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CENTRAL EUROPEAN REVIEW OF ECONOMICS & FINANCE

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Katarzyna Brożek¹

SUSTAINABLE DEVELOPMENT IN THE CONTEXT OF INNOVATION OF SELECTED COUNTRIES IN 2017-2021

Abstract

The aim of this article is to identify and quantify the relationship between innovation measures and predictors of sustainable development in selected countries. Public statistics resources were used as the source of data collection. The research period includes 6 time intervals, covering the years 2016-2021. The objects of the research turned out to be Poland, the United States, China, Japan and the EPO. The collected data were compiled using basic descriptive statistics. Several measures were identified and defined in an arbitrary manner, allowing research to be carried out and conclusions to be drawn. The results of the analysis were presented in tabular, graphical and descriptive form. The nature of the considerations is overwhelmingly empirical. The practical implication of the study may be the fact of indicating the strength of the relationship connecting selected innovation measures with energy consumption (measured by CO2 emissions per capita).

Keywords: innovation, sustainable development, R&D activities, patents, trademarks, CO2 emissions per capita.

JEL Classification: O32, O57, Q56

Paper type: Theoretical research article

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Introduction

Modern societies face complex challenges that require well-thought-out development strategies. In this context, the concept of sustainable development has emerged as not only a necessity, but also an important driver of innovation. Sustainability and innovation are the two closely linked concepts. Sustainable practices require finding new, environmentally friendly solutions, which drives innovation in various sectors such as energy, transport and agriculture. Sustainability encourages the development and adoption of green technologies i.e. the technologies that aim to reduce the environmental impact of various industries, supporting innovation in clean energy, waste reduction and environmentally friendly products.

The paper analyzes the relationship between sustainable development and the innovation process, pointing out the interdependence of these two aspects. In it there will be presented a couple of examples of how a sustainability-based approach stimulates creative thinking and leads to the development of solutions with greater transformative potential. By analyzing this complex relationship, the paper aims to highlight that the pursuit of sustainable development not only contributes to solving global problems, but also constitutes an important stimulus for creativity and technological progress, driving innovation in various fields. The aim of these considerations was to identify and quantify the relationship between innovation measures and predictors of sustainable development in selected countries.

The research problem: *Analysis of the impact of determinants of innovative activity on energy consumption per person in selected countries.*

The research questions:

1. Is there a relationship between the effectiveness of patents and CO₂ emissions per capita?
2. Is there a relationship between trademark effectiveness and CO₂ emissions per capita?
3. Do R&D expenditures affect the consumption of energy from renewable sources per capita, and to what extent?

The research hypotheses:

1. There is a relationship between the success rate in obtaining patents and CO₂ emissions per capita. As the effectiveness of patents increases, CO₂ emissions per capita decrease.
2. There is a relationship between the effectiveness of activities related to applying for a trademark and CO₂ emissions per capita.
3. Expenditures on research and development activities have a moderate impact on the consumption of energy from renewable sources.

1. Sustainable development in the context of innovation in the light of literature studies

In 2015, the UN endorsed the 2030 Agenda and the Sustainable Development Goals, a globally accepted pathway to achieving sustainable development in which science, technology and innovation are key drivers for the positive transformation of economies (Gil, 2017).

Moreover, sustainable development is now a competitive advantage for organizations. As observed by Velázquez-Álvarez & Vargas-Hernández (2012), they increase their social and environmental impact through innovative, cost-effective, durable, repairable, reusable, recyclable and biodegradable products and materials. Incorporating sustainability into a company's strategy is fundamental to success. Science and technology research help identify application segments of sustainability innovation systems, mainly covering industry.

Kanda *et al.* (2020) observe that innovation can have an adverse impact on sustainability, which is why ecological systems are crucial to connecting social systems with the environment. In some other paper Weitzel *et al.* (2018) hold a stance that sustainable development innovations aligned with the 2030 Agenda guide governments, businesses and academia to integrate the economic, social and environmental dimensions.

2. Data analysis of selected innovation measures for Poland, the EU, China, Japan and the United States in 2017-2021

This part of the paper is devoted to a detailed analysis of key innovation indicators, which constitute an important pillar in assessing the dynamics of economic development. In the light of accelerating technological changes and market competitiveness, submitted patents and obtained trademarks constitute a measure of the innovative activity of enterprises. By analyzing them, it is possible to show trends and identify countries with the highest creative potential. Additionally, R&D spending data sheds light on the private and public sectors' commitment to creative progress.

The first analyzed measure concerns the number of patent applications. The data are presented in **Table 1**.

Table 1. Number of patent applications in 2017-2021

	2017	2018	2019	2020	2021	Mean	Dynamics of changes between 2017-2021
Poland	4041	4322	3999	4098	3488	3989.6	-13.7%
EPO	166585	174397	181479	180346	188778	178317	13.3%
United States	606956	597141	621453	597172	591473	602839	-2.6%
China	1381594	1542002	1400661	1497159	1585663	1481415.8	14.8%
Japan	318479	313567	307969	288472	289200	303537.4	-9.2%

Source: Own elaboration after: <https://www.wipo.int>; [accessed: 25.08.2023]

Between 2017 and 2021, Poland saw a downward trend in patent applications, with the average number of patents filed being approximately 3,990 per year. This period was characterized by a significant decline of 13.7% compared to 2017. At the same time, the European Patent Office (EPO) experienced a marked increase, with an annual increase in patent applications of 13.3%. The United States recorded a slight decline of 2.6%, reaching an average number of reports of 602,839. In this context, China showed the most dynamic change, with an increasing trend of an impressive 14.8% on an annual average, which translated into an average number of reports of approximately 1,481,416. In contrast, Japan experienced a decline of 9.2% over the period, with an average number of reports of 303,537 per year. Another issue that was analyzed was the effectiveness of activities related to obtaining a patent. The relevant data are presented in **Table 2**.

Table 2. Effectiveness of activities related to obtaining a patent

	2017	2018	2019	2020	2021	Mean	Dynamics of changes between 2017-2021
Polska	71.9%	68.9%	76.1%	56.3%	95.2%	73.7%	32.4%
EPO	63.4%	73.2%	75.9%	74.1%	57.6%	68.9%	-9.1%
United States	52.5%	51.5%	5.7%	58.9%	55.3%	44.8%	5.3%
China	30.4%	28.0%	32.3%	35.4%	43.9%	34.0%	44.3%
Japan	62.7%	62.0%	5.8%	62.2%	63.8%	51.3%	1.7%

Source: Own elaboration based on publicly available data

In the case of Poland, the success rate in obtaining patents showed some irregularity, reaching its lowest level in 2020 (56.3%) and increasing significantly to 95.2% in 2021. The dynamics of changes between 2017 and 2021 reached 32.4%, which indicates a clear improvement in the efficiency of obtaining patents. When compared to other countries,

Poland presented a higher level of change dynamics than most of them. The European Patent Office (EPO) saw its success rate decline by 9.1% over the same period. As for the other selected countries, the United States shows a slight increase of 5.3%, China shows an impressive increase of 44.3% and Japan a minimal change of 1.7%.

The forecast of patent effectiveness indicator until 2025 was also examined. In the years 2023-2025, Poland is expected to have a constant increase in patent efficiency, reaching 77.72%, 66.50% and 78.66% of obtained patents, respectively. These results show that Poland may experience some variability, but the overall trend indicates a moderate increase in effectiveness in the context of patent activity. In the case of the European Union, patent effectiveness in the analyzed period was 60.62%, 58.99% and 57.37%, respectively. The downward trend indicates some difficulty in effectively converting patent applications into full-fledged patents. This may be due to such obstacles as increasing competition, the complexity of the patenting process and other regulatory factors.

When analyzing the issue of innovation, the number of trademark applications was also checked. The **relevant** data are presented in **Table 3**.

Table 3. Number of trademark applications in 2017-2021

	2017	2018	2019	2020	2021	Mean	Dynamics of changes between 2017-2021
Poland	40434	38905	38781	37629	42755	39700.8	5.7%
European Union Intellectual Property Office	371508	392925	407712	438511	497542	421639.6	33.9%
United States	613921	640181	672681	870306	899678	739353.4	46.5%
China	5739823	7365522	7833081	9345757	9454794	7947795.4	64.7%
Japan	560269	512156	546244	421166	364376	480842.2	-35.0%

Source: Own elaboration after: <https://www.wipo.int>; [accessed: 25.08.2023]

In Poland, the number of reports fluctuated around 39,700.8 per year, and the dynamics of changes between 2017 and 2021 was 5.7%. As for Europe, the European Union Intellectual Property Office (EUIPO) has seen significant growth, with an average number of submissions of 421,639.6. This means a growth dynamics of 33.9%, which may suggest the increasing importance of trademark protection.

In the United States and China, there is a dynamic increase in the number of trademark applications. The United States has an average number of reports of 739,353.4, i.e. an increase of 46.5% over the period analyzed.

In China, the number of reports reached an impressive 7,947,795.4 per year, which resulted in a dynamic increase of 64.7%. This may be the result of the growing importance of the Chinese market and the global nature of the activities of companies from this country. In contrast, Japan showed a decline in the number of trademark applications, with a value of 480,842.2 per year. The rate of change in Japan was -35.0%, which may reflect differences in business strategies, market interest or other factors affecting the need for trademark protection. The analyzed data show a varied picture of the number of trademark applications in the surveyed countries. EUIPO, the United States and China show clear increases, while Poland and Japan show stability or decline in this respect.

As in the case of patents, the effectiveness of trademark application activities was measured. The data are presented in **Table 4**.

Table 4. Effectiveness of activities related to obtaining a trademark

	2017	2018	2019	2020	2021	Mean	Dynamics of changes between 2017-2021
Poland	95.1%	88.6%	83.7%	59.7%	90.3%	83.5%	-5.1%
European Union Intellectual Property Office	90.3%	87.9%	89.0%	87.8%	91.6%	89.3%	1.4%
United States	58.9%	60.1%	65.3%	46.0%	54.6%	48.7%	-7.4%
China	49.1%	67.8%	81.8%	61.8%	82.1%	68.5%	67.3%

Source: Own elaboration based on publicly available data

In Poland, the dynamics of changes between 2017 and 2021 was a negative one (-5.1%), which suggests a decrease in the effectiveness of the process of obtaining trademark protection. In 2021, the percentage of obtained marks was 90.3%, which means an improvement compared to the previous year (59.7%), but in the next five years a slight weakening of effectiveness may be observed. The European Union Intellectual Property Office (EUIPO) maintained a relatively stable level of efficiency, oscillating around the average value for the analyzed period, i.e. 89.3%. This is an expression of a relatively equal approach to the process of obtaining trademark protection.

As in the case of patent effectiveness, the indicator's forecast until 2025 was also checked. In the case of Poland, the forecast indicates a decline in this indicator in the following years, reaching approximately 40-45% in 2023-2025. This suggests that the trademark registration process in Poland is becoming more competitive and demanding. In the case of the European Union, the forecast is more optimistic. After an initial period

of stability, EU efficiency shows an upward trend, reaching a level of approximately 91-92% in 2023-2025. This could mean that the trademark registration process becomes more efficient, which is beneficial for companies operating in the EU.

The last issue regarding innovation measures covers both research and development expenditure in 2017-2021 in the analyzed countries. The relevant data are presented in **Table 5**.

Table 5. Expenditures on research and development (% of GDP)

	2017	2018	2019	2020	2021	Mean	Dynamics of changes between 2017-2021
Poland	1.03	1.21	1.32	1.39	1.44	1.278	39.8%
UE-27	2.03	2.07	2.11	2.19	2.15	2.11	5.9%
United States	2.9	3.01	3.17	3.47	3.46	3.202	19.3%
China	2.12	2.14	2.24	2.41	2.44	2.27	15.1%
Japan	3.17	3.22	3.22	3.27	3.3	3.236	4.1%

Source: Own elaboration after: <https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm>; [accessed 26.08.2023] and http://www.stats.gov.cn/english/PressRelease/202201/t20220127_1827065.html; [Accessed: 26.08.2023]

The presented data on research and development expenditure (in relation to % of GDP) in 2017-2021 show the involvement of individual countries in developing innovative activities, reflecting their ability to invest in the future, technological development and strengthening competitiveness. Poland has recorded dynamic growth in research and development spending, with an increase of 39.8% between 2017 and 2021. The rate of expenditure in relation to GDP increased from 1.03% in 2017 to 1.44% in 2021. This suggests a desire to increase innovation and technological progress. At the European Union level, the R&D expenditure rate represented a stable average level of 2.11% of GDP over the period considered. The gradual growth between 2017 and 2021 (by 5.9%) demonstrates the commitment to developing a competitive economy based on innovation.

It was also examined what the forecast ratio of R&D expenditure in the context of GDP in 2025 will look like in the analyzed countries.

A gradual increase in research and development expenditure is expected in Poland (from 1.66% of GDP in 2023 to 1.85% of GDP in 2025), what not only indicates an increased commitment to innovation, but could also herald an impact of the country's long-term competitiveness. In the European Union, stable research and development expenditure is forecasted at the level of approximately 2.28% of GDP in 2023 and slightly higher (2.37% of GDP)

in 2025. Despite this stability, there is potential to increase spending to support economic growth.

3. CO₂ emissions and the use of renewable energy sources as issues affecting sustainable development

This part will analyze two important issues that play an extremely important role in the face of contemporary ecological and energy challenges - carbon dioxide (CO₂) emissions and the role of renewable energy. First, it was examined what CO₂ emissions per capita were in the surveyed countries. The relevant data are presented in **Table 6**.

Table 6. CO₂ emissions in the years 2017-2021 (in tones per capita)

	2017	2018	2019	2020	2021	Mean	Dynamics of changes between 2017-2021
Poland	9	9	8	8	9	8.6	0.0%
UE-27	8	8	8	8	8	8	0.0%
United States	16	16	16	14	15	15.4	-6.3%
China	7	7	8	8	8	7.6	14.3%
Japan	9	9	9	8	9	8.8	0.0%

Source: Own elaboration after <https://ourworldindata.org/co2>; [accessed: 27.08.2023]

The data on carbon dioxide (CO₂) emissions in 2017-2021 presented in **Table 6** show the degree of involvement of individual countries in reducing greenhouse gas emissions, which is an important element in the fight against climate change. By analyzing this comparison, it is possible to identify trends and differences in individual countries' approaches to emission reduction. In Poland and the European Union (EU-27), there has been stability in CO₂ emissions per capita, with a constant value of 8 tons per inhabitant. Both Poland and the entire EU maintained a similar average, at 8.6 and 8 tons, respectively, without showing any major changes in the analyzed period.

The United States showed a decrease in emissions from 16 tons per capita in 2017 to 15 tons in 2021, which generates a negative change dynamics of -6.3%. This may be the result of sustainable development activities and investments in renewable energy. China, on the other hand, although still relatively low in emissions when compared to other countries, has shown an upward trend. The increase from 7 to 8 tons per inhabitant between 2017 and 2021 represents a positive dynamic change of 14.3%. This may be due to intensive economic development and increased energy consumption. Finally, Japan showed a stability of 9 tons per capita, with an average value of 8.8 tons. Even though there are no significant changes in emissions, the country can still strive to improve energy efficiency.

Summing up, the analyzed data on carbon dioxide emissions show a varied picture of individual countries' actions to reduce their impact on the environment. The stability of emissions in Poland, the European Union and Japan contrasts with declines in the United States and increases in China, reflecting different priorities in climate and economic policy. **Figure 1** below shows the forecast of CO₂ emissions per capita.

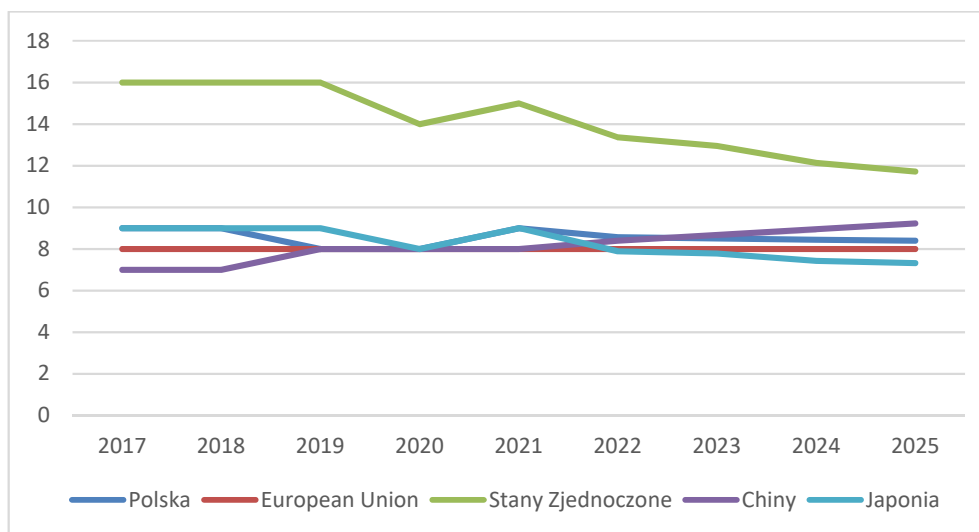


Figure 1. Prognosis of CO₂ emissions (in tones per capita)

Source: Own elaboration

In the case of Poland, CO₂ emissions per person are forecasted to be relatively constant, remaining at the level of 8.39-8.51 tons per person. This suggests that the country is making efforts to stabilize emissions and may be implementing measures to increase energy efficiency. The European Union can generate sustainable CO₂ emissions of 8 tones per person between 2023 and 2025, reflecting the EU's commitment to reducing negative environmental impacts and achieving the Sustainable Development Goals.

In the United States, CO₂ emissions are projected to decline, from 12.95 tons per person in 2023 to 11.72 tons per person in 2025. This may result from actions to reduce emissions and increase the share of renewable energy sources. In the case of China, CO₂ emissions are also expected to decline, from 8.67 tons per person in 2023 to 9.23 tons per person in 2025, which may be the result of its commitment to protect the natural environment despite economic growth. Finally, Japan can maintain relatively low CO₂ emissions, i.e. around 7.32-7.89 tons per person in 2023-2025, most probably due to long-term investments in clean development technologies.

When analyzing the issue of sustainable development and innovation, the consumption of energy from renewable sources was also checked. The relevant data are given in **Table 7**.

Table 7. Energy consumption from renewable sources (kWh per inhabitant)

	2017	2018	2019	2020	2021	Mean	Dynamics of changes between 2017-2021
Poland	1937	1852	2151	2293	2526	2151.8	30.4%
UE-27	5787	6181	6357	6850	6961	6427.2	20.3%
United States	7110	7224	7404	7710	8089	7507.4	13.8%
China	3194	3487	3800	4097	4580	3831.6	43.4%
Japania	3652	3929	3952	4284	4732	4109.8	29.6%

Source: Own elaboration after: https://ourworldindata.org/grapher/per-capita-renewables?tab=chart&time=2017..latest&country=CHN~OWID_EU27~JPN~POL~USA; [accessed: 27.08.2023]

The analysis of the presented data shows the use of renewable energy sources in the surveyed countries, indicating both the progress in sustainable energy production and the growing awareness of global challenges related to climate change. On this basis, it is possible to distinguish differences between countries and their contribution to global efforts for sustainable development. In Poland, energy consumption from renewable sources increased from 1,937 kWh per inhabitant in 2017 to 2,526 kWh in 2021, recording a dynamic increase of 30.4%. This could be due to investments in renewable energy sources, such as wind and solar power and various efforts to reduce greenhouse gas emissions. In the European Union, on the other hand, the average per capita renewable energy consumption reached 6,961 kWh in 2021, with a marked change of 20.3% over the period considered. This confirms the efforts of Member States to increase the share of renewable energy in energy production and to achieve climate goals.

The United States presents renewable energy consumption at the level of 8,089 kWh per inhabitant in 2021, with a growth rate of 13.8%. This state of affairs may be due to the growing role of wind and solar energy in the American energy mix. As for China, although starting from a lower level, the country showed a significant increase from 3,194 kWh per capita in 2017 to 4,580 kWh in 2021, which represents a positive change dynamics of 43.4%. This may be due to national investments in wind and solar energy and initiatives to reduce air pollution. Finally, Japan achieved an increase in renewable energy consumption from 3,652 kWh per capita in 2017 to 4,732 kWh in 2021, recording a visible change of 29.6%. This may be the result of various advances in photovoltaic technologies and emission reduction strategies.

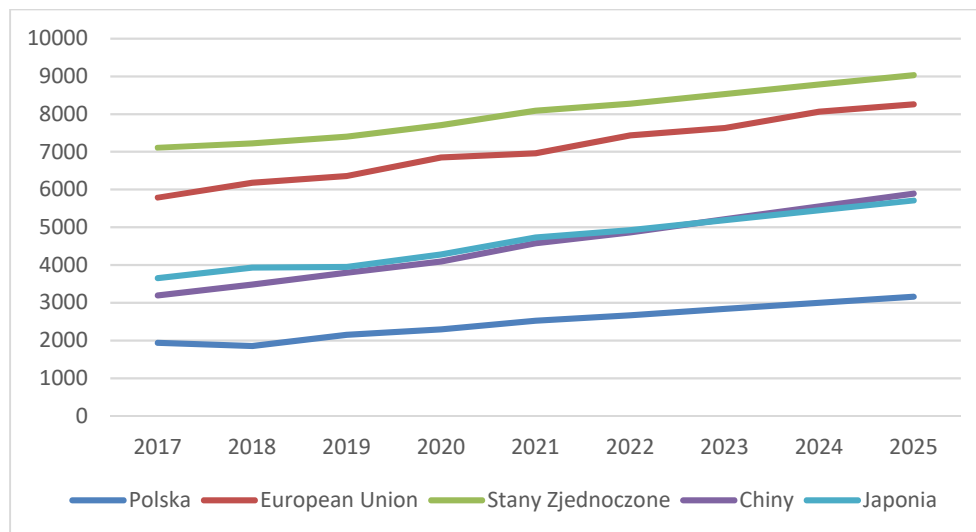


Figure 2. Forecast of energy consumption from renewable sources (kWh per inhabitant)

Source: Own elaboration

In Poland, a constant increase in the consumption of renewable energy is expected, reaching the level of 3,160.93 kWh per capita in 2025 (**Figure 2**). This is a positive step towards increasing the share of renewable energy sources in the national energy mix. The European Union may also continue this trend, as it is predicted that in 2025 one person will consume on average 8,260.57 kWh of energy from renewable sources. This reflects the EU's commitment to sustainable energy development and the growing share of renewable sources.

In the United States, renewable energy consumption per person is projected to increase, reaching 9,033.78 kWh in 2025, being the result of growing interest in renewable energy and investments in its development. As for China, despite its intensive economic growth, the country will strive to increase the consumption of renewable energy, reaching 5,893.90 kWh per capita in 2025. This may illustrate its commitment to green development. Finally, Japan may see an increase in renewable energy consumption per person, reaching 5,709.12 kWh per capita in 2025, while still continuing to invest in clean development technologies and efficient energy use.

Generally speaking, different approaches of the selected countries to energy transformation can be observed. However, the growth in renewable energy consumption in Poland, the EU, the United States, China and Japan clearly reflects global efforts to reduce emissions and sustainably use energy resources, although at different rates and in different contexts.

4. Relationships between energy consumption and selected innovation measures

In the last part of the research, there will be presented the focus on the intriguing issue of the relationship between energy consumption and selected innovation indicators. Exploring these relationships is an important step in understanding how sustainability efforts and innovative approaches can support each other. The analysis of innovation indicators in the context of energy consumption will shed new light on the dynamics of economic development, sustainable production and energy efficiency. By identifying some of the existing connections, it will be possible to determine whether countries achieving a higher level of innovation are also willing to use energy resources more effectively and/or whether modern technologies and inventive approaches influence the development of a more sustainable energy model. **Table 8** below presents the relationships between selected measures of innovation and energy consumption, on the one hand and the results of the Pearson correlation coefficient assigned to them, on the other. For this purpose, average values for the years 2017-2021 were used.

Table 8. Relationships between selected predictors of innovation and measures of energy consumption per capita (average values for the examined period)

Dependency	Correlation result
Patent effectiveness and CO2 emissions per capita	-0.26
Patent efficiency and renewable energy consumption per capita (kWh)	-0.22
Trademark efficiency and CO2 emissions per capita	-0.84
Trademark efficiency and renewable energy consumption per capita (kWh)	-0.47
R&D expenditure and CO2 emissions per capita	0.55
R&D expenditure and renewable energy consumption per capita (kWh)	0.60

Legend: Patent effectiveness should be understood as an indicator of the effectiveness in obtaining patents; at the same time, trademark effectiveness is the effectiveness of activities related to applying for a trademark.

Source: Own elaboration

The results presented in **Table 8** are the result of the analysis of the relationship between innovation rates and energy consumption per capita in the studied countries, when using Pearson correlation and a specific interpretive scale. The obtained correlation values are crucial for quantifying the strength of the relationship between the analyzed relationships.

The first group of relationships examined was the one between the effectiveness of patents and energy consumption. A moderate negative

correlation of -0.26 can be observed between patent efficiency and CO₂ emissions per capita; this may suggest that countries with higher patent efficiency aspire to lower CO₂ emissions per capita and more efficient energy use. A situation like this could indicate that innovation can lead to the creation of greener energy solutions. While examining another group of relationships, this time regarding trademarks in relation to energy consumption, it can be seen that CO₂ emissions per capita show a strong negative correlation with trademark effectiveness (-0.84), which may suggest that the studied countries more focused on trademark protection are, at the same time, more interested in sustainable energy use. The third group of relationships concerns research and development expenditure in relation to energy consumption. These relationships showed a positive but moderate strength, what may indicate more complex interactions between the R&D sphere and CO₂ emissions per capita. Nevertheless, in one case, there was noted a clearly noticeable relationship, which should be interpreted as follows: with an increase in expenditure on research and development activities, there also appears an increase in the consumption of energy from renewable sources per capita and vice versa.

Analyzing and interpreting these relationships provides valuable insights into how innovation can influence the more sustainable use of energy resources. However, it should be remembered that these results are only a starting point for further research in other words, more extensive analyzes taking into account the socio-economic context of each country for a more complete understanding of the interactions between these indicators are expected.

5. Discussion of the results

Innovations play a key role in solving problems related to climate change as, for example, emphasized by M.L. Weitzmann (1998). Also S.A. Churchill *et al.* (2019) claim that technological innovation is the key to sustainable resource use and economic growth. The massive analysis carried out by them showed that a strong relationship was observed only in the case of trademark effectiveness and CO₂ emissions per capita (-0.84). As the effectiveness of trademarks increased, CO₂ emissions per capita decreased. In other cases, associations were moderate or weak.

Numerous studies reveal the complex relationship between innovation and greenhouse gas emissions. C. Cheng *et al.* (2019) found mixed effects, with patents and renewable energy affecting emissions differently. In another study, C. Cheng *et al.* (2021) show that innovations improve emissions in some areas but make them worse in others. According to other sources, (c.f. Liu & Dong, 2021), low-carbon innovations have a limited impact on emissions. A.O. Acheamponget *al.* (2022) identify a U-shaped relationship between innovation and emissions. L. Daudaet *al.* (2021)

confirm the inverted U-shape in three developing countries. The research by D. Balsalobre-Lorente *et al.* (2021) reports positive effects of energy innovations on air travel; also J. Gu (2022) associates innovations with emission reduction and moderate relationships with economic development. These findings also highlight regional differences.

In the study by A. Cai *et al.* (2021) interprovincial carbon dioxide emissions in China were found to have a strong spatial effect. Carbon dioxide emissions in this region are not only related to their own factors, but are also influenced by factors of neighboring regions. In particular, green technological innovations and improvements in the industrial structure in neighboring regions have a negative impact on the region's carbon dioxide emissions. R. Miśkiewicz (2021) also wrote in a similar tone, pointing out that the development of information and innovative technologies had a statistically significant impact on greenhouse gas emissions.

Summary and conclusions

The paper analyzes the relationship between sustainable development and innovation, trying to understand how these two spheres interact in the context of various indicators and dynamic changes between 2017 and 2021. The study included selected aspects related to CO₂ emissions per capita, renewable energy use per capita, patent effectiveness, trademark effectiveness and research and development expenditure (as % of GDP). Using Pearson correlations, the analysis identified relationships between these measures.

The aim of these considerations was to identify and quantify the relationship between innovation measures and predictors of sustainable development in selected countries. The results of the analysis showed that there exists a relationship between innovation and CO₂ emissions per capita. Countries with higher patent and trademark efficiency tended to have lower CO₂ emissions per capita. This suggests that the development of new technologies and the protection of intellectual property may influence the creation of more ecological solutions and reduce the negative impact on the environment. This analysis allowed for positive verification of two research hypotheses, i.e. H1 and H2.

The analysis of the share of renewable energy in the energy mix, in the context of innovative activities, also provided valuable insights. Countries with increased trademark efficiency were characterized by a greater share of primary energy from renewable sources. This suggests that there is greater efficiency in the use of available renewable energy sources in these countries. However, higher spending on research and development did not lead to a higher share of renewable energy in every case analyzed. This may indicate more complex relationships between investments in innovation and the energy transformation. However, the study

showed that in one case there was a clear relationship between R&D expenditure and the use of alternative energy. It was found that with the increase in expenditure on research and development activities, there is also an increase in the consumption of energy from renewable sources per capita and vice versa; a result like this confirms the positive verification of the third hypothesis - (H3).

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ARTICLES

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THE DEVELOPMENT OF THE POLISH GREEN BOND MARKET IN COMPARISON TO SELECTED EUROPEAN COUNTRIES

Abstract

The issue of "green finance" in the modern economy is one of many elements that determine the competitiveness of countries on an international scale. The current climate targets resulting from the desire to shape the correct relationship between economic growth and the natural environment mean the need to incur appropriate financial outlays, the availability of which is often limited. One of the innovative sources of financing pro-environmental projects are green bonds.

The aim of the study is to determine the role of green bonds in the development of the Polish economy and to analyze and evaluate the development of the Polish green bond market in comparison to selected European countries. A critical literature review, comparative analysis, and financial data were used in this research. The article is divided into two sections. The first part encompasses a literature review that explores the essence of green bonds, considering both the benefits and barriers associated with this type of financing source. The second part comprises the analysis of statistical data. The scope of the study covered green bonds issued in Poland and selected European countries over the years 2018-2022. The conducted research indicates that the green bond market in Poland and selected countries worldwide is developing dynamically, but it faces numerous barriers hindering its growth. Among the most significant ones,

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it is crucial to point out the lack of uniform standards for green bonds and higher issuance costs compared to traditional bonds.

JEL Classification: O13, O16, Q56

Keywords: green finance, green bonds, green bond market, sustainable development, ESG.

Introduction

Dynamically progressing climate changes force us to introduce significant modifications leading to achieving climate neutrality. The growing ecological awareness of all market economy entities leads to the emergence of new solutions in many areas. The financial market and its participants do not remain passive towards the risk associated with changes in the natural environment. They strive to build a long-term sustainable development strategy through activities aimed at reducing pollution generated into the natural environment.

A relatively new concept in the field of economics is green finance, which has become one of the most discussed topics not only by scientists, but also by practitioners. Green finance can take many forms, the most popular of which include green bonds, green loans and green investments. The topic of green bonds as part of green finance discussed in this article is important from the point of view of the growing interest of both issuers of green bonds and investors. Therefore, the paper presents the concept of green bonds, taking into account the benefits resulting from the operation of green bonds on the financial market, as well as the barriers inhibiting the development of the green bond market. Moreover, the analysis of the development of the green bond market in Poland and selected European countries in 2018-2022, undertaken in the article, will allow indicating the direction and development prospects of this type of financing source.

The article was prepared on the basis of the study of the relevant Polish and foreign research literature, institutional publications and reports. The statistical data that has been used in this research was mostly taken from the Interactive Climate Bond Data Platform (for the period from 2018 to 2022) and from information available on the websites of Polish green bond issuers.

1. The concept of green bonds and their role in the economy

Despite extensive research, there is no universal definition of green bonds. Various interpretations have been created over the years, but the common denominator is the primary goal of utilizing funds from the issue. (Hajdys, 2020, p. 52). The topic has been discussed by various authors,

including C. Flammer (2020, p. 95), D.Y. Tang, Y. Zhang (2020, p. 1), D. Gilchrist, J. Yu, R. Zhong (2021, p. 7). It is worth paying attention to the definition presented by the ICMA (The International Capital Market Association). According to ICMA, "green bonds are any type of bond instrument where the proceeds or an equivalent amount will be exclusively applied to finance or re-finance, in part or in full, new and/or existing eligible Green Projects and which are aligned with the four core components of the GBP" (ICMA, 2021, p. 3). The basic criteria for green bonds developed by ICMA include:

- a) Use of Proceeds – allocating funds from the issue of green bonds for investments in green projects (e.g. mitigating climate change, protecting natural resources, preventing pollution),
- b) Process for Project Evaluation and Selection – the issuer is obliged to present the objectives and the adopted strategy in the field of sustainable development,
- c) Management of Proceeds – the use of funds from the issue of green bonds should be systematically monitored (it is recommended that the verification process be carried out by an external entity, e.g. an auditor),
- d) Reporting – the issuer of green bonds should inform investors about how the funds from the issue are used (annual reports including a list of projects with their short description and planned impact on the environment).

The concept of green bonds is based on the use of funds from bond issues for green projects related to, among others, renewable energy, increasing energy efficiency, green transport, preventing air and water pollution, sustainable agriculture and even green construction (ICMA, 2021, p. 5). From the point of view of the transformation of the economy to a low-emission one, these are very important projects, and green bonds play a significant role in the sustainable development of the economy. The essence of green bonds includes achieving economic profits combined with environmental protection (Wang, Zhi, 2016, p. 311). Green bonds, compared to traditional bonds, focus on preventing negative climate changes. The role of green bonds in the economy of each country is described by the most important benefits they bring.

The idea of green bonds arose when the practical beginning of reducing environmental pollution was introduced. The growing awareness of the risk of climate change and the consequences for enterprises, society and the entire financial sector leads to the creation of various solutions – including financial ones, because the implementation of environmentally friendly programs requires adequate financing (Banga, 2018, p. 21). Unfortunately, many enterprises or countries are unable to finance this type of projects from

their own funds or other external sources of financing, because the costs of green projects are usually quite high. The resulting financial gap was filled by the green bond market, which plays an important role in the pursuit of a pro-environmental economy (Laskowska, 2019, p. 114). This enables many entities to implement projects that reduce (and in the future, perhaps completely eliminate) the pollutants produced or increase energy efficiency in order to achieve climate neutrality.

From an investor's perspective, in addition to the standard benefits that come with investing in bonds, transparency in the manner and impact of financial resource utilization is highlighted as a key advantage (Ślażyńska-Kluczek, 2022, p. 36). On the other hand, it is an additional obligation for the issuer, resulting in additional costs. One of the significant barriers to the development of the green bond market is the higher issuance costs compared to conventional bonds. Green bond issuers incur costs associated with labeling, certification, and subsequently verifying and reporting the use of funds (OECD, 2017, p. 38). Additionally, issuers who violate green bond principles may face penalties. The growth of the green bond market may be hindered by issuer awareness of reputational risks associated with the possibility of questioning the "greenness" of the issued bonds. It's worth noting that the green bond market is relatively new and, as a result, not as popular as the conventional bond market. This can lead to a perception of lower liquidity, which further discourages potential investors (Brzozowska, 2017, p. 74). However, research conducted by economists from the German Institute for Economic Research indicates that green bonds were generally more liquid from 2014-2016 than conventional bonds (Wulandari, Schäfer, Stephan, Sun, 2018, p. 19). This may suggest a higher demand for green bonds in comparison to conventional debt instruments.

The green bond market is currently unregulated, which may lead to conflicts between issuers and investors. Although there are many guidelines and proposals, they are not yet binding, such as the norms defined by ICMA, ASEAN Green Bonds Standards, and the EU Green Bond Standard proposal. Moreover, the development of the green bond market is limited by investment opportunities for investors and the inadequate knowledge of potential green bond issuers regarding the essence, benefits, legal frameworks, and barriers related to issuing green bonds (Chiang, 2017, p.15). This leads to an imbalance between the supply of green bonds and the demand for them. Therefore, regulatory and standardization institutions play a crucial role in developing the green bond market.

Despite various obstacles, the advantages of investing in green bonds are becoming increasingly apparent. One of the key benefits for issuers of green bonds is the signal sent to the market regarding the issuer's

approach to ESG issues (environmental, social, and governance). Companies are now encouraged to adapt their business models to create not only financial value but also social and environmental value (Schoenmaker, 2017, p. 48). Such actions positively impact the issuer's image from investors, governments, and even customers. The increasing interest in green bonds by investors is also due to the issuer's increased exposure in the media, which eagerly covers environmental issues (Kultys, 2020, p. 123). Furthermore, the issuance of green bonds as relatively innovative financial instruments is associated with diversifying the investor base. The unit's previous sources of funding are also diversified, leading to a reduced exposure to fluctuations in demand for bonds. It is worth noting that the dynamic development of the green bond market can contribute to an increase in the size of issuances, enabling the realization of larger eco-friendly projects. The OECD points to increased communication between issuers and investors as an essential benefit for both parties, which is facilitated by the requirement to report on the use and effectiveness of funds raised through issuances (OECD, 2017, p. 38).

The environmental benefits associated with green bonds contribute to the growing demand for these bonds (Grabowski, Kotecki, 2020, p. 28). Investors recognize the potential inherent in sustainable development, leading to an increasing number of investors seeking to invest in entities that positively address environmental issues. However, it is important to note that the development of the green bond market would not be possible without a change in the business model of investors. Contemporary investment trends increasingly involve considering priorities other than just economic profits, such as issues related to sustainable development.

2. The green bond market in Poland and selected European countries in 2018-2022

The green bond market in Poland and selected European countries was subjected to empirical research. The first part of the analysis focused on the Polish green bond market from 2018 to 2022, while the second part of the study included a comparison of the Polish green bond market with selected European markets.

The first green bond was issued in 2007 by the European Investment Bank (EIB), marking the beginning of a new trend in securities issuance (Gemra, 2021, p. 32). Since then, the green bond market has been dynamically expanding, and Poland has made a significant contribution to the development of the green bond market. It became the first country in the world to issue green government bonds in December 2016, totaling 750 million euros. On the other hand, the first Polish corporate bonds, with a total volume of 900 million Polish zlotys, were issued only in 2019 by financial enterprises - banks. The table below (Table 1) presents the characteristics of selected green bond issuances, where

the funds were allocated for the implementation of environmental projects, which had a meaningful impact on the development of the Polish economy.

Table 1. The characteristics of selected green bond issues in Poland in 2018-2022

The issuer	Date of issuance	Issuance volume	Allocation of funds
State Treasury (green government bonds)	February 2018	1 bn EUR	Projects related to sustainable agriculture, low-emission transport, and renewable energy sources.
	February 2019	1,5 bn EUR	
PKN Orlen S.A. (green corporate bonds)	December 2020	1 bn EUR	Current investment projects, in line with the adopted strategy of achieving emission neutrality by the company by 2050
	May 2021	500 mln EUR	Construction and acquisition of new production capacity of renewable energy sources, further development of a network of fast chargers for electric cars and refueling infrastructure for buses and hydrogen cars, as well as development of waste recycling installations.
Cyfrowy Polsat S.A. (green corporate bonds)	February 2020	1 bn EUR	Modernization of telecommunications infrastructure (improving energy efficiency)
PKO Hipoteczny S.A. (green corporate bonds)	June 2019	500 bn PLN	Financing mortgages secured by green buildings
	December 2019		
mBank S.A. (green corporate bonds)	September 2021	500 mln EUR	Refinancing part of the retail mortgage portfolio financing highly energy efficient buildings
Miasto Łódź (zielone obligacje komunalne)	July 2021	50 mln PLN	Construction of retention tanks at the Group Sewage Treatment Plant and reconstruction of the tramway tracks on one of the streets in Łódź

Source: Author's own research based on information available on issuers' websites: mBank S.A. www.mbank.pl, PKO Hipoteczny S.A. www.pkobh.pl, Cyfrowy Polsat S.A. www.polsatbox.pl, PKN Orlen www.ornen.pl, Ministerstwo Finansów www.gov.pl/web/finanse, Miasto Łódź www.uml.lodz.pl [access: 20.02.2023]

Green bonds issued by the State Treasury, financial and non-financial sector enterprises, as well as local government units presented in the above table, significantly contributed to the sustainable development of the Polish economy. Environmental investments realized with funds from the issuance of green bonds have enabled, among other things, increased energy efficiency and reduced emissions. According to the assumptions of the European Green Deal, Europe is to become the world's first

climate-neutral continent by 2050 (KE, 2019, p. 3). It should be emphasized that issuers of green bonds enhance their competitive position over the long term. Entities that do not incorporate ESG issues into their business models become less attractive to investors. Investors increasingly eliminate financial instruments of entities that overlook ESG issues from their investment portfolios. The issuance of green bonds, and consequently the reporting obligation, allows for a transparent presentation of the issuer's approach to areas related to environmental protection, social responsibility, and corporate governance. It is crucial to underline that in many cases, the implementation of a green investment project by financial and non-financial sector entities, as well as by the government and local government units, would not be possible without funds from external sources, such as the issuance of green bonds, which are the subject of this study.

The selection of countries included in the second part of the study was not random and was driven by the intention to diversify the examined countries in terms of geographical location, economic development level, as well as the number of issuers and transactions with green bonds. The subject of the study encompasses the volume of green bond issuance for the entire European market, as well as the volume of green bonds issued in the examined countries. The study period covers the years 2018 to the first half of 2022. Data regarding green bonds are primarily sourced from the Climate Bonds Initiative Interactive Data Platform. The table below presents the characteristics of the subjective scope of this study.

Table 2. The characteristics of the subjective scope of research

Country	Geographical location	GDP per capita (current USD)*	Number of green bond issuers *	Number of green bond transactions *
Poland	Central Europe	18000	4	4
Italy	Southern Europe	35658	11	13
France	Western Europe	43659	20	40
Finland	Northern Europe	53655	10	13
United Kingdom	Northwest Europe	46510	23	29

* as of December 31, 2021.

Source: Author's own research based on World Bank data and Climate Bonds Initiative Interactive Data Platform, www.worldbank.org, www.climatebonds.net/market/data/ [access: 20.02.2023]

The scope of the study includes the following countries: Poland, Italy, France, Finland, and the United Kingdom. All these countries were issuers of green bonds during the studied years. In 2016, Finland, like Poland, inaugurated the issuance of green government bonds. In 2017, France launched its first green sovereign bond and has been issuing them

systematically since then. Currently, among the analyzed countries, it was France that led in the number of transactions related to green bonds in 2021. Following the Polish and French experiences in the issuance of green government bonds, Italy also entered this field, making its first such issuance in 2021. Previously, the country had been a leader in the market of sustainable financing through the issuance of ecological and social bonds. On the other hand, the United Kingdom was included in the study due to its achievements in the approach to financing green projects. In 2022, the United Kingdom was awarded for the largest green government bond and received the Green Government Bond Pioneer award (GOV.UK, 2022). The selected countries for the study were diversified in terms of geographical location, GDP per capita, the number of green bond issuers, and the associated number of transactions. Most of the analyzed countries are members of the European Union, ensuring equal access to the single market, including the capital market.

The analysis of the development of the green bond market in Poland and selected European countries requires an examination of overall European trends in this market. The years 2018-2022 have been a tumultuous period for the entire world, especially Europe. The outbreak of the coronavirus pandemic at the turn of 2019 and 2020, followed by the eruption of the war in Ukraine in early 2022, led to a disruption of socio-economic balance across Europe. Faced with the pandemic threat and armed conflict, issues related to sustainable development were temporarily pushed to the background. The priority during the pandemic was to limit the spread of the virus and assess its threat level. Meanwhile, the armed aggression of the Russian Federation on Ukrainian territory is likely to contribute to a temporary limitation of green project implementations. The chart below (Figure 1) illustrates the volume of green bonds in Europe and their rate of change from 2018 to the first half of 2022.

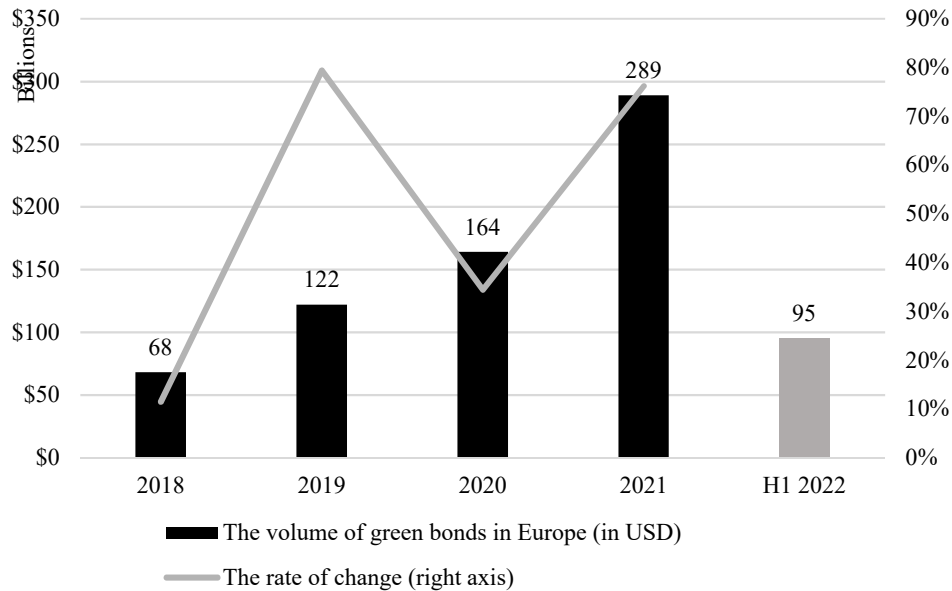


Figure 1. Volume of green bonds (in billion USD) and their growth rate (in %) in Europe for the years 2018 – H1 2022

Source: Author's own research based on Climate Bonds Initiative Interactive Data Platform, www.climatebonds.net/market/data/ [access: 20.02.2023]

The overall European green bond market is experiencing dynamic growth, as evidenced by the volume of green bonds in Europe showing an upward trend. Over the years 2018-2021, the level increased from 68 billion USD to 289 billion USD. The growth rate in 2019 was nearly 80%. However, the growth rate in 2020 slowed due to the coronavirus pandemic, reaching only 34%. This was temporary, and the growth rate in 2021 was back to 76%. It is worth noting that data for 2022 only cover the first half of the year, during which the volume of green debt instruments issued by European countries amounted to 95 billion USD. However, it can be speculated that the volume of green bonds in the European market may experience a decline for the first time, as by mid-2022, their value was only 32% of the previous year's volume. This may be a result of investment decisions being limited due to growing economic uncertainty caused by the war in Ukraine, rising inflation, and tightening monetary policies in many regions of Europe.

However, it is worth noting that Russia's invasion of Ukraine in the long term may contribute to the development of the green bond market. The aggression by the Russian Federation has been met with condemnation from Europe, resulting in numerous sanctions imposed by the European Union. European countries were characterized by a significant dependence

on Russian energy resources, including natural gas, oil, and coal, before the outbreak of the war. However, in the face of the war in Ukraine, awareness of energy security has become a top priority. Consequently, many countries are taking steps to limit and eventually achieve complete independence from Russian resources. This is, however, a lengthy and highly costly process. The war in Ukraine is likely to accelerate the energy transition. According to the European Union's objectives, member states should increase their involvement in expanding renewable energy technology to reduce their dependence on Russian fossil fuels. Investments in renewable energy sources can be financed using green bond issuances, suggesting that European countries may drive the global green bond market in the near future.

The presented situational overview of the European green bond market allows for an assessment of the market's development in the surveyed countries. The chart below illustrates the volume of green bonds in Poland, Finland, the United Kingdom, as well as Italy and France. It is important to note that the volume of green bonds issued in Poland in 2020 comes from a different source than all other data, as the Climate Bonds Initiative Interactive Data Platform does not include the values of issued Polish green bonds for the year 2020. Therefore, this data was obtained from the KPMG Report commissioned by the Ministry of Finance (KPMG, 2021, p. 56).

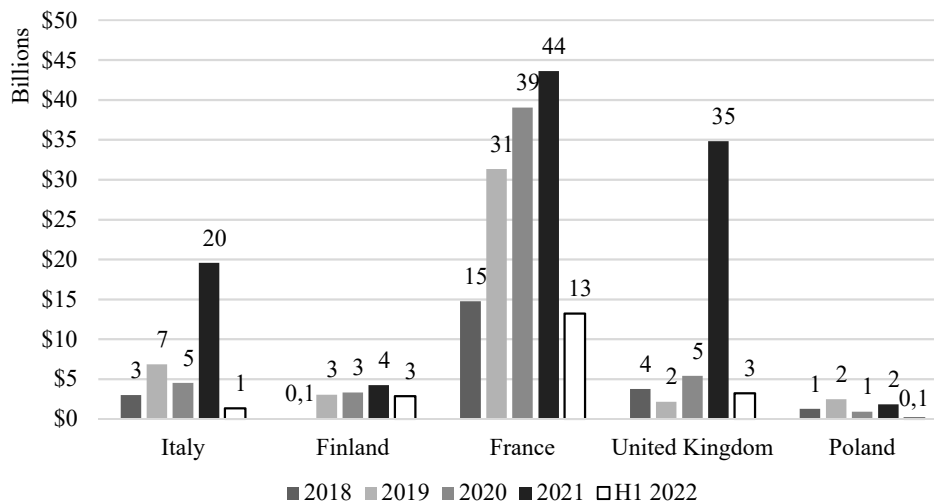


Figure 2. The volume of green bonds in Poland and selected European countries in 2018 – the first half of 2022 (in USD billion)

Source: Author's own research based on Climate Bonds Initiative Interactive Data Platform www.climatebonds.net/market/data/ [access: 20.02.2023r.] and KPMG, (2021), s. 56

France recorded the highest volume of green bonds among the surveyed countries, leading the majority of European countries in this regard. This is attributed to a favorable regulatory environment for the issuance of green bonds, including the French Energy Transition Law and recommendations from the financial market regulator. These collectively create favorable conditions for both the issuance and investment in green bonds. The scale of the Polish green bond market over the study period, compared to the French market, appears less optimistic. The differences in the volumes between these markets in absolute terms range from 13 billion USD to as much as 42 billion USD. However, it is essential to note the differences in the economic development of both countries. France's GDP per capita (Table 2) is nearly 2.5 times larger than Poland's GDP per capita. Therefore, it can be assumed that the Polish financial market is less developed than the French market.

The sizes of the Polish and Finnish green bond markets are comparable. The inaugural issuances of both countries took place in 2016. The funds from Finnish green bond issuances are predominantly allocated to sustainable buildings, sustainable public transport, and water and wastewater management (MuniFin, 2022, p. 9). The systematic development of the green bond market in Finland is a consequence of internal (Nordic) regulations regarding green bonds, including reporting recommendations, guidelines, and positions on the environmental impact reporting of green bonds. Additionally, to enhance the attractiveness of environmentally friendly investments, the Finnish government grants approved projects a margin discount of 0 to 10 basis points (MuniFin, 2022, p. 20).

On the other hand, the level of development of the green bonds market in Italy is comparable to that in the United Kingdom. It is noteworthy that both countries experienced dynamic growth in the volume of green bonds in 2021, reaching over 330% for Italy and almost 550% for the United Kingdom compared to 2020. The remarkable increase in the United Kingdom is a consequence of the largest inaugural issuance of green government bonds by the UK government. The proceeds from this issuance were used for innovative solutions in the field of transportation, such as zero-emission buses, marine wind energy, and decarbonization programs for homes and buildings (GOV.UK, 2021). Meanwhile, the dynamic growth in the volume of green bonds in Italy resulted from increased issuances by the government (2 issuances) and increased issuances in the non-financial corporate sector.

The level of development of the green bonds market in the examined countries is highly diverse. Currently, the green bonds market in Poland is still relatively small, especially when compared to the French market, for instance. However, it is essential to note that the size of the Polish green bonds market does not significantly differ (except for 2021) from countries such as Finland, Italy, or the United Kingdom. This is a very interesting

phenomenon, particularly considering that the value of Poland's GDP per capita, the number of transactions, and the number of green bond issuers in Poland are the lowest among all the surveyed countries. Prior to conducting this study, it might have been assumed that the Polish green bonds market would significantly deviate from the other surveyed countries. This indicates significant room for the development of green bonds as a source of financing for programs aimed at transforming the economy into a low-emission one.

Conclusions

The growing awareness of nations regarding advancing climate changes poses immense challenges towards achieving climate neutrality. Implementing environmentally friendly projects often requires substantial financial investments. In response to the increasing demand for funds necessary for the execution of green projects, green bonds emerge as a financial solution.

The green bond market is one of the youngest segments of the capital market. The dynamic growth of this market in many European countries stems from the necessity to mitigate negative climate changes. The size of the European green bond market in nominal terms has consistently increased over the years studied. The year-on-year change rate in the volume of green bonds has never reached negative values, even in the face of the COVID-19 pandemic. This indicates a high level of interest from both issuers and investors in this financial instrument. It's worth noting that the Polish green bond market does not significantly differ from countries such as Italy, Finland, or the United Kingdom (except for the record-breaking volume of green bonds in these countries in 2021). Meanwhile, France is one of the most active countries in the European green bond market. The diversity in the development of the green bond market in the surveyed countries primarily results from internal standards, regulations, and recommendations regarding green bonds.

The green bond market plays a significant role, measured by the benefits for investors, issuers, and the natural environment. However, it encounters various barriers, and one of them is the lack of uniform, binding standards for green bonds. The introduction of a unified standard would release the decisions of many investors and green bond issuers, allowing for the implementation of a greater number of environmentally friendly projects.

The current political-economic situation related to the ongoing war since 2022 can significantly contribute, in the long term, to the dynamic development of the green bond market. Countries are opting for an accelerated energy transformation - decarbonization, aiming to reduce dependence on Russia in terms of energy security. The issuance of green

bonds represents a serious alternative to traditional sources of financing for environmentally friendly projects.

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ARTICLES

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DISTRIBUTION OF THE TAX BURDEN OF A CAPITAL ENTERPRISE

Abstract

The article deals with the phenomenon of shifting income tax burdening the profits of capital enterprises. The tax system tends to discriminate fiscally against the owners of such enterprises, as it means paying tax on the profit made, and then from the profit made after dividends are paid also tax on dividends. This results in lower efficiency of capital allocation in the economy, and causes changes in the relationship between the cost of capital and labor and their use in production processes. As long as the factors of production can substitute for each other, this or even another tax can be borne by both factors to varying degrees depending on the specific characteristics of the market.

JEL Classification: H22, D50; D53; F49; G18; F12.

Keywords: tax, profit, enterprise, shifting, incidence, capital, labor.

Introduction

The taxation of capital enterprises consists of income tax on the company's realized profit and other taxes, especially those of a wealth tax nature. For the analysis of the effects of this taxation, the sectoral impact of profit income tax is important. Such analysis also applies to taxes in the form of property taxation, and even specific sales taxes, or even payroll taxes². Of course, each

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² This statement diminishes the importance of how the subject of taxation and the tax base are determined. In fact, these have their own economic significance. In the analysis undertaken, this issue does not play a major role, because despite the different impact

of these taxes affects the incidence phenomena in a different way, but each of them will have an impact depending on the incidence factors of the taxes. From a social as well as a purely economic point of view, the interesting thing is: who will bear the tax or its changes in real terms.

A tax levied on capital forming in an enterprise generally leads to a decrease in the rate of capital accumulation in the enterprise. Under the conditions of openness of the economy to trade, free movement of capital and labor, such a tax reduces the scale of enterprise investment undertaken in the country, and vice versa: its abolition or reduction increases the scale of investment undertaken in the country. This tax does not affect the scale of domestic savings, these can be supplemented with the resources of foreign capital, although then the indebtedness of the economy increases, and this is part of the investment credibility of a country. Moreover, differences in taxation between countries lead to the flow of capital to the country with a lower tax, reducing domestic investment and increasing investment in the country with more favorable tax conditions. Besides, in the country where capital flows in, a favorable situation described by the so-called abundant markets theory is created, where both productivity and wages increase and there is higher capital saturation. However, this is a simplistic approach that does not take into account other distortions of the process and all the complexities of the processes taking place, and the fact that the tax can distribute its economic burden not only to capital, but also to labor, and can even involve foreign resources.

The purpose of the article is to analyze the occurring models of CIT incidence and determine the factors of distribution of the tax burden between capital and labor. The article is organized as follows: firstly, the occurring models of CIT incidence in the literature are reviewed and the factors determining the phenomenon of tax shifting are discussed, then the analysis of trends in income tax on forming capital and dividend tax is presented, finally the analysis of the types of research and the main conclusions are made. The results of the analysis were based on statistical data from the database of the OECD organization.

1. Overview of the main models of CIT incidence

The question of the distribution of the tax burden has been dealt with since the beginning of the 20th century, but these analyses were of a partial or collateral nature. At that time, a trend of views was formed, which can be described as the trichotomous tradition, where three factors of tax

in the short term, the long-term effects will be regardless of the method of taxation dependent on the tax incidence factors.

incidence were identified³, i.e. capital, labor and the consumer. In general, they treated the economy in a simplistic way, treating the factors of production as evenly distributed in the economy, where the most efficient way to supply them is through market transactions. Here the weakness of the approach manifested itself, which, despite reaching a scientific consensus, failed to dispel many uncertainties. It can also be argued that the assumptions were in line with classical enterprise theory, often ignoring the internal relationships between employees, owners and managers. Tax revenues were a tax burden on the economy between consumers and producers, while losses exceeded even tax revenues. Distributed among the three factors, they allowed markets to reach market equilibrium again. The piecemeal approach also yielded a preference for short-term effects, in the analyses and interpretations conducted. Most of the analyses, however, were of a sideways nature. This was due, arguably, to the dominance of the Keynesian analysis approach to economic management. The focus on demand management, completely ignored issues of the effects of complex taxation, at most the price-forming nature of taxes could be of primary importance.

Finally, a fundamental change has come in determining the impact of tax burdens on production, income and prices. Essentially, the classical approach to the enterprise was modified, pointing out their internal differentiation, emphasizing their favoritism or discrimination by the tax system, which by the previous outlook had to be ignored. The main difference between those distinguished by A. Harberger⁴ in 1962 was the application of different taxation rules or rates to enterprises that differ in legal form. The model indicates that income tax on corporate profits is mainly charged to labor. It turns out that still in most countries the existence of income tax on the profit of capital enterprises, discriminates against a sizable group of owners. Hence, some owners paid only a personal income tax, while the rest, in addition to the personal tax, paid an indirect tax on the profits of capital enterprises. This regulation, despite criticism, from economists, is still applied. One of the main justifications for the existence of such taxation was: prevention of escape from personal taxation and high profitability of domestic and foreign corporations. Thus, while the traditional trichotomy assumed the existence of universal taxes, since 1962, tax discrimination

³ Tax shifting factors are similar in appearance to factors of production. When it comes to labor and capital, this approach primarily understands the wages of workers and the wages of capital owners. They are identical to the factors of production, while consumers are the counterweight (counterpoint) to the direction of shifting. From the point of view of the objectives of this article, it is the axis between capital and labor that is the most important part of the issue.

⁴ A.C. Harberger, 1962.

against capital enterprises has been recognized as a source of distortions in the economy, through the existence of a sectoral tax burdening the profits of capital enterprises. Such discrimination results in an inefficient allocation of capital in an economy where capital is mobile. The cost to the economy will exceed the tax revenue. However, it is worth noting that in the model created by A. Harberger called the two-sector model, capital and labor resources are fixed and fully utilized. The author of the model does not focus on the short term, but on the long term, hence the adjustment period was omitted. Nevertheless, it can be said that for these assumptions to be met there must be full price adjustment rather than quantity adjustment, which indicates that this model meets the requirements for the operation of a neoclassical-type economy, where adjustments occur very quickly, price adjustments and full employment dominate, while prices are flexible. Changes in monetary policy, for example, are not taken into account. The model of A. Harberger indicates that in the case of taxation of capital enterprise profits, the main burden of taxes is borne mainly by capital. In 1963 Musgrave and Krzyzaniak⁵ made an empirical study of the incidence side of taxes, but without any reference to A. Harberger's theoretical claims. This was important for the development of this field of research, while only with time there was an integration of such two approaches to the problem. For the two-sector model became the basic model for explaining phenomena, on the basis of which new types of models were also added.

Since A. Harberger's two-sector model was limited to analyzing the effects of a closed economy on: foreign trade, capital and labor flows, subsequent models abrogated this assumption. In this way, models of open economies were created. The repeal of these restrictions for the model resulted in different indications of shifting the tax burden, this time toward labor. This was due to lower mobility, the relative immobility of labor. The open economy model, also known as A. Harberger's four-sector model, includes opportunities for capital flows between the country and abroad, while products can also be sold in foreign markets. So, two sectors of companies can produce products that are internationally exchangeable or sellable only domestically. And also this model has become the starting point for theoretical and empirical considerations. Key aspects of the model are the question of the degree of product substitution internationally, the intensity of the use of capital and labor. Similar conclusions about the effect of tax shifting on labor resources were made by A. Harberger⁶ in the five-sector model, where the model of internationally tradable goods is low substitution, introduces in place of the sector of capital enterprises of internationally tradable products two sub-sectors

⁵ M. Krzyzaniak, R.A. Musgrave, 1963.

⁶ A.C. Harberger, 1994.

of capital enterprises with internationally tradable products with high and low levels of substitutability. However, the introduction of these changes did not change the effects of tax distribution, where labor became the main factor taxed. Both the two-sector model and A.Harbeger's four-sector or five-sector model became the center of incidence research as well as his reference point for other models created in large numbers by other researchers in public and corporate finance. The issue of key factors of tax distribution, is presented in the following subsection.

2. Factors of tax incidence

The distribution of the tax burden depends on the operation of the universal mechanism of the law of supply and demand. Specifically, the higher the price elasticity of the curves, the higher the shifting of the tax; the more difficult it is to predict who will ultimately economically bear the tax burden. The lower the price elasticity of the curves, the lower the potential shifting and the greater the predictability in imposing taxes. The latter situation is more favorable to the country's legislature. The universal law of supply and demand, however, does not resolve the direction of the tax burden incidence. The literature defines forward incidence by increasing the price, and backward shifting meaning reducing costs, particularly reducing wages. It is also difficult, without knowing the curves, to assess the scale of shifting long and short term. In the case of a burden on corporate profits, both shifting in price or to corporate costs are possible. To assess the scale of the phenomenon, it is not possible to use either general or detailed analyses of individual tax-distorted markets. Although a sub-analysis would illustrate potential changes, this would require knowledge of the price and income elasticities of the curves analyzed, the position of which we also do not know exactly. However, if one were to lean toward such an approach, one would have to consider changes in the following markets: domestic savings, capital, manufactured products, and the labor market. In a practical approach, an open and closed economy model is used as a certain approximation of reality. In the models, the factors of analysis are those that shift the demand and supply curves or shape the slope. Hence, the models are limited to the main five factors that make such changes. Others are not considered in the models, but they can be included in model modifications. However, these are factors of minor and non-fundamental importance.

The dependence of the tax burden incidence is expressed in the closed economy model through the following key aspects :

1. the substitutability of products produced in the taxed sector and the untaxed sector,
2. capital intensity or labor intensity of production.

The closed economy model is formed by both consumers and businesses divided into two sectors of capital and other businesses. The model assumes that the two enterprise sectors produce two different but substitutable products.⁷ Capital-intensive enterprises are capital-intensive in contrast to other enterprises, and at the same time, only they are subject to a sectoral tax on the profits of capital-intensive enterprises. Hence, the existence of such a tax discriminates in terms of taxation against such enterprises, which is also inefficient from the point of view of the allocative function of state finances. As a result, the mobile part of the capital can flow to other enterprises, in the form of: new external capital (debt and new contributions), or in the form of arbitrage of the legal form of the entire enterprise. This is triggered by the impulse of a tax increase, a market reaction to change. Capital is more mobile than labor resources. Increasing the price of the products of capital enterprises is limited in scope in accordance with the degree of substitutability, hence at a lower degree of substitutability, shifting part of the tax burden into the price is feasible. Thus, at a high degree of substitutability, it is possible to pass on the cost of the tax to mobile capital.

With regard to capital and once the tax is imposed, because of its mobility it will find application in the production of goods produced by other non-capital enterprises. Capital cannot remain unapplied in production, except for its unused portion due to insufficient profitability⁸, but its rental price may change. The rental cost of capital, as a result of such taxation, must increase or should maintain its previous level, depending on the distribution of this tax burden. In the long term, the mobility of capital means that the tax burden will be borne by capital, hence the remuneration of capital owners will fall. Given the mobility of capital, this should affect the entire economy in the long run. Since capital-intensive production cannot be easily replaced by labor, and some capital has been placed in non-capital enterprises, there will be a decrease in demand for labor in the capital enterprise sector, while an increase in demand will occur in the other enterprise sector. Thus, there will also be a need for equilibrium in the labor market, so labor resources encouraged by higher wages may also move to the non-capital enterprise sector. Here, however, with higher labor-intensity of production, there should be an increase in demand higher than the decrease in the capital enterprise sector⁹. The situation considered in the model, however, assumes the constancy of labor and capital resources, because it is known that an increase in resources can, of course, occur under the influence of changes in the labor market, but these

⁷ A.C. Harberger, 1962.

⁸ This refers to the inefficient part of capital allocation caused by the imposition of tax and the occurrence of a tax wedge.

⁹ There may be a problem of applying highly skilled labor during the adjustment period.

changes are neither rapid nor too strong. Thus, shortages or surpluses, should be treated as a certain adjustment process/transitional state occurring in the model in question. Hence, a tax increase paradoxically can have a positive effect of increasing the wage rate in the market and, at the same time, also a higher tax burden on the owners of capital than 100% of the tax revenue. Further factors affecting the effects of imposing a tax should be identified in the open economy model. In this model, further determinants of tax shifting should be added. These are the following:¹⁰:

1. international product substitution,
2. the size of the country,
3. international mobility of capital.

A factor that definitely modifies thinking about the degree of tax incidence is the possibility of international product substitution. This substitutability is of great importance and mainly concerns industrial production. Lack of substitutability makes it possible to shift the tax burden to foreign customers by raising the price. High substitutability of products-especially industrial products-does not make it possible to raise the price, it even forces the tax to be passed on in business costs. Thus, workers will feel the most in this situation through downward pressure on net wages, as the dominant sector of capital and industrial enterprises, in order to remain competitive in foreign markets, can neither raise the price nor increase the net real rate of return, hence will lower wages, which will translate into wage reductions throughout the country. The second factor mentioned is the size of the country. A country's high capital stock means that a country's government decision has a significant impact on the cost of bearing the tax burden of residents of other countries smaller in size. So the decision of a large country has an additional impact on countries that are small in this respect in the world. Regardless of the fact that the tax may be borne by capital or labor, taxation in a large country may transfer abroad the cost of the tax to non-resident capital owners, or foreign labor resources. It is not impossible that the burden may be shifted to non-resident capital owners while benefiting labor resources at home and abroad.

The third factor is the international mobility of capital. Naturally, the mobility of labor resources is lower than the international mobility of capital. The main reason for capital mobility is the differences in net rate of return between countries. Higher opportunities for net returns on capital result in almost constant flows between countries, of course, with some caveats that this openness of different countries may vary, for example, due to the existence of the so-called Tobin tax on speculative flows. The important thing is that, under the influence of the tax, the gross rate

¹⁰ Gravelle J., (2013), s. 4-5.

of return may increase while the net rate of return still remains unchanged. Of course, when it comes to the rate of return that takes into account country risk, net rates can vary permanently between countries. So high mobility means a constant net rate of return, the cost of the tax to be paid by the owners of capital will be passed on to the workers, because with international product substitutability, prices also remain constant. So this makes labor the direction of the tax shifting. Of course, it is worth asking the question of specialized labor and low-skilled labor. If there is a tendency to shift the tax burden to labor, it is most to low-skilled labor.

Table 1. Directions of tax incidence factors in a closed and open economy

Main factors in open and closed economies	share of capital in tax burden share of labor in tax burden	share of capital in tax burden share of labor in tax burden
High international mobility of capital	decrease	increase
High international substitution of products	decrease	increase
Country size	increase	decrease
Higher substitution of factors	increase	decrease
Taxed highly capital-intensive sector	decrease	increase

Source: J. Gravelle, 2013

The table above summarizes the impact of the tax burden distribution factors. Each of the identified tax burden distribution factors is related to the price elasticity of supply and demand for obvious reasons.

3. Trends in tax rates and fiscal efficiency

In an era of increasing globalization of economic processes, the importance of open economy models is better indicated by the effects of the introduction of taxation. However, the observation of normative tax rates proves that closed economy models can also yield explanations of economic phenomena and processes. In the years analyzed, profit tax rates in OECD countries had a clear downward trend. Although there have also been mixed-directional changes, the average normative rates among these countries have been decreasing, followed by the combined taxation of profits and dividends, as well as the combined taxation of profits regardless of tax jurisdiction. Due to similar trends in tax rates, the explanation of the distribution of the tax burden may be apt in a two-sector model, i.e., the impact of changes in tax rates on profits of capital enterprises should be applied to a closed-economy model, where the degree of product substitution and the capital intensity of production in each business sector will play a key role. This can be assumed, due to the fact that the adjustment of tax rates abroad induces a reduction

in the importance of capital flows for models, causing a lack of reasons for capital movement. This has the effect of closing the frontier for capital flows caused by changes in tax rates, the price for saleable products abroad remains relatively constant, because costs at home and abroad increase the same due to tax. This is represented in the figure below:

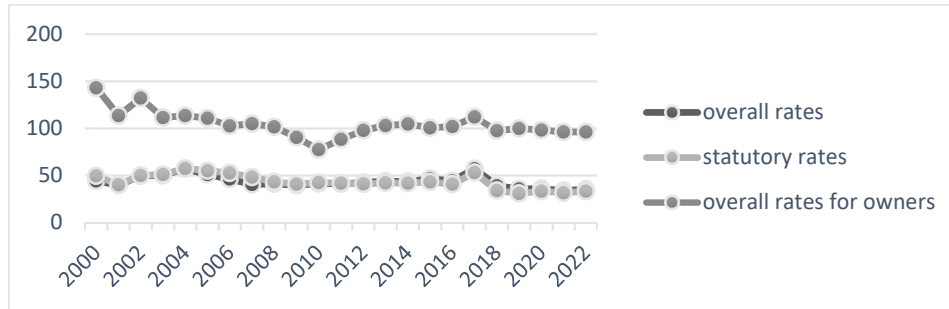


Figure 1. Arithmetic average tax rates on corporate profits in OECD countries from 2000 to 2022

Source: OECD. TAX DATABASE. Oecd.org, [accessed: 11.01.2023]

The overall taxation of owners shows more variation than the taxation of profits. This is illustrated in the figure below as the variance of the applicable normative rates. On the other hand, by 2010, the variance of the overall taxation of business owners decreased, mainly due to a reduction in the variance of dividend taxation, to a lesser extent by a reduction in the variance of profit taxation. Subsequently, the differential taxation of dividends increased and continued despite the continuation of the downward trend in tax rates. It is worth noting that the decline in dividend taxation in 2009 coincides with the timing of the global financial crisis (see. Figure 1). It is worth noting that the total taxation of corporate profits peaked in 2004 and 2017, then showed a downward trend, with less variation in rates (see Figure 2).

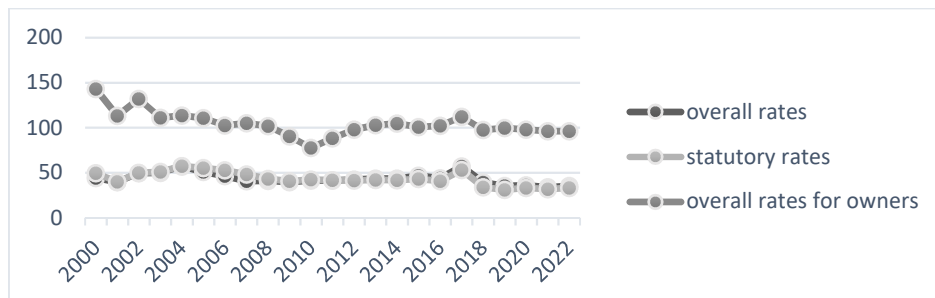


Figure 2. Variance of tax rates of OECD countries from 2000 to 2022

Source: OECD- TAX DATABASE, [accessed 11.01.2023]

Thus, the situation is different in terms of the variance of rates across countries, based on the figure above. However, it is important to consider that the significance of changes in tax rates depends on the relationship of a country's rates to the countries with which it trades the most. The occurrence of a certain trend, however, proves that countries are reducing taxes to a similar extent, where one can even speak of a trend. With such trends in tax rates, tax revenues have fluctuated with little coincidence with rates. These, in turn, peaked at around 3.5% of GDP in 2007, reaching a minimum in 2013. After that, revenues continued to rise until 2018. It is worth noting that changes in tax rates do not directly translate into fiscal efficiency.

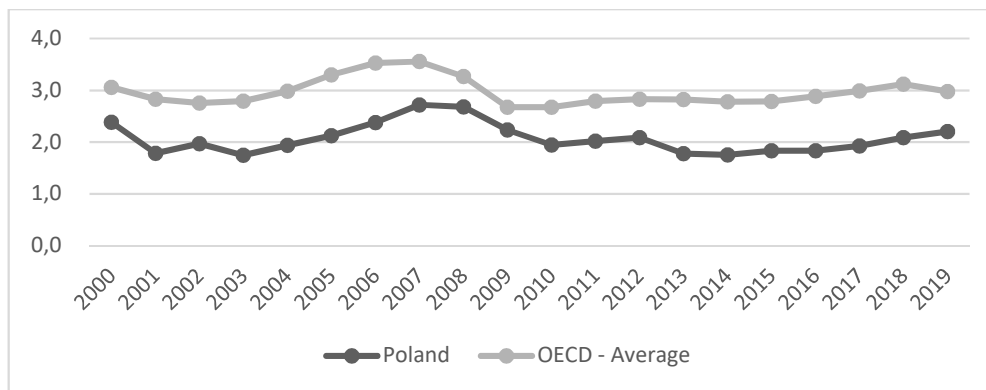


Figure 3. Tax receipts in Poland and on average in OECD countries in 2000-2019 in relation to GDP

Source: OECD, TAX DATABASE, [accessed: 11.01.2023]

The correlation coefficient of tax rates in Poland with average tax rates in OECD countries shows a strong correlation of 0.82. The higher correlation between rates for taxation for owners is 0.89. Thus, the results for Poland should be based from this point of view on the two-sector closed economy model rather than for the open economy model, which does not exclude this possibility regarding the prediction of future effects, or taking into account many other specific factors. For the analysis of a particular country, one should, of course, take into account the countries with which trade is highest. Also, the above indicator should be interpreted with a great deal of caution, as specific tax revenues can be the result of high as well as low tax tariffs. From the above studies, the finding is that, for the most part, the effects of changes in Poland should be considered cautiously taking into account the simplest shift effects between capital and labor in the country, that is, according to the degree of substitutability and capital intensity of production.

Table 2. Structure of tax revenues in Poland in 2020-2021 according to the OECD classification

Typy podatków	2020	2021
2000 Social security contributions	20,96%	19,84%
5000 Taxes on goods and services	19,81%	20,96%
1000 Taxes on income, profits and capital gains	11,57%	12,04%
1100 Of individuals	16,17%	16,18%
1200 Corporate	3,48%	3,95%
1300 Unallocable between 1100 and 1200	0,00%	0,00%
2100 Employees	8,74%	8,62%
2200 Employers	7,97%	6,51%
2300 Selfemployed or nonemployed	4,25%	4,71%
2400 Unallocable between 2100, 2200 and 2300	0,00%	0,00%
3000 Taxes on payroll and workforce	0,83%	1,14%
4000 Taxes on property	1,99%	1,93%
4100 Recurrent taxes on immovable property	1,85%	1,71%
4110 Households	0,51%	0,48%
4120 Others	1,23%	1,14%
4200 Recurrent taxes on net wealth	0,00%	0,00%
4300 Estate, inheritance and gift taxes	0,04%	0,05%
4400 Taxes on financial and capital transactions	0,46%	0,59%
4500 Nonrecurrent taxes	0,00%	0,00%
4600 Other recurrent taxes on property	0,00%	0,00%
6000 Other taxes	0,06%	0,07%
6100 Paid solely by business	0,00%	0,00%
6200 Other	0,06%	0,07%
Suma końcowa	100,00%	100,00%

Source: own compilation based on: OECD. https://stats.oecd.org/index.aspx?DataSetCode=TABLE_I4 [accessed: 13.02.2023]

The relevance of the research on the accrual of income tax paid by businesses is not due to its fiscal efficiency, although it is a fairly important tax it is less significant than others. The relevance of the research on the shift side of the tax is due to its importance as a capital tax, which is a factor with limited resources, and whose importance for the creation of capital resources is very important. This is because it relates to the issue of innovation in the economy.

4. Research on tax incidence

Statistical data on the structure of tax revenues, the amount of tax rates can not be the basis for assessing the phenomenon of tax incidence. These provide an opportunity to assess the economic burden of tax in general.

High rates can be an expression of hard tax policy, where a side effect, according to the Laffer curve, can be tax flight, i.e. a phenomenon that causes a different distribution of tax burdens within a group in general: owners, employees, or consumers. Research on tax shifting can be divided into three groups: survey research, time-sequence research and proper (empirical) research initiated by R. Musgrave and M. Krzyzaniak in 1963. In the literature, empirical studies lead the way because they can be conducted regardless of the timing of the change in taxes, are low-cost, and make it possible to take into account non-tax factors on the market equilibrium and their impact on the distribution of tax burdens. Within the framework of research, the results obtained show divergent results. This is due to the different approaches to the empirical model built. However, the discrepancies, once eliminated, indicate a partial distribution of tax burdens between capital and labor. Most models are built on the basis of the Cobb-Douglas production function or its generalized form of the C.E.S. (constant elasticity of substitution) function, and so due to this take into account the possibilities of substitution between the factors of production of capital and labor and land. The essence of capital and labor substitution is of fundamental theoretical and practical importance. The degree of substitution determines whether it is possible to substitute one for the other as a result of taxation. If this substitution were perfect, then capital would bear the entire tax burden. Of course, it is also possible to study the effect of taxation on prices, but then this does little to assess the effects on the sphere of production.

Summary

The analysis of the impact of taxation of capital formation in a capital enterprise on the distribution of tax burdens in the economy indicates that it is possible to completely pass the tax on to labor resources as well as, conversely, to carry the entire tax burden by the owners of capital, not only capital formation in a capital enterprise. The degree to which this burden is carried depends significantly on the 5 factors identified in tax incidence models, which were created independently of empirical studies on the subject. These models made it possible to map a country's market economy and capture the following determinants of incidence, i.e. international capital mobility, international product substitution, country size, substitution between capital and labor factors, and sector capital intensity. Certainly, moving to a more generalized analysis, we return to the formed knowledge of price elasticity of demand and supply. The above review is an initial step in the study of the incidence side of income taxes on the profits of capital enterprises. The impact of this tax is not obvious in this regard due to the complicated incidence mechanism backwards mainly on labor resources and the possibility of changing the capital

structure. The similarity of trends in normative tax rates makes it possible for even the two-sector incidence model to explain the impact of taxation on the supply of capital and labor in Poland.

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GLOBAL AND EUROPEAN TRENDS IN THE SUSTAINABLE BOND MARKETS

Abstract

The implementation of climate policy requires the mobilisation of a huge amount of capital to realise the investments envisaged in accordance with the Paris Agreement. Financing these investments requires both public funds at the supranational level, state governments, local and regional governments as well as private funds, from individual investors. It is essential to allocate capital in sustainable investments that will show positive effects of a long-term nature. These requirements are met by bond issuance and its wide range of types.

The aim of this paper is to present the differences in the development of the bond markets for financing sustainable development from a global perspective, including the European and Polish markets. Analysis of differences in the types of bonds issued and their volume, the activity of issuers, regulatory conditions, challenges and good practices and recommendations are indicated. The methodology of the study refers to a review of legal regulations, subject reports, and Climate Bonds Initiative's empirical data.

The research results indicate that, by 31 December 2023, climate bonds had recorded aligned GSS+ instruments (green, social, and sustainability bonds + SLBs) with cumulative volume of USD4.4tn. Europe was the largest source of aligned GSS+ debt instruments, with USD405bn representing 46% of the 2023 total. Among green bond issuers, the leaders in the global economy are financial enterprises (57% of issues) and non-financial enterprises (29%). Energy, buildings, and transport remained the three

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largest use of proceeds categories, collectively contributing 75% of the green debt volume. In terms of currencies for the issuance of green instruments, the main currencies were EUR and USD (63% of issues).

Keywords: climate policy, sustainable finance, bonds, GBP, CBS, EuGB.

JEL classification: G15, G18, G23, Q54

Paper type: Research article

Introduction

The development of sustainable markets, including bonds, is influenced primarily by the state of legal regulations, changes in climate risk and the preferences and requirements of institutional and corporate investors. Green bonds play an important role in this trend, as they enable obtaining capital for the development of zero-emission projects in sectors such as energy, transport, or the circular economy.

According to Climate Bonds Initiative (CBI), the value of green bonds issued so far in the world exceeded USD 4.4 trillion in 2023. The offer of debt instruments financing sustainable development is constantly expanding. In addition to social and sustainable bonds, investors are also increasingly interested in bonds related to the sustainable development goals (sustainability-linked bonds), enabling financing for the overall implementation of the climate neutrality strategy.

The first issues of green bonds took place in Europe. Their first issuer in the world was the European Investment Bank (EIB), which in 2007 issued the so-called Climate Awareness Bonds. These instruments initiated the practice of monitoring and reporting the use of emission funds for green projects (EIB, 2017). This advantage resulting from 'first mover advantage', combined with ambitious climate policy goals and dynamically developing regulations in sustainable financing, naturally predisposes the countries of Western and Northern Europe to become leaders of the green bond market.

Nearly 20 years of development of the green bond market is a good basis for analysing current development trends. Therefore, the aim of the study is to present the differences in the current development of bond markets financing sustainable development from a global perspective, including the European and Polish markets. Indication of differences in the type of bonds issued and their volume, issuers' activity, regulatory conditions, challenges as well as good practices and recommendations.

1. Sustainable development, legal regulations, and financing instruments

Sustainable development is related to actions aimed at protecting the environment and counteracting the climate crisis. This concept first appeared in the 1987 report of the World Commission on Environment and Development "Our Common Future", according to which "sustainable development is development in which the needs of the present can be met without compromising the opportunities of future generations." generations to meet their needs" (Brundtland, 1987, p. 18).

The 2030 Agenda for Sustainable Development (under UN Resolution 2030), adopted in 2015 by 193 member states, identified 17 Sustainable Development Goals (SDGs), including 169 specific tasks to be finalized by signatories by 2030. UN indicates that goals and objectives are interdependent and indivisible and ensure a balance between three aspects of sustainable development: environmental, social responsibility, corporate governance (ESG) (UN, 2015).

Another important act was the Paris Agreement, obliging 195 signatory countries to take action to mitigate ongoing climate change. The agreement entered into force in November 2016. The key goals of the Paris Agreement include keeping the increase in average global temperature below 2°C and taking actions to limit the increase in average global temperature to 1.5°C, which would significantly reduce the risk and impacts of climate change (UNFCCC, 2015). The Agreement also indicates the need to make financial flows consistent with the path of increasing the average global temperature below 2°C. This applies to directing financial resources to activities related to reducing greenhouse gas emissions and supporting development that is resistant to climate change (UNFCCC, 2015).

The European Commission defines sustainable finance (or finance) as relating to the process of considering environmental, social and governance (ESG) aspects when making investment decisions in the financial sector, leading to more long-term investments in sustainable economic activities and projects (EC, 2024). EU ESG regulations in the form of directives, regulations and implementing acts are characterized by a wide subjective and objective scope and numerous references to other sector-specific regulations. The main regulations include:

- Nonfinancial Disclosure Reporting Directive (NFRD, 2014/95/EU),
- Ordinance Sustainable Finance Disclosure Resolution (SFDR, 2019/2088),
- Regulation 2020/852 of the European Parliament and of the Council, the so-called Taxonomy on establishing a framework to facilitate sustainable investment and Regulation 2021/2178,
- Corporate Sustainability Reporting Directive (CSRD, EU/2022/2464),

- European Sustainability Reporting Standard (ESRS adopted on July 31, 2023),
- Corporate Sustainability Due Diligence Directive (CSDD, EC/2022/0051),
- Task Force on Climate – Realized Financial Disclosures (TCFD),
- Regulation of the European Parliament and of the Council of 22 November 2023 on European Green Bonds and optional disclosures for bonds marketed as environmentally sustainable and for sustainability-linked bonds (Regulation EuGB, EU, 2023/2631).

For financial institutions refer disclosure of ESG risk in accordance with the requirements of the third pillar of the CRR and climate risk management, the European Central Bank (ECB) guidelines on disclosures related to climate risk have been in force.

Sustainable development financing instruments vary depending on the market: money, capital, or investment funds. In the banking sector, there are both short- and long-term loans, e.g., for removing the effects of natural disasters, ecological loans for enterprises wanting to modernize infrastructure, implementing technological innovations or various types of improvements, as well as development loans for social economy entities and loans to support energy efficiency, as well as for sustainable development (Kosztowniak, 2023; 2024). Capital markets provide the opportunity to purchase shares in companies producing renewable energy (solar and wind) or developing environmentally friendly transport, or even waste management, or bonds supporting sustainable development. In turn, the investment fund market allows the purchase of Exchange Traded Fund (ETF) for renewable energy, i.e., green ETFs replicating the market results of main companies involved in the green economy (Flammer, 2021; Reboredo, Ugolini, 2020, pp. 25-38).

Among the debt instruments offered are several types of bonds financing sustainable development. The classification of bonds financing activities related to sustainable development is determined mainly by the purpose of issuing these instruments, i.e., by the method of use of the acquired funds declared by the issuer or by linking the bond interest rate with the issuer's achievement of specific Key Performance Indicators (KPIs) values related to ESG factors. An additional element that distinguishes the vast majority of issued sustainable bonds is a dedicated document constituting the framework for the issue prepared in accordance with applicable international standards (e.g., Green Bond Framework or Social Bond Framework) (Table 1).

Table 1. Main types of bonds financing sustainable development

Type of bond	Purpose and guidelines	Sample investment catalog
Green Bonds	<ul style="list-style-type: none"> • These instruments are distinguished by the need to define an emission target, the implementation of which is to have a positive impact on the natural environment (the so-called green emission target). • The most common green bond issuance standards on the market are the Green Bond Principles ("GBP") and Climate Bonds Standard ("CBS"). 	<ul style="list-style-type: none"> • renewable energy, • energetic efficiency, • pollution prevention and control, • protection of terrestrial and aquatic biodiversity, • ecological transport, • sustainable water and sewage management, • adaptation to climate change, • green construction
Transition Bonds	<ul style="list-style-type: none"> • Financing the transition of enterprises to a more environmentally sustainable business model and thus reducing the negative impact of a given enterprise on the natural environment (e.g., by reducing carbon dioxide emissions). • Emission standards are included in the Regulation of the European Parliament and of the Council (EU 2020/852 of 18/06/2020). 	<ul style="list-style-type: none"> • activities aimed at successively reducing the negative impact on the environment of further business activities of enterprises from high-emission sectors • changing the business model of their operations to a more environmentally friendly one (e.g., installation of devices that reduce the emission of burning fossil fuels, inclusion of renewable energy in the companies' energy mix, etc.).
Social Bonds	<ul style="list-style-type: none"> • Reducing emissions to levels that are expected to contribute to achieving positive social impacts. • The social bond (SB) guidelines are structured similarly to GBP. 	<p>providing or promoting:</p> <ul style="list-style-type: none"> • affordable basic infrastructure (e.g., clean drinking water, sanitation, sewerage) or access to basic services (e.g., health care and education), • access to affordable housing, • food security and a sustainable food system, • socio-economic development, as well as equality and empowerment • creating jobs and preventing or alleviating unemployment resulting from socio-economic crises

Sustainability Bonds	Goals consistent with green and social bonds. Sustainability Bonds are fixed-income financial instruments (bonds) where the proceedings will be exclusively used to finance or re-finance a combination of Green and Social Projects and which are aligned with the four core components of the International Capital Market Association (ICMA) Green Bonds Principles and Social Bonds principles	<ul style="list-style-type: none"> • green project categories suggested by the principles include energy, buildings, transport, water management, waste management & pollution control, nature-based assets including land use, agriculture and forestry, industry & energy-intensive commercial, information technology & communications (ICT) • social project categories suggested by the principles include affordable basic infrastructure, access to essential services, affordable housing, employment, food security and sustainable food systems, socioeconomic advancement, and empowerment.
Sustainability-linked bonds	Sustainability-linked bonds is a fixed income instrument (Bond) where its financial and/or structural characteristics are tied to predefined Sustainability/ESG objectives. The objectives are measured through predefined Key Performance Indicators (KPIs) and evaluated against predefined Sustainability Performance Targets (SPTs).	<ul style="list-style-type: none"> • reducing greenhouse gas emissions • increasing the share of renewable energy sources in the company's energy mix, etc.

Source: Own study based on: ICMA (2020, 2020a-c)

2. European green bond – uniform requirements for issuers and conditions for obtaining the EuGB label

When it comes to the regulation of the issuance of European green bonds, it has been standardized by Regulation of the European Parliament and of the Council (EU, 2023/2631). The European Green Bond Standard (EuB) Regulation adopted on November 22, 2023, must be applied in practice by issuers from December 21, 2024 (Article 72), including all issuance procedures and pre-issue and post-issue inspections, in scope of actual use of the funds obtained for sustainable investments.

Importantly, to standardize the standards for the issuance of green bonds, the European Commission decided to choose the form of a regulation rather than a directive, which in practice means that Member States do not have to create their own legal regulations in this area, and the applicable regulations regarding green bonds will be the same in each country.

Member State. The regulation therefore aims to define a single set of detailed requirements for issuers wishing to use the "European Green Bond" or "EuGB" label.

In terms of the subject matter, in accordance with the EuGB Regulation, environmentally sustainable bonds are among the main instruments for financing investments related to environmentally sustainable technologies, energy and resource efficiency, as well as environmentally sustainable transport infrastructure and environmentally sustainable research infrastructure and waste management.

In subjective terms, there is a wide list of institutions (public and private) that can issue green bonds, i.e.:

1. international financial institutions such as the World Bank group,
2. commercial (non-financial) enterprises, e.g., from the energy and construction industries,
3. financial institutions, e.g., banks, investment funds, insurance institutions,
4. units' local government territorial,
5. countries.

The quality guidelines for European green bonds in the regulation are intended to ensure uniform conditions for the issuance of such bonds by avoiding divergences between national requirements that could arise as a result of the transposition of the Directive and should ensure the direct application of these conditions to issuers of such bonds (recital 8 of the EuGB Regulation).

To implement the above assumptions, a register system was established, as well as supervisory procedures for external controllers of European green bonds. It also sets out optional templates for the disclosure of information on bonds marketed as environmentally sustainable and sustainability-linked bonds in the Union. Moreover, the regulation of the issue of green bonds is intended to counteract the phenomenon of *greenwashing*, i.e., the false use of markings indicating that funds from bonds are spent on environmentally friendly purposes.

Moreover, in accordance with Art. 3 of the Regulation, the "European Green Bond" or "EuGB" label shall only apply to bonds that comply with the requirements set out in Title II of the Regulation. The general principle of allocation of revenues obtained from green bonds is specified in Art. 4 section 1 of the regulation (so-called gradual approach). Such revenues should be allocated "in accordance with the taxonomy requirements", which, according to recital 11 of the Regulation, means that these revenues should be allocated to finance assets and expenses related to economic activities that meet the criteria for environmentally sustainable

economic activities, as defined in accordance with the provisions of Regulation 2020/ 852 (so-called EU Taxonomy).

Green bond revenues allocated to economic activities that qualify as environmentally sustainable must also be allocated within one of five categories:

- fixed assets that are not financial assets (e.g., shares, stocks, securities),
- specific investment outlays , in particular regarding assets or processes related to business activities consistent with the taxonomy or regarding the purchase of measures enabling the target activity to become low-emission or enabling it to reduce greenhouse gas emissions,
- specific operational expenditure incurred no more than three years before the issuance of the European Green Bond, in particular assets or processes related to business activities consistent with the taxonomy, including training and other needs related to the adaptation of human resources,
- financial assets that were created no more than five years after the issuance of the European Green Bond,
- household assets and expenses.

Issuers may, before allocating revenues from a European green bond, deduct issue costs from these revenues. The Regulation provides that issuers will be able to allocate up to 15% of the revenues from the European Green Bond to economic activities that comply with the taxonomy requirements, provided that the activities constitute:

- economic activities for which no technical eligibility criteria have entered into force by the date of issuance of the European Green Bond,
- activities in the context of international support, provided that such activities are subject to reporting in accordance with specific guidelines (including climate financing reported to the Commission under the UN Framework Convention on Climate Change and official development assistance reported to the Development Assistance Committee of the Organization for Economic Cooperation and Development).

In addition to mandatory regulations aimed at clearly regulating and standardizing green bonds, market standards and guidelines are important:

- The Green Bond Principles (GBP) were developed by the International Capital Market Association (ICMA). These regulations present a broad set of voluntary guidelines regarding the transparency and openness

of the processes of using funds, the types of eligible projects, their evaluation and selection, management of funds obtained and reporting. The aim of GBP is to provide better access to information for market participants and to promote the issuance of green bonds as a source of financing for pro-ecological projects. GBP do not explicitly require certification by an independent third party of the green bond issuance framework or the use of funds and impact reporting (ICMA, 2021a).

- Climate Bonds Standard (CBS) was developed by Climate Bonds Initiative (CBI) are detailed conditions for classifying projects as green, broken down into individual sectors (e.g., renewable energy, water management, construction, transport, etc.) (ICMA, 2021a).

3. Global and European differences in the issuance of green bonds

According to Climate Bonds Initiative by 31 December 2023, Climate Bonds had recorded aligned GSS+ instruments (green, social, and sustainability bonds + SLBs) with cumulative volume of USD4,4tn. In 2023, Climate Bonds captured aligned volume of USD870bn, 3% more than the 2022 figure of USD843bn. 68% of this came from the green theme which added USD587.3bn, reflecting a 15% YOY increase. Conversely, there was a YOY decline in the volume of social and sustainability bonds by 7% and 30% respectively. SLBs, the smallest segment, experienced a remarkable 83% increase in aligned volume, reaching USD21,4bn compared to USD11.7bn in 2022. Latin America is the only region where sustainability bonds constitute the largest share of the aligned GSS+ debt market, reaching 47% by the end of 2023. It is also the only region to consistently increase its sustainability bond volume in the past four years.

Regionally, Europe was the largest source of aligned GSS+ debt instruments, with USD405bn representing 46% of the 2023 total. Latin America delivered a 49% spike YOY. Conversely, anti-ESG sentiment affected aligned GSS+ volume in the USA, resulting in a 38% decline. The ten largest issuers accounted for 39% of the green volume, led by the UK which added USD22.5bn through multiple reopenings of its sovereign green bonds. More than half (53%) of the 2023 aligned green bond volume originated from Europe, contributing USD309.6bn and achieving 23% growth versus 2022. Aligned green bonds from Albania, Cyprus, Macedonia, and Montenegro emerged for the first time in 2023. Asia-Pacific was the second most prolific region for 2023 green bond issuance, contributing one-third of the total aligned issuance volume (USD189.4bn), 44% of which from China. (Fig.1).

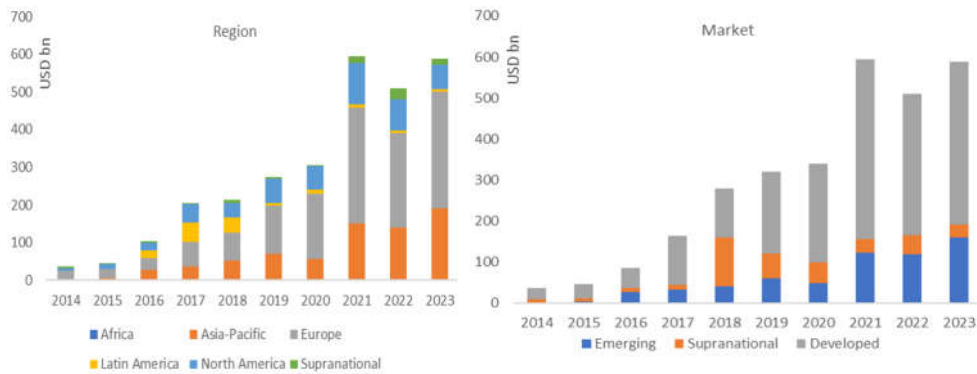


Figure 1. Climate bonds initiative according to region and market 2014-2023 (USD bn)

Source: Own preparation based on: CBN (2024)

To issuer type, in line with 2022, the corporate sector fuelled 2023 green volume, contributing 57% of issuance. Non-financial corporate issuers contributed 29% of the 2023 market share spread over 692 aligned green instruments amassing a sum of USD171.8bn. Financial corporates emerged as the second-largest issuer type with a 28% share of aligned green volumes. Chinese banks dominated, with the top three financial corporate issuers being Industrial Bank Co., Bank of China, and Industrial and Commercial Bank of China. Aligned green volume from local government issuers remained broadly similar YOY at USD11.5bn. Queensland Treasury Corporation made the largest contribution with an AUD3bn (USD2bn) deal financing low-carbon transport, solar energy, and water infrastructure. Sovereigns returned to the social bond market in 2023, having been absent in 2022 (Fig. 2).

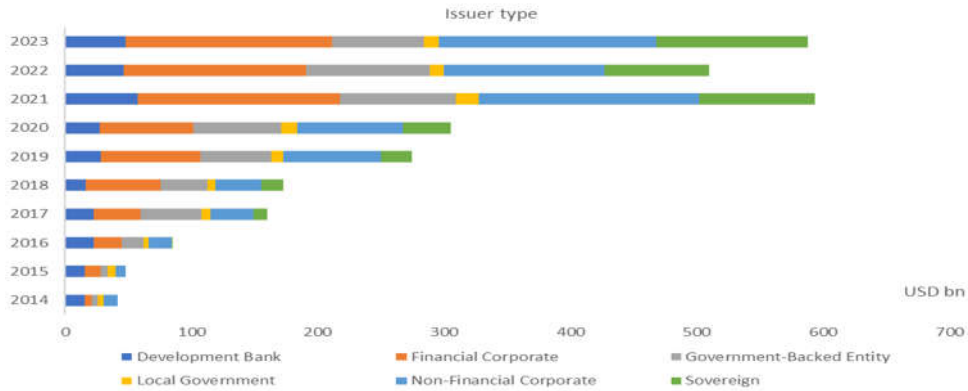


Figure 2. Climate bonds initiative according to issuer type 2014-2023 (USD bn)

Source: Own preparation based on: CBN (2024)

Energy, Buildings, and Transport remained the three largest use of proceeds (Up) categories, collectively contributing 75% of the green debt volume. However, this is a drop versus the 77% in 2022 and cumulative 79%. Smaller categories are gaining share as more issuers (including large sovereigns) finance a broader range of projects. The largest change came in the buildings category, whose estimated share dropped to 18% in 2023 from 25% in 2022. By contrast, Land use has been on the rise for several years, achieving 6% in 2023 versus 5% in 2022 and cumulatively; much of this comes from Latin American issuers (Fig. 3).

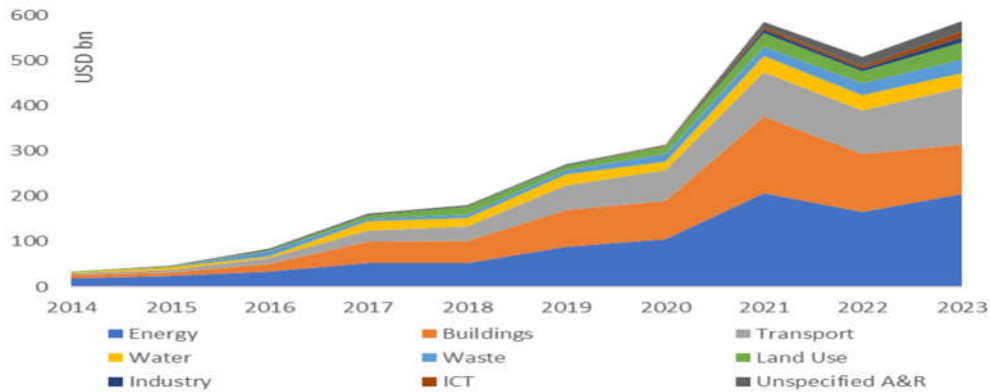


Figure 3. Climate bonds initiative according to use of proceeds 2014-2023 (USD bn)

Source: Own preparation based on: CBN (2024)

In terms of currencies, the issue of green instruments, GSS deals were priced in 44 currencies, with 63% of the issuance from the top two currencies: EUR (USD339.5bn) and USD (USD212bn). Of the aligned green volume, 87% came from five currencies: EUR, USD, CNY, GBP, and INR. EUR dominated the green theme for the sixth consecutive year with 44% of the volume. The USD remained the second most prominent currency. INR and GBP both experienced surges during 2023: INR driven by issuance from clean energy company ReNew Power and India's entry into the sovereign green bond market, GBP largely due to increased sovereign issuance from the UK. Hard currencies took two-thirds of the sustainability volume in 2023. MXN came third with 18 deals, and 50% of the volume originating from the Mexican Government. In the social theme, USD and KRW were tied at the top during the year, each reaching USD47bn (CBN, 2024).

4. Opportunities and challenges and recommendations regarding the Polish market

At the beginning, it is worth emphasizing that green bond issues are not new on the Polish market. The first green treasury bonds in Poland were issued by the Ministry of Finance in December 2016 and reached a value of EUR 750 million. At that time, the model provided one-third funding for sustainable agriculture ('sustainable farming'), as part of the funding for national participation in the EU's Rural Development Programme. A similar amount was allocated for the government's long-term railway investment program ("clean transport") in the field of passenger transport. Only one fifth of the proceeds from the issue was allocated to renewable energy ("excise tax refinancing"), and the rest to the activities of national parks.

Issuances of green corporate debt were initiated in Poland in 2019 by mortgage banks - when two issues took place with a total volume of PLN 900 million. There were five issues in 2020, all by non-financial companies. In turn, in 2021, there were five issues, including two pioneering benchmark issues with a volume of EUR 500 million each. In 2024, there are already 20 issuers of sustainable bonds on the Warsaw Stock Exchange (WSE).

For the further development of the sustainable investment market, clear legal regulations and favorable supply and demand conditions shaped by a system of various fiscal and non-fiscal incentives are important.

Opportunities for the development of the sustainable market bonds is provided in Poland by the Capital Market Development Strategy (SRRK), adopted by the Council of Ministers in 2019. This strategy provides for the development of the green bond market as one of the tools to effectively support the financing of the transformation of the economy towards low-emission. In addition, the EuGB regulations adopted at the EU level (2023/2631) guarantee the unification of requirements for issuers

and conditions for obtaining the EuGB label, as well as the harmonization of the legal framework for the issuance of green bonds, the eligibility criteria of projects financed by them, and the disclosures required from issuers. The legal transparency of these regulations will support the further development of the market for sustainable financing instruments.

The initiative to regulate the green bond market also responds to the needs of Polish entrepreneurs. Although the use of green bonds is currently not a popular tool in Poland, attention should be paid to alternative and non-refundable programs operating on our market, which are undoubtedly preferred by entrepreneurs. By 2030, a total of PLN 260 billion from EU and national funds will be allocated to green transformations. Support will be provided through cohesion policy programs, the Recovery and Resilience Instrument, the Just Transition Fund, the REACT-EU Initiative, programs of the National Fund for Environmental Protection and Water Management, the Common Agricultural Policy, and national earmarked funds.

Research conducted by KPMG (2021) shows that the key determinants of the decision to issue green bonds are image benefits for the issuer, increased demand from investors and the expansion of their base, potentially more favorable pricing conditions for green debt (so-called greenium) and the occurrence of possible regulatory benefits. Moreover, from the investors' point of view, factors influencing the decision to purchase green bonds include issues related to managing one's own exposure to climate risk, adapting to regulatory changes and image benefits. The advantages of green bonds include the fact that these bonds generate exposure to traditional types of financial risk known to investors.

The KPMG Report (2021) shows that the investment plans and development strategies of Polish cities and non-financial enterprises indicate a significant development potential of the green bond market among municipal and corporate issuers, mainly in the energy, transport and construction sectors. Market participants see the potential to popularize green municipal bonds among retail investors if the availability of the municipal debt market for this customer segment increases.

Among the challenges development of the green bond market in Poland, current additional costs of organizing the issue related to the preparation of the green bond framework and external verification, as well as operational challenges, should be mentioned². The issue of a lower cost of capital in green emissions is also unclear. Another challenge is to raise awareness

² Some changes in this respect will be brought by the Regulation of the European Parliament and of the Council (EU, 2023/2631) from December 21, 2024, which, as mentioned, provides for the possibility of deducting issue costs from revenues from European green bonds.

of the possibilities of issuing green bonds and to increase the credibility of investors operating in accordance with the EUGB regulation and market standards such as Green Bond Principles and Climate Bonds Standard.

Directional recommendations that may contribute to stimulating the development of the green municipal and corporate bond market in Poland (although those formulated by KPMG in 2021 are still valid) should include activities addressed to both issuers of these instruments and investors. Belong to them:

- Elimination or reduction of additional costs related to the issuance of green bonds by establishing a grant program to partially cover additional costs resulting from the green nature of the issue and establishing a Polish institution carrying out an independent external assessment of the credibility of green emission goals.
- Indirectly, the costs of the issue may also be reduced by establishing a Green Bond Competence Center, which would support entities in preparing to organize the first green issue.
- Considering the introduction of an incentive mechanism for issuers and investors.
- Expanding the investor base by developing and implementing a platform enabling individual investors to purchase green municipal bonds without the need to have a brokerage account or with a very simple and cost-free process for the investor to set up a brokerage account in any entity and regulating the possibility of financing local governments using quasi-crowdfunding solutions, modeled on the British Community Municipal Investments (CMI).
- Educational and promotional activities and supporting market transparency, including the organization of training and the development and implementation of the Polish Sustainable Finance Platform.

Summary

Green bonds are the latest development in both the global debt market and (generally) the capital market. Regulation (EU) 2023/2631 of the European Parliament and of the Council harmonized the requirements for issuers and conditions for obtaining the EuGB label. The proposed changes introduce a wide range of entities authorized to issue green bonds, provide for maintaining high investment standards and mechanisms of effective pre- and post-issuance control. It is expected that this Regulation (EuGB) will influence the popularization of green bonds and will be another milestone towards climate neutrality. The initiative to regulate the green bond market responds to the needs of many issuers (institutional and commercial as well as wholesale and retail).

Climate research results Bonds Initiative (CBI) for the years 2014-2023 indicate the dynamic development of sustainable bond markets as well as their significant differences at the global (continent), regional (EU) and national levels. These differences concern the type of bond issue, the activity of individual groups of investors and supporting incentives, and thus the prospects for accelerating the climate transformation.

The research results indicate that, by 31 December 2023, Climate Bonds had recorded aligned GSS+ instruments (green, social, and sustainability bonds + SLBs) with cumulative volume of USD4.4tn. 106 countries participated in the emissions. Europe was the largest source of aligned GSS+ debt instruments, with USD405bn representing 46% of the 2023 total. Among green bond issuers, the leaders in the global economy are commercial enterprises (57% of issues) and non-financial enterprises (29%). Energy, Buildings, and Transport remained the three largest use of proceeds categories, collectively contributing 75% of the green debt volume. In terms of currencies for the issuance of green instruments, the main currencies (of all 64 currencies) were EUR and USD (63% of issues).

KPMG's research for the Polish green bond market shows that the key determinants of the decision to issue green bonds are image benefits for the issuer, increased demand from investors and expansion of their base, potentially more favorable pricing conditions for green debt (so-called greenium) and the occurrence of possible regulatory benefits.

From the investors' point of view, factors influencing the decision to purchase green bonds include issues related to managing one's own exposure to climate risk, adapting to regulatory changes and image benefits. The advantages of green bonds include that they generate exposure to traditional types of financial risk known to investors.

Barriers to the development of the Polish market include increasing issuance costs, low level of economic benefits in the short term, including tangible benefits from green bonds compared to ordinary bonds (greenium), operational challenges and restrictions on the ability of individual investors to purchase municipal bonds. Another challenge on the capital market is to reconcile the expectations of issuers, who count on lower costs of capital, with the expectations of investors, who seek high profits. Meeting this challenge requires the development of institutional support programs (e.g., fiscal, and non-fiscal).

Moreover, increasing the credibility of investors and raising awareness among all market participants is crucial for the development of the market. These activities are promoted by the Warsaw Stock Exchange (WSE), which in 2023 decided to create a segment on the Catalyst market dedicated to sustainable bonds (Warsaw Sustainable Segment). The development of this segment is achieved through the issuance of sustainable bonds

and covered bonds, and in 2024 there will already be 20 issuers operating in this segment. In the years 2021-2023, WSE was a partner of two editions of the Green Bond Framework program, addressed to companies and local government units, in cooperation with the International Finance Corporation (IFC), a member of the World Bank Group.

To sum up, it is worth emphasizing that while the European green bond market has been unified (EU, 2023/2631), the global market for these bonds requires regulation and standardization at the supranational level. In its absence, investments will be at risk of *greenwashing*.

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ARTICLES

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ASSESSING THE IMPACT OF CLIMATE POLICIES AND RISKS ON THE MACROECONOMIC SITUATION OF EU COUNTRIES

Abstract

Extreme weather events and the need to trigger the necessary adaptation processes in the economy are sources of direct and indirect climate risks. The diverse nature of climate change means that geographical regions are exposed to incur financial losses to varying degrees, with implications for the country's macroeconomic situation. This variation can also lead to a geographical concentration of risk and undermine financial stability. The aim of the study is to present climate risks and their impact on changes in the socio-economic situation, including the financial situation of economies, labour markets and living conditions related to pollution and environmental change. The study undertook an overview of legal regulations, theoretical aspects, research findings, including the Yale Center for Environmental Law & Policy. Statistical data sources were drawn from Eurostat, the OECD, and the World Bank. The findings indicate that Southern and Western European countries are most exposed to the physical risks associated with climate change, including deteriorating living conditions associated with pollution. There is a growing demand for ESG experts in the labour market. The 2024 Environmental Performance Index (EPI) provides, that countries' wealth is a strong predictor of their overall

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environmental performance, but some countries vastly outperform their economic peers, while others lag. Among the leaders of the greenest countries are Estonia, Luxembourg, Germany, Finland and United Kingdom, and Poland (19th position).

Keywords: climate policy, climate risk, macroeconomic situation, EPI scores, EU.

JEL classification: G15, G18, G23, Q54

Paper type: Research article

Introduction

The significant temperature rises, and the increasing number of wildfires, hurricanes and rainstorms are important sources of direct climate risk and causes of substantial financial and social losses. Economic adaptation measures and restrictive regulations introduced by the public administration are expected to reduce the negative effects of rapid climate change in the long term. However, they are also sources of transition risk, as they carry the cost of discontinuing certain economic activities, as well as the need to set aside investments to meet new standards and implement new "green" technologies. On the other hand, they create markets for new products and represent an opportunity for development of innovative enterprises and new jobs.

The nature of climate change depends on the geographic location. Countries in the southern part of Europe are prone to more frequent high temperatures and consequent forest and building fires. Northern parts of Europe, on the other hand, are more likely to be hit by heavy rains and floods. The diverse nature of climate change means that the cost of materializing direct climate risks depends largely on geographic location. Moreover, different sectors of the economy require different investments to adapt to a zero-carbon production profile. They also have different energy supply structures. These factors expose different EU countries to differentiated transition risks. The overlap in the distribution of these two types of risk can result in a concentration of risk in different geographic regions and EU countries (IPCC, 2014).

Such significant variation in the nature and magnitude of climate change motivates the investigation of the scale and scope of the costs incurred by EU economies for climate-induced losses, as well as the socioeconomic changes caused by the detrimental effects of climate on the economy and efforts to achieve a zero-carbon economy. The research presented here makes an important contribution to the literature on the nature of climate risk in EU countries and the magnitude of losses incurred as a result of the impact

of climate risk on EU economies through direct and indirect transmission channels.

The remainder of the article is structured as follows. The first chapter presents the conclusions of the literature review, the second chapter presents the main regulations introduced for the mitigation and reporting of direct and indirect risks. The third chapter reviews the main types of climate risks, and the fourth the impact of climate risks on the macroeconomic situation of EU countries

1. Literature review

Rapid climate change exposes enterprises and financial institutions to the risk of incurring additional costs, known as climate risk. Households also bear the costs of climate change. Due to the nature of the impact of climate change on the economy, climate risk is divided into physical and transition. Physical risk results from the direct impact of climate change on the economy, including impact of floods, hurricanes, landslides, long-term drought or rising sea levels. These events can be predicted to some extent, but the exact moment, location and strength with which they occur are unknown. In turn, transition risk results from the need to transform the economy based on energy from fossil sources to the low-carbon economy. In this process, economic entities are uncertain about the nature of regulatory changes, the direction of technological changes, or changes in consumer preferences shaping the volume of sales (ECB/ESRB, 2023).

One of the basic causes of warming and climate change is the increase in the concentration of greenhouse gases in the atmosphere. To reduce losses related to atmospheric warming and the severity of future effects of climate change, a transformation towards a "low emission" economy is necessary (IPCC, 2014). Further increases in greenhouse gas emissions increase the likelihood of extreme temperatures. The long-term development of this type of physical hazards may lead to a rise in sea levels (IPCC (2018), an increase in the variability and strength of rainfall (Allen and Ingram 2002), leading to an increase in the risk of landslides and floods, increased frequency of extreme temperatures, droughts and more frequent fires (IPCC (2018).

In turn, the impact of climate risk on households most often focuses on the property consequences that result from damage to real estate resulting from both acute and chronic physical threats. The results of research by Bin and Polasky (2004) indicate that negative weather changes and chronic floods contribute to the decline in the value of real estate located in these areas. This reduces the value of collateral for mortgage loans and contributes to a decline in the value of loans that could be granted by banks. Noth and Schüwer (2018) show that climate change-related disasters increase the probability of household insolvency

and increase non-performing asset ratios in banks. Moreover, they point out that real estate prices in New York City's flooded neighbourhoods after Hurricane Sandy dropped by almost 20%, and three years later they were still valued 10% lower than in non-flooded neighbourhoods. It suggests that asset prices may reflect the expectation that areas affected by climate disasters will be affected again in the future.

For businesses, research based on historical data shows that natural disasters resulted in short-term declines in business sales. Barrot and Sauvagnat (2016) showed that following a major natural disaster, the supply chain is disrupted, as a result of which US companies record an average decline in sales growth of 2-3 percentage points and, consequently, a decline in the value of equity of approximately 1%. The literature also provides evidence supporting the thesis of the negative impact of natural disasters on global supply chains, with frequent references to countries such as Japan and Thailand (Abe and Ye 2013; Park et al. 2013; Bland and Kwonga 2011).

Geographic location plays an important role in the impact of climate change. It is important, among others: in the case of agriculture. Research by Schlenker and Roberts (2009) shows that the agricultural sector is exposed to the effects of higher temperatures and changes in precipitation, the effects of which will vary depending on the crop and geographical location. As a result, this affects the profitability of farms and their ability to take out a loan. Fisher et al. (2012) predict that changes in temperature and precipitation in some countries will reduce corn, soybean and cotton yields.

2. Climate change regulations

The European Parliament and the EU Council play a leading role in creating and implementing regulations regarding a sustainable economy, including limiting the negative effects of climate change. These regulations apply both to the non-financial sector and to the financial institutions that finance their operations, mainly banks and insurance companies.

One of the first regulations imposing an obligation on financial and non-financial institutions to report data on the use of sustainable investment and business practices was the NFRD Directive (2014/95/EU), which obliged large entities exceeding the criterion of an average number of 500 employees during the financial year as at the balance sheet date, to include data on environmental, social and labour issues and respect for human rights in the activity report. The inspiration to expand and specify the information requirements was the adoption by the UN General Assembly of the global sustainable development agenda known as the Agenda for Sustainable Development, which sets the sustainable development goals. Taking into account these objectives, Regulation 2019/2088 of the European Parliament

and of the Council on the disclosure of information regarding sustainable investments by financial market participants, established rules for disclosing information to investors by financial market participants on (i) the introduction of sustainable development risks into their activities, (ii) taking into account adverse effects on sustainable development, (iii) sustainable investment objectives or on promoting environmental or social aspects in the investment decision-making process and in the advisory process

In order to increase transparency and to provide financial market participants with objective comparisons in terms of the percentage of investments financing environmentally sustainable economic activities, the provisions of Regulation 2019/2088 of the European Parliament and of the Council have been supplemented by the CSRD Directive 2022/2464. The information requirements imposed by this directive on financial and non-financial institutions are intended to help the EU achieve climate neutrality by 2050. The CSRD is one of the most important EU legal acts specifying which entities are subject to the ESG reporting obligation and from what year.

Another source of regulations on sustainable development is the European Sustainable Development Standards (ESRS), which were adopted on July 31, 2023, under Commission Delegated Regulation (EU) 2023/2772. This document constitutes the first set of standards adopted by the European Commission. The provisions of the regulation complement the Corporate Sustainability Reporting Directive, which obliges large enterprises and listed companies to publish regular reports on the social and environmental risks they are exposed to and on the impact of their activities on people and the environment. In addition, it defines cross-sectional norms and standards regarding the disclosure of information in the field of environmental protection, social policy and corporate governance, ensuring the comparability and reliability of disclosed data subject to mandatory verification by statutory auditors.

At the proposal stage is the process of enacting a directive implementing the CSDD (EC/2022/0071), concerning due diligence in the area of corporate sustainability, which was adopted by the EC on February 23, 2022. Its provisions set out companies' obligations to identify actual and potential harmful impacts on human rights and the environment and defines responsibility for violations of these obligations. The scope of the CSDD includes companies' own activities, the activities of subsidiaries, entities within the value chain with which the company has a regulated business relationship - direct or indirect (Table 1).

Table 1. Major EU regulations adopted under the Action Plan: financing sustainable economic growth

No.	Group of rules	Regulations
1.	Unified classification system for sustainable development activities (taxonomy)	Regulation 2020/852 (Taxonomy regulation) and delegated acts
2.	Standards and labels for sustainable financial products	Proposal for an EP and Council Regulation on European Green Bonds, COM/2021/391
3.	Supporting investment in sustainable projects	Regulation 2020/852 (Taxonomy regulation) on establishing a framework to facilitate sustainable investment
4.	Sustainability issues in financial consulting	Delegated Directive 2021/1269 supplementing MIFID II on product governance
5.	Reference indicators for sustainable development	Regulation 2019/2089 amending Regulation (EU) 2016/1011 as regards EU Climate Transition Benchmarks, EU Paris-aligned Benchmarks and sustainability-related disclosures for benchmarks (and delegated acts)
6.	Sustainability in market research and credit ratings	Guidelines on disclosure requirements applicable to credit ratings
7.	Sustainability obligations on institutional investors and asset managers	Regulation 2019/1238 on the pan-European individual pension product (OIPE) Delegated Directive 2021/1270 supplementing the UCITS Directive Delegated Regulation 2021/1255 supplementing the AIFMD Delegated Regulation 2021/1257 supplementing the IDD Delegated Regulation 2021/1253 Delegated Directive 2021/1269
8.	Prudential requirements for banks and insurance companies	Draft Amendments: CRR and CRD, Solvency II
9.	Disclosure and accounting	Directive 2014/95 (NFRD); Directive 2022/2464 (CSRD). Regulation 2019/2088 (Disclosure regulation - SFRD) Delegated regulation 2022/128838 and 2021/2178, Delegated Regulation C/2023/5303 (ESRS), Taxonomy Regulation
10.	Corporate governance	Draft Directive on Corporate Due Diligence in the Area of Sustainable Development, COM/2022/71 (CSDD).

Source: Own elaboration based on: (Kosztowniak, 2023; 2024)

Other important sustainability regulations for banks and nonfinancial institutions include:

- Global Reporting Initiative (GRI) – the reporting framework, which creates an international standard for companies to report information on their application of CSR principles,
- Integrated Reporting Guidelines (International Integrated Reporting Council, IIRC) – the set of indicators and data for improving the quality of published company data,

- EC Guidelines for Reporting Non-Financial Information – the set of reported data on climate risk,
- Recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) appointed by the Financial Stability Board for establishing a framework to enable companies to manage climate risk, both transient and physical, and reap the benefits of related opportunities.

The regulations presented, among other things, call for taking into account environmental, social and corporate governance factors in the conduct of banks' current and long-term operations and changing the sectoral structure of their loan portfolios. They contribute to a shift away from financing "dirty" industries (mining and quarrying, trade, transportation) to financing "green" projects or transformation towards "green" projects. As a result, the flow of financing for a sustainable economy is being increased, while financing of dirty assets is being reduced, due to an increase in risks and accompanying costs for banks and their customers.

3. Overview of the main climate risks

Climate risk can affect the financial system and the real economy through two channels: physical risk and transition. Physical risk (*physical risk*) includes economic costs and financial losses resulting from the increasing intensity and frequency of extreme weather events caused by climate change. These risks include damage to infrastructure, crop damage, building fires, supply chain disruptions (Hsiang, et al.2017; Xu, et.al. 2018).

Transition risk is related to the costs generated by the need to adapt the economy to a more sustainable and low-carbon development path. Importantly, the risk of transformation will materialize before much of the physical risk materializes. This risk may materialize, among others, through the need to adapt to new regulations and technological changes, but also market risk resulting from the disruption of the current structure of demand and supply of electricity, natural resources, products and services provided (Adrian et.al., 2022; Brudtland, 1987).

Climate risk is revealed by phenomena such as temperature, rainfall and wind speed. We are then dealing not only with a shift in the expected value (e.g. an observed increase in the average temperature), but also with an increase in their variance (e.g. increasing variability of the observed temperatures). The cost of the climate risk, mainly physical risk, is revealed in the form of an increase in payments for climate disasters. In addition, climate risk may apply to both the following sectors:

- non-financial means, i.e. households, manufacturing companies,

- financial institutions, i.e. banks, insurance companies or investment funds, in which there is an increase in exposures related to the financing of dirty sectors and the need to change asset portfolios, in accordance with the ESG regulations) (Kosztowniak, 2023).

With the transition risks that arise during the transition to a low-carbon economy, asset values may also be adjusted:

- non-financial – e.g. a decrease in real estate prices (which do not meet energy efficiency standards),
- financial – e.g. a decrease in value of shares, bonds related to the so-called dirty sectors such as mining and quarrying or transport.

From the point of view of economic entities and entire economies participating in climate change, it is important to manage climate risk, including assessment, mitigation and monitoring (Kosztowniak, 2023). The management processes and activities could have forms of:

- analysis of climate risks and opportunities – an in-depth analysis of climate risks and opportunities, including their identification and materiality assessment, in qualitative and quantitative terms,
- analysis of transmission channels – assessment of the impact of the materialization of risks and opportunities on the operations of companies; preparation of a scenario analysis,
- foresight analysis and scenario analysis – modelling changes in the macroeconomic environment under the influence of the materialisation of climate risks, including foresight analysis of the state of the economy in various scenarios,
- adaptation and mitigation strategies – transformation of the business model as an opportunity to gain a strategic advantage and build resilience to climate change, in the following areas: environmental, social and governance (ESG),
- climate risk reporting – preparation of reports on climate risks in accordance with global standards and best practices.

Among the activities intensifying the increase in climate risks are, for example, an increase in environmental pollution or excessive exploitation of natural resources (e.g. water) felt by both companies and society.

In the case of environmental pollution, they can be a source of natural pollution (forest fires, volcanic eruptions, lightning) and, above all, the activities of enterprises. The development of heavy industries and their regional concentration is conducive to air pollution, waste growth and water pollution. In addition to these environmental effects, these activities increase

operating costs. Emitters in the EU are obliged to pay fees in accordance with the EU Emissions Trading System (ETS) regulations.

According to Eurostat data (2024), Germany, Poland, Italy, Spain and the Netherlands are among the largest emitters of air pollution. In these countries, such high emissions are related to the development of the so-called heavy industries for many years. Countries that have developed light industries or tourism and recreation emit much less pollution, such as Malta, Iceland, Cyprus or Luxembourg (Table 2).

Table 2. Air emissions accounts by NACE Rev. 2 activity in EU27 in 2008-2021 (mio tonne)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
EU27	3 762	3 433	3 512	3 456	3 388	3 286	3 180	3 222	3 214	3 259	3 204	3 054	2 744	2 866
Belgium	105	94	101	94	90	88	86	89	88	88	89	89	82	83
Bulgaria	62	54	57	62	57	52	55	58	56	58	54	52	46	52
Czechia	124	114	116	114	110	105	105	104	106	104	105	99	90	95
Denmark	101	94	92	92	85	84	78	78	81	81	83	80	70	65
Germany	835	767	795	781	793	801	758	767	763	752	729	665	582	616
Estonia	20	16	21	20	20	22	21	17	19	20	19	14	11	12
Ireland	51	46	54	52	54	54	55	57	62	64	65	64	51	54
Greece	120	113	109	105	104	97	94	90	88	94	93	87	76	77
Spain	338	300	287	293	290	263	265	276	263	278	272	253	218	227
France	401	378	383	368	362	361	341	342	341	345	333	328	292	307
Croatia	25	22	22	22	20	19	19	19	19	19	18	19	18	18
Italy	455	394	404	397	380	345	329	337	336	337	331	323	293	312
Cyprus	9	8	8	8	7	6	7	6	7	7	7	7	7	7
Latvia	11	10	11	11	10	10	10	10	10	10	11	11	9	10
Lithuania	22	18	18	19	19	18	19	19	19	20	21	21	23	23
Luxembourg	8	8	8	8	8	7	8	9	8	8	9	9	8	9
Hungary	60	54	55	55	50	49	50	52	52	54	54	53	50	50
Malta	3	3	3	3	3	3	3	2	2	2	2	2	2	2
Netherlands	188	182	189	181	177	176	176	182	180	178	173	170	152	152
Austria	67	60	64	62	59	58	56	57	56	59	57	60	54	57
Poland	369	349	361	364	355	352	344	345	353	367	367	352	339	361
Portugal	67	64	60	59	58	56	56	60	58	63	60	56	50	48
Romania	136	114	110	117	116	102	101	101	99	101	103	100	96	99
Slovenia	16	15	15	15	14	14	13	13	13	13	14	14	13	13
Slovakia	44	39	39	39	36	34	33	33	34	35	35	33	30	34
Finland	67	64	72	65	59	60	55	52	55	52	54	51	44	44
Sweden	57	51	58	53	50	49	47	48	48	47	46	44	39	40
Iceland	5	5	5	5	5	5	5	6	6	7	7	6	5	5
Norway	59	55	58	63	62	62	62	69	60	63	66	66	61	63
Switzerland	38	37	38	37	38	38	36	36	36	36	35	35
United Kingdom	561	504	512	486	491	474	449	430	402	389	382	369

Note: Air pollutants and greenhouse gases. No data for Serbia and Türkiye

Source: Own elaboration based on: Eurostat (2024)

It is worth noting that the progressive increase in pollution is an important factor in the increase in global temperature, as pointed out by, among others, Xu, Ramanathan and Victor, D. (2018), as well as the OECD (2024) and the World Bank (2024).

Within the EU countries, the values of various types of waste requiring recycling or disposal are also constantly increasing. For the years 2014-2021 they amounted to:

- waste electrical and electronic equipment: from 2,7 to 4,7 mio tonne,
- packaging waste by waste management operations: from 161,18 to 189,75 tonne (Eurostat, 2024).

Other effects of climate change are differences in renewable freshwater resources, which result from climatic conditions and economic activities. The largest states of these resources are France, Norway, Türkiye, Sweden, Germany and Italy. Other countries, including Poland, have smaller water resources. However, there is a large group of countries that have very low resources, e.g. Luxembourg, Kosovo and Malta. Low water resources will affect social problems (living conditions of the population) as well as business conditions for companies (Figure 1).

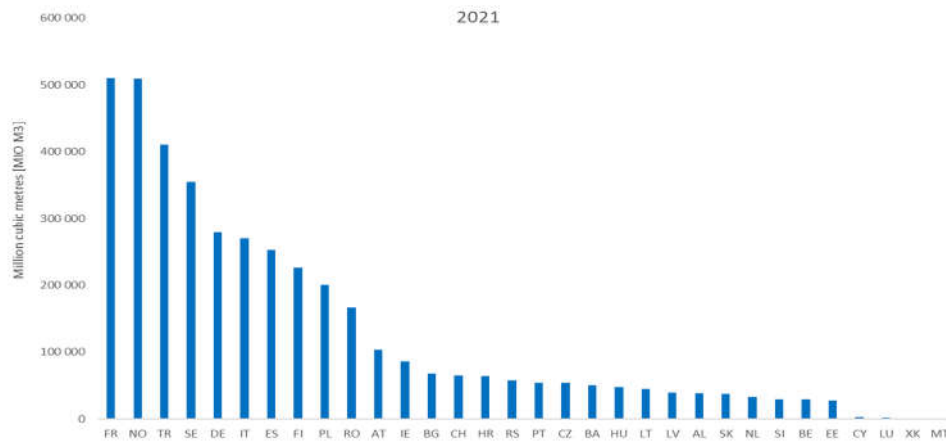


Figure 1. Renewable freshwater resources (MIO M3)

Source: Own elaboration based on: Eurostat (2024)

4. Impact of climate risks on the macroeconomic situation of EU countries

Due to the multidimensional nature of climate risks, their impact is complex. Climate change affects the living conditions of societies (households) as well as the conditions for doing business, entire economies and financial systems (Kalkuhl, Wenz, 2020).

Climate change means losses for economies, high social costs and radical changes in the regulatory and macroeconomic environment. For this reason, climate risks are increasingly attracting the attention of investors, financial sector regulators and regulators. The pressure to transform economies towards climate neutrality is growing (UN, 2015).

The analysis of reports from financial institutions (OECD, 2024; World Bank, 2024) shows that the main determinants of structural changes in economies, particularly important in the labour market and in the social sphere, include:

- automation, digitization and innovation processes enabling technological development,

- demographic changes, including the growing share of elderly people, with a decreasing share of people of working age in the total population,
- increasing population migration,
- rapid urbanization,
- scarcity of resources (mineral raw materials, fresh water and clean air resources) and climate change (temperature increase and its fluctuations, hurricanes, floods, droughts, etc.).

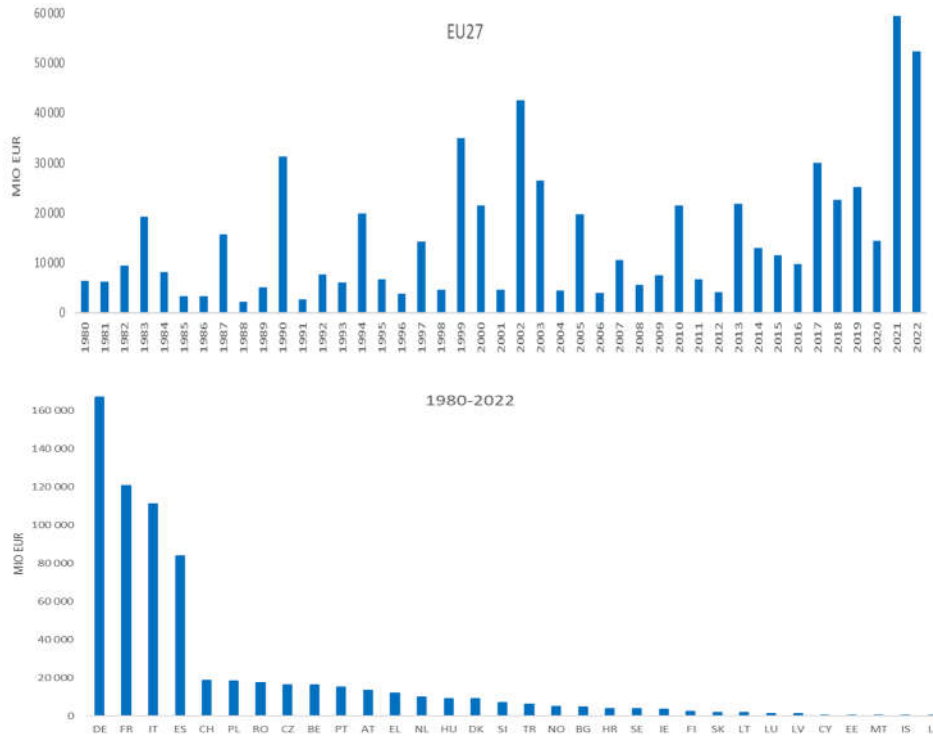
There is a growing demand for specialists in the field of ESG, including those supporting the transformation processes of economic entities and participating in the assessment of climate risks and non-financial reporting (so-called reporting (NFRD, 2014; SFRD, 2019; CSRD, 2022; TCFD, 2024; Taxonomy, 2021). Needs for ESG experts are reported by both non-financial and financial enterprises (Kosztowniak, 2023; 2024).

Between 2014 and 2021 the employment in the environmental goods and services sectors in the EU27 countries is growing from 3.9 to 5.2 million employees, including:

- in 2008-2021: France from 0,5 to 1,1 million employees and the Netherlands and also in Switzerland from 0,1 to 0,2 million employees as well as,
- in 2014-2021: in Germany from 0,5 to 0,7 million employees and Poland from 0,2 to 0,3 million employees (2014-2021) (Eurostat, 2024).

In the macroeconomic context, the issue of reducing climate risks and their negative effects to maintain financial stability is important (IMF, 2020; ESRB, 2020; Giuzo et. al. 2019). Appropriate climate risk management (as already mentioned) is important in both non-financial and financial companies. Banks, insurance companies or investment funds may be exposed to changes in the valuation of assets and liabilities. To absorb risks (e.g. market, liquidity or credit risks), these institutions are required by law to accumulate reserve funds and increase capital in accordance with buffers. Banks are taking measures to change their portfolios, e.g. loan portfolios, to gradually reduce their exposure to dirty sectors across the entire portfolio (Kosztowniak, 2024).

According to Eurostat (2024), the estimated value of climate-related losses in the EU27 countries, although it was variable in the period 1980-2022, in the last two years fluctuated at the level of EUR 50 000-60 000 mio. Among the EU countries, the largest cumulative losses for the period 1980-2022 were suffered by Germany, France, Italy, Spain and other countries, including Poland, suffer much lower losses (Figure 2).



**Figure 2. Climate related economic losses
(values at constant 2022 prices, MIO EUR)**
Source: Own elaboration based on: Eurostat (2024)

Counteracting climate risks, including undertaking climate transformation of enterprises and entire economies, requires financial resources. Attempts are being made to finance the growing needs in this area from various sources (UNFCCC, 2015; UN, 2015):

1. at the EU level from: the Structural Funds (EC, 2024), and the issuance of bonds supporting sustainable finance, including the so-called green bonds (EIB, 2017; Flammer, 2021; Regulation EU, 2023/2631),
2. at the national level from: public and private funds, an issuance of bonds and tax revenues.

Revenues from environmental taxes in the EU27 increased from EUR 285 120 million in 2013 to EUR 320 824 million in 2022. Among the Member States, the highest revenues in 2022 were achieved by e.g. Germany (63,336), France (54,856), Italy (42,919), the Netherlands (22,756), and Poland (18,321) respectively (Table 3).

Table 3. Environmental tax revenues in EU27 in 2013-2022 (MIO EUR)

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
EU27	285 120	291 985	300 020	311 235	317 644	325 790	331 207	301 734	329 721	320 824
Belgium	9 906	10 256	10 618	11 469	11 997	12 423	12 628	11 588	12 560	12 286
Bulgaria	1 201	1 221	1 352	1 451	1 469	1 470	1 839	1 859	1 979	4 095
Czechia	3 331	3 347	3 477	3 728	3 897	4 129	4 595	4 148	4 373	4 077
Denmark	10 713	10 622	10 847	11 065	10 808	10 933	10 221	9 892	9 704	9 274
Germany	57 937	58 263	58 063	58 432	59 250	59 723	61 111	57 468	65 179	63 336
Estonia	485	533	563	645	681	709	890	657	724	830
Ireland	4 445	4 684	4 977	5 117	5 232	5 119	5 021	4 487	4 953	4 410
Greece	7 240	7 270	7 401	7 281	7 759	7 402	7 896	6 818	7 701	11 578
Spain	19 611	19 344	20 821	20 793	21 371	22 075	22 018	19 600	21 203	20 529
France	42 897	43 716	47 493	50 125	53 052	56 039	56 327	50 226	54 447	54 856
Croatia	1 583	1 746	1 910	2 044	2 189	2 308	2 386	2 058	2 258	2 273
Italy	55 257	58 070	56 144	59 481	58 000	58 575	58 299	50 777	54 907	42 919
Cyprus	490	534	544	554	602	613	583	520	563	609
Latvia	723	790	859	908	942	983	900	916	918	867
Lithuania	587	634	692	748	807	900	921	969	1 039	1 024
Luxembourg	1 008	980	954	933	953	1 028	1 087	880	1 057	950
Hungary	2 490	2 558	2 784	2 943	3 097	3 155	3 367	3 032	3 152	3 167
Malta	205	241	266	279	304	319	348	295	277	287
Netherlands	21 564	22 216	22 925	23 754	24 635	25 877	27 570	25 366	26 526	22 756
Austria	7 725	7 975	8 204	8 384	8 845	8 784	9 059	7 975	8 775	8 420
Poland	9 503	10 562	11 402	11 557	12 512	13 474	13 545	13 330	16 590	18 322
Portugal	3 758	3 932	4 344	4 819	5 052	5 272	5 418	4 729	5 026	4 647
Romania	2 957	3 587	3 952	4 085	3 840	4 034	4 732	4 196	5 299	7 675
Slovenia	1 428	1 453	1 509	1 569	1 578	1 660	1 796	1 539	1 634	1 636
Slovakia	1 873	1 932	1 998	2 019	2 149	2 226	2 362	2 294	2 383	2 708
Finland	5 953	5 957	6 118	6 709	6 893	6 848	6 730	6 487	6 288	6 529
Sweden	10 251	9 544	9 801	10 341	10 150	9 814	9 779	9 618	10 218	10 765
Iceland	261	288	337	387	482	470	443	382	368	492
Liechtenstein	28	33	37	36	36	33	37	36	36	.
Norway	9 183	8 733	8 189	8 044	8 124	8 110	7 630	6 452	7 393	7 288
Switzerland	7 032	7 268	8 484	8 587	8 518	8 620	9 047	9 037	9 188	9 889

Source: Own elaboration based on: Eurostat (2024)

An expression of various pro-ecological activities is, among others, increasing renewable energy sources. According to Eurostat data, the share of renewable energy in the gross final energy consumption by sector in EU27 estimated 23% in 2022. The leaders in this respect were countries such as: Iceland (79%), Norway (76%), Sweden (66%), Finland (48%), and e.g., in Germany (21%), Slovakia (18%) and Poland (17%). These significant shares of renewable energy allowed for significant savings and the possibility of allocating the funds saved for other socio-economic purposes (Table A.1).

One of the tools for a global look at the state of climate risks and their measurement is the *Environmental Performance Index (EPI)* developed by the Yale Center for Environmental Law & Policy (Yale University) in cooperation with the Center for International Earth Science Information Network (Columbia University).

The 2024 EPI provides a data-driven summary of the state of sustainability around the world. Using 58 performance indicators across 11 issue categories, the EPI ranks 180 countries on climate change performance, environmental health, and ecosystem vitality. These indicators provide a gauge at a national scale of how close countries are to established environmental policy targets. The EPI offers a scorecard that highlights leaders and laggards in environmental performance and provides practical guidance for countries that aspire to move toward a sustainable future (Block, et al., 2024).

EPI indicators provide a way to spot problems, set targets, track trends, understand outcomes, and identify best policy practices. Going beyond the aggregate scores and drilling down into the data to analyse performance by issue category, policy objective, peer group, and country offers even greater value for policymakers. This granular view and comparative perspective can assist in understanding the determinants of environmental progress and in refining policy choices. The indicator was calculated for three areas:

- ecosystem vitality (45%),
- climate change mitigation (30%) and
- environmental health (25%).

This broad set of metrics is a powerful tool to track progress towards the UN Sustainable Development Goals, the climate mitigation targets in the 2015 Paris Climate Change Agreement, and the biodiversity protection goals in the Kunming-Montreal Global Biodiversity Framework. Overall EPI scores help identify which countries have been most successful at addressing a wide variety of global environmental challenges, spotlighting sustainability leaders, and calling out laggards. Delving into the details beyond overall scores-examining individual issue categories, indicators, and peer comparisons-provides a more nuanced understanding of the trends and drivers of environmental performance (Figure 3).

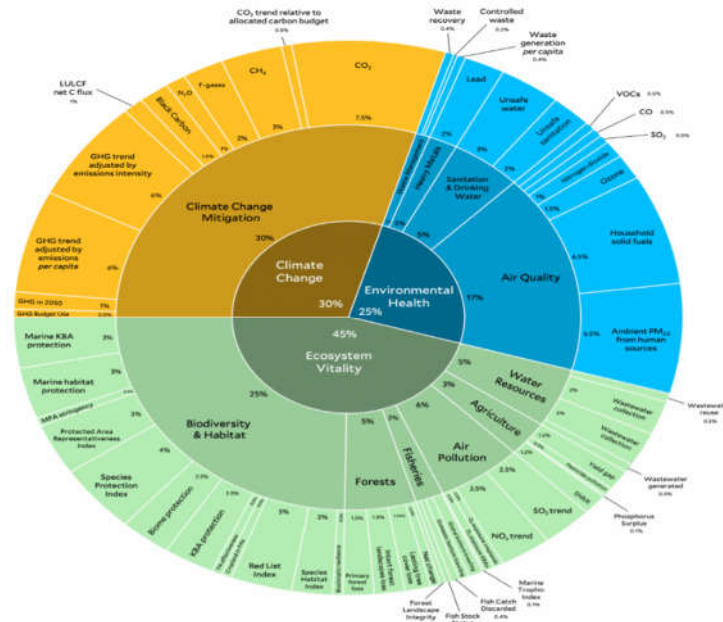


Figure 3. The 2024 EPI Framework

Source: Block et. al. (2024)

The 2024 EPI combines data on dozens of sustainability-related issues into one result. To make the indicators easier to interpret, raw environmental data has been transformed into indicators that rank countries on a scale of 0-100, from worst to best performers. The EPI measurement results indicate that the top 20 greenest countries include mainly Western European countries.

The countries that scored the most points were: Estonia (75.3), Luxembourg (75.0), Germany (74.6), Finland (73.7) and United Kingdom (72.7) and Poland in 19th position (64.4 score) (Table 4).

Table 4. The 20th greenest countries in the world according to 2024 EPI global rankings

Rank	Country	Score	REG
1	Estonia	75.3	1*
2	Luxembourg	75.0	1
3	Germany	74.6	2
4	Finland	73.7	3
5	United Kingdom	72.7	4
6	Sweden	70.5	5
7	Norway	70.0	6
8	Austria	69.0	7
9	Switzerland	68.0	9
10	Denmark	67.9	9
11	Greece	67.4	2*
12	Netherlands	67.2	10
13	France	67.1	11
14	Belgium	66.7	12
15	Malta	66.6	13
16	Ireland	65.7	14
17	Czech Republic	65.6	3*
18	Slovakia	65.0	4*
19	Poland	64.4	5*
20	Iceland	64.3	15

Note: Score for level 0-100; the higher the level, it's the greater the environmental impact. Regional rankings (REG): * for Eastern Europe, others for Global West.

Source: Environmental Performance Index 2024 (2024b)

Leaders for EPI total for Eastern Europe are: Estonia, Greece, Czech Republic, Slovakia and Poland. Divided into scopes:

- ecosystem vitality: Poland, Czech Republic, Slovakia, Estonia, Lithuania,

- climate change mitigation: Estonia, Greece, Albania, Slovenia, Croatia,
- environmental health: Estonia, Cyprus, Greece, Slovakia, Slovenia (Table 5).

Table 5. EPI scopes and regional rankings for Eastern Europe

Countries\ categories	EPI total		Scopes					
			Ecosystem vitality		Climate change mitigation		Environmental health	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Estonia	75.3	1	76.6	4	82.8	1	63.9	1
Greece	67.4	2	67.9	11	71.3	2	61.9	3
Czech Republic	65.6	3	78.0	2	52.2	9	58.8	6
Slovakia	65.0	4	77.8	3	48.9	13	60.5	4
Poland	64.4	5	79.3	1	53.5	6	49.9	10
Lithuania	63.9	6	74.3	5	52.4	7	58.8	6
Croatia	62.6	7	72.8	7	56.0	5	51.7	9
Slovenia	62.5	8	67.7	12	57.5	4	59.0	5
Hungary	60.1	9	73.8	6	49.2	12	48.1	12
Latvia	59.9	10	68.6	9	52.4	7	52.8	8
Romania	57.2	11	68.4	10	49.3	11	46.4	13
Bulgaria	56.3	12	70.8	8	45.7	15	42.5	16
Cyprus	54.0	13	57.2	13	42.6	18	62.0	2
Albania	52.1	14	51.8	16	59.4	3	48.5	11
North Macedonia	50.0	15	55.1	15	51.3	10	39.1	18
Serbia	49.3	16	56.1	14	43.6	16	43.4	15
Montenegro	47.6	17	50.2	18	43.1	17	48.5	11
Bosnia and Herzegovina	45.6	18	51.3	17	45.9	14	36.0	19
Türkiye	37.6	19	35.6	19	37.0	19	41.8	17

Source: Environmental Performance Index 2024 (2024b)

The research conducted by the Yale Center for Environmental Law & Policy and Columbia University shows that environmental activity is correlated with the level of economic development. Countries' wealth is a strong predictor of their overall environmental performance, but some countries vastly outperform their economic peers, while others lag (Figure 4).

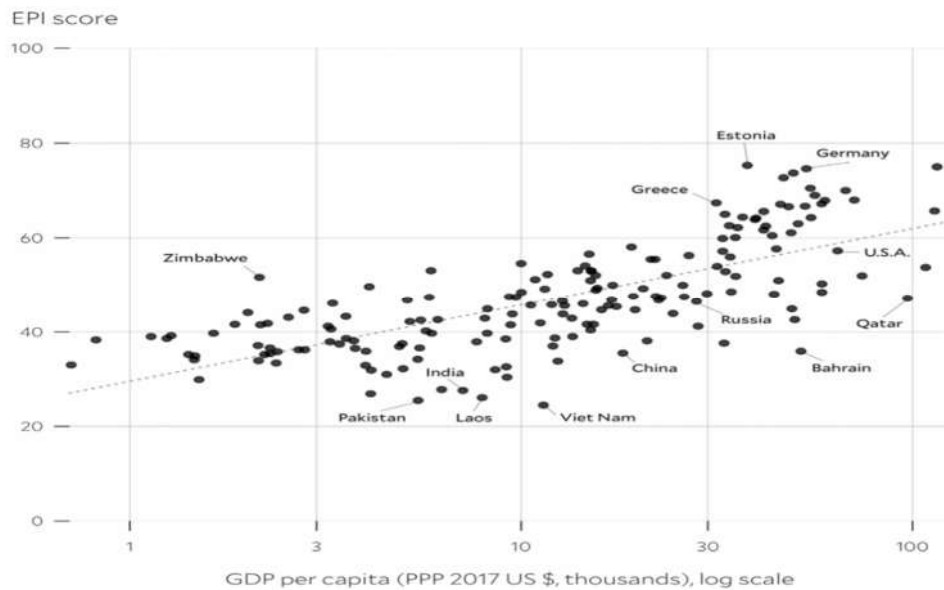


Figure 4. EPI scores vs GDP per capita

Source: Environmental Performance Index 2024 (2024a)

Summary

Climate policy is becoming a key economic policy in the European Union due to the progressive increase in climate risks, observed in the form of physical and transition risks, and affecting directly and indirectly various spheres of socio-economic life. The nature of climate change depends on the geographic location.

The European Parliament and the EU Council play a leading role in creating and implementing regulations regarding a sustainable economy, including limiting the negative effects of climate change. These regulations apply both to the non-financial sector and to the financial institutions that finance their operations, mainly banks and insurance companies.

Economic adaptation measures and restrictive regulations introduced by the public administration are expected to reduce the negative effects of rapid climate change in the long term. However, they are also sources of transition risk, as they carry the cost of discontinuing certain economic activities, as well as the need to set aside investments to meet new standards and implement new "green" technologies. On the other hand, they create markets for new products and represent an opportunity for development of innovative enterprises and new jobs.

Climate policy and risk are broadly regulated by law in the form of taxonomies and directives, orders and various types of guidelines (NFRD, CSRD, ESRS, CSDD and others).

Climate risks affect the living conditions (quality of life) of households and the conditions for businesses to operate. Among the leading emitters of pollution in Europe are: Germany, Poland, Italy, Spain and the Netherlands. Climate change is driving an increase in the demand for employment in the environmental services and goods sector, including ESG specialists who carry out corporate transformation processes, assess risks and prepare non-financial reports.

Attempts are made to estimate the negative effects of climate change in the form of financial losses, to quantify their scale (nuisance) and international comparisons. The results of the analyses indicate that the greatest financial losses are incurred by the most developed European countries, whose economic potential is based on heavy industries, i.e. Germany, France, Italy and Spain as well as Poland.

In order to take measures to counteract (mitigate) a further increase in climate risks, various programs are undertaken, and funds are collected for pro-ecological investments, e.g. in the form of the issue of green bonds or an increase in taxation. The largest environmental taxes are paid by countries such as: Germany, France, Italy, Netherlands and Poland. The leaders of projects in renewable energy sources are Iceland, Norway, Sweden and Finland.

A synthetic assessment of complex determinants of climate risks in the form of the so-called Environmental Performance Index developed by the Yale Center for Environmental Law & Policy (Yale University) in cooperation with the Center for International Earth Science Information Network (Columbia University). According to EPI 2024 among the 20th greenest countries in the world, there are: Estonia, Luxembourg and Germany. Among the Eastern European countries, the leaders are: Estonia, Greece and the Czech Republic.

In order to achieve better results of climate policy, it is important both to have a coordinated policy at the level of EU countries and to consistently promote its solutions throughout the globe. Only an integrated global climate policy will deliver measurable and long-term results.

Table A.1. Share of renewable energy in gross final energy consumption by sector in EU27 in 2004-2022 (%)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
EU27	10	10	11	12	13	14	14	15	16	17	17	18	18	18	19	20	22	22	23
BE	2	2	3	3	4	5	6	6	7	8	8	8	8	9	9	10	13	13	14
BG	9	9	9	9	10	12	14	14	16	19	18	18	18	19	21	22	23	19	19
CZ	7	7	7	8	9	10	11	13	14	15	15	15	15	15	15	16	17	18	18
DK	15	16	16	18	19	20	22	23	25	27	29	30	32	34	35	37	32	41	42
DE	6	7	8	10	10	11	12	12	14	14	14	15	15	15	17	17	19	19	21
EE	18	17	16	17	19	23	25	26	26	26	26	29	29	30	30	32	30	37	38
IE	2	3	3	3	3	4	6	7	7	8	9	9	9	11	11	12	16	12	13
EL	7	7	7	8	8	9	10	11	14	15	16	16	16	17	18	20	22	22	23
ES	8	8	9	10	11	13	14	13	14	15	16	16	17	17	17	18	21	21	22
FR	9	9	9	9	11	12	13	11	13	14	14	15	15	16	16	17	19	19	20
HR	23	24	23	22	22	24	25	25	27	28	28	29	28	27	28	28	31	31	29
IT	6	8	8	10	11	13	13	13	15	17	17	18	18	18	18	18	20	19	19
CY	3	3	3	4	5	6	6	6	7	8	9	10	10	10	10	14	17	19	19
LV	33	32	31	30	30	34	30	33	36	37	39	38	37	39	40	41	42	42	43
LT	17	17	17	16	18	20	20	20	21	23	24	26	26	26	26	25	27	28	30
LU	1	1	1	3	3	3	3	3	3	3	4	5	5	5	6	7	12	12	14
HU	4	7	7	9	9	12	13	14	16	16	15	14	14	14	14	13	14	14	15
MT	0	0	0	0	0	0	1	2	3	4	5	5	6	7	8	8	11	13	13
NL	2	2	3	3	4	4	4	5	5	5	5	6	6	6	7	7	9	14	15
AT	23	24	26	28	29	31	31	32	33	33	34	33	33	33	33	34	37	35	34
PL	7	7	7	7	8	9	9	10	11	11	12	12	12	11	11	15	16	16	17
PT	19	20	21	22	23	24	24	25	25	26	30	31	31	31	31	30	31	34	35
RO	17	18	17	18	20	22	23	22	23	24	25	25	25	24	24	24	24	24	24
SI	18	20	18	20	19	21	21	21	22	23	22	23	22	22	22	22	25	25	25
SK	6	6	7	8	8	9	9	10	10	10	12	13	12	11	12	17	17	17	18
FI	29	29	30	30	31	31	32	33	34	37	39	39	41	41	41	43	44	43	48
SE	38	40	42	43	44	47	46	48	49	50	51	52	53	53	54	56	60	63	66
IS	59	60	61	72	68	70	71	72	74	74	73	72	75	74	77	79	84	80	79
NO	58	60	61	60	62	65	62	65	65	66	68	69	69	70	72	74	77	74	76
BA	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
Bosnia and Herzegovina	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
ME	·	36	35	33	32	39	41	41	42	44	44	44	43	42	40	39	38	44	40
Montenegro	·	16	17	15	16	17	16	16	18	19	20	20	20	18	20	18	17	19	19
North Macedonia	·	30	31	32	33	32	31	35	33	32	35	32	35	37	36	37	38	45	41
AL	·	13	14	15	14	16	21	20	19	21	21	23	22	21	20	21	26	25	25
Serbia	·	21	20	20	19	18	18	18	19	19	20	18	24	23	25	24	24	22	19
XK	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·

Source: Own elaboration based on: Eurostat (2024), https://ec.europa.eu/eurostat/databrowser/view/sdg_13_40/default/table?lang=en&category=sdg_13

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DIGITALIZATION OF CITIZENS IN EU MEMBER STATES: GLOBALIZATION AND EU INITIATIVES

Abstract

The development of digitalization in the countries of the European Union (EU) is a crucial factor shaping modern economies and societies. In the era of globalization, digitalization has become a foundation that influences the competitiveness of economies, innovation, and the quality of life of citizens. This article aims to provide a detailed assessment of the level of digitalization in individual EU countries based on available statistical data. The analysis includes indicators such as Gross Domestic Product (GDP), households with Internet access at home, households with broadband Internet access, individuals who used the Internet away from home or work, individuals who have never used a computer, individuals ordering goods or services online for private use, individuals using the Internet to interact with public authorities, and the frequency of Internet use and online activities. These indicators have been normalized to allow for direct comparison and the creation of a ranking of the digitalization levels of EU countries. The results of the analysis indicate significant disparities in the level of digitalization between Western and Eastern EU countries, resulting from economic, social, and infrastructural differences.

Keywords: digitalization, IoT, ICT, EU.

JEL classification: O33

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Introduction

The development of digitalization in the countries of the European Union (EU) is one of the most significant factors shaping contemporary economies and societies. In the era of globalization, digitalization has become an indispensable element that influences the competitiveness of economies, innovation, and the quality of life of citizens. The implementation and advancement of information and communication technologies (ICT) are crucial for the efficient functioning of various sectors of socio-economic life, ranging from public administration and education to the private sector.

In the era of globalization, digitalization plays a pivotal role in market integration, accelerating the exchange of information, and enhancing the mobility of capital and labor. Globalization necessitates that EU member states adapt to the rapidly changing international environment, where digital technologies are becoming the bedrock of modern economies (Lee, Falahat and Sia, 2019, p. 2-8).

1. The multifaceted impact of digitalization on the modern economy in the light of scientific research

Digitalization enables EU enterprises to compete on the global market by increasing operational efficiency, reducing costs, and introducing innovative products and services. Examples such as e-commerce platforms, cloud services, and Internet of Things (IoT) solutions illustrate how digital technologies are revolutionizing traditional business models (Octawia, Indrawijaya, Sriayudha and Hasbullah, 2020, p. 517-521). E-commerce platforms like Amazon and Alibaba have transformed the way consumers shop, providing access to global markets from mobile devices. Cloud services offered by companies such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud allow firms to scale their operations and manage data flexibly and cost-effectively (Gupta, Mittal and Mufti, 2021, p. 1-8). IoT solutions, which integrate diverse devices into intelligent networks, enable the collection and real-time analysis of vast amounts of data, supporting more informed business decision-making (Sadeeq, Abdulkareem, Zeebaree, Ahmed, Sami and, 2021, p. 1-7).

Digitalization also impacts international scientific and research and development (R&D) collaboration. Modern technologies facilitate the rapid exchange of data, real-time collaboration, and access to scientific resources from anywhere in the world. Tools such as video conferencing, online collaboration platforms (e.g., Microsoft Teams, Slack), and scientific databases (e.g., Google Scholar, PubMed) enable scientists and researchers to conduct joint research projects regardless of their physical location (Fortunato, Bergstrom, Börner, Evans, Helbing, Milojević, and Barabási, 2018, p. 3-10).

In the context of global challenges such as climate change, pandemics, and natural resource management, digitalization fosters the creation of global collaboration networks that contribute to innovative solutions to world problems. For instance, in combating climate change, digital technologies enable the monitoring of greenhouse gas emissions, the management of renewable energy sources, and the modeling and forecasting of climate change impacts (Mondejar, Avtar, Diaz, Dubey, Esteban, Gómez-Morales and Garcia-Segura, 2021, p. 2-13). During the COVID-19 pandemic, digitalization played a crucial role in facilitating remote work, online education, and tracking and managing the virus's spread through mobile applications and data analysis systems (Mondal and Mitra, 2022, p. 158-169).

Digitalization also significantly impacts social aspects, contributing to the improvement of quality of life and the enhancement of social inclusion. Through digital technology, it is possible to reduce social inequalities by providing better access to education, healthcare, and public services. E-education allows access to educational materials and online courses from anywhere, which is particularly important for individuals living in regions far from major educational centers. Digital educational platforms such as Coursera, edX, and Khan Academy enable the acquisition of new skills and qualifications, thereby increasing employment opportunities (Sitnicki, Horbas, Derkach and Rozbeiko, 2023, p. 11-15).

In the healthcare sector, telemedicine and e-health facilitate remote medical consultations, patient monitoring, and access to specialized medical services without the need for travel. This is especially crucial in the context of a pandemic, where minimizing direct contact is key to preventing the virus's spread. Technologies such as health management apps, remote health monitoring devices, and online patient registration systems contribute to improving the quality of healthcare (Beaulieu and Bentahar, 2021, p. 2-8).

Digitalization also supports civic engagement and social participation. Digital platforms enable citizens to access public information more easily, participate in public consultations, and communicate with local and national authorities. Social media, online forums, and applications for reporting public space issues (e.g., road potholes, lighting failures) increase citizen engagement in community life and improve communication between residents and public administration (Boulianne and Theocharis, 2020, p. 111-119).

2. EU programs for enhancing the level of digitalization

The European Union has consistently implemented extensive initiatives aimed at enhancing the level of digitalization in its member states. These efforts include various programs, strategies, and funds designed to support the development of digital infrastructure, improve citizens' digital skills, and promote technological innovation. One of the key documents was the Digital

Agenda for Europe, adopted in 2010 as part of the Europe 2020 strategy. The Agenda aimed to create a single digital market that would contribute to economic growth and improve the quality of life for EU citizens. It focused on the development of broadband infrastructure, establishing high-quality, high-speed broadband networks accessible to all EU citizens. It also promoted digital public services to simplify administrative processes and increase the accessibility and efficiency of public services. Investments in digital education and training aimed to enhance ICT skills among citizens and workers. Additionally, the Agenda emphasized the establishment of legal frameworks to ensure data privacy and online security (COM/2010/0245).

The Horizon 2020 program, the EU's largest research and innovation program, also played a crucial role in promoting digitalization. Part of its funding was allocated to the development of information and communication technologies and supporting research and innovation projects in the ICT field. This program supported research and development in ICT, funding projects aimed at developing new digital technologies such as artificial intelligence, blockchain, and 5G technologies. Furthermore, the program promoted digital innovation by supporting small and medium-sized enterprises (SMEs) in implementing innovative digital solutions. Initiatives aimed at integrating modern digital technologies into traditional industrial sectors were also a significant part of the program (COM/2011/0811).

The continuation of digitalization efforts is embodied in the Digital Europe Program, launched in 2021. Its goal is to further support Europe's digital transformation by investing in key areas such as the construction and development of supercomputing infrastructure to support advanced scientific research and innovation. Promoting the development and implementation of artificial intelligence technologies across various economic sectors, including healthcare, agriculture, and public administration, is another critical component of the program. The program also aims to strengthen Europe's capabilities to prevent and respond to cyber threats by developing cybersecurity infrastructure. Investments in training and educational programs to enhance digital skills among EU citizens and supporting the digitalization of SMEs and public administration through the implementation of modern technologies and solutions are additional priorities of the program (OJ L 166, 11.5.2021).

Another important aspect of the EU's efforts is the pursuit of creating a Digital Single Market, which aims to remove barriers to cross-border digital services and e-commerce. Initiatives in this area include the reform of copyright laws to facilitate access to digital content across the EU while ensuring the protection of intellectual property rights. Eliminating geoblocking, which restricts access to online services and content based on the user's geographic location, and modernizing telecommunications regulations to facilitate the development

of 5G networks and new digital services are other essential elements of the EU's actions (COM/2015/0192).

The actions undertaken by the EU over the years, aimed at increasing the degree of digitalization in member states, play a crucial role in shaping a modern, competitive, and sustainable European economy. Investing in digital infrastructure, developing digital skills, and promoting technological innovation are essential to ensuring that Europe remains a leader in the global digital transformation. The continuation and intensification of these efforts are critical for the further development and strengthening of the EU's position on the global digital stage. In the context of these extensive activities, the purpose of this article is to provide a detailed assessment of the level of digitalization of individual European Union (EU) countries based on available statistical data.

3. An empirical analysis of the level of digitalization in EU member states

The subject of analysis comprises diverse indicators that enable a multifaceted perception of the state of digitalization. Aiming for a multidimensional analysis, data from the Eurostat database for the years 2021-2023 were compiled and are briefly justified below:

1. Gross Domestic Product (GDP) at current market prices: GDP is a fundamental economic indicator reflecting the value of goods and services produced in individual regions. Analyzing this indicator allows for an assessment of the overall economic condition of countries, which directly affects the financial capabilities and development of digital infrastructure.
2. Households with Internet access at home: This indicator is crucial for assessing the degree of digital inclusion in society. A high percentage of households with Internet access may indicate widespread availability of information and communication technologies (ICT) and the potential for utilizing online services.
3. Households with access to broadband Internet: Broadband Internet is essential for effectively using advanced online services such as video streaming, teleconferencing, and remote work. Analyzing this indicator helps evaluate the quality of Internet connections available to users.
4. Individuals who used the Internet away from home or work: This indicator illustrates the mobility of Internet users and the availability of wireless networks in public spaces. A high percentage of such users may indicate a well-developed network infrastructure and the growing role of mobile devices in everyday life.
5. Individuals who have never used a computer: This indicator is significant for assessing the level of digital exclusion. A high percentage of individuals who have never used a computer may point to barriers in accessing technology, such as a lack of digital skills, financial constraints, or lack of infrastructure.

6. Individuals ordering goods or services online for private use: This indicator reflects the advancement of the e-commerce market in a given country. A high percentage of people making online purchases indicates trust in digital forms of transactions and the availability and convenience of using such services.
7. Individuals using the Internet to interact with public authorities: This indicator measures the advancement of e-government services, which aim to facilitate citizens' access to public services. A high level of online interaction with public authorities may indicate a well-developed digital administration infrastructure and effectiveness in promoting e- services.
8. Frequency of Internet use and online activities: Analyzing the frequency and type of online activities provides information on the degree of integration of digital technologies in citizens' daily lives. Regular Internet use and a variety of activities indicate a high level of digital competence and a wide range of available online services.

The presented indicators and the data used in this study serve as a reference point for conducting a comprehensive analysis of the level of digitalization in the European Union countries, enabling the identification of key areas requiring further actions and investments.

Due to the diversity of measurement units for individual indicators, normalization was necessary to enable direct comparison. Normalization involved scaling the indicator values to a range of 0-100, according to the following formula:

$$\text{Normalized Value} = \frac{(X_i - X_{min})}{(X_{max} - X_{min})} \times 100$$

where:

- X_i is the original value of the indicator for a given country,
- X_{min} is the minimum value of the indicator among all EU countries,
- X_{max} is the maximum value of the indicator among all EU countries.

As a result of normalization, a value of 0 indicates the lowest level of a given indicator among EU countries, while a value of 100 represents the highest level. This ensures that each indicator contributes equally to the final result.

For indicators where lower values are preferable (e.g., the percentage of people who have never used a computer), an inversion process was applied. This involved subtracting the normalized value from 100, so that higher values indicate better digitalization outcomes.

$$\text{Inverted Value} = 100 - \text{Normalized Value}$$

The final digitalization index for each country was calculated as the arithmetic mean of the normalized indicators. This provided a uniform measure reflecting the overall level of digitalization in a given country. The formula is as follows:

$$\text{Digitalization Index} = \frac{\sum_{i=1}^n \text{Normalized Value}_i}{n}$$

where:

- n is the number of indicators included in the analysis.

Based on the calculated Digitalization Index values, EU countries were ranked from highest to lowest, creating a digitalization level ranking. This ranking enables the comparison of the overall digital advancement across different countries, considering both economic and social aspects.

The adopted research method, which includes data collection, normalization, inversion of negative indicators, and calculation of the final digitalization index, allowed for obtaining reliable and comparable results. This made it possible to create a ranking that reflects the actual level of digitalization in individual European Union countries, taking into account the multifaceted nature of this phenomenon.

Table 1. Ranking of EU Countries by Digitalization Level

L.P.	Country	Digitalization Index
1.	Denmark	94.3
2.	Sweden	91.7
3.	Finland	89.5
4.	Germany	88.2
5.	Netherlands	86.9
6.	Estonia	85.4
7.	Ireland	84.1
8.	France	83.7
9.	Austria	81.3
10.	Luxembourg	80.1
11.	Belgium	79.4
12.	Czechia	78.2
13.	Spain	76.9
14.	Portugal	75.3
15.	Poland	74.8
16.	Italy	73.7
17.	Slovenia	72.1
18.	Malta	71.5
19.	Cyprus	70.8
20.	Lithuania	69.7
21.	Latvia	68.3
22.	Greece	66.9
23.	Hungary	65.4
24.	Slovakia	64.1
25.	Croatia	62.7
26.	Bulgaria	60.5
27.	Romania	58.3

Source: Own elaboration

The analysis of the level of digitalization in the European Union countries reveals a clear differentiation between Western and Eastern countries, which can be attributed to several key economic, social, and infrastructural factors. A detailed analysis of the data allows for the identification of both the elements that distinguish these regions and those that unify them in their pursuit of the common goal of full societal digitalization.

Scandinavian and Western European countries, such as Denmark, Sweden, Finland, Germany, and the Netherlands, exhibit the highest levels of digitalization. This dominance is a result of stable economic conditions that enable significant investments in modern technologies and digital infrastructure. For instance, Denmark and Sweden not only invest in the development of broadband internet networks but also in innovative research and development projects, which translates into widespread application of ICT technologies across various sectors of the economy (Falch and Henten, 2018, p. 715-723).

A high level of digital education in Western countries is another factor contributing to their digital advancement. Educational programs that emphasize the development of IT skills from early school years are widely accessible. In Finland, the educational system integrates programming and digital skills into the standard curriculum, resulting in a high level of digital competence across the entire society (Korhonen, Juurola, Salo and Airaksinen, 2021, p. 166-179).

Developed digital infrastructure, including broadband internet access, is the foundation for digital advancement in Western countries. The high percentage of households with internet access in Denmark (over 90%) is the result of long-term investments and strategic actions to improve technology accessibility (Meyerhoff and Jordanoski, 2020, p. 285-291).

Eastern European countries, such as Bulgaria, Romania, and Poland, despite dynamic economic growth and progressing digitalization, still face significant challenges. A low GDP per capita compared to Western countries limits the financial capacity for large-scale infrastructure projects. Nonetheless, these countries show significant progress, supported by EU funds and initiatives aimed at developing broadband internet and digital education. The increase in internet availability in Romania to 77.68% in 2023 illustrates the effectiveness of these actions, although further investments are still needed to reduce regional disparities.

Conclusion

One of the key elements uniting EU countries in their pursuit of digitalization is the common initiatives and programs at the EU level. European funds, such as the Digital Europe program, aim to support the development of digital infrastructure, promote technological innovation, and enhance digital skills across the region. These actions not only bridge

the digital divide between East and West but also contribute to harmonizing digital standards throughout the EU.

International cooperation within the European Union is a crucial factor enabling the exchange of knowledge and best practices among member states. Cross-border projects that promote cooperation in digitalization allow for better utilization of resources and experiences, accelerating the process of digital transformation. Common digital equality policies, which promote access to technology for all citizens, regardless of their place of residence or socio-economic status, form the foundation of sustainable digital development.

Although Western and Eastern EU countries are at different stages of digital development, the common goal is to achieve full societal digitalization. Western countries need to continue investing in innovation and education to maintain their technological edge, while Eastern countries should focus on eliminating infrastructural and educational barriers. However, it should be emphasized that every country, regardless of its current level of digitalization, is taking steps towards modernization and adaptation to the global digital economy. Investments in digital education and infrastructure development are key to achieving long-term success and sustainable digital development in the European Union. Joint actions at the EU level, as well as individual national initiatives, contribute to building a cohesive and digitally advanced society across Europe.

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CONTEMPORARY PERSPECTIVE ON INTANGIBLE BENEFITS OF IT PROJECTS IN ORGANIZATION

Abstract

Intangible benefits play a key role not only in assessing the value of projects, but also in shaping the strategic function of the organization. In particular, new intangible benefits such as cybersecurity are becoming increasingly important in today's digital world. The article analyses the significance of intangible benefits as an important factor in assessing the value of implemented projects. A literature study is provided showing what intangible benefits have been identified to date. These benefits were then compared with intangible benefits in projects implemented in a large organization from the energy industry (based on a sample of nearly 100 projects). This comparison allows for a more up-to-date look at the intangible benefits of IT projects in large organizations, especially those implementing internal projects.

JEL classification codes: H430, J220

Keywords: project management, project benefits, intangible benefits, internal projects.

Introduction

Project benefits can be broadly categorised into two main types: tangible and intangible. The impact of tangible benefit management on the implementation of company strategy has been widely studied

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in the literature. Melton et al. (2008) presents tangible project benefits as financial (sustainable, one-off, cost avoidance, or increase in performance of sales) and non-financial project management benefits. Becerik (2006) categorises tangible benefits as “the rate at which inputs are converted to outputs”, emphasising that they are quantifiable and measurable in monetary terms. Similarly, Braun et al. (2009) presents tangible benefits as measurable in monetary terms or measurable units, including cost savings, revenue growth, increased market share, enhanced operational efficiency, reduced cycle times, and improved productivity. Due to their measurable nature, tangible benefits are relatively easy to assess and communicate to stakeholders.

Intangible benefits of a project, on the other hand, are not as often studied in the literature and their appropriate definition and measurement is an ongoing research challenge. They are more difficult to measure in monetary terms and refer to the profits that an organisation can generate after a project is implemented. However, they have a very significant impact on the organisation, but are difficult to quantify and cannot be easily reported, so are often treated with low importance (Oliomogbe, 2017). They are also more often assessed on subjective grounds or using qualitative measures. Those benefits include aspects such as enhanced customer satisfaction, improved brand reputation, strengthened stakeholder relationships, increased employee morale, and compliance with regulatory standards. Despite their intangible nature, such benefits play a key role in the long-term success and sustainability of the organisation (Nurn and Tan, 2010).

Therefore, the aim of this article is to identify and analyse the current intangible benefits of projects, based on a collection of projects in the IT department of a large company. In order to achieve this objective, the following was first identified intangible benefits presented so far in the literature and compared them with newly identified intangible benefits. Furthermore, the breakdown of these benefits and their impact on the strategic functioning of the organisation is analyzed.

Economists emphasise the growing importance of intangible assets in today's business landscape, with more than 25% of a company's value being attributed to factors such as brand image and market share. This underscores the need to properly recognise and prioritize intangible benefits alongside tangible ones in project analysis and decision-making processes (Tanfous, 2013). Balancing the consideration of both tangible and intangible benefits allows for a more holistic understanding of the project's impact on the organisation's strategic objectives and long-term sustainability (Nogeste, 2005). As Bennington and Baccarini (2004) point out, project managers tend to focus on project outcomes instead of realising benefits, while senior stakeholders focus mainly on the benefits of the project. Intangible assets have a substantial

impact on organizational value and competitiveness, and project managers should ensure a comprehensive evaluation of project outcomes (Archibald, 2003).

1. Project benefits and their management

In project management, the successful delivery of projects that yield tangible and intangible value and desired outcomes is crucial in today's dynamic and competitive business environment. Effective project management transcends mere task completion and schedule adherence, and it encompasses the active management and realisation of benefits associated with each project. According to the Project Management Institute (PMI), project benefits are defined as the positive impacts and value derived from the successful completion of a project. These benefits serve as the primary motivator for organisations to invest resources, time, and effort in specific initiatives.

PMI defines benefits management as a systematic and structured approach that aims to identify, plan, track and realize the expected benefits of a project. This process involves the integration of benefit management practices throughout the project management lifecycle, starting from the initiation of the project and continuing through to project closure. The core objective of benefits management is to ensure that project objectives are well defined, benefits are identified and prioritised, and suitable strategies and actions are put in place to realise those benefits. By effectively managing benefits, project management professionals can facilitate value creation, improve decision-making processes, and guarantee that projects achieve their intended outcomes and benefits (Aguilera, 2016).

Benefit identification is the first step that must take place to ensure proper benefit management. This process requires a comprehensive analysis of the organisation's strategic goals, existing challenges, and stakeholders' expectations. Engaging stakeholders and subject matter experts is crucial during this phase to acquire a holistic understanding of the benefits that hold the greatest relevance and value for the organisation. By involving key stakeholders and experts, project managers can ensure that the identified benefits align closely with organisational objectives and are perceived as valuable by those invested in the project's success.

After identifying benefits, the subsequent step in benefits management involves the development of a benefits management plan. This plan serves as a strategic document that presents the actions necessary to deliver and evaluate the identified benefits. The benefits management plan can be provided as a comprehensive roadmap that specifies the activities, resources, and timelines essential to achieve the desired outcomes. By outlining a detailed plan, project managers can effectively guide the project team towards achieving the intended benefits within the stipulated

timeframe. Additionally, the benefits management plan establishes clear roles and responsibilities for team members, defines success criteria for benefit realisation, and outlines measurement methods to assess progress and impact. This ensures transparency, accountability, and alignment throughout the project lifecycle, allowing stakeholders to monitor the project's success in delivering the anticipated benefits (Zwikael and Chih, 2014).

A benefits realisation strategy plays a pivotal role in ensuring that the identified benefits of a project are effectively realised. This strategy encompasses the development of approaches and activities to maximise the likelihood of success in the realisation of the benefits. The key components of a benefit realization strategy may involve the implementation of process improvements, organisational changes, or adopting new technologies to facilitate the achievement of desired results. In addition to proactive measures to enhance benefit realisation, a robust benefits realization strategy can also incorporate risk management measures. Those risk management practices are designed to identify potential obstacles or challenges that could impede the realisation of benefits and to implement mitigation strategies to address these risks effectively. By integrating risk management into the benefits realisation strategy, project managers can proactively identify and address potential threats, thus ensuring a smoother and more successful realization of project benefits (Byatt, 2010).

Throughout the project lifecycle, monitoring and measuring progress towards realising the identified benefits is a critical aspect of benefits management. This process involves the establishment of metrics, data collection, and analysis to evaluate the project's effectiveness in delivering the anticipated benefits. Regular monitoring enables project management professionals to track the project's performance against predefined metrics, identify any deviations from expected outcomes, and take corrective actions when necessary. By continuously evaluating progress and analysing results, project managers can ensure that the project remains aligned with its objectives and that the benefits are being realised as intended (White and Casey, 2017).

The responsibilities for project benefits management are typically distributed among various key roles within the project management framework. The project owner plays a crucial role in achieving benefits, ensuring that the expected benefits are identified, prioritised, and ultimately achieved (Zwikael et al., 2019). In addition, the project sponsor is responsible for overseeing the identification of project benefits, a critical activity for project success (Breese et al., 2020). Collaborative efforts between sustainable project management, benefits management, and project governance can significantly influence project success, highlighting the importance of shared responsibilities in achieving project benefits (Khan et al., 2022).

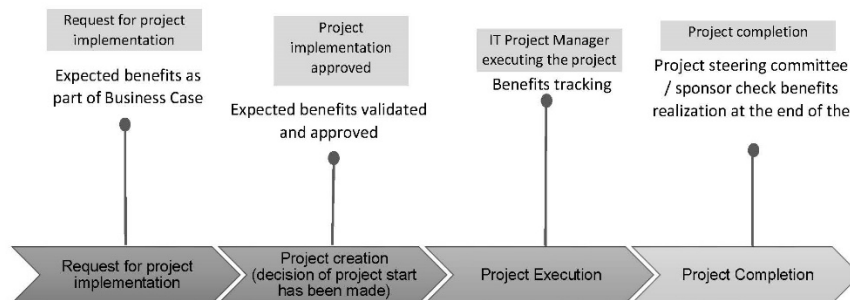


Figure 1. Benefits management process in project management

Source: Own study

The process of benefits management in the organisation that will be analyzed in the following chapters takes place as shown in Fig. 1. It can be seen that this process starts before the approval to start a project as part of the business case. During project approval, expected project benefits must be validated and accepted. While the project is running, the project manager is responsible for monitoring whether the benefits of the project are realized as planned, and at the end of the project, the achieved benefits are verified by the steering committee against the objectives set.

2. Intangible project benefits

As was already mentioned, intangible project benefits are the most unrecognized area in project benefit management, yet they often claim critical benefits for the organisation. This is because they are indispensable to maintaining the organisation's compliancy health, data security, support the organization's strategic objectives, and allow for increased customer satisfaction with the solutions received through experience.

According to Oliomogbe (2017), the generation of intangible benefits from project management deployment is crucial for both permanent organisations and project-based organizations. A coherent approach to studying the intangibles of project management deployment is necessary, combining theoretical and empirical methodologies. The theoretical approach grounds the investigation in established project management literature, while the empirical approach validates and aligns the research with project management practices.

Given the nature of intangible benefits, which are challenging to quantify and often involve subjective elements, an interpretivist approach is essential. This approach addresses criticisms of project management research being

overly positivist or mechanistic, allowing for a deeper understanding of the complexities surrounding intangible benefits in project management deployment (Oliomogbe, 2017).

The literature provides diverse perspectives on understanding and handling intangible benefits in projects. Many studies focus on intangible benefits such as intellectual capital (Evans et al., 2015; Labra and Sanchez, 2013; Lentjusenkova and Lapina, 2016; Pedro et al., 2018), organisational capital (Martín-de-Castro et al., 2006) and corporate brand (Pereira-Villazon et al., 2021). In addition to those benefits, Oliomogbe and Smith (2013) derive such intangible benefits as human capital, social capital, and eventually innovation-related capital. Similarly, Silva Junior et al. (2023) view the intangible benefits of a project from the perspective of intellectual capital, human capital, organisational capital, customer perspective and internal process perspective. Thurimella and Padmaja (2014) underline that intangible benefits cannot be measured in simple terms of product metrics, but project benefits should also include factors such as customer satisfaction and professional satisfaction. Similarly, Murphy and Simon (2002) also point out the impact of intangible benefits from a customer satisfaction, as it can result in significant market benefits. Hares and Royle (1994) categorise the project intangible benefits in IT investment into four groups. The first group involves internal improvements, such as changes in production processes and operations management, leading to increased output and reduced production costs. The second group comprises customer-orientated benefits, such as improved customer service that results in higher customer retention and satisfaction. The third group focusses on identifying new market trends that can lead to the development of new products or services to capture new sales and market positions. The final group emphasises the importance of adaptability to change, enabling firms to adjust products, services, and production processes in rapidly evolving industries.

An interesting conceptual model has been proposed by Jovanovi et al. (2019). Measure the impact of customer service representative aspects on intangible benefits taking into account factors such as ecological aspect, voluntarism, and social aspects.

Finally, Hyde and Wilson (2004) give a broader point of view on the intangible project benefit types, focussing on the improvements in various areas.

To summarise the above examples, the intangible benefits of the project along with the authors of the literature are gathered in Table 1.

Table 1. Summary of the types of intangible benefits

Intangible Benefit	Author
Intellectual capital	Evans et al., 2015
Organizational capital	Martín-de-Castro et al., 2006
Corporate brand	Pereira-Villazon et al., 2021
Intellectual Capital, human capital, organisational capital, customer perspective, internal process perspective	Silvia Junior, 2023.
Customer satisfaction and professional satisfaction	Thurimella and Padmaja, 2014
Ecological aspect, voluntarism, and social aspect	Jovanović et al., 2019
Organisational capital, human capital, social capital, intellectual capital, innovation related capital	Oliomogbe and Smith, 2013
Internal improvements, customer service, foresight, adaptability	Murphy and Simon, 2002
Improved quality of work life / working conditions, improved organisation communications, improved organization learning and efficiencies, improved ability to attract, retain and develop software professionals, more coherent organization culture	Hyde and Wilson, 2004

Source: own study

3. Analysis of intangible benefits in the real organisation

Intangible benefits were analysed in an organization operating in the energy sector, in the IT department. The data sample is from 2023 Q2 – 2024 Q1 and includes almost 100 analysed projects.

The project intangible benefits were implemented in the organisation in the projects which refer to many different goals and products achieved after the implementation. According to the data presented in Fig. 2, it is evident that the most common project product is the implementation of a new application, accounting for approximately 19% of all projects. Additionally, around 17% of the projects focus on application updates. This indicates that a significant portion, totalling more than 35% of project-related goals, is focused on enhancing or introducing new applications within the organization.

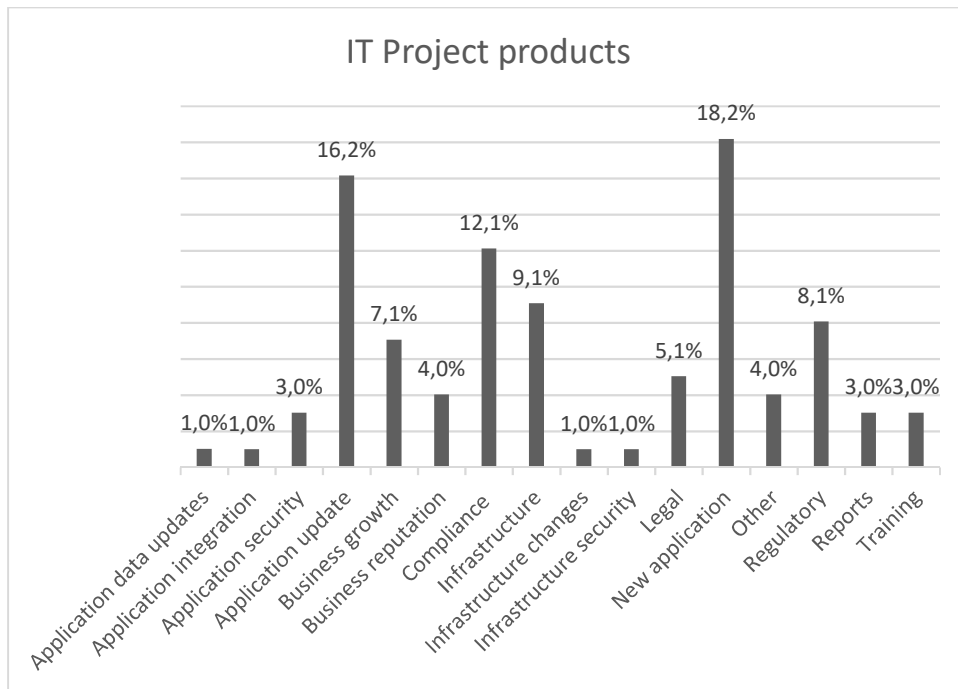


Figure 2. Percentage distribution of IT project product types in the sample of IT projects studied

Source: Own study

Furthermore, a substantial proportion of projects, more than 20%, are associated with compliance and regulatory requirements. These projects are specifically geared towards addressing the results of audits or adapting to changes in legal mandates. This highlights the importance placed by organisations on ensuring adherence to regulatory standards and legal frameworks, which can have far-reaching implications for the organisation's operations and reputation.

It is vital to acknowledge the significance of infrastructure-related projects within organisations. According to the data provided, nearly 12% of projects are associated with infrastructure products, encompassing activities such as creating new infrastructure updating existing infrastructure, or improving security measures for the available infrastructure. Integration of cybersecurity measures with infrastructure security products is crucial to ensuring the safety and integrity of IT-related projects within organisations. This synergy between infrastructure security and cybersecurity not only protects sensitive data and systems but also fosters a culture of vigilance and preparedness against evolving cyber risks. The data gathered indicate the presence of another security-related product within the projects,

specifically focused on cybersecurity in applications. This underscores the critical importance of addressing cybersecurity concerns at the application level to improve overall security posture and mitigate potential risks.

Intangible project benefits that were identified in the organisation include the types such as cybersecurity, compliance, brand equity, customer satisfaction, organizational strategy, and user experience, what has been shown in details in Fig. 3.

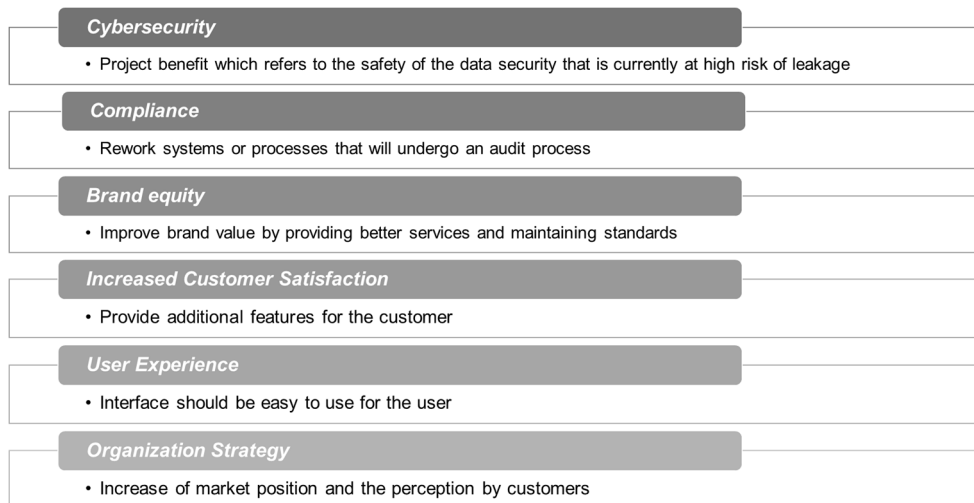


Figure 3. Benefits intangible project identified in the studied organization

Source: Own study

Cybersecurity is the most up-to-date project benefit which refers to the safety of the data security that is currently at high risk of leakage. By carrying out projects that aim to ensure the security of the applications used in the organisation, the company may not be exposed to the risks and penalties resulting from data leakage. Leakage of company data can lead to a reduction in the company's competitiveness and even disrupt the energy security of the state. By leaking the data of individuals, the organisation is exposed to penalties related to lack of data confidentiality. Ofori-Yeboah et al. (2021) delve into the cost-benefit analysis of cybersecurity investments in supply chain security, highlighting future cost savings from preventing losses due to breaches. Additionally, Franco et al. (2022) offer a framework for planning and managing cybersecurity projects in small and medium enterprises, emphasizing the role of cybersecurity economic metrics in decision-making and effective strategy development. These studies collectively underscore the importance of considering

intangible benefits alongside tangible costs in cybersecurity decision-making processes to maximise the overall value and effectiveness of cybersecurity initiatives.

Compliance benefits focused projects are based on a conclusion from audit findings and are required for process or systems rework, that are intangible benefits. It is very important to implement changes that help an organisation remain compliant to avoid penalties and legal problems, but valuing this benefit is difficult to assess. It can be considered as the probability of non-compliance multiplied by the potential penalties resulting from the situation.

In the context of project management and organisational success, brand equity plays a crucial role as a key goal for many organisations. Projects that aim to improve brand equity by delivering superior services and maintaining high standards often yield intangible benefits that are essential for long-term success. Economists emphasise the growing importance of intangible assets in today's business landscape, with more than 25% of a company's value being attributed to factors such as brand image and market share.

The majority of projects are based on meeting customer requirements. Sometimes it is about satisfying the internal customer, and other times it is about the external customer. If the customer is not satisfied with the results of the project, the project cannot be considered successful. It is possible to measure customer satisfaction through surveys, making the benefits of the project tangible, but surveys are often not linear. This measurement also cannot be treated objectively because it is based on people's feelings and they are generated by many variables.

Improving the user experience is an intangible benefit that is often related to the user interface. The view of the application is adapted to the customer's requirements, so that it is easy and convenient to use. Sometimes innovative features are added as well. The creation of a user-friendly interface and sophisticated functionality that helps speed up the process for the user is a benefit of the project, without the possibility of quantification.

The quest to achieve business strategy by obtaining benefits from intangible projects is one of the reasons for implementing an IT project in an organisation. The business strategy sets goals within which development must occur, including in the field of IT solutions and the opportunities and threats they bring. Increased market position and customer opinion is a key value added through the implementation of the project focused on the benefit, such as organization strategy.

The organisation's focus is on ensuring compliance and improving user experience, which is highly visible in Fig. 4.

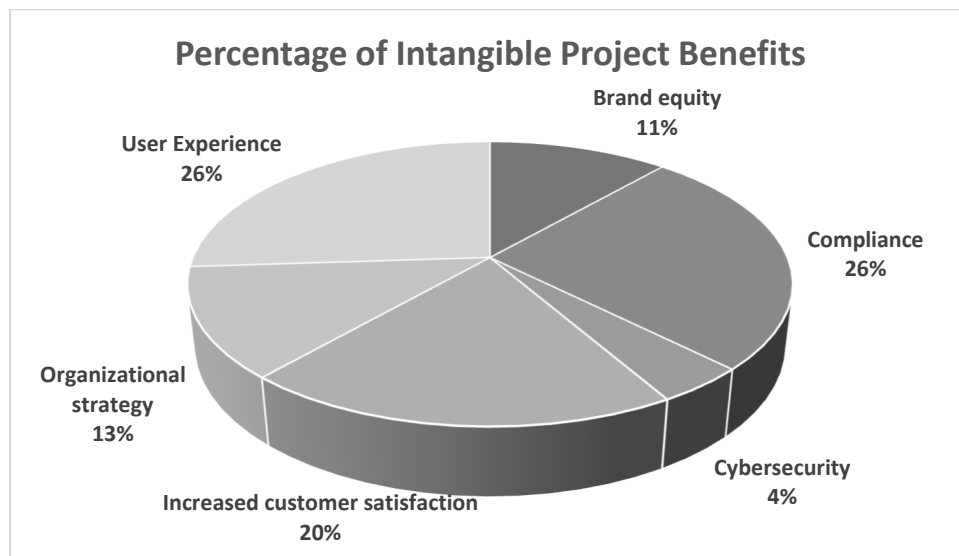


Figure 4. Percentage distribution of intangible benefit types in the sample of IT projects studied

Source: Own study

These intangible benefits comprise more than 50% of all expected intangible benefits in the surveyed data sample. The results indicating that 20% of the project data is focused on increasing customer satisfaction suggest a significant emphasis on meeting user needs and improving user experience within IT organisation. This finding aligns with the notion that 46% of projects are specifically geared towards delivering satisfaction to customers and improving user experience. The strategic orientation of IT organisations towards prioritizing customer satisfaction and user experience is essential to ensure the successful adoption and utilisation of IT solutions by end users. By focussing on delivering satisfactory products and maintaining high-quality user interfaces, IT organisations can enhance user engagement, loyalty, and overall satisfaction with the provided solutions. However, the results indicate that 13% of the projects refer to organizational strategy and 11% of projects, referring to brand equity.

Implementing projects whose project benefits align with the organisation's strategy is indeed simpler due to the necessity of project cost acceptance. The decision to implement is made at the level of decisions related to the organisation's strategy, rather than at the project level. IT projects are implemented to ensure an organisation's brand value, a critical aspect of marketing strategy that includes various elements that contribute to consumer perceptions and preferences toward the brand.

The limited representation of benefits from cybersecurity projects, at only 4% of projects, may appear relatively small compared to other project focuses. However, the significance of cybersecurity cannot be understated, especially in the current landscape, where cyber threats pose serious risks to organisations. Cyberattacks and data breaches have the potential to undermine all other benefits of the project described, including brand equity, customer satisfaction, and compliance with organizational standards.

Conclusions

Analysis of the literature has shown some of the intangible benefits of project that may be indicated by organisations can indicate when implementing projects. Individual articles, though few in number, have provided valuable insights into the complexities of benefit realization in project implementations. This applies especially to IT projects where intangible benefits play a significant role. The analysis of the case study made it possible to examine IT projects in a large organisation, which makes the studied space innovative, as previously published articles rarely analysed intangible benefits in large organizations.

Differences in the definition of project types were noted between the analysed project sample and the literature analysis. The main change that was identified was the emergence of a relatively new intangible benefit related to cybersecurity. From a research perspective, there is a need for further exploration of the topic related to changes in intangible benefits over time, including a close examination of the intangible benefits resulting from the need for cybersecurity in energy organisations, but not only. Cybersecurity as a project benefit has not been analysed in the literature due to the fact that it has only recently started to be a relevant factor in enterprises.

The empirical research conducted in the IT industry is particularly relevant due to the industry's project-based nature. IT organisations operate predominantly through projects, and the delivery of these projects is instrumental in achieving strategic objectives and remaining competitive in international markets. Although the study is focused on the IT sector, the findings are likely applicable to other industries that utilise project management methodologies. By exploring how intangible benefits derived from project management deployment contribute to the competitiveness of project-based organisations, insights can be gained to develop and implement effective project management strategies. These strategies can facilitate the generation, management and exploitation of intangible benefits, ultimately improving the overall performance and success of project-based organisations across various sectors.

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