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Assessment of the Contemporaneous Impacts of Gross Domestic Product and Renewable Energy Consumption, Applying the Dynamic Panel Data: Evidence from Developed Countries

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ABSTRACT

The vast majority of the investigations analyze the effect of renewable energy utilization on gross domestic product (GDP) with single equation model and the others utilize dynamic panel data. The motivation behind this investigation is to build up a concurrent equations model to investigate the collaboration amongst GDP and sustainable power utilization in a dynamic panel data. This model uses GDP and renewable energy consumption as endogenous variables and seven factors as exogenous variables. By using a dynamic panel data of 30 developed countries from 1990 to 2015, with using the two-stage least-squares method. The results confirm the important influence of renewables and non-renewables as well as capital and labor force on GDP in developed countries. Also both GDP and real oil price play an important role in renewable energy consumption. Our findings suggest that energy planners and policy makers need to increase renewable energy investment to ensure sustainable economic development in future.

Keywords: Simultaneous Equations, Gross Domestic Product, Renewable Energy Consumption
JEL Classifications: C30, F62, Q42

1. INTRODUCTION

Over the last decades, various investigations have analyzed the connection between energy utilization and financial development. Gross domestic product (GDP) is one of the primary measures of full scale economy. Since not just as the most critical marker of financial execution investigates and appraisals utilized, yet numerous different things that are viewed as macroeconomic results measured.

GDP is a measure of financial development. GDP gives us the aggregate market estimation of every single last great and administrations created inside a nation's limits in a particular day and age-month to month, quarterly or yearly. The primary reasons have constrained government arrangements to grow low-petroleum product economies and enhance energy productivity are non-renewable energy source deficiency, environmental change and a dangerous atmospheric abnormality. Decrease of energy cost and carbon dioxide emanations (CO_2) are the essential expected accomplishments of energy productivity. Accordingly, sustainable power is turning into an inexorably generous wellspring of energies option. Sustainable power sources are intended to be the quickest developing wellspring of energy till 2030 (Omri and Nguyen, 2014).

Solar energy serves as one of the cleanest sustainable power sources. It was being used considerably before people even figure out how to light a fire. The other essential sustainable power is wind energy that has slightest negative effects on nature. "Geo" implies earth and "thermal" means energy. Geothermal energy implies energy drawn or supplied from underneath the earth. It is totally spotless and reasonable. Sunlight based energy is delivered by sun and wind energy is created by moving of winds. The heat caused by sun drives the breeze. The wind turbines can change the active energy in the wind into power. The energy of the streaming water can be caught and called as hydroelectric power. This is the procedure by which an option energy is created. The earth stipends many power sources. Much the same as the geothermal and solar energy, which have been utilized as a part of warming homes and lighting for quite a long time.

Sustainable power is a principal part of the energy segment and on account of advantages gave to the general public and economy, their part is expanding with reference to information of international energy agency. Sustainable power represented 13.1% in worldwide aggregate essential energy supply (further in the following, total primary energy supply [TPES]) in 2004 and 2009. Nonetheless, it is required to build the offer of fossil energy sources, for example, oil, coal and natural flammable gas (Müller et al., 2011).

Biomass and waste are the discernible sorts of renewable energy, speaking to 9.9% in worldwide TPES and 75.9% in worldwide renewable energy supply in 2009. Be that as it may, their share in worldwide renewable energy has a diminishing pattern. The second biggest kind of renewable energy is hydro. It represented 2.3% in worldwide TPES and 17.7% in worldwide renewable energy supply in 2009. This is by 0.1 and 1.0 rate focuses not exactly in 2004. It is normal that amid 2009–2035 the volume of hydro power will increment by 2.1% a year and will surpass the development rates of petroleum product and atomic energy; in any case, its share will tend to diminish (Müller et al., 2011).

The third biggest sort of renewable energy on the planet is geothermal energy. It gave 3.9% in worldwide renewable energy supply in 2009. This is by 0.7 rate focuses more than in 2004. The commitment of wind, sun oriented and tide energies is as yet minor regarding information of international energy agency. They represented 0.3% in world TPES and 2.5% in worldwide renewable energy supply. On account of the quick advancement of wind, solar and geothermal limits in future, the share of these sorts of energies will triple, i.e., will increment till 22.4% (2035) in the structure of worldwide renewable energy supply (Müller et al., 2011).

The information given by the worldwide energy agency demonstrated that amid 1990–2009 sustainable power area developed at a normal yearly rate of 1.8%, which was somewhat higher than the development rate of worldwide TPES (1.7% a year). Development rates were especially high for solar photovoltaic (PV) (promote in the following PV) (43.5% a year) and wind power (25.1% a year). In any case, this is because of the way that their bases were low in 1990. Biogas had the following most noteworthy development rate (14.9%) a year, trailed by the fluid biofuels and solar thermal, which both developed at 10.0% a year. Strong biofuels (counting charcoal) encountered the least development (1.2% a year) among the renewable energy (Müller et al., 2011).

International energy agency expects the sustainable power contribution will stay as one of the quickest developing energy areas on the planet amid the following two decades. It will develop at a normal yearly development rate of 2.5% when the world essential energy request will increment considerably as large (by 1.3% a year), and will ensure for future eras the supply of energy. In any case, looking for that this will be understood extra new venture is required (Müller et al., 2011).

At last, different researches affirmed the relationship amongst's GDP and utilization of sustainable power source. Sustainable power utilization influences GDP and in this manner GDP influences energy utilization, also, the two will have extraordinary impact on the economy. In this paper, a two-route correspondence amongst GDP and utilization of sustainable power is relied upon to be analyzed. The indication of this article is sorted out as takes after. Section 2 presents the literature review, section 3 reports the data and model planning and segment 4 reports the methodology and model estimation. Section 5 is about exact findings of concurrent equations model and segment 6 concludes the article.

2. LITERATURE REVIEW

The connection between energy and economic growth has been researched in a few studies utilizing different methodologies. Zhang and Cheng (2009) studied the presence and direction of Granger causality between monetary development, energy utilization, and carbon emission in china from 1960 to 2007. Their outcomes demonstrate the presence of a unidirectional Granger causality running from GDP to energy utilization, and a unidirectional Granger causality running from energy utilization to carbon emission over the long run recommending that neither carbon emission nor energy utilization prompts monetary development.

The theory of causality between energy utilization and financial development has likewise shown to be neutral in a few researches. Utilizing a similar procedure, Yildirim et al. (2014) connected the Toda Yamamoto system and bootstrap-corrected causality test with a specific end goal to investigate the causality between sustainable power and monetary development in the USA. They likewise found no causality between financial development and aggregate sustainable power utilization.

Ocal and Aslan (2013) found that sustainable power utilization negatively affects monetary development for the instance of Turkey. Chang et al. (2009) endeavored to research the advancement of sustainable power sector under various monetary development rate administrations by applying panel threshold regression display in organisation for economic co-operation and development (OECD) member countries. The outcomes demonstrated that countries with high financial development can expand the sustainable power utilization, while nations with low-monetary development can't develop the utilization of sustainable power.

Apergis and Payne (2010a) utilized panel co-incorporation and error correction model to examine the causality connection between sustainable power and monetary development for twenty OECD nations. As indicated by their discoveries, there is a long run harmony connection between genuine GDP, sustainable power utilization, genuine gross fixed capital development and the work drive. They additionally discovered bi-directional causality for long and short run between sustainable power and development. Comparative outcomes were found for the instance of Eurasia Apergis and Payne (2010).

Utilizing comparable procedure, Apergis and Payne (2011a) found the presence of unidirectional causality running from monetary development to sustainable power utilization in the short term and furthermore bidirectional causality between these factors in the long run in incipient economies. Tugcu et al. (2012) explored the connection amongst sustainable and non-sustainable power utilization (NSPU) and financial development in the G7 nations. They utilized autoregressive distributed lag way to deal with co-integration and found that both sustainable and non-sustainable power are important for financial development with bidirectional causality for all G7 nations. Comparable outcomes were given by Pao and Fu (2013) and Ohler and Fetters (2014).

Notwithstanding, Al-Mulali et al. (2014) demonstrated that inexhaustible power utilization is more critical than nonrenewable power utilization in advancing monetary development in 18 Latin American nations over the long run and the short run. Afterward, Al-Mulali et al. (2013) considered the instance of high wage, upper middle wage, lower middle salary, and lower income nations by utilizing the fully modified ordinary least square strategy. The research indicated along run bidirectional causality between sustainable power and GDP development for most (79%) of the nations. Be that as it may, results demonstrated the presence of unidirectional long run relationship from GDP development to sustainable power utilization for 2% of the nations, and neglected to build up long run connection between these variables for 19% of the nations. This study brought up the level of criticalness of the bidirectional long run connection between the factors is slowly more vital while moving from the low Income to the high income nations.

Magnani and Vaona (2013) received panel data unit root and co-integration and additionally Granger non causality tests in view of the generalized method of moments estimator framework for considering relation between sustainable power era and monetary development at provincial level in Italy. They found that sustainable power era has appositive effect on monetary development by diminishing limitation on balance of installments and presentation to the instability of petroleum derivatives cost.

Sadorsky (2009a) examined the connection between sustainable power and monetary development in incipient nations. He expressed that development in income significantly affected expanding sustainable power utilization. Be that as it may, in the opposite, the results by Marques and Fuinhas (2012) recommended negative effect of utilizing sustainable power on monetary development and that, the financial development does not add to expanded sustainable power utilization. Based on the review of literature and to the best of our insight, studies on the connection between sustainable power utilization and financial development is as yet restricted and the results are not consistent.

Our goal here is to check the inadequate writing on the part of sustainable power in clarifying reasonable financial development. Smiech and Papiez (2014), set up a bi-directional causation between sustainable power utilization and monetary development for incipient economies. Sadorsky (2009b) reports that over the long run, a 1% expansion in genuine pay per capita expanded the utilization of sustainable power per capita by around 3.5% for these economies.

Payne (2009) investigated the sectorial causal connection amongst sustainable and NSPU and Economic development in the US. Their discoveries set up no causality between sustainable power utilization and genuine GDP in the business and mechanical divisions, while positive uni-directional causality exists from private sustainable power utilization to genuine GDP. On renewables, there are just a couple of studies inspecting the impacts of biomass biofuels on the earth with fluctuating outcomes. Bilgili and Ozturk (2015) checked on this writing and researched 51 African nations. They found that a 1% expansion in biomass will build GDP by 0.82% in these nations.

A summary of literature is displayed in Table 1 to keep space. It is recognizable that the discoveries from the literature are blended notwithstanding for the investigations where energy blend is disaggregated. Given that there is as of now an overall push to build the offer of sustainable sources; a panel study about rather than a contextual investigation on a solitary nation is considered. The determination of nations following the renewable energy country attractiveness index list and heterogeneous panel estimation strategies give new discoveries in the literature as do Valle Costa et al. (2008).

In this paper, Panel data is utilized as a part of a system equation model, with the instance of developed countries.

3. DATA AND MODEL DESIGNING

Taking GDP and sustainable power utilization as two endogenous factors, this study builds up a synchronous equations model with two direct frame equations, including 2 foreordained factors and seven exogenous factors. The chosen factors incorporated into the framework depend on the monetary hypothesis and accessible empirical evidence.

An expansion in GDP may require more energy utilization and likely abatement of the natural quality. Likewise, the high GDP should prompt an abnormal state of sustainable power utilization under the pressure of natural devaluation. From one perspective a few studies including, among others, Omri and Nguyen (2014), Apergis and Payne (2012), Sadorsky (2009a) for the most part find that the GDP is a critical determinant of sustainable power utilization, however then again a few researches propose a generation work where, alongside conventional data sources, inexhaustible and non-sustainable wellsprings of energy are utilized into the creation procedure (Cerdeira et al., 2016), (Bilgili and Ozturk, 2015), (Apergis and Payne, 2011b).

Considering the above discussion, we create, in this investigation, an exact empirical system equation that is reliable with the more extensive writing and accessible observational proof. Taking GDP and sustainable power utilization as two endogenous factors, this work builds up a synchronous equations model with two direct shape equations, including two foreordained factors and seven exogenous factors. The GDP equation contains 3 exogenous factors, and the REC equation contains the lagged endogenous variable GDP (−2) that is increased by a spurious variable and three exogenous factors. The particulars of the synchronous equations demonstrate are as per the following:

Table 1: Recent researches on renewable energy consumption and GDP

Study	Methodology	Period	Country	Findings
(Apergis and Payne, 2010a)	>ENAP	1985–2005	20 OECD countries	ER>><DG
(Apergis and Payne, 2010b)	>ENAP	1992–2007	13 Eurasian countries	ER>><DG
(Menegaki, 2011)	Panel, random effect	1997–2007	27 European countries	GDP and RE are neutral to each other
(Fang, 2011)	OLS	1978–2008	China	DG<ER>
(Tiwari, 2011)	Structural VAR	1960–2009	India	DG<ER>
(Tugcu et al., 2012)	ARDL approach for co-integration	1980–2009	G7 countries	The relationship is different for countries and varies with specification
(Ozturk and Bilgili, 2015)	Dynamic panel analysis	1980–2009	51 Sub-Sahara African countries	Biomass has positive effect on GDP
(Bilgili and Ozturk, 2015)	>ENAP, DOLS	1980–2009	G7 countries	Biomass has positive effect on GDP
(Cho et al., 2015)	>ENAP vector error-correction model	1990–2010	31 OECD and 49 non-OECD countries	GDP>RE** fo developed and GDP<>RE for less-developed countries

GDP<>RE bi-directional relation-ship between GDP and RE, GDP>RE uni-directional causality exists from GDP to RE, OLS: Ordinary least squares. ARDL: Autoregressive distributed lag, OECD: Organisation for economic co-operation and development

$$GDPit = C1+C2*GFCFit+C3*LFit+C4*RECit+C5*NRECit+uit \quad (1)$$

$$RECit = C6+C7*CO_2it+C8*TOit+C9*ROPit+C10*\log(GDPit)+ 11*dummy*GDPit(-2)+\varepsilon it \quad (2)$$

The subscripts i (I = 1…N) denotes the nation i in our example, with N being equivalent to 30 and (t = 1,…,T) shows the day and age which T being equivalent to 26. The error terms, u and, are thought to be autonomous and indistinguishably disseminated with a zero mean and steady fluctuation. Genuine GDP (consistent 2005 US$) as a measure of financial yield and genuine gross fixed capital formation (GFCF) (constant 2005 US$) are utilized as an intermediary for the development of capital stock, add up to labor force (LF) is utilized as a measure surp incipiently who supply work for the creation of merchandise and ventures amid a predefined period. CO_2 shows the carbon dioxide discharges in metric kilo tons. ROP signifies the Brent real oil price in metric $/bbl. To show the exchange transparency, measured as fares in addition to imports as a level of GDP. The energy sources are utilized as a part of this model is sustainable power utilization (REC), and NSPU in quadrillion btu units. The required information on oil cost is gathered from the US. Energy Information Administration (EIA, Energy Information Administration, 2013) and the others are acquired from the world development indicators online database distributed by the World Bank (different issues). Toward the finish of this part, it is seen that fake variable is equivalent 1 for high income developed countries and 0 for others.

This period is chosen in light of accessibility of information for the balanced panel and on the grounds that the greater part of the activities for renewables have been conducted amid this time. Figure 1 presents the offer of sustainable power sources in complete last energy utilization in 2002 and 2012 in developed countries.

For the empirical analysis, this paper utilizes an balanced panel for 30 developed countries from 1990 to 2015. The nations are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.

Table 2 displays the average of every factor in our model. There was heterogeneity crosswise over nations for these statistics. For instance, the normal yearly genuine GDP was 1.14104E+13 for United States, trailed by Japan (4.34864E+12) and Germany (2.75483E+12). The most elevated normal yearly utilization of renewables is recorded for US (532.8091), Canada (270.1005), France (109.3694) and Norway (108.4217). The three nations with most astounding yearly normal level of sustainable power were Iceland, Sweden and Norway.

Tables 3 and 4 demonstrate the relationships among the factors of the first and second equations, individually. For the main equation the results demonstrate that GDP had high connection with capital arrangement, work, NSPU and sustainable power utilization. These discoveries demonstrate that the majority of the factors assume a critical part in advancing GDP over the nations. For the second equation, REC had higher connection with CO_2 emission and GDP, and lower relationship with trade openness and real oil cost.

4. METHODOLOGY AND MODEL ESTIMATION

In this part, suitable econometric system is portrayed and applies these for our balanced panel.

4.1. Panel Unit Root Test

Our study is proceeded by conducting the panel unit root test proposed by Levin et al. (2002). The goal is to choose which factors ought to enter the experimental model in their first-order differential frame and which factors ought to be in their level form. The result of unit root test is summarized in Table 5 for all of the panels, which demonstrate that the greater part of the factors were incorporated of same order, i.e., I (1). It finds that the greater part of the factors are non-stationary at levels, and stationary at their first-order differentials.

4.2. Panel Co-integration Test

In the following level, the presence of a long-run balance connection between the factors is analyzed. Each of our factors

Figure 1: Share of renewable energy sources in total final energy consumption; 2002 and 2015 in developed countries

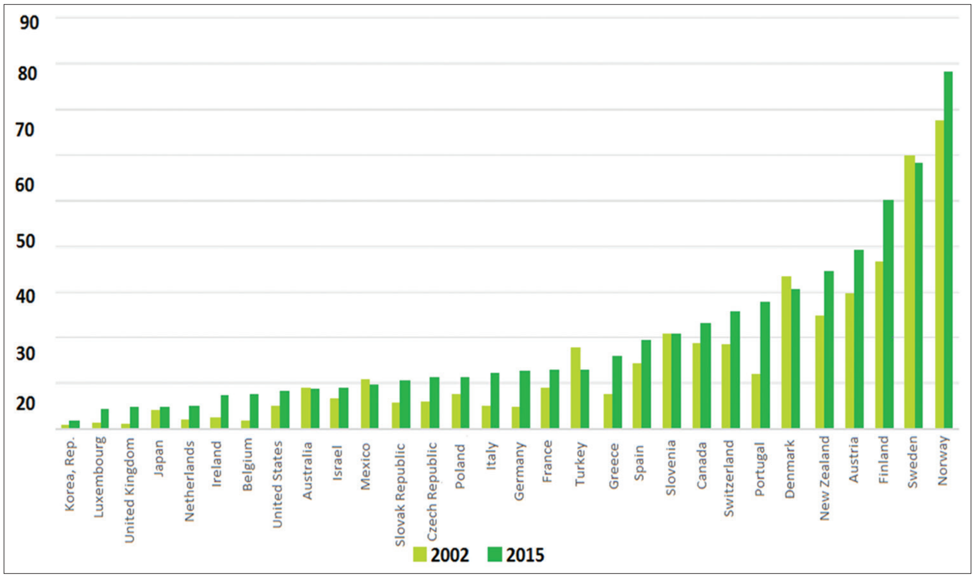

Table 2: Average of each variables in the model

Country	GFCF	CO_2	GDP	LF	ROP	NREC	REC
Australia	1.6023E+11	328536.4	6.12518E+11	9989044	43.97	470.5754	39.73131
Austria	69121231954	63562.13	2.89039E+11	3975778	43.97	106.4363	38.52256
Belgium	77551268941	111258.7	3.54504E+11	4427912	43.97	190.1745	8.406535
Canada	2.23164E+11	502872.2	1.02597E+12	16725033	43.97	957.5315	270.1005
Czech republic	33562216523	121212.1	1.22484E+11	5155806	43.97	130.3634	10.967032
Denmark	49315468234	53734.38	2.40027E+11	2891447	43.97	75.2942	11.0696
Finland	41201241354	57521.56	1.78686E+11	2614183	43.97	63.11738	37.0527
France	4.28659E+11	369622.6	2.01732E+12	27789710	43.97	561.998	109.3694
Germany	5.6188E+11	827600.9	2.75483E+12	40683914	43.97	1174.487	78.1084
Iceland	2903598477	2074.855	14363405837	166902.7	43.97	3.004786	9.759263
Ireland	39921339502	38518	1.62729E+11	1808241	43.97	49.7066	1.920126
Israel	30490588286	56578.98	1.25142E+11	2521916	43.97	74.59874	5.68819
Italy	3.42378E+11	436527.8	1.72726E+12	23812244	43.97	673.8013	49.98836
Japan	1.05095E+12	1184780	4.34864E+12	66629250	43.97	1762.338	87.26249
South Korea	2.47212E+11	424804.8	7.59671E+11	22811947	43.97	663.7219	8.387251
Luxembourg	6661766858	9844.895	31673510217	195930.4	43.97	14.93412	0.766386
Mexico	1.59578E+11	390791	7.87618E+11	41382751	43.97	547.8645	72.15033
Netherlands	1.30032E+11	169089.5	6.16726E+11	8119803	43.97	362.8504	9.21451
New Zealand	21066983453	30718.79	98841114400	2018973	43.97	54.59967	24.13803
Norway	54630271130	39507.76	2.7454E+11	2378712	43.97	101.4169	108.4217
Poland	53119296241	324943.7	2.73926E+11	17567905	43.97	364.6104	26.93681
Portugal	40941880490	55405.54	1.80119E+11	5221265	43.97	79.46604	23.24306
Slovak republic	15438688456	39101.4	57573276245	2610746	43.97	57.34404	5.541803
Slovenia	7680914745	15136.83	34035705896	969740.1	43.97	20.66905	4.985035
Spain	2.60987E+11	281355.4	1.00351E+12	19318081	43.97	431.4341	53.49811
Sweden	76876049540	51927.72	3.46859E+11	4682662	43.97	79.03001	87.27323
Switzerland	93275672250	40686.87	3.86821E+11	4124625	43.97	69.72641	24.63052
Turkey	81373737125	215710.6	4.17047E+11	22205978	43.97	285.2909	57.01421
UK	3.81793E+11	531349.6	2.12244E+12	30100243	43.97	833.8354	15.39357
US	2.4528E+12	5394699	1.15011E+13	1.46E+08	43.97	8102.887	532.8091

GFCF: Gross fixed capital formation, GDP: Gross domestic product, LF: Labor force

Table 3: Correlation for the first equation's variables

	GDP	REC	NREC	LF	GFCF
GDP	1	0.86132	0.959235	0.970968	0.996413
REC		1	0.869967	0.823077	0.842873
NREC			1	0.955742	0.958964
LF				1	0.971034
GFCF					1

GDP: Gross domestic product, LF: Labor force, GFCF: Gross fixed capital formation

is incorporated of order one, panel co-integration test created by Pedroni (1999a) is applied. The proposed test statistics are: The panel v-statistics, panel rho-statistics, panel PP-statistics, panel augmented Dickey-Fuller (ADF)-statistics, assemble rho-statistics, amass PP-statistics and gathering ADF-statistics.

Tables 6 and 7 exhibit the discoveries. Out of seven test statistics in the main equation, four affirm the nearness of co-integration among the factors. In this way, it is inferred that real GDP, GFCF, LF, sustainable utilization and non-inexhaustible utilization series contributed to a long-run balance relationship. In second equation, six test statistics affirm the nearness of co-integration among the factors. Subsequently, it is presumed that sustainable power utilization, real GDP, real oil price, trade openness series shared a long-run balance relationship.

Table 4: Correlation for the second equation's variables

	REC	CO_2	TO	ROP	GDP
REC	1	0.870063	−0.289952	0.090213	0.86295
CO_2		1	−0.297456	0.008739	0.970531
TO			1	0.294621	−0.308139
ROP				1	0.061783
GDP					1

GDP: Gross domestic product

Table 5: Results of unit root test for all the variables

Variables	Level		First difference	
	Statistic	P	Statistic	P
CO_2	−2.21493	0.0211	−5.69847	0.0000
GDP	−1.96325	0.0131	−9.97143	0.0000
GFCF	−1.60763	0.0549	−9.9476	0.0000
LF	0.77032	0.7264	−4.86418	0.0000
REC	9.20421	1.0000	−5.01276	0.0000
ROP	12.9253	1.0000	−16.1375	0.0000
TO	−2.71416	0.0047	−13.9214	0.0000

GDP: Gross domestic product, GFCF: Gross fixed capital formation, LF: Labor force

4.3. Panel Causality Analysis

The existence of co-integration between variables confirms that there ought to be at least, one causal relationship, but it fails to give its direction. Subsequently, the methodology from Engle and Granger (1987) to inspect the short-run and in addition the long-run causal elements between the contending factors is taken after. This test expects factors to be stationary; in this manner, it is connected on the first difference of the series. The discoveries set up bidirectional causality amongst GDP and sustainable power utilization in the short-run (Table 8).

5. EMPIRICAL FINDINGS OF SIMULTANEOUS EQUATIONS MODEL

5.1. Model Estimation

As two equations in this paper are over-distinguished, 2SLS can be utilized to appraise the synchronous equations model. In Table 9, the estimation of the model is exhibited. The discoveries on long-run recommend that alongside customary sources of info, for example, capital and labor, both renewables and non-renewables assume a noteworthy part during the economic development in the developed countries. In view of these outcomes, it is contended that renewable energy consumption assumes a greater part in GDP. The discoveries of the second equation demonstrate that both GDP and real oil price assume a critical part in renewable energy utilization in the chosen nations. Subsequently, to guarantee supportable monetary improvement in future, policy makers need to advance the generation and utilization of sustainable power.

Table 6: Pedroni panel co-integration test results (first equation)

Alternative hypothesis: Common AR coefficients (within-dimension)				
Variables	Statistic	P	Weighted statistic	P
Panel v-statistic	1.895236	0.0361***	−0.020463	0.4985
Panel rho-statistic	4.035674	1.0000	3.846835	0.9999
Panel PP-statistic	−0.685119	0.2748	−1.712164	0.0537***
Panel ADF-statistic	−4.720652	0.0000***	−1.901644	0.0326***
Alternative hypothesis: Individual AR coefficients (between-dimension)				
	Statistic	P		
Group rho-statistic	6.468531	1.0000		
Group PP-statistic	−2.315146	0.0135***		
Group ADF-statistic	−1.972723	0.0337***		

Variables: GDP, GFCF, LF, REC, NREC. Trend assumption: No deterministic trend. Lag selection: 1. Denote rejection of null hypothesis of no co-integration at 0.5% significance level. GDP: Gross domestic product, GFCF: Gross fixed capital formation, LF: Labor force, AR: Autoregressive, ADF: Augmented Dickey-Fuller

Table 7: Pedroni panel co-integration test results (second equation)

Alternative hypothesis: Common AR coefficients (within-dimension)				
Variables	Statistic	P	Weighted statistic	P
Panel v-statistic	−0.511569	0.6598	2.405781	0.0098***
Panel rho-statistic	0.1263548	0.5374	−1.641148	0.0394***
Panel PP-statistic	−8.997237	0.0000***	−6.541341	0.0000***
Panel ADF-statistic	−11.89473	0.0000***	−4.756184	0.0000***
Alternative hypothesis: Individual AR coefficients (between-dimension)				
	Statistic	P		
Group rho-statistic	−0.345315	0.3394		
Group PP-statistic	−8.035065	0.0000***		
Group ADF-statistic	−3.414763	0.0007***		

Variables: REC, GDP, TO, ROP. Trend assumption: No deterministic trend. Lag selection: 1. Denote rejection of null hypothesis of no cointegration at 0.5% significance level. GDP: Gross domestic product, AR: Autoregressive, ADF: Augmented Dickey-Fuller

Table 8: Granger causality analysis

Null hypothesis	Observation	F-statistics	P
D (REC) does not granger cause D .	780	7.89803	0.0005
D (GDP) does not granger cause D .		35.9725	1.E-15

☆Denote rejection of null hypothesis at 1% significance levels. GDP: Gross domestic product

Table 9: Estimation of the model

Variables	Coefficient	SE	t-statistic	P
GDP				
REC	3.53E+09	5.71E+08	6.105889	0.0000
GFCF	3.291223	0.091369	38.01312	0.0000
NREC	80938827	43096407	1.913036	0.0493
LF	8159.003	1310.237	6.312851	0.0000
R-squared	0.986408			
REC				
TO	−8.439865	5.3806711	−1.603631	0.1348
ROP	0.1597563	0.070312	2.363251	0.0239
GDP (−2)*dummy	3.12E-11	4.61e-12	6.804357	0.0000
Log (GDP)	8.207863	2.759910	3.114156	0.0023
CO_2	2.39E-05	9.67e-06	2.491897	0.0212
R^2	0.792891			

SE: Standard error, GDP: Gross domestic product, GFCF: Gross fixed capital formation, LF: Labor force

6. CONCLUSION

With the quick improvement of worldwide economy, the utilization of petroleum product energy has been developing quickly. In light of overall consideration towards practical advancement, renewable energy as the significant option for accomplishing that has been generally concerned.

A concurrent equations model is utilized to investigate the interaction amongst GDP and renewable energy consumption. It set up a dynamic panel data of 30 developed countries from 1990 to 2015. The model was evaluated by utilizing the two-stage least squares method. The discoveries on long-run recommended that capital, labor and both renewables and non-renewables assumed a noteworthy part during the economic development in the developed countries. In view of these outcomes, it is contended that renewable energy utilization assumes a greater part in GDP. The discoveries of the second equation demonstrate that both GDP and real oil price assume an essential part in sustainable power utilization in the chosen nations. There are several researches on the impact of renewable energy utilization on GDP with single equation model, and the others utilize dynamic panel data. With comprehensive research, dynamic panel data in a system equation model is used to analyze two side effects of sustainable power utilization on GDP.

One of the impediments of our model was that disaggregated information inside the renewables (i.e., biomass, solar, wind and hydroelectricity) because of inaccessibility of information for the chosen period could not be examined. Advancing human skill, utilizing high innovations, removing money related and political boundaries, encouraging taxes and credit incentives for environmentally friendly energy are significant instruments for expanding the generation and utilization of sustainable power

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