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The Nexus between Energy, Environment and Growth: Evidence from Latin-American Countries

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ABSTRACT

The purpose of this research is to explore the association among energy, environment and economic growth in Latin-American countries from 1990-2014 by using multivariate Structure. This study used number of co-integration techniques to confirm log run relationship among environment, and energy. The study findings also show the effect of the energy on environment in the long run by using FMOLS and DOLS. In addition, this research also employed the causality test to study the causal relation among the variables. The outcomes of the various tests of co-integration endorse a long-run relationship among renewable energy (REN) and non-renewable (NREN) consumption and environment. The long run results show that the use of renewable energy source can reduce the CO_2 emissions in selected countries. Moreover, the non-renewable energy consumption is increasing CO_2 emissions. In addition, the direction of the causality is unidirectional from REN to CO_2, NREN to CO_2 and GDP to CO_2. However, there is absence of two-way causality among the variables in the model.

Keywords: Energy, Panel Co-integration, CO_2 Emissions, Economic Growth
JEL Classifications: F21, O44, Q43

1. INTRODUCTION

Renewable energy, non-renewable energy, carbon emission (CO_2) and economic GDP nexus is being discussed as contemporary areas in the academic research work of energy economics (Apergis and Payne, 2010; Mert and Bölük, 2016; Ozturk, 2010; Tugcu et al., 2012). Also, energy is given significant attention by the economists and policy decision makers due to its pivotal role in the economic growth and development, particularly the instable fuel prices have palpable effect on the global economy (Mahmoodi, 2017). Al-Mulali et al. (2013) State that the emissions of greenhouse gas and fossil fuels price variation in different countries in the world upsurges the renewable energy demand from last three decades. Recently, many countries design policies to invest in renewable energy projects and have been increasing, dramatically. In recent, many studies investigate the association of growth and energy with numerous variables data samples which will be discussed later, however, these studies finds mix results by employing alternatives econometrics techniques. So, Ozturk (2010) mentions that these contradictory results are due to different econometric techniques and difference in countries characteristics.

In emerging economies there is upsurge in consumption of renewable energy according to the recent 2017 global tracking framework data. The data reveals that the total energy consumption in 2014 is 18.3% and it will rise to 36% by 2030 (SEFORALL). Furthermore, "world energy consumption increases from 575 quadrillion British thermal units (Btu) in 2015 to 663 quadrillion Btu by 2030 and then to 736 quadrillion Btu by 2040. Energy consumption in non-OECD countries increases 41% between 2015 and 2040 in contrast to a 9% increase in OECD countries" (IEO, 2017). Moreover, the objective of sustainability in energy consumption is achieved by creating efficient forms of electricity generation with low carbon emission and higher investment in green (cleaner) energy technology. In broader view, the emerging trend of investment in renewable energy that edges to improve the climate variation. To produce renewable energy from different sources such as biofuel, wind, solar PV and hydropower is seeming to be economical as compare their counterparts' non-renewable energy forms. In 2016 investors invested more in renewable energy projects for less money. Further, International Energy Agency (IEA) is a renowned body, which issued globally consumption of REN and its role in reducing carbon pollution, according to IEA renewable energy production will surge to 39% by 2050 and by generating electricity from this source will reduce the CO_2 globally 50% by 2050.

International Renewable Energy Agency (IRENA) is an organization, it is enlightening the significances atmospheric friendly renewable energy projects and excites the world to practice viable methods of green or renewable energy. The sample countries from Latin America have been chosen from Renewable Energy Countries Attractiveness Index (RECAI) of 2017. By following this index, the given study is going to explore the "Energy, Environment and Growth" in Latin American countries. Under study countries are Chile, Mexico Argentina, Brazil, Peru and Uruguay, and in index[1] are at number 8, 9, 11, 17, 28 and 35, respectively. By following most positive information from IRENA, in recent decade, Latin American countries have been myriad investment in renewable energy sector, increasing 80 billion dollars from 2010 to 2015 (except large hydropower). In Latin American countries renewable energy reported is 16.4 billion dollars in 2015 which is round about 6% of the whole world.

In the region, Brazil is more prominent and takes some serious steps to develop renewable energy and 70% investment calculated between 2005 and 2009. In 2015, green energy investment in Brazil accounted 40% more than total in the region, which is 7.1 billion dollars (Bloomberg New Energy Finance, 2016). The second highest country is Mexico, where renewable energy sector investment doubled such as 4 billion dollars in the year of 2014 and 2015. Likewise, Chile placed on third position in the region with 3.4 billion dollars investment in clean energy projects. However, Argentina is the third leading power marketplace in Latin American countries. Argentina faced shortage of power problem and government take very important initiatives to deftly increase the power capacity. Therefore, the government determine a long-term goal of 20% electricity demand will be covered by renewable energy projects until 2025. Similarly, the financial institutions and enterprises invested 915 million dollars in to Mexican green energy projects in 2012[3]. The clean energy projects in Mexico also influence the climate change and state decided to regulate the climate change law to decrease the greenhouse gas effect by 30% in 2020 and 50% by 2050. Similarly, Peru and Uruguay also have retained their relaxed power generation markets with handsome private investment. These counties are also playing their significant role to reduce emission by promoting renewable energy projects in the region.

In recent decade, educationists, regulators and governments have discussed renewable energy generation, climate change awareness and reduction of CO_2 emission influence on economy. The government strengthened the clean energy projects through sponsorships, relaxation in tax and import duty and other benefits. The renewable energy is cost-effective and environment friendly than conventional ways of energy generation. In line with Western countries, the benefits of renewable energy have initiated in regions Latin America, Asia and Africa. The growing demand of renewable energy technologies also has generated emergent productions and arrangements cross the border. Furthermore, many researchers are estimating and documenting on the relationship of growth and energy. Therefore, renewable energy related researches are still a contemporary and a typical topic to investigate. The proposed study is aiming re-examing renewable energy, non-renewable energy and GDP growth nexus in panel countries. The time period for this research is from 1990-2014. Moreover, the current study highlights the importance of green energy and contributes in the existing literature of renewable energy and which would useful for academicians and energy policy makers.

2. LITERATURE REVIEW

In last few decades the literature on growth and green energy are increasing dramatically. These studies have shown various association i.e. uni directional, bi-directional and neutral between growth and consumption of energy. Moreover, Mahmood (2017) also highlighted the adverse effects of energy consumption on the environmental condition particularity emission of the greenhouse gases and CO_2. His study results found the positive relationship between GDP growth and Carbon Dioxide emission whereas negative and significant relationship between Renewable Energy on CO_2 and environmental degradation. Khan et al., (2020) emphasized on the importance of RE as alternate of fossil fuel sources to mitigate the CO_2 emissions and its adverse effects on environment. Moreover, results of the study concluded that economic growth is causing the environmental deterioration and non-renewable energy is sources are used in both industrial and domestic consumption which creates huge environmental effects. Dincer (2000) and Broggio et al. (2014) also considered Renewable energy as feasible alternate solution to reduce the effects of environmental degradation and CO_2 emissions. Midilli et al. (2006) highlighted the use of fossil fuel as energy source as incompatibility with the concept of sustainability and emphasized on the use renewable energy as possible best substitute. Results of study conducted by Bouyghrissi et al. (2020, p. 9) found that as a "1% increase in RENC will enhance the GDP by 0.042% in the short and 0.061% in the long run," moreover, unidirectional causal relations was found among renewable energy and economic growth and corban dioxide emissions. Saidia and Omrib (2020) investigate the impact of renewable energy on CO_2 emission and economic growth which found that effective use of renewable energy increases the economic growth and decreases the CO_2 emissions which can be used rightly for well-established urbanized environments or countries.

One of the pioneer studies of Sadorsky (2009) study securitize the determinants of green energy and its impact on GDP per capita and income by using two empirical models. His results have shown a significant and positive relationship and a long-term effect of green energy on GDP per capita. Similarly, Apergis (2010) reports that a positive significant and a long-run affiliation among growth and renewable energy. The study also shows the existing of bidirectional causility between varaibles and similalr results are obtained by the study of Salim and Rafiq (2012). Furthermore, Apergis and Payne (2012) study depicts a "causal association between economic-growth, non-renewable energy and renewable energy". Accordings to findings in residentional areas a positive effect of green enegy consumtion on real GDP. Similalry, the evidenve of causal relation among renewable enrgy and growth is also observed in India for the period 1960-2009 (Tiwari, 2011).

For Chinese economy, Fang (2011) found a positive association between renewable energy consumtion, real economic growth, GDP per capita and per capital annual income by using OLS method. Al-Mulali et al. (2013) established a bi-directional association between growth and re-newable energy (REN) for crossed countries accessible data. Simlilarly, Pao and Fu (2013) study found the confirmation of response assumptions between net renewable enery consumption and real economic growth, and non-hydroelectric renewable energy usage and GDP growth. Pao and Fu (2013) confirmed their previous study results in Brazil by using Granger causality test. Following VECM and VERDL methods, Sebri and Ben-Salha (2014) found the existance of growth hypothesis in BRICS countires. Further, Oztruk and Bilgili (2015) examined the energy- growth relation in fifty one Afrian economies. Accoridng to findings a "1% increase in biogas will upsurge the economic growth by 0.82%" in sample countries. Also, renewable energy consupmtion (baomass) has a a direct impact on economic growth in 51 Afrian countries (Ozturk and Bilgili, 2015).

The study of Menegaki (2011) study shows a netural relationship in European countires. However, Apergis (2010) found a two-directional causaliy between GDP and renewable energy in United States and in 80 countries respectively. Simialrly, Al-Mulali et al. (2013) also observed a bi-directional association among energy and growth. Salim and Rafiq (2012) explored the given relation in emerging countries and stated that the emissions and economic growth are improving by adopting renewable energy sources. Tugcu et al. (2012) findings showed the causal and long-run association between non-reneable energy and renewable energy usage and GDP. Their investigation showed that non-reneable energy and reneable energy usage have great impact on GDP growth, further, they found bidirectional causilty among them. However, Manzano-Agugliaro et al. (2013) claimed that green energy (renewable energy) is mostly focused in a few economies, such as USA and China. Conversely, Cho et al. (2015) establish a causal connection amongst REN consumption and GDP growth by examining developed counries (OECD) and less develpded countries (non-OECD). The same findings are observed by Alper and Oguz (2016) in Europrean countries (Bulgaria, Estonia, Poland and Solvenia). Therefore, by investigating the data sample of developing economies, Author documented that renewable energy and GDP growth relationship demand for economic situation (Destek, 2016). Furthermore, Bhattacharya et al. (2016) established trade and renewable energy nexus to show that renewable energy consmption leverage the sustainable development. Some recent studies i.e. Paramati et al. (2017) also explored the given relationship and they found that reneweable energy conusmption has negative effect on CO_2 while positive impact on ecnomic growth.

From decades, Researchers are examining the casual relationship between CO_2 and renewable energy consumption around the globe by employing different econometric techniques. The findings of Apergis (2010) shows a causal affiliation among "nuclear energy consumption and CO_2" in nineteen developed and less developed economies. Furthermore, in Spain, Denmark, Portugal and USA they studied causal relationship between sources of renewable energy and CO_2, and found a growth hypothesis among the variables. Similarly, Apergis and Payne (2012) study suggests that GDP growth assumption positive relation with renewable energy generation and CO_2 emissions.

Moreover, Bhattacharya et al. (2017) chooses 85 developed and less developed countries and used GMM and FMOLS models. The findings showed that REN consumption has a sgnificant positive assocition with GDP growth, and negative impact on CO_2 emission. Therefore, a sample of Next Eleven Emerging Economies suggests that growth and REN consumption has a causal relationship in Philippines, Turkey and Veitnam (Shahbaz et al., 2016). Similarly, Yıldırım et al. (2014) also detect a causal relation among "economic growth and renewable energy consumption" for the Next eleven economies. In sum, the varying outcomes on "gorwth-energy-environment nexus" is due to the econometric techniques and sample economies.

3. DATA AND VARIABLES

This research utilizes panel data from 1990 to 2014, which is obtained from WDI. The empirical analysis based on panel data techniques for six-Latin American countries. In addition, Panel unit root tests are used to check the stationary of the variable of the study. The details of the variable's description are given in Table 1.

The propose model is

$$CO_2 = f\,(REN, NREN, GDP, FDI, GFCF) \quad (1)$$

Alternatively

$$CO_2 = \beta_1 + \beta_2 REN + \beta_3\, NREN + \beta_4\, GDP + \beta_5 FDI + \beta_6 GFCF + \mu_t \quad (2)$$

To perform co-integration assessment without checking the stationarity show ambiguity and spurious results. Therefore, the present study used following various unit root tests to identify the stationary/nonstationary of the chosen variables. The tests include; IPS (2003), LLC (2002), Fisher-ADF and PP-Fisher. These tests are based on the null hypothesis that "there is unit root exist against the alternative that there is no unit root exist in the series".

In second stage, this study used various "Panel Cointegration Tests" to know the long run affiliation. In addition, FMOLS and DOLS is used to examine the impacts and Causality test is utilized to detect the causality among variables of the study.

4. DATA ANALYSIS AND RESULTS

Table 2 shows the results of "Cross Sectional Dependency" Test. The null hypothesis of the test is "there is cross sectional independence and the alternative hypothesis is cross sectional dependence".

The result of the Table 2 proposed that both "Breusch -Pagan LM and Pesaran Scaled LM" tests are rejecting the null hypothesis and accepting the alternative hypothesis. Therefore, the given results show that "there is no cross-sectional dependence" in the model.

The results of various unit roots i.e. "LLC, IPS, ADF Fisher and PP Fisher" are presented in Table 3. The findings of the various unit root test revealed that variables i.e. GDP, REN, NREN, GFCF and POP became stationary after taking first difference. In sum, the order of the all variables are I (1).

he results of the Kao (1999) approach show see Table 4 that the probability is lower than 5%, so we can say that there is long run co-integration exist among "renewable, non-renewable energy consumption and CO_2 emission" in six-Latin American countries.

The results of Pedroni (2004)'s co-integration is given in Table 5. The findings also reveal the long run co-integration exist between REN and NREN and CO2 emission in selected countries. The results of Table 6 conclude that there is co-integration between the examined variables.

4.2 DOLS and FMOLS Results

The results of the model based on DOLS and FMOLS are presented in Table 7. The results in the first and second column of Table 7 are similar i.e. directions and significance level. Therefore, this paper considers both DOLS and FMOLS results.

Table 7 shows the long run result of the two models DOLS and FMOLS have same coefficients; according to the direction but the coefficient, values are slightly different in both models. The results of the both models show, that use of renewable energy can reduces the CO_2 emissions, which is good, sign for environment in these countries. In DOLS model, the coefficient of REN is significant with negative sign i.e. −0.63. It shows that a 1% level increase in REN sources will causes a decline in CO_2 by 0.63%. Similarly, the findings of FMOLS also shows that the CO_2 emissions decreases due to use of REN i.e. a 1% increase in REN consumption will cause a decline in CO_2 emissions by 0.20%.

Whereas, based on outcomes of DOLS and FMOLS, NREN has a positive and substantial influence on CO_2 emission in long run in panel countries the coefficients of NREN are 0.85, 0.78, and statistically significant respectively. The proposed model suggested that as 1% level of significance non-renewable energy has increased $C0_2$ emission in positive direction. Furthermore, the GDP per capita coefficient is also negative and its effect is significant on CO_2. Lastly, the effect of real GFCF and FDI on CO_2 is positive and significant. The proposed model suggested that the higher use of REN is better for the environment of panel countries instead of consumption of non-renewable energy, which is harm full for the environment. In addition, GDP can cause to decrease the emissions of CO_2 because once the GDP per capita increased than the panel countries can easily shift to renewable energy sources from non-renewable energy. Lastly, Table 8 results shows that the direction of causality is from CO_2 to FDI, NREN to CO_2, GDP per capita to CO_2, REN to CO_2, and the CO_2 to

Table 1: Variables description

Variables	Description of variables	Source of data
CO_2	Carbon dioxide emission	WDI
GDP	the GDP per capita in constant 2010 US dollars	WDI
NREN	the non-renewable energy consumption	WDI
FDI	shows Foreign Direct investment	WDI
REN	is the renewable electricity consumption	WDI
LGFCF	represents log of gross fixed capital formation	WDI

Table 2: Cross Sectional Dependency Test

Variables	CO_2	REN	NREN	GDP	FDI	GFCF
Breusch-Pagan LM	151.14	121.32	77.987	67.610	24.239	12.893
p-value	0.00	0.001	0.000	0.00	0.021	0.044
Pesaran scaled LM	24.85567	22.32	11.499	9.6053	2.3786	1.9899
p-value	0.00	0.00	0.00	0.00	0.017	0.034

Table 3: Unit root Tests results

Var.	LLC	IPS	ADF Fisher	PP Fisher
GDP	−0.466 (0.321)	−6.361*** (0.00)	115.85*** (0.00)	185.29*** (0.00)
Δ*GDP*	−15.96*** (0.00)	−15.76*** (0.00)	275.79*** (0.00)	1250.41*** (0.00)
CO_2	3.078 (0.99)	7.309 (1.00)	0.173 (1.00)	0.169 (1.00)
ΔCO_2	−3.27*** (0.000)	23.03** (0.02)	65.90*** (0.00)	65.90*** (0.00)
REN	−1.301* (0.09)	0.650 (0.74)	19.81 (0.98)	20.31 (0.98)
Δ*REN*	0.771*** (0.00)	−3.55*** (0.00)	62.91*** (0.00)	119.2*** (0.00)
NREN	−1.87** (0.03)	−0.01*** (0.49)	31.616 (0.67)	26.49 (0.87)
Δ*NREN*	−6.69*** (0.00)	−8.10*** (0.00)	133.4*** (0.00)	227.6*** (0.00)
FDI	−2.07** (0.01)	−2.18** (0.01)	22.2** (0.03)	28.25*** (0.00)
Δ*FDI*	−6.64*** (0.00)	−7.74*** (0.00)	75.2*** (0.00)	155.7*** (0.00)
GFCF	−0.306 (0.37)	1.2833 (0.90)	5.892 (0.92)	5.790 (0.92)
Δ*GFCF*	−5.508*** (0.00)	−7.109*** (0.00)	66.92*** (0.00)	69.46*** (0.00)

LLC, IPS, ADF Fisher and PP Fisher shows the Levin et al. test (2002), Im, Pesaran and shin (2003), Fisher ADF test and PP-Fisher rest respectively. All the variables show robust results such as integrated of order one. Standard error values shows in parenthesis.

Table 4: Kao (1999)'s Residual Co-integration test (ADF)

Dept. Variable CO_2	t-statistic	Prob.
	−2.218213**	0.0133

***Shows the 1% level of significance whereas **Show at 5% level of significance.

Table 5: Pedroni (2004)'s Co-integration

CO_2 dependent variable							
Within dimension			Weighted statistics		Between dimension		
-	Test stat	Prob	Test stat	Prob	Test stat	Test stat	Prob
Panel-v-Stat	6.371***	0.0000	2.7547***	0.0029	-	-	-
Panel rho-stat	−2.944***	0.0016	−0.368391	0.3563	Group rho-Statistic	−0.956223	0.1695
Panel PP-stat	−2.709***	0.0034	−0.894900	0.1854	Group PP-Statistic	−1.52179*	0.0640
Panel ADF-stat	−1.6534**	0.0491	−1.8779**	0.0302	Group ADF-Statistic	−1.155394	0.1240

Table 6: Johansen-Fisher Panel Co-integration Test Results

Dependent variable CO_2				
	(Trace test)	Prob.	(Max-eigen test)	Prob.
None	293.9***	0.000	207.4***	0.0000
At most 1	112.6***	0.0000	85.51***	0.0000
At most 2	45.15***	0.0000	34.43***	0.0006
At most 3	19.93*	0.0684	13.80	0.3138
At most 4	14.99	0.2422	14.99	0.2422

The null hypothesis is that the variables are not cointegrated. Under the null tests, all variables are distributed normal, n(0,1). *** and **Significant at the 1%, 5% levels, respectively. Fisher's test (1932) applied regardless of the dependent variable. Lag intervals for test: 1 1. Asymptotic p-values are computed using X2 distribution.

Table 7: DOLS estimator and FMOLS Results

Variables	DOLS		FMOLS	
	Coefficient	t-Statistics	Coefficient	t-Statistics
NREN	0.8570	2.2489**	0.7812***	15.960
REN	−0.6315	−2.2745**	−0.2074***	4.1128
GDP	−3.0320	−2.6158**	−1.0644***	3.7438
FDI	0.0572	3.1112***	0.0278***	6.0325
GFCF	0.6781	4.1291***	0.5999**	2.4523
R. Sqd	0.941518			
Adj. R. Sqd.	0.857516			
Sum sq.Resid	20.17851			

Estimates refer to (fixed-effects) long-run elasticity of output with respect to the relevant regression. T-ratios are in parenthesis and a *denotes statistical significance at the 10% level and a **denotes statistical significance at the 5% level and a ***denotes statistical significance at the 1% level.

Table 8: Pairwise granger causality test

Null hypothesis	F-Statistics	Prob.
DFDI does not Granger Cause DCO_2	0.41006	0.8707
DCO_2 does not Granger Cause DFDI	2.13849*	0.0559
DLNREN does not Granger Cause DCO_2	4.09015***	0.0011
DCO_2 does not Granger Cause DLNREN	0.95730	0.4585
DGDP does not Granger Cause DCO_2	2.42119**	0.0320
DCO_2 does not Granger Cause DGDP	0.95766	0.4582
DREN does not Granger Cause DCO_2	2.06482*	0.0649
DCO_2 does not Granger Cause DREN	1.73118	0.1225
DLNGFCF does not Granger Cause DCO_2	0.75366	0.6081
DCO_2 does not Granger Cause DLNGFCF	3.58112***	0.0030

*Denote 10% significance level.**Denotes 5% significance level. ***Denotes 1%significance level.

GFCF. However, there is no any bidirectional or unidirectional causality between FDI to CO_2, CO_2 to NREN, CO_2 to GDP, and GFCF to CO_2.

5. CONCLUSION

The presnt study is expected to have contribution in the literature by re- examining the "energy Environment and Growth" nexus in six Latin countries from 1990-2014 by using multivariate Panel methods. This research used number of co-integration techniques to confirm a long run association among energy, growth and environment. In addition, this study also compares "non-renewable and renewable energy" to decide which source is harmful or appropriate for environment. The outcomes of the Cointegration tests confirm a long-run connection amongst REN and NREN consumption and environment.

According to the long run results, the relation between REN and CO_2 emissions is negative or in other word, the higher REN consumption can reduce CO_2 emissions and it is environment friendly source of energy. However, the effect of NREN is positive on CO_2 meaning its consumption is harmful for environment in these countries. Therefore, renewable energy source is appropriate for environment. Lastly, the direction of causality is uni-directional from REN to CO_2, NREN to CO_2 and GDP to CO_2. However, there is no bidirectional causality in the proposed model.

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