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Sustainable Economic Development and Greenhouse Gas Emissions: The Dynamic Impact of Renewable Energy Consumption, GDP, and Corruption

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Abstract: The paper investigates the relationships between economic, social, and environmental dimensions of sustainable development. GDP growth represents the main economic dimension, greenhouse gas (GHG) emissions and renewable energy consumption the environmental dimension, and corruption the social dimension of sustainable development. The investigation of these relationships is based on the concept of the Environmental Kuznets Curve hypothesis about the non-linear relationship between economic growth and environmental pollution. The authors used the panel data of EU countries and Ukraine for 2000–2016 years from the Eurostat database. The obtained results confirmed the Environmental Kuznets curve hypothesis for the EU and Ukraine. All the indicators were statistically significant at 1% and 5% levels. The findings proved that increasing renewable energy (RE) by 1% led to a decline of GHG in the interval (0.166103, 0.220551), and an increase of the Control of Corruption Index by 1% provoked a decline of GHG by 0.88%. The conducted study enabled the authors to conclude that Ukraine needs to increase the GDP level per capita given the economy diversification and via the introduction of more effective and "clean" production technologies.

Keywords: economic growth; environmental Kuznets curve hypothesis; quadratic model; renewable energy; sustainable development; European Union; Ukraine

1. Introduction

The ongoing trends of economic development provoke the appearance of new issues and tasks for the government on choosing the way for future development. Therefore, the abovementioned issues are required to provide economic, social, and ecological policy for achieving the goals and targets of sustainable development. According to the Agenda of European Union (EU), sustainable development is the main orientation of development and implementing of all politics in all spheres, which allow the increase of countries' competitiveness [1,2] to develop better conditions for companies [3] and living condition for society [4,5].

Therefore, the EU considers the achievement of sustainability through the use of renewable energy as a way that could mitigate not only the negative consequences of climate change but also develop direct and indirect economic benefits by reducing dependence on imported fuel [6].

The linkages between economic, environmental, and social dimensions of sustainable development can be represented by the Environmental Kuznets Curve (EKC) hypothesis. GDP growth represents the main economic dimension, greenhouse gas (GHG) emissions and renewable energy consumption the environmental dimension, and corruption the social dimension of sustainable development. The aim of this paper is to investigate the relationships between GDP growth, GHG emissions, renewable energy consumption, and corruption based on the concept of the EKC hypothesis about the non-linear relationship between economic growth and environmental pollution in the EU and Ukraine, seeking to reveal differences and similarities and taking into account the high corruption level in Ukraine and the low penetration of renewables.

The reminder of the paper is structured in the following way: Section 2 presents the literature review; Section 3 provides the methods applied in the study; in Section 4 the results of calculations are discussed; in Section 5 the conclusions are outlined.

2. Literature Review

According to the Energy Roadmap 2050 that was signed in 2011, EU countries should achieve the goal on the share of RES in total energy consumption of more than 25% in 2050; however, in 2020 it should be 20% [7]. Thus in 2017, among 28 EU countries, the share of renewable energy sources (RES) in Hungary decreased by 0.7% compared with the 2011 year (14%). However, with the increasing of the share of RES in EU countries as a whole from 13.4% in 2011 to 17.5% in 2017, the level of regional dispersion increased, particularly for Belgium (share of RES in the 2017 year, 9.1%), Luxembourg (6.4%), Netherlands (6.6%), Poland (10.9%), and Slovakia (11.5%) (Figure 1). For the years 2011–2017, the highest level of average annual growth rate of RES was obtained by Malta (31.95%); however, it should be highlighted that the general level of RES of 7.2%, which was the f RES at 7.2%, was one of the lowest in the EU member states; the United Kingdom was 19.42%.

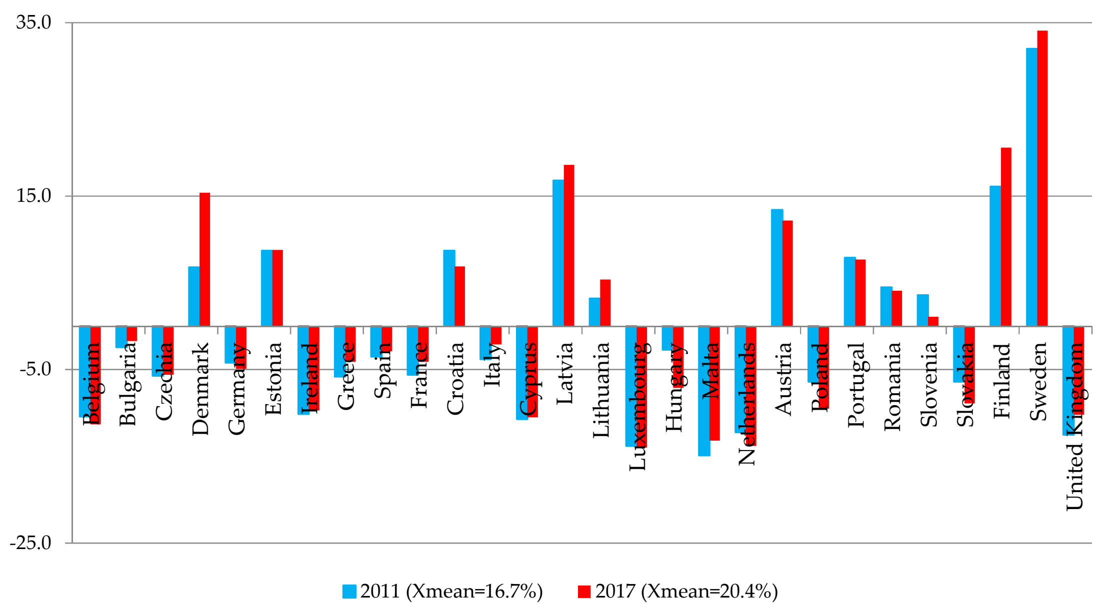

Figure 1. Renewable energy consumption for EU countries in 2011 and 2017.
Sources: developed by the authors on the basis of EUROSTAT data base [8].

Increasing the share of RES in the total energy consumption provokes the situation that all economic spheres and entities should adopt their activities according to the EU requirement of decreasing the negative impact on the environment through implementing relevant ecological policies. The main result of increasing the RES is reducing greenhouse gas emissions (GHG) emissions among 28 EU countries, which were 8.7 tonnes of CO_2 equivalent per capita in 2016. Note that it was lower by 7.45% compared with 2011 (the base year for comparison that was indicated in the Energy Roadmap 2050). At the same time, the highest decrease of GHG was in 2008–2009, which was a result of declining economic activities due to the financial crisis.

The main indicator that characterizes the intensity of GHG emissions in the separate region is GHG emissions per capita. The comparison of this indicator with the level of economic growth for some EU countries (2011–2106) is shown in Figure 2. Among all countries, only Luxemburg was in the category with the highest level of GHG emissions and economic growth. Thus, in 2016 the GHG emissions in Luxemburg were 19.8 tonnes of CO_2 equivalent per capita, which was 2.3 times higher than in EU countries (8.7 tonnes of CO_2 equivalent per capita); at the same time, real GDP per capita was 3 times higher.

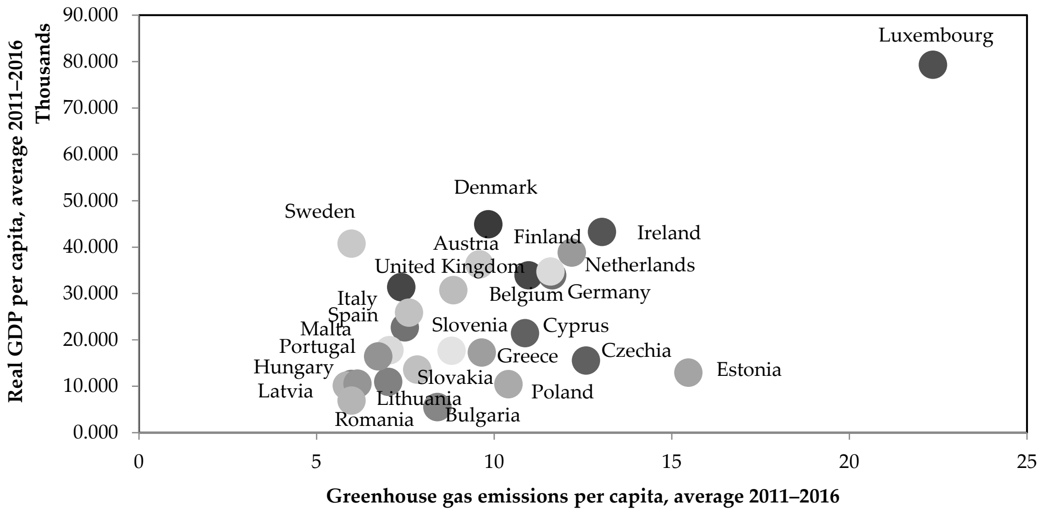

Figure 2. Comparison of average rates of greenhouse gas emissions per capita and real GDP per capita among EU 2011–2016 years.
Sources: developed by the authors on the basis of EUROSTAT data base [8].

In this case, while EU countries are trying to increase the RES in the total energy consumption to 25% in 2050 as a whole, this is not enough to significantly reduce the share of GHG emissions in the separate countries.

According to the EKC hypothesis, economic growth is the instrument for achieving an increase in quality of life indicators and improving environmental safety. Thus, developing countries should follow the economic growth policy, which as a result leads to achieving ecological and economic targets. At the same time, government policy, which focuses only on environmental safety, restricts economic growth [9]. The graphic interpretation of this hypothesis can be shown as an inverted U shaped curve.

Support of economic growth by the International Monetary Fund (IMF) had a significant impact on the economic policy of the developing and developed countries and could be a good example of the use of the EKC hypothesis. At the same time, the experience of the developed EU countries proved that economic growth and environment improvement could be achieved in the whole EU, even if some countries do not correspond to the indicated criteria by reducing their share of GHG emissions. Note that on the 7th of February 2019, the Ukrainian government accepted the main strategic targets of the countries' development—join the EU and have full membership in the EU and the North Atlantic Treaty Organization. The main document that regulates the RES development is the Energy Strategy of Ukraine 2030. According to this document, the target RES is only 10% [10]. Thus, comparing with the latest EU members that have common boundaries with Ukraine, this indicator was lower than in Poland in 2017 by 0.9%, Slovakia by 1.5%, Hungary by 3.3%, and Romania 14.5%. As Herbey and Suksangium [11] declared, only compliance with EU standards and joining the EU's Third Energy Package will allow Ukraine to overcome one of the key constraints on the growth of the level of RES—the level of corruption in the energy sector. Besides, in [12,13,14] the increase of RES was indicated as a key element in providing the economic and energy safety of the country. The authors of the papers [15,16,17] have the same point of view, highlighting that limitations of fuel resources as the main energy resources provoke the effective use of energy resources and development of renewable resources.

This purpose of this case is to analyze if the joining of the EU by Ukraine actually led to keeping the long-term stable relations between the four macroeconomic indicators of GDP per capita, GHG emissions, renewable energy consumption, and corruption. The proof of such linking could open for the Ukrainian government new options for achieving sustainable economic development.

The issues of linking economic growth, GHG emissions, and renewable energy consumption are mainstream among the empirical economic investigations in recent years. In order to confirm or contradict the above relationships, researchers use an economic and mathematic apparatus of data dynamics analysis, such as fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS), and the augmented Dickey–Fuller (ADF) (see Table 1).

Table 1. Summary of the empirical literature on linkages between GDP growth and energy consumption.

Author	Country	Period	Methodology	Results
Al-multi et al. [18]	108	1980–2009	FMOLS	79% feedback; 2% conservation; 19% neutral
Ben Javli et al. [19]	24	1980–2010	FMOLS and DOLS	CO_2 < – > GDP (short-run); CO_2 – > REC; GDP < – > REC
Bildirici [20]	10	1980–2009	ARDL	BE < – > GDP
Bilgili and Ozturk [21]	7 (G7)	1980–2009	OLS–FMOLS, DOLS	Biomass has a positive effect on GDP
Fang [22]	1 (China)	1978–2008	OLS–FMOLS	RE ≥ GDP
Ocal and Aslan [23]	1 (Turkey)	1990–2010	ARDL; Toda–Yamamoto causality	REC has a negative impact on GDP > REC
Ozturk and Bilgili [24]	51	1980–2009	DOLS	Biomass has a positive effect on GDP
Sadorsky [25]	7 (G7)	1980–2005	FMOLS, DOLS, ECM	GDP per capita and CO_2 per capita are found to be major drivers behind per capita REC
Salim and Rafiq [26]	6	1980–2006	FMOLS, DOLS	GDP < – > RE in the short-run
Tiwari [27]	1 (India)	1960–2006	ADF	RE ≥ GDP
Chang, Shieh [28]	Baltic Sea Region countries	1990–2015	FMOLS, DOLS	GDP < – > EE

Note: FMOLS – fully modified ordinary least squares, DOLS – dynamic ordinary least squares (DOLS), ADF – the augmented Dickey–Fuller, ARDL – autoregressive distributed lag model, ECM – error correction model, CO_2 – CO_2 emissions, REC – combustible renewables and waste consumption, BE – biomass energy consumption, RE – renewable energy consumption.

Sterpu et al. [29] checked the EKC hypothesis on the existence of long- and short-term relationship between greenhouse gas emissions, economic growth, gross inland energy consumption, and renewable energy consumption for EU28 for 1990–2016 through use of panel cointegration techniques. The findings showed that in the long-term perspectives, the increasing of renewable energy consumption led to provoking the declining of GHG emissions among 28 EU countries.

Using the example of 24 Sub-Saharan African countries in [30], the authors also used the EKC hypothesis to allocate the long- and the short-term relationship between CO_2 emissions, economic growth, renewable energy consumption, and trade openness. Using the dataset 1980–2010 the scientist did not show the EKC hypothesis for analyzing the countries.

Cho et al. [31] considered the causal link between renewable energy consumption and economic growth for 31 OECD countries and 49 non-OECD countries for the period 1990–2010. The heterogeneous panel cointegration test confirmed the existence of a long-term relationship between the subject variables for developed countries, so the authors concluded that for these countries, it was economic growth that played an important role for the growth of renewable energy consumption.

Saidi and Mbarek [32] studied the impact of clean energy consumption, CO_2 emissions, and renewable energy on economic growth for nine developed countries. The findings indicated that renewable energy consumption was a key component of the countries' economic growth in the long run. Hence the pursuit of rigorous energy policy by the governments of the countries was an effective instrument of economic growth. On the other hand, CO_2 emissions had a negative impact on economic growth.

Aidt [33], in the example of 110 countries between 1996 and 2007, investigating the relationship between sustainable development and corruption using the panel data model (Equation (1)), came to the conclusion that there was a statistically significant correlation between them:

$$dlngw_{it} = \beta_0 CORRUPTION_{it} + \sum_{k=1}^{\bar{k}} \beta_{1k} INSTITUTIONS_{it}^{k} + \sum_{l=1}^{\bar{l}} \beta_{1l} STOCKS_{it}^{l} + \\ + \sum_{s=1}^{\bar{s}} \beta_{1s} SHADOW_{it}^{s} + \mu_i + \gamma_t + \varepsilon_{it}. \quad (1)$$

The author used the Corruption Perception Index, published by Transparency International [34], and the Control of Corruption Index, which was calculated by the experts from the World Bank [35], as the indicator of the corruption level. The variables of Equation (1) were growth in genuine wealth per capita.

Mohammed [36] indicated corruption as the main issues of sustainable development for Nigeria. The same conclusions were obtained in the paper "The Impact of Corruption on Sustainable Economic Growth and Development in Nigeria" [37]. For that purpose, they used instruments of econometric analysis. It should be highlighted that a huge range of the scientists investigated the link between the level of corruption, good government, and indicators of macroeconomic stability: indicators of economic growth [38,39,40,41,42] economic freedom and democracy [43,44,45,46], innovation potential [47,48] and country macroeconomic [49,50,51,52,53,54], and social [55,56,57,58,59] and ecological aspects of a country's development [60,61,62,63,64,65,66].

3. Methods

Under the investigation with the purpose to analyze the causal link between GDP, renewable energy consumption (RE), corruption, and greenhouse gas emissions (GHG) according to the investigations [29,30,67,68], the authors used the quadratic function of dependence (Equation (2)), which is based on the EKC hypothesis:

$$E = F(Y, Y^2, Z) \quad (2)$$

where E is environmental pollution (per capita GHG emissions), Y is output (per capita GDP), and Z are the explanatory variables.

Due to the necessity of considering the level of corruption as the GDP and renewable energy consumption on indicating the GHG emissions, the function (Equation (2)) for a panel study could be written as:

$$\mathrm{GHG}_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + \beta_3 RE_{it} + \beta_4 CORRUPTION_{it} + e_{it} \quad (3)$$

where i symbolizes the countries, t is time, $\mathrm{e_{it}}$ is error term, $\beta_1, \ldots, \beta_4$ are the regression parameters that are evaluated, GHG is greenhouse gas emissions in kt of CO_2 equivalent, *GDP* is GDP per capita (current US$), *RE* is renewable energy consumption (% of total final energy consumption), and *CORRUPTION* is the Control of Corruption Index.

The dataset of the years 2000–2016 for *GDP, CORRUPTION* and *RE* were obtained from the World Data Bank [69], and GHG from the European Environment Agency [8]. The descriptive statistical analyses of the mean values, standard deviations, coefficients of variation for the equation's variables (3), and their correlation matrix for different countries are presented in Tables 2–3.

Table 2. Descriptive statistics and correlation matrix for greenhouse gas emissions in kt of CO2 equivalent (GHG), GDP per capita (*GDP*), Control of Corruption Index (*CORRUPTION*), renewable energy consumption (*RE*) for EU countries.

Descriptive statistics	GHG	*GDP*	*GDP*^{2}	*CORRUPTION*	*RE*
Mean	10.55651	28,305.96	1.21×10^9	1.045315	15.09562
Std. Dev.	4.190357	20,254.17	1.91×10^9	0.7978944	11.52696
CV	0.3969	0.7155	1.5785	0.7633	0.7636
Observations	476	476	476	476	476
Correlation matrix					
GHG	1.000				
GDP	0.6025	1.000			
GDP^2	0.6274	0.9219	1.000		
CORRUPTION	0.4792	0.7297	0.5444	1.000	
RE	–0.4001	–0.0477	–0.0756	0.0551	1.000

Table 3. Descriptive statistics and correlation matrix for greenhouse gas emissions in kt of CO2 equivalent (GHG), GDP per capita (*GDP*), Control of Corruption Index (*CORRUPTION*), renewable energy consumption (*RE*) for EU taking into account Ukraine.

Descriptive statistics	GHG	*GDP*	*GDP*^{2}	*CORRUPTION*	*RE*
Mean	10.41504	27,411.4	1.17×10^9	0.9758824	14.65597
Std. Dev.	4.186494	20,458.54	1.89×10^9	0.8663196	11.56454
CV	0.4020	0.7464	1.6154	0.8877	0.7891
Observations	493	493	493	493	493
Correlation matrix					
GHG	1.000				
GDP	0.6178	1.000			
GDP^2	0.6336	0.9176	1.000		
CORRUPTION	0.5027	0.7407	0.5387	1.000	
RE	–0.3497	0.0013	–0.0501	0.1343	1.000

The obtained results showed that consideration of the main indicator tendencies of Equation (3) for Ukraine and EU countries did not lead to changes in the correlation matrix for GHG, *GDP, CORRUPTION* and *RE*. It had an impact only on the changing of their mean values, standard deviations, and coefficients of variation. The results in Tables 2–3 showed that lnGHG were positively correlated with ln*GDP*, ln*GDP*^{2}, and ln*CORRUPTION*, and had a negative impact on the relationship with lnRE.

Thus, the findings allowed the development of the causal relationship between GHG, *GDP, CORRUPTION* and *RE* by using the panel data of all countries (Ukarian and EU), eliminating the risks of losing information. The main stages for that analysis were:

1) Panel unit root tests using the Im, Pesaran, and Shin's test (IPS) [70], Levin, Lin, and Chu test (LLC) [71], and the Fisher-type tests (ADF Fisher and PP Fisher) [71], which allowed us to check the null hypothesis on the existence of the unit root among the ranks of the given Equation (3). Thus, on the basis of the IPS technique, the following equation was:

$$\Delta y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^{p} \varphi_{ij} \Delta y_{i,t-1} + \varepsilon_{i,t-1} \quad (4)$$

where y takes the meaning of each parameter of Equation (3); Δ is the first difference operator; $\rho_i = 0$ for all i—the null hypothesis; $\rho_i < 0$ for at least one i—alternative hypothesis, non-existence of a unit root.

2) Checking of a long-term relationship between the series of Equation (3) and estimating a long-run equilibrium relationship between that data using the Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) panel cointegration techniques.

4. Results and Discussion

In Table 4 the panel unit root tests for the series of Equation (3) were presented, which showed the stationary at level 1% significance for *GDP*, *GDP*^{2} and *CORRUPTION* only for the LLC test and at level 5% for GDP in the IPS test. At the same time, all tests rejected the null hypothesis of no stationary for variables at their first-differenced, which allowed making the conclusion on the existence of the integrated one of order one for all series, and therefore could be cointegrated as well.

Table 4. Panel unit root tests for panel EU countries and Ukraine.

Variable	LLC	IPS	ADF Fisher	PP Fisher
GHG	–2.8102	4.8556	–2.5366	–2.5366
GDP	–12.7420*	–2.3160**	0.3190	0.3190
GDP^2	–10.7988*	–1.0315	–1.2060	–1.2060
RE	0.8264	10.0154	–4.3610	–4.3610
CORRUPTION	–8.4212*	–0.1325	–0.6360	–0.6360
ΔGHG	–15.8061*	–9.9517*	40.1852*	40.1852*
Δ*GDP*	–15.9700*	–7.8836*	16.4586*	16.4586*
Δ*GDP*^{2}	–18.2930*	–8.9400*	23.1020*	23.1020*
Δ*RE*	–14.9078*	–8.6349*	28.7201*	28.7201*
Δ*CORRUPTION*	–15.0328*	–9.5172*	30.2075*	30.2075*

*, ** represents significance at the 1% and 5% levels.

The results of Pedroni panel cointegration tests [72] are shown in Table 5. It should be noted that five from 11 statistics (three panels and two groups) indicated the cointegration between GHG, *GDP*, *CORRUPTION* and *RE* considering the Intercept form of the model; for considering Intercept and Trend form of the model the cointegration was obtained using the panel PP-statistic, panel ADF-statistic, group PP–statistic, and group ADF-statistic (four panels and two groups).

Table 5. Pedroni panel cointegration tests.

Dimension	Test Statistics	Intercept	Intercept and trend
	panel v-statistic	–1.985564	–0.746728
	panel rho-statistic	1.778527	4.278082
	panel PP-statistic	–4.119349*	–12.08920*
	panel ADF-statistic	1.878507	–3.210207*
Within-dimension		(weighted statistic)	
	panel v-statistic	–1.793092	–3.405320
	panel rho-statistic	1.770340	3.629683
	panel PP-statistic	–8.246130*	–14.25874*
	panel ADF-statistic	–3.474707*	–4.212715*
	group rho-statistic	3.938405	5.342713
Between-dimension	group PP–statistic	–14.71261*	–21.74294*
	group ADF-statistic	–2.283612**	–2.621766*

*and ** represents significance at the 1% and 5% levels.

As indicated by Dogan and Seker [68], the EKC hypothesis could be shown if the coefficients of Equation (3), β_1 and β_2, corresponded to the following requirements: $\beta_1 > 0$; $\beta_2 < 0$. Besides, β_3 values were negative and β_4 was unindicated, as the investigation of corruption influence on GHG emission had not yet been found in previous studies.

The results of using FMOLS and DMOLS panel cointegration techniques for GHG, *GDP*, *CORRUPTION* and *RE* are presented in Table 6.

Table 6. The findings of Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) panel cointegration techniques for greenhouse gas emissions in kt of CO2 equivalent (GHG), GDP per capita (*GDP*), Control of Corruption Index (*CORRUPTION*), renewable energy consumption (*RE*).

Variables		FMOLS		DMOLS	
Dependent	**Independent**	**Coefficient**	**Prob**	**Coefficient**	**Prob**
GHG	*GDP*	6.21×10^{-5}*	0.0007	0.000231*	0.0043
	GDP^2	-7.41×10^{-10}	0.0000	-2.58×10^{-9}*	0.0047
	RE	–0.220551*	0.0000	–0.166103*	0.0001
	CORRUPTION	–0.875822**	0.0198	–0.988443	0.1603
R-squared		0.956056		0.999383	
Adjusted R-squared		0.952794		0.990009	
S.E. of regression		0.909366		0.421821	
Long-run variance		1.201792		0.006649	

*and ** represents significance at the 1% and 5% levels.

The empirical results of $\beta1 = 6.21\times10^{-05} > 0$ and $\beta2 = -7.41\times10^{-10} < 0$ (for FMOLS panel cointegration technique) and $\beta1 = 0.000231 > 0$ and $\beta2 = -2.58\times10^{-9} < 0$ (for DMOLS panel cointegration technique) showed the EKC hypothesis for the EU. Thus, according to the current tendency of the variables' changing, including Ukraine in the EU could not influence the achieving of the goals that were indicated by the EU countries on declining greenhouse gas emissions and on increasing renewable energy consumption [73,74]. The adequacy of the EKC hypothesis corresponded to the similar investigations for EU countries [29,68] and did not correspond with the results that were obtained in the paper [75]. The determination coefficient R-squared for different estimation models of the impact of GDP, CORRUPTION, and RE on GHG was at the highest level.

It should be noted that all coefficients in Equation (3) were statistically significant at level 1% and 5%, excluding indicator CORRUPTION for the DMOLS panel cointegration technique. The increasing of GDP per capita had the statistically significant impact on declining GHG, which according to the EKC hypothesis could be described as follows: at the first stage, after economic development leads to increases in pollutions, after the achievement of the marginal level of development, it starts to decline.

RE and GHD had statistically significant impacts at level 1% with the FMOLS and DMOLS panel cointegration techniques. This means that increasing RE by 1% led to decreases of G

HG in the interval (0.166103, 0.220551).

The level of corruption had a statistically significant impact at level 5% only for the FMOLS panel cointegration technique. Thus, increasing the Control of Corruption Index by 1% provoked the decline of GHG by 0.88%. According to the findings, for Ukraine, the key issue of achieving sustainable development is increasing the effectiveness of the national system to prevent and counteract corruption.

The important factors that characterize the features of the ongoing development and efficiency of the institutional determinant among the economic growth factors are the efficiency of the quality of governance. Thus, in the framework of the investigation, as the main criteria that explained the efficiency of the political institutions was the Worldwide Government Indicators (developed by the World Bank): Voice and Accountability; Political Stability and Absence of Violence; Government Effectiveness; Regulatory Quality; Rule of Law; and Control of Corruption. It should be noted that the findings could be used for checking the hypothesis as follows: effective governance leads to higher social and economic indicators. In this investigation, the Control of Corruption was chosen as the main criteria. This factor is deferent for Ukraine and EU countries.

Besides, corruption is the driver of the social and political problem's circle: from the one side, the efficiency of the political institutions could not be without societal support; from the other side, society does not support non-effective governance. The permanent ignoring of the above-mentioned conflict provokes the most significant issue for Ukraine on achieving stable economic growth and joining the EU. Thus, it is necessary to highlight that further investigation considering the other parameters of the Worldwide Government Indicators would allow one to indicate and estimate the index's indicators that characterize the governance efficiency on stable economic growth.

5. Conclusions

The obtained results showed the long-term relationship between GDP, CORRUPTION, RE, and GHG for EU countries and Ukraine indicating the clear relationship between economic, social, and environmental dimensions of sustainable development. The achieving of targets on increasing of RES in total energy consumption at 25% in 2050 and declining of GHG emission will be achieved despite a huge level of regional differences in the abovementioned indicators. Besides, under the current tendencies of the variables' changing, if Ukraine joins the EU, it will not influence the achievement of the indicated goals and targets.

The EKC hypothesis for the EU and Ukraine was shown and this allowed us to define the main ways of decreasing GHG emissions in the Ukraine. At the first stage, it is necessary to increase the GDP per capita through the diversification of the economic activity and implementation of clean technologies. The policies to combat corruption are also very important for achieving economic growth, penetration of RES, and GHG emission reduction in the Ukraine. The statistically significant impact at level 5% of the Corruption Index on GHG emissions shows the necessity to develop and implement effective mechanisms to decrease the level of corruption in order achieve to sustainable development in the Ukraine. The findings showed that increasing RE by 1% will lead to a decrease of GHG in the interval (0.166103, 0.220551). Thus, the Ukrainian government should promote renewable energy sources and motivate the increased usage of renewable energy to comply with goals of EU countries that have common boundaries with the Ukraine. In this case, the proposed way is developing a subsidies system for producing energy with the lowest level of pollution, attracting additional green investment for financing green projects to increase the share of renewable energy in the total energy consumption. The combating of corruption also allows one to define transparent support systems for cleaner and renewable energy sources and guaranties GHG emission reduction.

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