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Relation between Renewable Energy, Energy Consumption and Economic Growth in Iran

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ABSTRACT

This study examines the correlation between economic growth, carbon dioxide, renewable energy, energy consumption and population for the period 1975-2010, using time series (ARDL, VECM model and Granger causality) to the economy of Iran. ARDL approach demonstrates that emissions of carbon dioxide and renewable energy are positively correlated with economic growth. The model also shows that the population has a negative effect on growth. The Granger test has relationship unidirectional causality between economic growth and renewable energy consumption. Four Granger causalities are running from CO2 emissions, renewable energy, energy consumption and population to GDP.

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INTRODUCTION

The environmental consequences of global warming and greenhouse gas greenhouse increase concern the use of fossil fuels. Therefore, renewable energy has become an important component of the global energy consumption.

Environmental awareness has become a central issue in the political debate, and in particular the transition to a low-carbon has been one of the major economic challenges. In this context, the implementation of the Europe 2020 strategy for sustainable economic growth based on the use of sustainable energy sources, with three main objectives, that is (i) drastically cut carbon dioxide (CO2), (ii) increasing the share of renewable energy sources in final energy consumption, and (iii) increasing energy efficiency. This set of objectives at European level has been translated into national targets for each Member State, taking into account country-specific economic circumstances.

The rest of the paper is organized as follows: section 2 presents the previous literature regarding the causal link between the use of renewable energy, energy consumption, population and economic growth for both consumer country studies and multi-country. Section 3, 4 and 5 present the data, methods and results. Section 6 provides conclusions.

2 Literature Survey:

In this section, we revisit some empirical studies. Our main is to explain the new determinants of economic growth and their association with them.

Halicioglu [1] examined the causal relationship between carbon emissions, energy consumption, income and trade in the case of Turkey using the test limits ARDL cointegration procedure. The results indicate that the limits, there are two forms of long-term equilibrium. The first form is that carbon emissions are explained by energy consumption, income trade and the second form is that carbon emissions, energy consumption and trade are key factors of income.

Sadorsky [2] considers panel data from 18 developing countries to explain the impact of renewable energy and growth. This empirical work shows that renewable energy has a positive impact on economic growth.

Apergis and Payne [3] studied the relationship of cause and effect between the emissions of carbon dioxide, energy consumption and production of six Central American countries in a model correction vector of the panel

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and results indicate that in the long-term consumption of energy has a positive and statistically significant impact on CO2 emissions, but shows the actual production of the EKC hypothesis.

Fodha and Zaghdoud [4] examined the relationship between economic growth and emissions of pollutants (CO2 and SO2), and found that there is a long-run cointegrating relationship between the emissions of two pollutants and GDP. They also concluded that the policy of reducing emissions and to invest more in clean-up costs will not disrupt economic growth in Tunisia.

Kim et al. [5] examined the link between carbon dioxide emissions and economic growth in the case of Korea. Using Granger causality, the authors found a causal link between economic growth, carbon emissions of carbon dioxide, renewable energy and globalization and growth dioxide.

Ozturk and Uddin [6] consider the emissions of carbon dioxide as the dependent variable to assess the changing environment. Usually, empirical studies use as explanatory variables GDP per capita squared GDP per capita energy consumption, trade openness, and foreign direct investment. Our study aims to evaluate new determinants of economic growth. For that, we assume that renewable energy, non-renewable energy and globalization explain the growth. In fact, energy efficiency is crucial to explain economic growth.

Shahbaz et al. [7] examine the relationship between renewable energy, non-renewable energy, energy consumption, economic growth and the factors Endowment Pakistan. The authors chose the period 1972-2011, using multivariate time series (unit root ARDL cointegration and VECM Granger causality). This study shows that renewable energy contributes to economic growth.

Dagher and Yacoubian [8] studied the relationship of cause and effect between energy consumption and growth in Lebanon for the 1980-2009 periods. The authors claim to analyze the dynamic causal relationship between variables. The results suggest that energy consumption restrings economic growth in Lebanon.

Jayanthakumaran et al. [9] also conclude that India has an extraordinarily high micro-enterprises that are low consumers and not competitive enough to reach many international markets. First, the idea behind the growth hypothesis is that consumption of energy plays a vital role in the economic growth process directly and / or in addition to labour and capital.

Shahbaz and Leitão [10] argue that the link between economic and energy consumption growth the Portuguese case, applying the foundations of the existence of EKC. The authors used econometric strategy as time series analysis (OLS and the ARMA model). Result shows that growth is positively correlated with energy consumption.

Tang et al. [11] investigate the energy and growth of the Portuguese economy consumption. The authors apply a multivariate model (VECM and Granger causality), and they found bidirectional causality between energy and economic growth.

Sbia et al. [12] show that renewable energy contributes to economic growth. These studies show that renewable energy issues a reduced environmental impact. Sbia shows that growth variables and renewable energy are positively correlated.

3 Data, Specification Models and Methodology:

3.1. Data:

This study uses annual data series time to Iran from 1975 to 2011 real GDP per capita (GDP) in billions of constant 2005 dollars, the emissions of carbon dioxide CO2 (metric tons per capita), the use of energy (ENE) of oil equivalent per capita kg, consumption of renewable energy sources (REC) are proxies for renewable fuels and waste (in tonnes of oil equivalent). Population is the total Iran's population.

In this study, all data were collected from the World Development Indicators (WDI) database online [13].

3.2 Model:

Following the literature (Solarin and Shabaz [14]), GDP measured is a linear function according to the following equation:

$$\mathrm{GDP_t} = \mathrm{f}(CO2_{\mathrm{t}}, \mathrm{REC_t}, ENE_{\mathrm{t}}, POP_{\mathrm{t}}) \quad (1)$$

To find the long-run relationship between economic growth, consumption of renewable energy, energy consumption and population the following log-linear form is proposed:

$$\mathrm{LnGDP_t} = \alpha_0 + \alpha_1 \mathrm{LnCO2_t} + \alpha_2 \mathrm{LnREC_t} + \alpha_3 \mathrm{LnENE_t} + \alpha_4 \mathrm{LnPOP_t} \quad (2)$$

All the variables transformed to natural logarithms for the purpose of the analysis. We have used Microfit 4 and Eviews 8 to conduct the analysis.

4 Econometric Techniques:

4.1 ARDL Bounds Testing of Cointegration:

The Autoregressive Lag (Distributed ARDL) proposed by Pesaran et al approach [15] is applicable for the variables I (0) or I (1) or integrated fractional. The analysis begins by investigating the unit root test of variables using augmented Dickey and Fuller [15] and Philips ADF test the null hypothesis that the series has a unit root is known against the alternative of stationarity. The part of the equation 3 ARDL model is:

$$\Delta LnGDP_t = \mathrm{a}_0 + \sum_{i=1}^{n} \mathrm{a}_{1i}\Delta LnGDP_{t-i} + \sum_{i=1}^{n} a_{2i}\Delta LnCO2_{t-i} + \sum_{i=1}^{n} \mathrm{a}_{3i}\Delta LnREC_{t-i} + \sum_{i=1}^{n} \mathrm{a}_{4i}\Delta LnENE_{t-i} + \sum_{i=1}^{n} a_{5i}\Delta LnPOP_{t-i} + \lambda\, ECM_{t-1} + u_t \tag{3}$$

ECM $_{t\text{–}1}$ is the error correction term which is expanded from the following estimated cointegration equation:

$$ECM_t = LnGDP_t - \mathrm{a}_0 + \sum_{i=1}^{n} \mathrm{a}_{1i}\Delta LnGDP_{t-i} + \sum_{i=1}^{n} a_{3i}\Delta LnCO2_{t-i} + \sum_{i=1}^{n} \mathrm{a}_{3i}\Delta LnREC_{t-i} + \sum_{i=1}^{n} \mathrm{a}_{4i}\Delta LnENE_{t-i} + \sum_{i=1}^{n} a_{5i}\Delta LnPOP_{t-i} \tag{4}$$

In the ARDL bounds testing approach the first step is to estimate Equation 3 by Ordinary Least Square (OLS).

The Error Correction Term (ECM_{t-1}) indicates the speed of the adjustment and shows how quickly the variables return to the long-run equilibrium and it should have a statistically significant coefficient with a negative sign.

4.2 Granger Causality Analysis:

The cointegration approaches are employed to test the existence or absence of long-run relationship between variables. To test the direction of causality between carbon emissions, economic growth, renewable energy consumption and trade openness the Granger [16] approach based on the Vector Error Correction Model (VECM) is employed.

The test answers the question of whether x causes y or y causes x. x is said to be Granger caused by y if y helps in the prediction of the present value of x or equivalently if the coefficients on the lagged y’s are statistically significant. In the presence of long-run relationship between variables in the model, the lagged Error Correction Term (ECM_{t-1}) was obtained from the long-run cointegration relationship and was included in the equation as an additional independent variable. The following model was employed to test the causal relation between the variables Equation 3:

$$\begin{bmatrix} \Delta\,\mathrm{Ln\,YGDP_t} \\ \Delta\mathrm{LnCO2_t} \\ \Delta LnRECt \\ \Delta\mathrm{Ln}ENE_\mathrm{t} \\ \Delta\mathrm{Ln}POP_\mathrm{t} \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \end{bmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14i} & \beta_{15} \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} & \beta_{25} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} & \beta_{35} \\ \beta_{41} & \beta_{42} & \beta_{43} & \beta_{44} & \beta_{45} \\ \beta_{51} & \beta_{52} & \beta_{53} & \beta_{54} & \beta_{55} \end{bmatrix} \begin{bmatrix} \Delta\,\mathrm{Ln\,YGDP_t} \\ \Delta\mathrm{LnCO2_t} \\ \Delta LnRECt \\ \Delta\mathrm{Ln}ENE_\mathrm{t} \\ \Delta\mathrm{Ln}POP_\mathrm{t} \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \end{bmatrix} ECM_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix} \tag{5}$$

ECT_{t-1} is the lagged error-correction term. The VECM captures both the short-run and the long-run relationships. The long-run causal relationship can be established through the significance of the lagged ECTs in equations based on test and the short-run Granger causality is detected through the test of significance of F-statistics of Wald test of the relevant j coefficients on the first difference series.

5. Results and Descriptive Statistics:

Table 1 provides some descriptive statistics on the selected variables period 1975-2011. The summaries contain common statistical means, the average standard deviation (Std. Dev.) Maximum and minimum of each series after logarithm transformation form.

We used unit root tests to ensure that no variable is integrated at I (1) or beyond. We used the ADF unit root test to check the stationarity. The results in Table 2 indicate that all the variables are non-stationary in their shape and stationary at their first differences.

The optimum lags are selected relying on minimizing the Akaike Information Criterion (AIC). The maximum lag order two was set. With that maximum lag lengths setting, the ARDL (3, 3, 3, 0, 0) model is selected using AIC. When testing for cointegration, the VAR model with two lags, as suggested by AIC and HQIC is considered.

As can be seen from Table 3, 4 the Null Hypothesis of no cointegrating relationship against alternative of at most one cointegrating relationship cannot be rejected in any of the models at a 5% level of significance, suggesting that there is cointegrating relationship among variables.

Table 1: Descriptive statistics for different variables.

Variables	GDP	CO2	REC	ENE	POP
Mean	2288.218	4.945604	225.5104	31.29909	59219394
Std. Dev.	453.3948	1.662115	77.72552	169.7711	11401075
Maximum (Year)	3140.356	7.852563	401.5900	977.0000	76420000
Minimum (Year)	1579.396	2.793954	96.66600	0.979000	36000000
N. Observation	33	33	33	33	33

Source: Author's calculation using Eviews 8

Table 2: Augmented Dickey-Fuller Stationary Test Results.

Variable	Constant No Trend	Critical Value	Variable	Constant No Trend	Critical Value
Ln GDP	-0.774839	-2.986225	ΔLn GDP	-3.492103*	-2.967767
Ln CO2	-0.119703	-2.957110	ΔLn CO2	-6.695717*	-2.960411
Ln REC	-2.357929	-2.957110	ΔLn REC	-5.443833*	-2.960411
Ln ENE	-5.811091	-2.957110	ΔLn ENE	-9.250757*	-2.960411
Ln POP	-2.570586	-2.957110	ΔLn POP	-6.936157*	-2.960411
The number inside brackets denotes the appropriate lag lengths which are chosen using Schwarz Criterion. * Denotes for 5% significance level					

Source: Author's Estimation using Eviews 8

Table 3: Unrestricted Cointegration Rank Test (Trace).

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.801346	98.25018	60.06141	0.0000
At most 1*	0.516983	49.76444 4	0.17493	0.0041
At most 2 *	0.452933	27.93333	24.27596	0.0165
At most 3	0.268387	3 9.837784	12.32090	0.1259
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

Source: Author's calculation using Eviews 8

Table 4: Unrestricted Cointegration Rank Test (Maximum Eigenvalue).

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.801346	48.48574	30.43961	0.0001
At most 1*	0.516983	21.83111	24.15921	0.1002
At most 2 *	0.452933	18.09555	17.79730	0.0451
At most 3	0.268387	9.375099	11.22480	0.1039
Trace test indicates 3 cointegrating eqn (s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values				

Source: Author's calculation using Eviews 8

The null hypotheses of no cointegration are rejected, implying long-run cointegration relationships amongst the variables. Economic growth (GDP), carbon dioxide emissions (CO2), renewable energy consumption (REC), energy consumption (ENE) and Population (POP) are stationary over the period 1975- 2011. These variables share a common trend and move together over the long run.

Table 5: Long-run Estimation Results.

Dependent Variable: Ln GDP				
Variable	Coefficient	St. Error	T-Ratio	Prob
Ln CO2	1.00**	.058245	17.2111	[.000]
Ln REC	0.05**	0.017055	2.7490	[0.013]
Ln ENE	-0.01**	.0067542	2.0821	[.051]
Ln POP	-1.03**	.11655	-8.8857	0.000]
C	24.47**	2.0050	12.2050	[0.000]

Note** significant at 5 % level
Source: Author's calculation using Microfit 4.

Estimates of long-term are described in Table 5. All estimated coefficients can be interpreted as long-run elasticities, because the variables are in natural logarithms. The long-term coefficients estimated from labour have the same order of magnitude at 10% significance.

The coefficient on CO2 emission shows a positive impact on GDP in Iran. The elasticity of CO2 emission with respect to output is1.00.For the model indicates that a 1% increase in renewable energy consumption, increase GDP by approximately 0.05%. This suggests that renewable energy consumption is sensitive to real output.

The coefficient of population is found to affect the level of development significantly and negatively by about 1.03% on average. This suggests that the process of economic development is not dependent on population in Iran. The coefficient of trade energy consumption is significant at 10% level.

Table 6: Error correction model (ECM) for short-run elasticity (3, 3, 3, 0, 0) selected based on Akaike Information Criterion.

Dependent Variable: D Ln GDP			
Variable	Coefficient	T-Statistic	Probability
D Ln CO2	0.29**	2.7080	[0.014]
D LnREC	0.04**	2.3123	[0.032]
D Ln ENE	.013***	2.0459	[0.054]
D Ln POP	-0.96**	0-4.9604	[0.000]
dC	22.72**	5.3746	[0.000]
ECM (−1)	-0.93**	-5.9663	[0.000]
The Short-Run Diagnostic Test Results			
R-Squared	.80035		
Akaike info Criterion	58.8849		
Schwarz Criterion	51.1783		
F-Statistic	8.4631	[0.000]	
Durbin-Watson	1.8739		

Note: **shows a percent level of 5%, ***shows a percent level of 10%.
Source: Author's calculation using Microfit 4

We can conclude that the cointegration is supported by the significantly negative coefficient obtained for ECM $_{t-1}$. The error correction (ECM) is used to check the short term relationship between variables. The coefficient of ECM_{t-1} is statistically significant at the 5% significance level, indicating that the speed of adjustment for short-term research of the long-term balance is important. The error correction term is statistically significant and its magnitude is very high indicating a faster return to equilibrium in the case of imbalance.

This term indicates the speed of the adjustment process to restore balance. The relatively high coefficients imply a faster adjustment process. The values of the coefficients of the ECM_{t-1} (-0.93) indicating that all variables to adjust the long-term equilibrium in about 1.07 period following a short-term shock.

The coefficient of the renewable energy consumption is 0.04. This coefficient suggests that 0.04% of renewable energy consumption is about 0.04% increase in GDP. The short run elasticity of GDP compared to emission CO2 is positive and statistically significant. The coefficient emission CO2 suggests that 1% of emission CO2 is about 0.29% increase in GDP.

The coefficient of population in the short term is negative but not significant. The elasticity of GDP with respect to population is -0.96, suggesting that a 1% increase in population will lead to decrease of about 0.96% of GDP in the short term in Iran.

Table 7: VECM Granger Causality results.

Variable	*Short-run*					*Long -run*
	DLn GDP	DLn CO2	DLn REC	DLn ENE	DLn POP	ECM(-1)
DLn GDP	-	34.0432*** [0.000]	5.3467** [0.021]	4.1858** [0.041]	24.6052*** [0.000]	35.5964*** [0.000]
DLn CO2	72.1773*** [0.000]	-	2.0397 [0.153]	0.28832 [0.591]	137.4586*** [0.000]	-
DLn REC	1.3422 [0.247]	0.74357 [0.389]	0.016370 [0.898]	-	0.42191 [0.516]	5.6019** [0.018]
DLn ENE	0.467700 [0.494]	18.9798*** [0.000]	2.7037** [0.100]		0.82236 [0.364]	41.2113*** [0.000]
DLn POP	.90648 [0.341]	0.0030971** [0.956]	0.35682 [0.550]	0.0038186 [0.951]	-	5.9437** [0.015]

x → y means x Granger causes y.
Note: ***, **, *denote and the statistical significance at the 1%, 5% and 10 levels, respectively.
Source: Author's calculation using Microfit 4

We perform the estimation of the VECM to draw conclusions about the direction of causality. The existence of a cointegration relationship between the variables, as the statistics show cointegration in Table 3, 4, indicates that there is Granger causality in these variables in at least one direction, but it does not show the direction of causality. Table 7 shows the results of Granger causality based error correction, including short-term weakness Granger causality and long-term Granger causality.

The Granger causality test results of unidirectional short term causality between long-term consumption renewable energy to GDP. In addition, these results show that the consumption of renewable energy and economic growth has a positive and statistically significant.

The Economic growth has bidirectional causality with carbon dioxide emissions. However, emissions of carbon dioxide have unidirectional causal to GDP and population.

6 Conclusion:

This research evaluates the linkage between economic growth, carbon dioxide emissions, energy consumption, renewable energy and population. In this study, we apply a time series analysis (ARDL and Granger causality) for the period 1975-2011.

This study considers the simultaneous use of renewable energy consumption in order to the relative impact in the economic growth process. The interdependence between renewable energy consumption and economic growth suggests that both types of energy sources are important for economic growth and likewise economic growth encourages the use of renewable energy sources.

The results show that population and renewable energy are positively correlated with the economic growth. We can renewable energy is a vehicle that encourages the environmental rules.

In terms of policy recommendations, this study demonstrates that the use of renewable energy is essential to achieve sustainable development. Appropriate trade policy may be crafted to achieve these objectives both in the short and the long run. A major challenge is to find a balance among the use of energy, environmental protection and production.

Fossil fuel is the largest funder of greenhouse gas emissions. However, to minimize environmental damage from the use of energy, a smart national policy should focus on the use of some kind of alternative, for example, renewable energy. The goal should be to increase reliance on secure, reliable, clean and cost of energy efficient and sustainable.

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