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# Assessment of green investment impact on the energy efficiency gap of the national economy

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## Abstract

The paper deals with the analysis of the green investment impact on the energy efficiency gap. The findings of the bibliometric analysis proved the increasing trend of the published documents on green investment and energy efficiency gap. In the study, the author used Scopus Tools Analysis, Web of Science Results Analysis and VOSviewer for providing the bibliometric analysis. In the paper the author checked the hypothesis as follows: cointegration exists between GDP, energy efficiency, green investment and share of renewable energy; green investment had a positive impact on the percentage of renewable energy; green investment had a positive effect on the countries energy efficiency and decreased the energy efficiency gap. The author used the unit root test for checking the stationarity of the selected variables. Pedroni panel cointegration test used for monitoring the cointegration between variables. Fully Modified Least Square model used for identifying the relationship between variables. The findings proved the stationarity of the data at the first level. It allowed providing the Pedroni cointegration test and long-run covariance test. Thus, the empirical results showed that increasing of green investment leads to increasing of energy efficiency by 0,56 points, gross domestic product per capita – 0,18 points, renewable energy – 0,39 points. The increasing of renewable energy allowed increasing of energy efficiency by 0,38 points, gross domestic product per capita – 0,19 points, green investment – 0,54 points. Besides, rising of the countries' energy efficiency allowed growing of gross domestic product per capita by 0,27 points, green investment – 0,31 points and declining of renewable energy by 1,14 points. If the increase of energy efficiency leads to decreasing of energy efficiency gap the following could be concluded: increasing of green investment lead to reducing of energy efficiency gap; increasing of renewable energy in the total energy consumption allowed declining the energy efficiency gap. In this case, in Ukraine, the mechanisms for improving the investment climate should be developed at the national level, considering the EU experience. Such activities allowed to attract additional green investment in renewable energy projects.

**Keywords:** green investment, cointegration, correlation, green finance.

**JEL Classification:** O13, P28, P48, Q43.



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## Introduction



e immediate reaction from the government with the purpose to minimize it. In this case, the Ukrainian government should synchronize the energy policy (including energy market) with EU norms and regulation as Ukraine wish to become the EU members. Besides, the extending of renewable energy among all sectors and levels lead to increasing of country's energy efficiency and consequently to decrease the energy efficiency gap. Such activities contribute the additional financial recourses which are limited in the national economy due to the political and macroeconomic imbalance. Thus, the green investment could be the alternative economic window for decreasing of energy efficiency gap.

## Literature Review

The bibliometric analysis of the papers in Scopus and Web of Science proved the hypothesis on growing interests from the world scientific community to the linking between green investment, energy efficiency and energy efficiency gap.

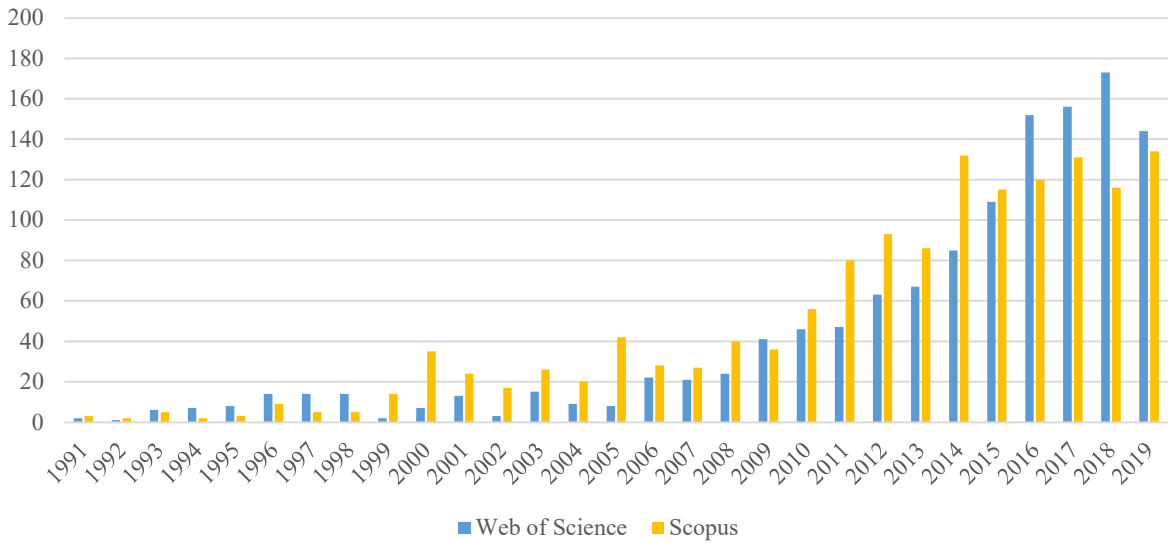


**Figure 1. Dynamic of documents on "green investment" and "energy efficiency" in Scopus and Web of Science**

Source: developed by the author using Web of Science and Scopus

The findings proved that numbers of papers have been increasing from the 2008 year in both scientific databases. Scopus indexed 1460 documents on the selected theme and Web of Science indexed 1291 articles on green investment and energy efficiency for 1991-2019 years. Such publishing tendency confirmed the actuality of the chosen topic. The scientists with the American affiliation have published 35% of the papers among top-10 countries (figure 2).

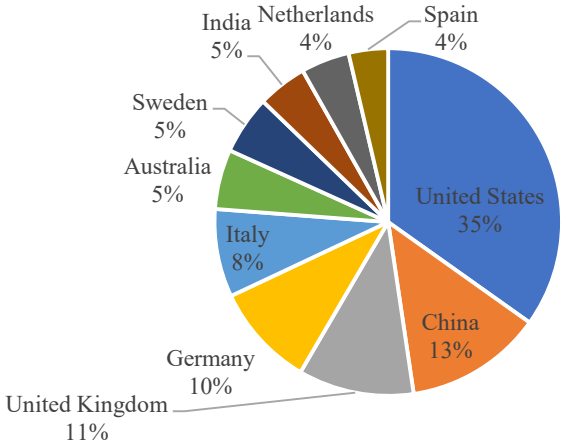


**Figure 2. The structure of the scientists' affiliation in the papers on green investment" and "energy efficiency" in Scopus**

Source: developed by the author using Scopus.

At the same time, the National Natural Science Foundation of China financed the most significant share of the papers. Figure 3 contains the scientists pull who are investigating the issues on energy efficiency and green investments.

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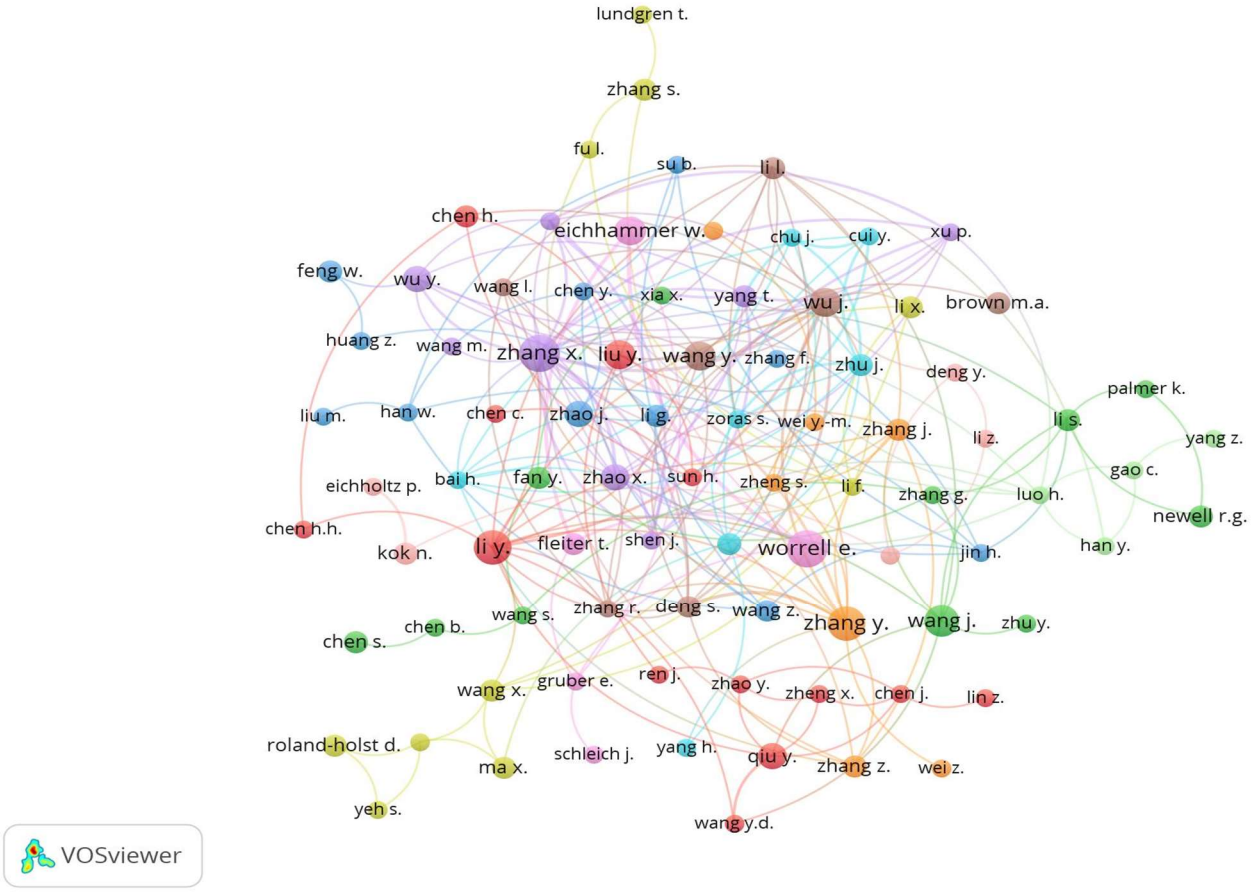


**Figure 4. The authors who are investigating the issues of energy efficiency and green investment**

Source: developed by the author using VOSviewer.

The results of the analysis showed that most scientists investigated the energy efficiency from the engineering point of view, less from business and economics.

Thus, the scientists Sadineni S. B., Madala S., Boehm R. F. in the paper (Sadineni et al., 2011) confirmed the decreasing of cost due to the installation of energy-saving technology. The scientists Anderson S. T. & Newell R. G. (2004) proved that energy audit allowed declining the losses of the energy in the building. The scientists Ucar A. and Balo F. (2010) achieved the same conclusion.

Miketa A. & Mulder P. (2005) analyzed the energy productivity in developed and developing countries. They concluded that developing countries had a more significant energy efficiency gap than developed countries.

The Chinese scientists Zhao X., Zhang X. and Shao S. confirmed that investment allowed declining the energy gap through the increasing of energy efficiency (Zhao et al., 2016). In the paper (Elliott et al., 2013) the scientists using the econometric model and panel data proved that foreign direct investment had a different impact on energy efficiency for different regions and cities. The findings showed that the scientists identifying the massive range of the parameters which effect on the country's energy efficiency: renewable energy (Yevdokimov et al., 2018); green investment (Pimonenko, 2018; Chygryn et al., 2019); macroeconomic stability (Lyulyov et al., 2018) and social progress (Bilan et al., 2019a, 2019b); environmental performance (Dkhili, 2018; Pimonenko et al., 2018). In the paper (De Groot et al., 2001; Kwilinski, 2018), the authors confirmed the hypothesis that investment to the firms' sustainable development leads to decreasing of the energy gap in the company. In the investigations (Ren et al., 2014; Pimonenko et al., 2017; Lyeonov et al., 2019; Chygryn et al., 2015) the authors confirmed the hypothesis that foreign direct investments allowed developing at renewable energy and declining CO2 emissions and energy efficiency gap. In the paper (Al-Mulali et al., 2014), the scientists concluded the positive effect of renewable energy on GDP and the country's energy efficiency. The scientists from Great Britain (Cherrington et al., 2013) checked the impact of the feed-in tariff on developing renewable energy which allowed declining of the energy gap in the country. The results of analysis allowed concluding the scientists had not investigated the energy efficiency gap from the economic

points of views. In this case, the aim of the paper is checking linking between green investment and energy efficiency gap.

## Methodology and research methods

The hypothesis of the investigation as follows:

H1: cointegration exists between GDP, energy efficiency, green investment and share of renewable energy.

H2: green investment had a positive impact on the share of renewable energy.

H3: green investment had a positive impact on the countries energy efficiency and decreased the energy efficiency gap.

The study used the cointegration test for checking the abovementioned hypothesis. At the first stage, the author did the unit root tests with the purpose to check the stationarity of selected variables. At the second stage, the cointegration between data was reviewed by the Pedroni panel cointegration test. Then, Fully Modified Least Square model was used for identifying the relationship between the selected variable. The study used Eurostat for collecting raw data. The indicator of energy efficiency level was used as a measure of the energy efficiency gap. Noted if the energy efficiency increase, the energy efficiency gap will decrease. The private investments, jobs and gross value added related to circular economy sectors was taken as the measure of green finance. As the additional variables were used as follows: the share of renewable energy in gross final energy consumption by sector and GDP per capita based on purchasing power parity. All calculations were done by using EViews 11. The object of investigation EU countries and Ukraine for 2009-2019 years.

## Results

At the first stage, the normalization of parameters was done. The unit root test allowed checking the stationarity of the date. The finding of unit root test showed in Table 1. In the study, for checking the stationarity of the date, the methods were used as follows: Levin, Lin and Chu; Im, Pesaran and Shin, ADF and PP-Fisher Chi-square.

Table 1. Unit root test of the parameters using the methods: Levin, Lin and Chu; Im, Pesaran and Shin, ADF and PP-Fisher Chi-square

| Methods | Level | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | EE | | GDP | | GI | | RE | |
| | Stat. | Prob. | Stat. | Prob. | Stat. | Prob. | Stat. | Prob. |
| *Levin, Lin and Chu* | -5,26 | 0,00 | 2,3 | 0,98 | -4,73 | 0,00 | -5,86 | 0,00 |
| *Im, Pesaran and Shin* | -1,78 | 0,04 | 6,06 | 1,00 | -0,57 | 0,28 | 0,41 | 0,66 |
| *ADF-Fisher Chi-square* | 86 | 0,05 | 37,79 | 0,98 | 83,49 | 0,07 | 66,39 | 0,46 |
| *PP-Fisher Chi-square* | 93,83 | 0,01 | 19,57 | 1,00 | 113,82 | 0,00 | 124,62 | 0,00 |
| | 1st difference | | | | | | | |
| *Levin, Lin and Chu* | - | - | -9,19 | 0,000 | -13,52 | 0,00 | -5,61 | 0,000 |
| *Im, Pesaran and Shin* | - | - | -2,92 | 0,002 | -5,87 | 0,00 | -1,95 | 0,002 |
| *ADF-Fisher Chi-square* | - | - | 106,45 | 0,001 | 163,64 | 0,00 | 91,19 | 0,002 |
| *PP-Fisher Chi-square* | - | - | 117,53 | 0,000 | 264,257 | 0,00 | 189,63 | 0,000 |

Stat – statistics; Prob. – probability; GDP – gross domestic product per capita; EE – energy efficiency; GI – green investment; RE – renewable energy.

Source: developed by the author.

The findings in Table 1 confirmed that after the 1st differences, all data had become stationarity. During the checking, only energy efficiency had stationary data at the level. After that, the cointegration between selected variables was checked using Pedroni test. The findings showed in Table 1.

Table 2. Pedroni panel cointegration test of the variables

| Tests | Within-dimension: | | | |
|---|---|---|---|---|
| | Statistic | Probability | Weight | |
| | | | Statistic | Probability |
| *Panel v-Statistic* | -1,19 | 0,881 | -2,69 | 0,991 |
| *Panel rho-Statistic* | 1,7 | 0,962 | 1,41 | 0,921 |
| *Panel ADF-Statistic* | -7,65 | 0,000 | -15,51 | 0,000 |

Table 2 (cont.). Pedroni panel cointegration test of the variables

| | | | | |
|---|---|---|---|---|
| *Panel PP-Statistic* | -1,5 | 0,042 | -5,36 | 0,000 |
| | **Between-dimension** | | | |
| | **Statistic** | | **Probability** | |
| *Group rho-Statistic* | 3,98 | | 1,000 | |
| *Group ADF-Statistic* | -19,78 | | 0,000 | |
| *Group PP-Statistic* | -5,63 | | 0,000 | |

Source: developed by the author.

Considering the data six from eleven tests had a statistical significance impact at level 1%. It allowed concluding about cointegration between gross domestic product per capita, energy efficiency, green investment and renewable energy. The existing of the cointegration allowed providing the long-run relationship using the Panel Fully Modified Least Square methods and long-run covariance estimates.

Table 3. The findings of the assessment of the long-run relationship between selected variables

| Dependent variables | Independent variables | Long-run coefficient | Probability |
|---|---|---|---|
| **EE** | GDP | 0,46 | 0,000* |
| | GI | 0,56 | 0,002* |
| | RE | 0,38 | 0,000* |
| **GDP** | EE | 0,27 | 0,000* |
| | GI | 0,18 | 0,000* |
| | RE | 0,19 | 0,000* |
| **GI** | GDP | 1,36 | 0,000* |
| | EE | 0,31 | 0,045** |
| | RE | 0,54 | 0,000* |
| **RE** | EE | -1,14 | 0,000* |
| | GDP | 1,12 | 0,000* |
| | GI | 0,39 | 0,000* |
| * and ** represents significance at the 1% and 5% levels. | | | |

Source: developed by the author.

The findings from Table 3 showed that increasing of gross domestic product per capita by one-point lead to swelling of energy efficiency by 0,46 points, green investment – 1,36 points, renewable energy – 1,12 points. The increasing of green investment leads to increasing of energy efficiency by 0,56 points, gross domestic product per capita – 0,18 points, renewable energy – 0,39 points. The increasing of renewable energy allowed increasing of energy efficiency by 0,38 points, gross domestic product per capita – 0,19 points, green investment – 0,54 points. Besides, rising of the countries' energy efficiency allowed growing of gross domestic product per capita by 0,27 points, green investment – 0,31 points and declining of renewable energy by 1,14 points. If the increase of energy efficiency leads to decreasing of energy efficiency gap the following could be concluded: increasing of green investment lead to reducing of energy efficiency gap; increasing of renewable energy in the total energy consumption allowed declining the energy efficiency gap. In this case, in Ukraine, the mechanisms for improving the investment climate should be developed at the national level, considering the EU experience. Such activities allowed to attract additional green investment in renewable energy projects.

## Conclusion

The bibliometrics analysis proved the increasing tendency of published documents on green investment and energy efficiency gap. The findings confirmed the cointegration between selected variables: GDP, energy efficiency, green investment and share of renewable energy. Moreover, the Pedroni test proved the stationarity of the data and allowed providing the long-run relationship tests between selected variables. The findings showed that green investment had a positive impact on the share of renewable energy and energy efficiency and decreased the energy efficiency gap. In this case, the mechanisms to improve the investment climate should be developed. It allowed attracting green investment for the green project, which lead to decreasing the energy efficiency gap.

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