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Exploring the Relationship between Energy Consumption and Economic Growth in Lower Middle and High Income Economies using Panel Data Techniques

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ABSTRACT

In this paper, the panel relationship between energy consumption (ECP) and economic growth Gross domestic product (GDP), is investigated for the thirty-one countries from 1971 to 2014. These countries are divided into two panels based on lower-middle-income and high-income-level economies. Traditional ADF unit root test is used to confirm the stationarity at first difference. Also, four panel unit root tests, namely LLC (2002), IPS (1997, 2003), Fisher test proposed by Maddala and Wu (1999), Hadri (2000) tests confirmed the stationarity of variables for both panels at first difference. Furthermore, the long-run relationship between ECP and GDP is explored by four advance panel cointegration techniques, i.e., Kao (1999), Pedroni (1999, 2004), Fisher (1999), and Westerlund (2007). Moreover, the pairwise panel causality test is used to identify the Granger causality between ECP and GDP. Lastly, the dynamic OLS estimator of Saikkonen (1991) and the fully modified OLS estimator of Phillips and Hansen (1990) is used to estimate the parameters of the cointegration relationship. According to the empirical results, ECP and GDP are cointegrated for both panels. Long-run Granger causality running from GDP to ECP for both income level economies is also revealed. The energy conservation policies can play a vital role in boosting economic growth, especially for lower-middle-income economies.

Keywords: Panel Cointegration, Energy Consumption, Economic Growth, FMOLS, DOLS
JEL Classifications: C32; Q43

1. INTRODUCTION

Energy consumption (ECP) is a key to help in the stability of economies and supports trading between countries, generating revenue. The revenue aids the financial issues and growth programs of the government. From the past decades, it has been noted that the demand for ECP has been rapidly increasing. ECP is a major component that plays a key role to stable the growth of economy of any nation; therefore, consumption of energy and growth of an economy is always the highest and topmost area studied by economists, statisticians, business people, policymakers, and government different energy agencies. It is also found that the causal relationship of these two variables has crucial strategies. Therefore, various researches are conducted to explore a significant long run association among ECP per capita and Gross domestic product (GDP) per capita. According to the literature, it is not easy to explore the presence of long-run cointegration. According to Ozturk et al. (2010), the topic of the causal relationship between ECP and economic growth has been well studied in the energy economics literature for both developing and developed countries. From the literature, it is also found that the results of approximately all the studies variates empirically. It can also be seen that the results of many studies have conflict from each other. The reasons may be due to the dissimilar frequency of time or the different variables or countries used in the studies. The methodologies used in the studies, i.e., econometric or time series strategies, are also a point of conflict in different studies. Additionally, to explore the causality relationship between

ECP and GDP is also an uphill task. For an evidence, Rehman (2021), Wang and Wang (2020) and Wang et al. (2019) studied the impact of economic growth with other macroeconomic and financial variables i.e. urbanization, international trade, and foreign direct investment etc. Ouedraogo (2010) explained that an energy-dependent country should always be careful about its energy policies. Small bad news, i.e., a single negative shock on energy supply, can damage GDP. Quite the reverse, the impact of negative shocks due to energy policies can be less effective on the GDP for any country having a causality direction runs from GDP to ECP. This study explores the long-run relationship and causal direction between ECP and GDP by using the time series panel data techniques. Furthermore, weak and strong relationship is found by the panel causality test. Different income level economies are distributed into two panels.

This research paper is an addition to the empirical literature to establish a long-run association and to explore the causal relationship between ECP and GDP. The annual data covers from 1971 to 2014 of thirty-one nations are used in this study. Remaining paper is organised as following: section 2 presents Literature review. Section 3 covers the data and methodology. Results and discussion is presented in section 4, while section 5 concludes the paper.

2. LITERATURE REVIEW

Rehman (2021) used panel cointegration, heterogeneous panel causality tests, panel quantile regression and impulse response function to explore the association between ECP, international trade, and foreign direct investment with economic growth. He used data of BRICS and ASEAN countries from 1990 to 2017. He used 3 years moving average method to fill the unavailable data of a few countries from 2015 to 2017. He found positive and long-run equilibrium associations among all variables. Additionally, he also revealed bidirectional causality between economic growth and ECP based on a heterogeneous panel causality test. Chen et al. (2020) also explored the relationship between renewable ECP and economic growth using a threshold regression model. They used data from 103 countries from 1995 to 2015. They further revealed that the relationship between renewable ECP and economic growth is positive or negative based on the threshold that the developing countries surpass or remain below a certain threshold. They used multiple macroeconomic variables for threshold modeling, i.e., GDP and total labour force, etc. Subsequently, Wang and Wang (2020) used three threshold factors, namely per capita income, urbanization level and non-renewable energy intensity, to verify the nonlinear and positive relationship between economic growth and renewable ECP. They used the data of thirty-four OECD countries from 2005 to 2016. They also found a single threshold effect when non-renewable energy is used and a double threshold effect when urbanization and per capita income are used as threshold variables based on the Panel threshold regression model.

Wang et al. (2019) uncovered the relationship between energy prices, growth GDP and urbanization on ECP per capita. They divided 186 countries into three panels, i.e. high, upper-middle and lower-middle-income from 1980 to 2015. They found long term cointegration among all variables based on the Granger causality test. Gozgor et al. (2018) proposed a theoretical growth model based on panel autoregressive distributed lag and panel quantile regression to explore the association between non-renewable and renewable ECP with economic growth. They used a panel of twenty-nine countries from 1990 to 2013. They found a positive association between ECP and economic growth. Shahbaz et al. (2018) also revealed a positive relationship between ECP and economic growth. They used the quantile-on-quantile approach, a generalization of the quantile regression model. They used quarterly data from 1960 to 2015 of ten energy-consuming countries. Mitić et al. (2017) also studied the long-run relationship between carbon dioxide (CO_2) and economic growth for a panel consisting of seventeen transition nations. They used annual data from 1997 to 2014. They found that there is a long-run cointegration present between the CO_2 and economic growth (GDP). They also revealed that a 0.35% change could be expected with a change of 1% in GDP. Their findings were based on DOLS and FMOLS.

Inglesi-Lotz (2016) studied studied the impact of renewable ECP on GDP using panel data techniques. He used 34 OECD countries which are distributed into developed and developing countries. The annual data frequency was used from 1990 to 2010. He revealed a positive and statistically significant relationship present between renewable ECP and GDP. Moreover, he suggested promoting renewable energies that can be constructive for GDP and the environment. Ozturk et al. (2010) also investigated the long-run association between GDP and ECP through panel data sets based on three income level economies. Fifty-one nations are distributed according to World Bank, i.e., lower income-level, upper and lower-middle-income economies from 1971 to 2005. According to their findings, cointegration was present between the two variables for all types of income level economies. They also showed a granger causality from GDP to ECP in the case of low-income economies. While for upper and lower-middle-income economies, they found a bidirectional causal relation. Additionally, they also revealed no strong relationship between these two variables for all the three-panel data sets. Apergis and Payne (2009) also worked on the GDP and ECP. They used a panel of major American nations containing Panama, Nicaragua, Costa Rica, El Salvador, Honduras and Guatemala, based on annual data from 1980 to 2004. They found bidirectional Granger causality between GDP and ECP based on the Pedroni (1999) panel cointegration test and error correction model (ECM) for the short and long-run, respectively.

Similarly, Narayan and Smith (2008) worked on the panel cointegration with structural breaks among ECP, GDP and capital formation from 1972 to 2002 annual data of G-7 countries. According to their findings, three variables are cointegrated. They also revealed that in the long-run, ECP and capital formation granger causes the real GDP. Soytas and Sari (2003) used the annual panel data of G-7 and ten emerging markets from 1950 to 1992 except for Argentina, Indonesia and Poland. They found a bidirectional causal relationship between ECP and GDP for Argentina. Furthermore, they explored that the causality runs from ECP to GDP in four countries from G-7, namely, France, Japan, Germany and Turkey. Their findings are based on the vector error correction model and cointegration techniques. Soytas and Sari (2003) also used cointegration and vector error correction techniques to explore the causality relationship between ECP and GDP for the ten emerging markets and G-7 countries. They used annual data from 1950 to 1992, except only for Argentina, Indonesia, and Poland. They revealed bi-directional causality in Argentina. Also, they found the causality runs from GDP to ECP in Italy and Korea, but causality runs from ECP to GDP in Turkey, France, Germany, and Japan. They concluded that the energy conservation policies could damage the GDP in Turkey, Germany, France, and Japan. From the brief literature, it can be concluded that only a few studies related to income level are found on the investigation of the long-run or short-run relationship between ECP and GDP on the panel data.

3. DATA AND METHODOLOGY

This study uses annual data related to ECP and GDP per capita. ECP measured in Kg of oil equivalent per capita while Gross domestic product measured per capita with a constant 2010 US $. The annual data starts from 1971 and ends in 2014 (due to the availability of the data). Total 31 countries are distributed into two panels based on income levels. These panels of countries are classified according to the World Bank country classification (2020).

To reduce the heteroscedasticity, ECP and GDP are employed with natural logarithms. Descriptive statistics of logarithmic ECP and GDP for both panels are presented in Table 1. Furthermore, to study the relationship and causality analysis, traditional unit root test, i.e., Augmented dickey fuller (ADF) test and panel unit root analysis, i.e., Levin et al. (2002), Im et al. (1997, 2003), Fisher test by Maddala and Wu (1999), and Hadri (2000) are used. Panel cointegration analysis, namely Kao (1999), Pedroni (1999, 2004), Fisher panel test, and Westerlund (2007), are used in this study. Granger causality tests are used to find the causality direction. Lastly, panel dynamic ordinary least squares (DOLS) and panel fully modified ordinary least square (FMOLS) are used to find the weak or strong relationship. Additionally, the Wald test is also used to confirm the results from FMOLS and DOLS.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Graphically from (Figure 1a and b), ECP and GDP are appeared to be non-stationary. Also, the scatter plots for both panels slightly indicate an expected positive relationship between ECP and GDP. However, due to the pooling of all yearly country data, different distinct lines possibly represent the cross-section relationship between the variables for each year. Results from Table 2 show that overall, the lower-middle-income economies in the panel per capita GDP grew by 2% each year on average over the 44 years. The per capita ECP has grown by 0.88%, a much smaller percentage.

For each variable, time-series variation within each country is much larger than the variation between countries for a year. Similarly, like the lower-middle-income economies, high-income economies panel per capita GDP has grown by 2% each year on average over the 44 years. The per capita ECP has grown by 1.2%, a smaller percentage. For each variable, time-series variation within each country is much larger than the variation between countries for a year.

4.2. Unit Root Tests

The time series variables must be stationary in a long-run analysis to avoid spurious results. Therefore, before examining the panel cointegration, all variables must be integrated of order one. They are initially applied for each country separately to examine the non-stationarity in ECP and GDP over the 44 years. For this, traditional Augmented Dickey-Fuller test is used. The results can be seen in Table 3. Both ECP and GDP contain unit root at a level. After the first differential, all the data becomes stationary at a 1% significance level. These results confirm that both panels, i.e., lower-middle and high-level income economies, are stationary at

Figure 1: (a) Lower middle income level economies, (b) High income level economies

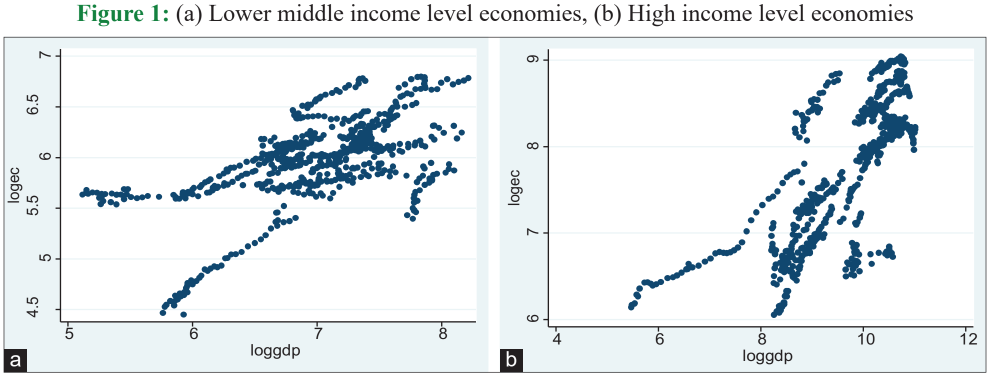

Table 1: Panels of countries based on income levels

Lower middle income economies	Bangladesh	Cameroon	Congo Republic	Egypt	Ghana	Honduras	India	Indonesia
	Kenya	Myanmar	Pakistan	Philippines	Sri Lanka	Sudan	Zambia	-
High income economies	Argentina	Australia	Austria	Brazil	Canada	Chile	China	Costa Rica
	Denmark	Finland	Germany	Japan	Panama	Kingdom of Saudi Arabia	Spain	Uruguay

World Bank classifications 2020

Table 2: Descriptive statistics

Lower middle income economies	Variable	Mean	Std. Dev.	Min	Max	Obs.
	D.logec					
	Overall	0.00884	0.04198	−0.2265	0.25797	N=645
	Between		0.01157	−0.0064	0.03072	n=15
	Within		0.04046	−0.2174	0.25751	T=43
	D.loggdp					
	Overall	0.02075	0.04194	−0.168	0.18247	N=645
	Between		0.01297	0.00136	0.04636	n=15
	Within		0.04002	−0.1696	0.19068	T=43
High income economies	D.logec					
	Overall	0.01262	0.05283	−0.2295	0.3551	N=688
	Between		0.01248	−0.0061	0.04069	n=16
	Within		0.05142	−0.238	0.32703	T=43
	D.loggdp					
	Overall	0.02083	0.04344	−0.296	0.16762	N=688
	Between		0.01614	−0.0043	0.07549	n=16
	Within		0.04052	−0.2708	0.19278	T=43

Here "ECP" used for energy consumption and "GDP" stands for economic growth (per capita) for all tables

Table 3: Results of ADF unit root test

Country	Lower middle income level				High income level			
	Logec		Loggdp		Logec		loggdp	
	ADF value		ADF value		ADF value		ADF value	
	Level	1st diff	Level	1st diff	Level	1st diff	Level	1st diff
1	−2.2	-3.92	−0.669	−3.585	−1.915	−4.847	−1.877	−4.791
2	−2.368	−7.002	−0.591	−4.82	−0.733	−4.126	−2.17	−4.733
3	1.15	−4.873	0.022	−2.275	−1.568	−6.128	−0.321	−4.877
4	−0.096	−5.075	2.541	−5.264	−1.818	−3.815	−2.483	−4.093
5	−2.107	−4.352	−1.264	−3.346	−2.119	−5.865	−2.443	−4.642
6	−1.223	−6.591	−1.854	−4.61	−2.611	−3.536	−2.995	−4.009
7	−0.896	−4.896	−2.306	−4.308	−1.481	−2.814	−3.905	−3.006
8	−0.366	−2.819	−0.685	−3.643	−2.512	−4.012	−1.486	−4.256
9	0.028	−3.268	−1.297	−4.057	−2.374	−4.845	−1.435	−6.439
10	−2.31	−6.004	−0.723	−3.193	−2.162	−4.959	−0.618	−4.517
11	−0.884	-2.619	−1.137	−2.044	0.077	−3.122	−1.909	−3.361
12	0.06	−3.616	−2.02	−3.186	−0.775	−5.824	−1.632	−4.313
13	−2.328	−3.213	−3.221	−3.581	−1.24	−4.424	−1.935	−3.682
14	−1.477	−5.145	−2.164	−3.493	−3.155	−2.853	−2.123	−3.927
15	−0.217	−3.544	−2.416	−3.253	0.473	−5.529	−0.175	−4.31
16	-	-	-	-	−2.293	−4.963	−0.809	−4.082

Logarithms of energy consumption (log ec) and economic growth (lofgdp)

first difference. Additionally, the traditional ADF test is based on a single time series and found to lack the power to distinguish the unit root for panel data. Panel unit root tests increases the power to identify the unit roots in time series data. Results of panel unit root tests are presented in Table 3.

4.3. Panel Unit Root Tests

For non-stationarity in Panel data sets, panel unit root tests are applied of 2nd generation. According to panel unit root tests, the panel data should be stationary at first. After this, the test for cointegration between the variables can be used. ECP and GDP for the two panels are tested in levels and at first difference (Table 4). Results reveal that the data becomes stationary after the first difference at a 1% significance level. The LLC (with time trend and panel mean) with cross-sectional mean subtracted, and cross-sectional dependence fails to reject the null of panel non-stationary for both logecp and loggdp. However, the first difference (without trend) shows that the panel data becomes stationary. Similarly, the IPS test and the Fisher test (with trend option in a DF-based) also do not reject the non-stationary levels. After the first difference, both variables become stationary at a 1% significance level. Moreover, findings from Hadri test (2000) also shows that the data is non-stationary at levels. Hence, ECP and GDP from both panels contain unit roots at a level and becomes stationary after the first difference.

4.4. Panel Cointegration Tests

According to the findings from panel unit root tests from Table 4, the long-run relationship between ECP and GDP for the two panels is investigated based on income level economies. The panel cointegration explored by the (Kao, 1999), a framework introduced by Pedroni (1999, 2004), and Fisher test of cointegration is shown in Table 5. Moreover, the Westerlund test for panel cointegration is also present in Table 6. According to Kao test, there is a significant panel cointegration present between the ECP and GDP for the case of lower-middle-income level economies. Similarly, seven tests from Pedroni and the fisher test for cointegration reveal significant panel cointegration between the ECP and GDP for lower-middle-

Table 4: Panel unit root tests

Lower middle Income level countries							
Demean trend							
Logecp							
LLC		**IPS**		**Hadri**		**Fisher**	
Level	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**
1.701	−10.46*	3.376	−12.73*	15.037*	3.75	18.73	215.62*
1.13	−18.62*	-	-	-	-	-	-
Loggdp							
LLC		**IPS**		**Hadri**		**Fisher**	
Level	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**
4.749	−6.349*	6.886	−9.189*	15.066*	5.98*	12.34	146.47*
−1.57	−12.56*	-	-	-	-	-	-
High Income level countries							
Demean trend							
Logecp							
LLC		**IPS**		**Hadri**		**Fisher**	
Level	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**
−0.972	−8.880*	0.937	−13.22*	9.477*	2.25	29.45	229.78*
−0.75	−18.97	-	-	-	-	-	-
Loggdp							
LLC		**IPS**		**Hadri**		**Fisher**	
Level	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**	**Level**	**1st diff**
−0.831	−12.43*	2.953	−12.49*	17.16*	1.451	16.655	212.07*
−1.56	−12.60*	-	-	-	-	-	-

*Significant at 1% level of significance

Table 5: Panel cointegration test

	Lower middle income level	High income level
	Statistic	Statistic
Kao	−8.916*	−3.200*
Pedroni		
Within Dimension		
Panel v-Statistic	9.150*	4.598*
Panel rho-Statistic	−35.954*	−28.227*
Panel PP-Statistic	−18.980*	−16.108*
Panel ADF-Statistic	−11.250*	−10.214*
Between Dimension		
Panel rho-Statistic	−30.419*	−26.068*
Panel PP-Statistic	−24.225*	−23.168*
Panel ADF-Statistic	−14.837*	−14.230*

*Significant at 1% level of significance

Table 6: Westerlund test for cointegration

Test statistics	Lower middle income level	High income level
	Value	Value
Gt	−4.681*	−4.679*
Ga	−39.379*	−39.377*
Pt	−19.339*	−19.399*
Pa	−35.260*	−35.350*

*Significant at 1% level of significance

income economies. The findings are similar to the (Ozturk et al., 2010). Nevertheless, these results came from countries with different time frequencies in the lower-middle-income level panel. For the case of high-income economies, Kao test shows evidence of a long-run relationship between ECP and GDP. Similar results are found through Pedroni and fisher test of cointegration, i.e., rejects the hypothesis for no cointegration between the ECP and GDP. Westerlund ECM-based cointegration test also verifies the cointegration results (Table 6). For both panels based on income level economies, the Westerlund test verify the presence of cointegration. These findings are similar to (Ozturk et al., 2010) and (Soytas and Sari, 2003). Additionally, according to Westerlund test, for high-income level economies, the estimated long-run cointegration that yields elasticity of ECP is 0.721 GDP per capita and short run adjustment, i.e., the speed of adjustment is found to be −1.212. Similarly, for lower-middle-income level economies, the estimated long-run relationship yields elasticity of ECP is 0.426, and speed of adjustment coefficient is −1.213. It reveals any discrepancy in the equilibrium relationship between ECP and GDP due to any shock; 12% of discrepancy is corrected in a year for both income level economies. All values are economically and statistically significant at a 1% level of significance.

4.5. Panel Causality Analysis

Furthermore, causality relationship direction between GDP and ECP based on the following estimated panel based regressions (for details see [Ozturk et al., 201]):

$$\Delta\log(GDP)_{it} = \theta_{1i} + \sum_{q}\theta_{11iq}\Delta\log(GDP)_{it-q} + \sum_{q}\theta_{12iq}\Delta\log(EC)_{it-q} + \omega_{1i}ECT_{t-1} \quad (1)$$

$$\Delta\log(EC)_{it} = \theta_{2i} + \sum_{q}\theta_{21iq}\Delta\log(EC)_{it-q} + \sum_{q}\theta_{22iq}\Delta\log(GDP)_{it-q} + \omega_{2i}ECT_{t-1} \quad (2)$$

Table 7: Panel Granger causality test results

	Source of Causation	Δln GDP	Δln EC
High income level	Δln GDP	--	5.95629*
	Δln EC	1.59566	--
Lower middle income level	Δln GDP	--	8.1302*
	Δln EC	0.14046	--

*Significant at 1% level of significance

Table 8: FMOLS and DOLS estimates

	Estimation Method	FMOLS		DOLS	
		Pooled	Grouped	Pooled	Grouped
Lower middle income level	Long-run coefficient	0.430* (0.034)	0.406* (0.033)	0.413* (0.0041)	0.411* (0.082)
High income level	Long-run coefficient	0.727* (0.044)	0.705* (0.068)	0.689* (0.084)	0.720* (0.125)

*Significant at 1% level of significance

Table 9: Wald test statistics

	Statistic	FMOLS		DOLS	
		Pooled	Grouped	Pooled	Grouped
Lower middle income level	t-statistic	4.654*	−3.562*	3.936*	7.872*
	F-statistic	21.662*	12.691*	15.495*	61.972*
	Chi-square	21.662*	12.691*	15.495*	61.972*
High income level	t-statistic	8.643*	10.263*	7.750*	7.954*
	F-statistic	74.710*	105.333*	60.065*	63.274*
	Chi-square	74.710*	105.333*	60.065*	63.274*

*Significant at 1% level of significance

The equation (1) and equation (2) are proposed by the Pesaran et al. (1999). Equations are estimated by pooled mean group estimator (PMGE). Causality testing is based on null hypothesis i.e. $H_0=\theta_{12iq}=0$ and $H_0=\theta_{22iq}=0$ for all i and k. (Pesaran et al., 1999). (Table 7) represents the panel causality results. Panel causality test rejects the null hypothesis in unidirectional for a panel of lower-middle-income level economies. The findings suggest that GDP does a granger cause ECP. Nevertheless, ECP does not granger cause GDP. These results are similar to the (Ozturk et al., 2010). It reveals that GDP determines ECP. Therefore, the energy conservation policies related to lower-middle-income economies would not directly affect GDP. However, for the panel of high-income level economies, the granger causality runs from the GDP to ECP, i.e., unidirectional causality between them. Hence, there is a significant and unidirectional causality between GDP and ECP for the high-level income economies.

4.6. Panel FMOLS and DOLS Estimates

DOLS and FMOLS estimates are presented in Table 8. These findings show that ECP stimulates GDP in high-income level and lower-income level economies. Results are approximately similar to Table 6, i.e., Westerlund test results. The estimated elasticity is 0.44 for the lower-middle-income level economies, 0.51 for the high-level income economies. The strong relationship runs from ECP to GDP is significantly rejected for both income level economies at a 1% significance level. Also, from the Wald test (Table 9), the t-statistic and the Chi-square tests are significant. Therefore, we can conclude that the cointegrating regressor coefficient value is not equal to 1.

Results from Table 8 suggested that the long-run cointegration present between the GDP and ECP is highly significant in both cases, i.e., FMOLS and DOLS. Coefficients are approximately the same pooled and grouped for lower-middle and high-income countries. The estimation for lower-middle-income countries is approximately 0.4; on average, a 1% change in GDP leads to a 0.4% change in the EC. Similarly, for high-income level countries, the estimation is approximately is found to be 0.7, i.e., a change of 1% In the GDP has led to a 0.7% change in the EC. Moreover, the estimated elasticity, i.e., 0.721 and 4.431 for low middle-level income and high-income level economies, respectively, is approximately similar to the Westerlund test provided. These results revealed no strong relation between ECP and GDP as the estimated cointegration is not near to 1 for both income level economies. Finally, according to the Wald test (Table 9), all the coefficients are highly significant at 1%.

5. CONCLUSIONS

It is found from the vast literature that most of the studies are related to exploring an association between GDP and ECP based on developed, developing, and underdeveloped economies. Economists, government agencies, and policymakers mostly worked on ECP and GDP. Energy (per capita) is beneficial for any nation to boost the economy. Similarly, changes in GDP (per capita) can affect ECP. A causal relationship is investigated in this study between GDP (per capita) and ECP (per capita). Thirty-one countries are distributed into two panels based on World Bank income level economies rankings. Income level economies Panels namely lower-middle-income and high-income level economies. Annual data starts from 1971 and ends in 2014. Initially, the traditional Augmented Dickey-Fuller test confirms that the stationarity in the data at first difference. After that, panel unit root tests are applied to identify the unit root in panels, namely the LLC (2002), Fisher test proposed by Maddala and Wu (1999), IPS (1997, 2003), and Hadri test (2000). According to the findings, the panel unit root is present in both variables at a level. After taking the first difference, panel data becomes stationary. Furthermore, to find the long-run relationship between ECP and GDP, panel cointegration analysis has been done through Kao (1999), Pedroni (1999, 2004), Fisher tests, and Westerlund test. Lastly, the pairwise Granger causality test reveals a strong and significant unidirectional Granger causality from GDP (per capita) to ECP (per capita) for lower-middle-income level economies.

Therefore, it can be concluded that the ECP policies do not strongly impact the GDP per capita. It is an alarming situation for these countries to review their energy policies. This result shows that these countries are dependent on the GDP per capita. As the GDP increases, ECP will also increase and vice versa. A little shock in the GDP will damage ECP. Additionally, it reveals any discrepancy in the equilibrium relationship between ECP and GDP due to any shock; 12% of discrepancy is corrected in a year for both income level economies. A unidirectional causal relationship is also found, i.e., GDP to ECP. Therefore, there is also a risk for these high-level income economies to change their energy policies. Moreover, the estimates of cointegration elasticity are found through the panel DOLS and FMOLS. The estimated elasticity is quite similar to Westerlund test estimates. The estimated elasticity for the lower-middle-income level economies is 0.720, while for the high-level income economies are found to be 0.411.

Future studies should involve more countries in the panels and use more historical data to find more fruitful results. The policymakers should show serious concentrations on the energy conservation policies, which can play a vital role in boosting economic growth, especially for lower-middle-income level economies.

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