level of significance. As a result, the null hypothesis of no co-integration is rejected. However, in equations (5 and 7), when trade openness and employment are used the dependent variables, the F-statistics (1.769 and 2.10), respectively, are less than the lower critical bound values at 5% level of significance. Therefore, the results fail to reject the null hypothesis of no co-integration.

4.3 Estimation Results of Long-run and Short-run Elasticities

The estimates of the long run and short run are reported in Tables 4 and 5, respectively using the ARDL approach. Commencing with the long run elasticities, table 4.4 shows that renewable energy consumption, employment and trade openness have a positive and a significance effect on economic growth at 1%, 5% and 10% levels of significant, respectively. The relationship is such that a 1% in renewable energy consumption leads a 0.36% increase in economic growth. This results are in line with Sadorsky's (2009) findings. Again a 1% increase employment and trade openness leads to economic growth rising by 1.66% and 0.027%, respectively. As for capital, it exhibits a positive but insignificant effect on economic growth.

Table 4 Long run results

Dependent Variable = LGDP			
Long Term Results			
Variable	Coefficients	Standard Error	T-statistics
Constant	-10.9967	16.0471	-0.6852
LRE	0.3616*	0.6821	0.5301
LTR	0.0270***	0.2875	-0.0938
LEM	1.6551**	1.0920	1.5171
LK	0.9461	0.9464	0.9997
R-squared 0.99 Durbin Watson Stat 2.35			

Source: Own calculations

Table 5 presents the short run elasticities and shows that renewable energy consumption, trade openness and employment have a positive and a significant impact at 1% level of significance on economic growth. Specifically, a 1% increase in renewable energy consumption, trade openness and employment boosts economic growth by 0.041%, 0.32% and 0.30%, respectively. Capital has a positive but insignificant impact on economic growth. Table 5 also presents the error correction term. The coefficient of the error correction terms indicates the speed of adjustment in the long run due to a shock. The coefficient of the ECM terms (-0.28) imply that 28% of the disequilibrium in economic growth of the previous year's shock adjust back to the long run equilibrium in the current year.

Table 5 Short run analysis

Variable	Coefficient	Standard error	T-statistics
Constant	0.7601*	0.0579	13.1227
LRE	0.0408*	0.0127	3.2199
LTR	0.3187*	0.0216	14.7287
LEM	0.2975*	0.04458	6.6737
LK	0.1073	0.0088	12.2409
ECM_{t-1}	-0.2823*	0.002	-3.4303
R^2	0.98		
D.W test	2.35		
*represent 1%, significance level			

Source: Own calculation

The ARDL model passes all the diagnostic tests (Table 6). The results suggest that the error terms of the short run models have no serial correlation, they are free of heteroskedasticity and are normally distributed. It established that the short run models are not spurious because the Durbin-Watson statistics was found to be greater than the R^2. The Ramsey RESET test validated that the functional form of the model is well specified

4.4 Short-run diagnostics

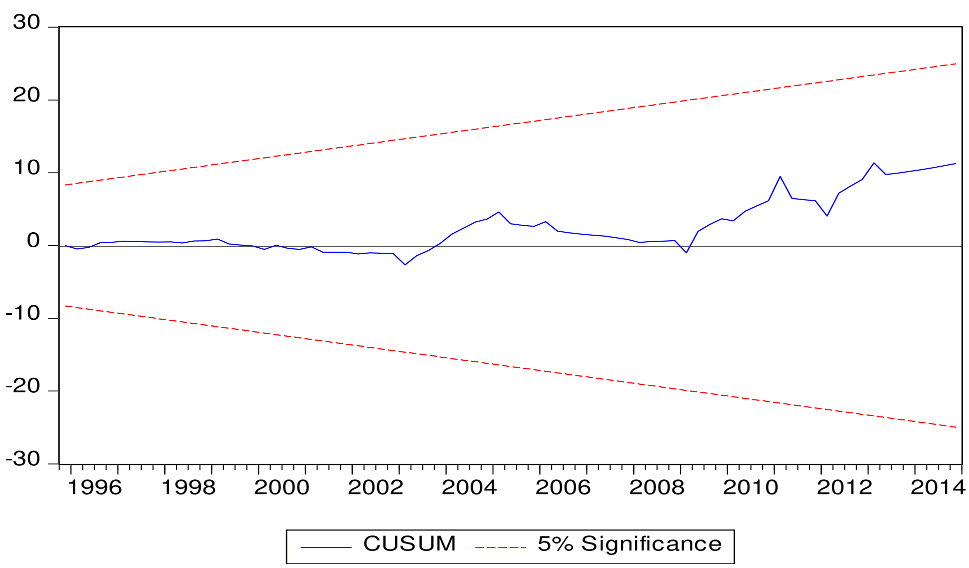
Table 6 Short-run diagnostics

Short run diagnostics		
Test	F-statistics	P-value
Normality	2.3282	0.3122
Heteroskedasticity	1.2094	0.2845
Serial correlation	2.3647	0.1004

Source: Own calculation

Figure 4.1 illustrate the graphical representation of Cumulative Sum (CUSUM) stability test. This test is used to assess the stability of the long run parameters. It can be realised from the plot that test statistics fall within the critical bound of 5% level of significance. Therefore, the null hypothesis that all coefficients of the regression are stable cannot be rejected. This implies that the coefficients in the error-correction model are stable and there is no structural breaks

Figure 1 CUSUM



4.5 Granger Causality

If a set of variables are found to have one or more co-integrating vectors, this shows that there is an existence of causality among the variables. Table 7 reports the findings of the Vector Error Correction Model (VECM) which determines the direction of causality between the underlying variables. The results validate that there is a long run causality flowing from trade openness, capital and employment to renewable energy consumption. This is on account that the coefficient of the error correction term in Equation 9 has a negative sign and is statistically significant at 5% level of significance. It was further established that economic growth Granger-causes renewable energy consumption. This results are consistent to the finding of Ocal and Aslan (2013). A weak long run causality flowing from economic growth, renewable energy consumption, trade openness and employment to capital is also established. In the short run, the results suggest that renewable energy consumption and capital Granger-causes each other.

Table 4.7 Vector Error Correction Model (VECM)

Dependent variable	Types of Causality					
	Short run					Long run
	∑ΔLgdp	∑ Δlre	∑ Δltr	∑ Δlk	∑ Δlem	ECT_{t-1}
ΔLgdp	……..	0.33	0.08	0.20	0.35	-0.0397
Δlre	0.02	……….	0.45	0.97*	0.96	-0.2567**
Δltr	0.04	0.18	…………..	0.09	0.41	-0.1523
Δlk	0.09	0.19*	0.01	………..	0.61	0.1517
Δlem	0.001	0.001	0.04	0.01	……….	0.0765***

Source: Own calculation

5. CONCLUSION

The existence of the four competing hypothesis on the relationship between energy and economic growth has become a key of interest and research for energy economists and the policy makers. The findings on this topic are inconclusive due to the use of different data sample, different data used for different countries and the econometric models which are used. This debate is still under consideration as countries are searching for energy policies that will bring sustainable growth without compromising the environment. In doing so, our study utilizes the production to investigate the linkage between renewable energy consumption and economic growth by incorporating trade openness, employment and capital formation as intermittent variables. The time series data for Turkey is used for the period 1990-2014. The Augmented

Dickey Fuller (ADF), Phillips and Perron (PP) and Dickey Fuller Generalised Least Squared (DF-GLS) unit root tests are employed to assess whether none of the variables are not integrated at $I(2)$. To confirm the existence of the long run among the variables, the Autoregressive Distributed Lag model is applied.

The empirical findings evidence the existence of a long run relationship between economic growth, renewable energy consumption, trade openness, employment and capital. Specifically, renewable energy consumption has a positive and significance effect on economic growth. The results are such that a 1% increase in renewable energy consumption boots economic growth by 0.36% in the long run. The Vector Error Correction Model (VECM) results confirm that there is a unidirectional causality flowing from economic growth to renewable energy consumption without feedback. This implies that renewable energy consumption is dependent on economic growth but not the other way around. As a result, energy conservation policies will not have an adverse effect on economic growth in Turkey.

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