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Assessment of Green Investments' Impact on Sustainable Development: Linking Gross Domestic Product Per Capita, Greenhouse Gas Emissions and Renewable Energy

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Abstract: The paper analyses the linkages between GDP per capita, greenhouse gas (GHG) emissions, and renewable energy (RE) in the total final energy consumption and green investments (PICE) which are measured as private investments, jobs, and gross value added related to circular economy sectors. The object of the analysis is the EU countries during the 2008–2016 period (crisis and post-crisis period). In the paper, data from the following databases was used: the Eurostat, the World Data Bank, and the European Environmental Agency. For addressing the linkages between the aforementioned indicators, the following methods were applied: panel unit root test, Pedroni panel cointegration tests, and the fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) panel cointegration techniques. The findings show that FMOLS and DOLS demonstrate the same results as GHG, PICE, RE influence on GDP of the EU countries. The findings prove there is linking between gross domestic product per capita, greenhouse gas emissions, renewable energy in the total final energy consumption and green investments. The findings also show that green investment (PICE) could provoke the growth of GDP per capita by 6.4%, the decline of GHG by 3.08%, and the increase of renewable energy in the total final energy consumption by 5.6%.

Keywords: sustainable development; renewable energy; greenhouse gas emissions; green investments

1. Introduction

The current tendency of greening the economic development contributes to analysing the most significant drivers that boost this process. All EU countries signed the agreement on achieving Sustainable Development Goals 2030 (SDGs 2030). According to this agreement, the EU countries, on a voluntary basis, try to reduce their negative impact on the environment and harmonise their economic, social, and environmental development. The results of many studies [1–5] indicate that one of the main drivers which provide the financial base for sustainable development is green investment. Several studies [6,7] have found that the biggest share of green investments was spent on spreading and implementing renewable energy which could reduce greenhouse gas emissions (GHG emissions) [8,9].

Noteworthy here, the experts have created the Sustainable development goal index to demonstrate countries' success on the way to achieving SDGs 2030. Thus, according to the official report [10], in 2018, the first five places were occupied by Sweden, Denmark, Finland, Germany. All these countries belong to the group of high-income countries in which 2016 Gross National Income (GNI) per capita was \$12,235 or higher. For these countries, allocation of additional capital for achieving SDGs is not a huge issue.

At the same time, such countries as Slovak Republic, Hungary, Portugal, Poland, Bulgaria, Serbia, Romania, Greece occupied the ranks from 25 to 48. Among these countries, three are high-income countries (Slovak Republic, Hungary and Greece) and upper-middle-income countries with 2016 GNI per capita being between \$3,956 and \$12,235 (Bulgaria, Serbia, Romania), only Moldova belongs to low middle-income countries in this group.

In this case, for upper and low middle-income countries allocation of additional financial resources is a big issue due to their unstable economic situation. As green investments can help in achieving important sustainable development goals: GDP per capita growth, increase of renewable energy utilisation and GHG emission reduction, the main input of this paper is to test this hypothesis and to assess the impact of green investments on GDP per capita, the share of renewables in the final energy consumption and GHG emissions in the EU member states and to develop policy recommendations stemming from the results of this empirical study.

As indicated above, increasing the share of renewable energy in the total energy consumption requires additional financial resources. In this case, it would be appropriate to analyse the statistical significance between GDP per capita, GHG emissions, renewable energy consumption and the volume of green investments. The authors of this paper have checked the following hypothesis:

H1: There is a linking between green investment, GDP per capita, GHG emissions and the share of renewable energy in the total energy consumption.

In the next section of this paper, data and methods used are presented. Note that our previous investigation has been focused on a more general analysis of green investment development. In this case, the object of our analysis is the EU countries during the 2008–2016 period while our purpose has been to explain that green investment is one of the ways to attract financial resources.

The remainder of the paper is structured in the following way: Section 2 provides a literature review on the subject and formulation of the hypothesis; Section 3 delivers data and methods applied in the study; Section 4 presents discussions of the results and Section 5 concludes.

2. Literature Review

The main dimensions of sustainable development then GDP per capita is growing selected for this study are as follows: use of renewable energy sources and GHG emission reduction. These are also the main EU energy policy targets including energy efficiency increase. In addition, increase of utilisation of renewable energy sources also provides for energy efficiency improvements [2].

According to the dataset, the EU as the whole tries to decrease the GHG emissions compare to the 1990 year (Figure 1).

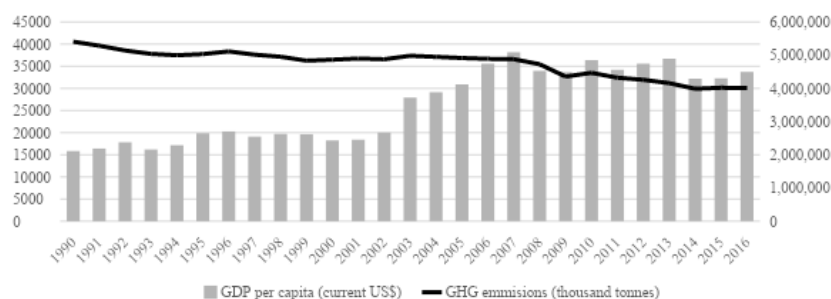


Figure 1. GDP per capita and greenhouse gas emissions (GHG) emissions for EU countries (1990–2016) [11,12].

In this case, the snowballing effect on decreasing GHG emissions could be achieved through increasing the share of renewable energy in total energy consumption (Figure 2).

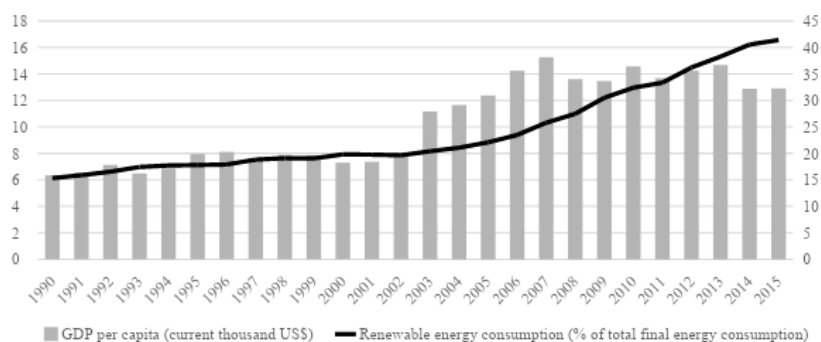


Figure 2. GDP per capita and renewable energy consumption for EU countries (1990–2015) [11,12].

The findings in Figures 1 and 2 showed that increasing the share of renewable energy in total energy consumption leads to decreasing GHG emissions.

The huge range of investigation deals with the analysis of preconditions to develop green investment market as a financial driver of sustainable development. However, according to the results of the previous investigations [13–23] the main factor which restricts the developing of green investment market is misunderstanding the meaning and goals of green investment among scientists, experts and investors. Thus, Martinez-Oviedo and authors in the papers [24–31] highlighted that green investment is a capital to low carbon and climate resilient initiatives, clean technologies, renewable energy, or natural capital that can be considered environmentally beneficial. The one group of scientists proved that the main goal of green investment is declining of CO₂ emission [32–45]. The third group of scientists defined green investment as investment into renewable energy [46–63]. In this case, it is necessary to investigate and develop the universal approach to define and classify green investment which will be based on the classification of green assets.

It should be underlined, that a lot of the scientists investigate the relationship between economic development and efficiency of SDGs 2030 achieving through the analysis of linking between: Environmental Performance Index and countries GDP [31,64–67], Environmental Performance Index and Institutions Quality [68–72]; economic, social and ecological indicators of the countries development [73–84], socioeconomic development and economic growth [85], economic growth, environmental pollution and social development which measured by the level of morbidity [86–89].

The author Greco in the paper [89] analysed the sustainable economic development from the point of view of behavioural economics theory. Greco [89] highlighted that the economic growth related to the solving of social conflict and improving the quality of life and work conditions.

The scientist [90–95] proved the hypotheses on linking between ecological, social and economic indicators which influence on country's GDP. The scientists Zajączkowska M. [95], Kisiała W. [96] and Malkina, M. [97] proved the relationship between social indicators, ecological indicators which include efficiency of renewable energy, macroeconomic stability in low-middle income countries [79–99]. Besides, the range of scientists [99] paid attention to analyse the linking between political parameters on economic growth (eliminating of the ecological factors).

Some group of authors in the paper [100–112] tried to prove the relationship between renewable energy, economic growth and volume of foreign direct investment in energy efficient projects and country's brand. In this case, the foreign direct investment analysed as the green investment by the authors. Noted, that using such types of green investment limited the complexity of impact analysis of green investment in the efficiency of sustainable economic development.

The findings allowed making conclusions that most investigation analysed the correlation between CO₂ emissions, renewable energy and investment in renewable energy. Under this investigation, the authors analysed instead of CO₂ emissions – GHG emission as it was indicated the goal of SDGs

2030. Therefore, green investment was defined as the private investments, jobs, and gross value added related to circular economy sectors which are an integrated indicator which involves the social, ecological and economic impact of the investment.

3. Data and Methods

For checking H1 hypothesis and further analysis of the main drivers of sustainable development, the authors used the modified model of economic growth as follows:

$$\text{GDP} = F(\text{PICE}, \text{GHG}, \text{RE}) \quad (1)$$

where GDP – GDP per capita, PICE – private investments, jobs and gross value added related to circular economy sectors; GHG – GHG emission; RE – share of renewable energy in the total energy consumption.

Modified function (2) can be demonstrated as panel cointegration equation:

$$\ln \text{GDP}_{it} = \phi + \alpha \ln \text{PICE}_{it} + \beta \ln \text{GHG}_{it} + \gamma \ln \text{RE}_{it} + \mu_{it} \quad (2)$$

where α, β, γ – regression's parameters which are evaluated and explain the elastic of output relate on PICE, GHG, RE; μ is the error term; $i = 1, \dots, N$; $t = 1, \dots, T$.

For checking above-mentioned hypotheses, the authors used the databases as follows: World Data Bank, Eurostat, European Environmental Agency. For the analysis, the EU countries during the 2008-2016 period were chosen (Table 1).

Table 1. Indicators, meaning and sources for analysis

Variables	Meaning	Sources
GDP per capita (GDP)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural	World Data Bank [11]
Greenhouse gas emissions (GHG)	Total greenhouse gas emissions in kt of CO ₂ equivalent are composed of CO ₂ totals excluding short-cycle biomass burning (such as agricultural waste burning and Savannah burning) but including other biomass burning (such as forest fires, post-burn decay, peat fires and decay of drained peatlands), all anthropogenic CH ₄ sources, N ₂ O sources and F-gases (HFCs, PFCs and SF ₆).	European Environment Agency [12]
Green Investment (PICE)	Private investments, jobs and gross value added related to circular economy sectors. The indicator includes "Gross investment in tangible goods", "Number of persons employed" and "Value added at factor costs"	Eurostat [113]
Renewable energy (RE)	The share of renewable energy in total energy consumption	Eurostat and the European Environment Agency [12,113]

Sources: compiled by the authors.

Under the research, the following methods were used: panel unit root tests using the Im, Pesaran, and Shin's (IPS); Levin, Lin, and Chu test (LLC); and the Fisher-type tests (Augmented Dickey–Fuller test (ADF) Fisher and Phillips–Perron test (PP) Fisher). In the basis of the abovementioned tests is the checking of the hypothesis, which assumed the existing a unit root in the panel data on the time series and alternative absence in the unit root.

Thus, the findings in Table 3 showed that six from eleven results of the test exclude null hypothesis (no cointegration of time series). Therefore, the obtained results affirmed the cointegration between GDP, GHG, PICE, RE for the EU countries existed on significance at the 1% and 5% levels. It allows making the conclusion, about the long-term relationship among GDP, GHG, PICE, RE which could be checked by using the FMOLS and DOLS panel cointegration techniques. For that purpose, four assumptions were checked:

- assumption 1: Influence of GHG, PICE, RE on GDP;
- assumption 2: Influence of GDP, PICE, RE on GHG;
- assumption 3: Influence of GDP, PICE, GHG on RE;
- assumptions 4: Influence of GDP, GHG, RE on PICE.

The obtained results of using FMOLS and DOLS panel cointegration techniques were presented in Table 4.

Table 4. The findings of the fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DMOLS) panel cointegration techniques for four assumptions.

Dependent	Variables		FMOLS		DMOLS	
	Independent		Coefficient	Prob	Coefficient	Prob
GDP	PICE		6.40	(0.00) *	5.80	(0.00) *
	GHG		0.39	(0.00) *	0.41	(0.00) *
	RE		38.18	(0.00) *	37.24	(0.00) *
GHG	GDP		9.35	(0.00) *	9.33	(0.00) *
	PICE		−3.08	0.27	4.61	0.33
	RE		−5139.85	(0.00) *	−5142.43	(0.00) *
RE	GDP		0.002	(0.00) *	0.0021	(0.00) *
	PICE		5.600	(0.00) *	7.0	(0.0002) *
	GHG		0.01	(0.00) *	0.0021	(0.003) *
PICE	GDP		0.19	(0.0001) *	0.21	(0.005) *
	GHG		0.004	(0.0003) *	0.0053	(0.002) *
	RE		99.44	(0.01) **	100.31	(0.013) **

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

Sources: calculated by the authors.

The findings showed that FMOLS and DOLS demonstrated the same results as GHG, PICE, RE influence on GDP for EU countries. The obtained results were statistical significance −1% for all three parameters. Thus, the increasing by 1% of PICE leads to increasing of GDP by 6.4% (FMOLS) and 5.6% (DMOLS), the increasing by 1% of GHG lead to increasing of GDP by 0.39% (FMOLS) and 0.41% (DMOLS), the increasing by 1% of RE provoked the increasing of GDP by 38.18% (FMOLS) and 37.24% (DMOLS).

It should be noted, that increasing of RE by 1% lead to decreasing of GHG by −5139.85%. Therefore, increasing by 1% of PICE provoked the increasing of RE by 5.6% (FMOLS) and 7% (DOLS). At the same time, increasing of RE by 1% provoked the increasing of PICE by 99.44% (FMOLS).

The obtained results proved the hypothesis of linking between green investment, GDP, GHG emissions and share of renewable energy in the total energy consumption for EU countries. In this case, the findings proved that green investment could provoke the increase of the share of renewable energy in the total energy consumption and decreasing of GHG emissions. At the same time, the spreading of RE leads to declining of GHG.

Besides, all indicators green investment (PICE), GHG emission and share of renewable energy in the total energy consumption had a statistically significant impact on GDP. Thus, the increasing of green investment (PICE) could provoke the growth of GDP by 6.4%, the declining of GHG by 3.08% and the increasing of renewable energy in the total energy consumption by 5.6% (FMOLS).

The traditional investment market in the countries' potential candidate to EU membership should be "greening" (Figure 3).

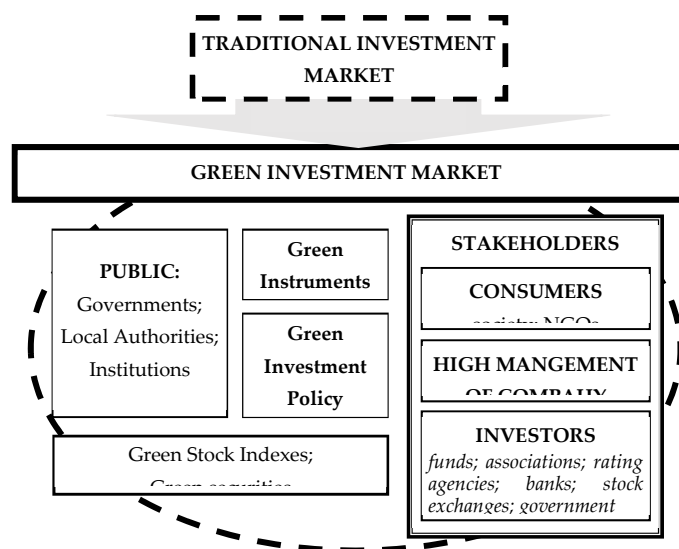


Figure 3. The framework concept of transformation from traditional to green investment market.

Source: developed by the authors on the basis [108–112,114,115].

The same analysis should be done for the countries' potential candidate to EU membership with the purpose to allocate the mechanism to minimize the negative imbalances in the EU on the way on achieving SDGs 2030. In this case, for further investigation, it is necessary to analyse the EU incentive mechanism to stimulate the attractiveness of green investment as a part of the direct foreign investment.

5. Conclusions

This empirical study has been operating data on the EU member states and the econometric modelling proves that green investments have a positive economic effect. The findings show that green investment could provoke the growth of GDP per capita by 6.4%, reduction of GHG emissions by 3.08% and the increase of renewable energy in the total final energy consumption by 5.6%. These findings proving there is cointegration between GDP and green investments are similar to the results presented in [32–45].

As the energy utility industries are the power generators of GDP and the causes of environmental damages in countries at the same time, their activities should be transformed according to the SDGs goals.

Such transformations so that to fit the SDGs require more of green investments for implementing more energy-efficient projects (oriented on renewable energy, clean technologies etc.). Together they would allow reducing GHG emissions.

The results of our analysis of the EU countries' experience in attracting green investments for renewable energy projects prove that openness and transparency of non-financial reporting are the main factors influencing investors' decisions.

Besides, regular publishing of non-financial reports leads to decreasing of greenwashing and strengthening of positive green brands. And this, in turn, would lead to increasing investing's attractiveness of companies for green investors.

As the EU experience shows, such reports should be published by companies on a regular basis and this norm should become obligatory on the government level. Moreover, potential candidates for the EU membership should analyse and implement incentive instruments so that to follow the principles of openness and transparency in their companies' non-financial reporting basing on the provided framework of transformation from traditional to green investment market.

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