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ENVIRONMENTAL EFFECTS OF GREEN BONDS AND OTHER FORMS OF FINANCING IN THE EUROPEAN UNION

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Abstract:
Prioritising the implementation of environmental policies is a cornerstone for European Union member states. While sharing common objectives, individual countries apply their own approaches to implementing and financing sustainable development and the green transition, considering national economic characteristics. This raises the crucial question of the extent to which various funding sources contribute to the success of environmental policies. In the past decade, many instruments for financing sustainable development have emerged, with green bonds prominently positioned as a pivotal tool for directing financial flows towards the achievement of green objectives. This paper studies the relationship between different financing instruments, such as the availability of issued green bonds, the extent of total debt, economic development, fiscal instruments, and, on the other hand, the specific indicators used to evaluate the effects of implementing environmental policies. The study focuses on the environmental policies of European Union member states and associated member states from 2015 to 2022, with the intent to examine the effect of policies on indicators such as energy consumption, greenhouse gas emissions, and economic losses from extreme weather events. Through correlation analysis, the study aims to specify the direction and significance of the influence of each independent variable on the dependent indicators. The findings reveal that green bond financing serves as a catalyst for positive changes in reducing energy consumption and carbon emissions, while general government debt emerges as a significant factor in financing environmental policies.

Keywords:

sustainable finance, green bonds, environmental policies, environmental effects, greenhouse gas emissions

JEL Classification: *G15, H54, Q56*

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Introduction

Climate change is one of the greatest challenges of our times. It introduces uncertainty into the global economic development and impacts human health, quality of life, and food security. As researchers grapple with the urgent need to combat climate change in the last few decades, they have turned their attention to identifying the most effective solutions. While sharing common objectives, individual countries apply their own approaches to implementing and financing the sustainable development and green transition, considering the national economic characteristics. This raises the crucial question of the extent to which various funding sources contribute to the success of environmental policies. A consensus exists that a lot of financial resources, public and private, should be allocated to fight climate change and in parallel with that a growing awareness that the financial markets should play a significant role in dealing with this challenge. As a result, sustainable finance has seen enormous growth in the last decade. Sustainable finance relates to the specific financial instruments allowing the direct allocation of resources to environmental projects and activities. According to Climate Bonds Initiative data the cumulative issuance of sustainable finance instruments has reached 3,7 trln. dollars in 2022 and the new issuance in the same year amounted to 858,5 bln. dollars. Despite the development of various instruments, the green bond is by far the most prominent one with its issuance being more than half of the whole market. Green bonds are debt instruments the proceeds of which are used to finance environmentally friendly projects. Non-surprisingly Europe stands out as a leading issuer of green bonds. An impetus in the market growth of this instrument was given by the increased level of standardization of bonds as besides the private, industry-based standards the EU approved a voluntary, public Green Bond Standard, based on EU Green Taxonomy. The standardization contributes to decreasing information asymmetry and increased trust of investors in this instrument. A similar positive effect have had the increased disclosure requirements. Among other effects, green bonds are expected to promote environmental effects for their issuers and economy-wide, thus playing a significant role in fulfilment of the ambitions stated in the Paris Agreement and the Green Deal.

Therefore, the study tries to identify what are the environmental effects of the use of green bonds, as well as other funding sources in the European Union by using certain variables, which are associated with improved environmental quality. The study examines several indicators that we believe are crucial for evaluating the effects of green bonds: greenhouse gas emissions, energy consumption and economic and social damages of climate risks. Those indicators are related to the sustainable development goals.

We use greenhouse gas (GHG) emissions[1] at the forefront, because substantial reduction of global GHG was one of the long-term objectives of the Paris Agreement and the EU Green Deal aims at reducing net GHG emissions with at least 55% by 2030 compared to 1990 levels for the European continent. On the other hand, the major share of proceeds of green bonds are allocated for climate change mitigation purposes and thus we expect an increase in the volume

[1] GHG emissions are emissions in the atmosphere of carbon dioxide (CO2), methane, nutrious oxide, and other gases, which absorb heat and contribute to the global warming. CO2 is the primary GHG. GHG emissions are produced by human economic activities like burning fossil fuels for energy, transportation and industry as well as agriculture and land use.

of green bonds to contribute to reduction of GHG emissions. The reduction on a firm-level can be achieved either directly, by financing projects leading to a reduction in emissions, or indirectly by promoting firm's overall environmental behavior.

As far as energy consumption is concerned, we use this indicator as most of the studies focus on the link between green financing and energy efficiency, described as using less energy to produce a unit of goods and services. Further the logic is that increasing energy efficiency translates into less energy consumed in the production process. Improved energy efficiency plays a role in reducing GHG emissions as confirmed by literature.

Economic and social damages of climate risks constitute another critical facet of our study, addressed through green bond financing. Besides climate change mitigation, the green bonds are also used, although to a much lesser extent to help with the adaptation to climate change by building resilience and thus reducing climate-related losses.

According to data from the European Environmental Agency in the period 1980-2022 weather and climate-related extreme events caused economic losses of assets amounting to EUR 650 bln. in the EU member states. Climate-related disasters impede economic growth and induce shifts in production costs, thereby triggering price volatility.

Literature Review

Our research has its theoretical justification based on the sustainable finance literature, which has been growing intensely in the last decade. A vast part of this literature is devoted to green bonds. Most of the research focuses on the pricing of green bonds and their effects. Relevant to our paper are the studies that try to estimate the environmental effects of green bonds. On a corporate level *Flammer (2021)*[2] documents the effects of green bond issuance on company performance, including the environmental performance and her results show that, following the issuance of green bonds, companies improve their environmental performance, namely higher environmental ratings, and lower CO 2 emissions. In the same vein research by *Fatica and Panzica* (2021)[3] finds a negative and statistically significant link between green bonds and total and direct CO2 emissions, implying that green bond issuance is associated with reduction of emissions. The results are more pronounced for non-refinancing bonds, i.e. bonds issued to finance new environmental projects and not to refinance old debt. The research also documents additional effect in emission reduction for bonds with external review as well as for bonds issued after the Paris Agreement. In research devoted to European issuers of green bonds *Mazzacurati (2021)*[4] finds that the average total GHG emissions of European Economic Area green bond issuers show a significant decrease between 2009 and 2019, amounting to 38% as well as their carbon intensity falls with 35%. In contrast, *Ehlers, Mojon and Packer (2020)*[5] do not find evidence that green bonds necessarily lead to lower carbon intensity on an entity level.

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[2] Flammer, C. (2021) Corporate Green Bonds, *Journal of Financial Economics*, Vol. 142, Issue 2, November 2021, pp. 499-516.

[3] Fatica, S. and Panzica R. (2021) Green bond as a tool against climate change? *Business Strategy and the Environment, Vol. 30, Issue 5*, 2021.

[4] Mazzacurati, J. (2021) Environmental impact and liquidity of green bonds, *ESMA Report on Trends, Risks and Vulnerabilities, No. 2, 2021.*

[5] Ehlers, T., Mojon, B. and F. Packer, (2020) Green bonds and carbon emissions: exploring the case for a rating system at the firm level, *BIS Quarterly Review* September 2020.

The negative link between green finance and GHG emissions on a country level is documented by *Li, Faridi and Nazar (2023)*[6] for the ten biggest issuers of green bonds, namely China, Canada, France, Germany, Japan, the Netherlands, Spain, Sweden, the UK, and the US between dec. 2008-dec. 2019. Research for the top ten supporters of green debt of *Chang et al. (2022)*[7] also confirms the green finance plays a role improving the environmental quality in eight of the ten countries. A paper of *Zhang, Mohsin and Hesary (2022)*[8] for G20 countries for the 2008-2018 period finds that CO2 emissions in the environment are reduced by green finance, renewable energy investment, and technological innovation, whereas CO2 emissions are increased by factors such as economic growth, energy consumption, trade, and foreign direct investment.

Yet, the literature on the link between green bonds and economic losses from climate related events is very scarce. *Mittnik, Semmler and Haider (2019)*[9] documented a positive link between CO2 concentration and frequency of climate-related disasters. Their dynamic macro model explores the linkages: economic production and growth leads to the extraction and usage of fossil fuel, which give rise to CO2 emission, and increasing temperature. These effects then reduce economic growth and economic welfare which are then addressed by mitigation and adaptation policies, pursued by monetary and financial instruments, including bond issuance. The authors propose combining fiscal, financial, and monetary policies for tackling climate change. *Cantelmo, Melina and Papageorgiou (2023)*[10] research the macroeconomic effects of climate-related events in the disaster-prone countries and find that relative to non-disaster-prone countries they grow yearly with 1 % less on average and those events cause a welfare loss amounting to 1,6% decrease in consumption. Moreover, their public debt level is 1.54% higher than that of other countries. The main channels via which natural disasters affect the economy on a macro level are the destruction of capital and a temporary decline in productivity growth. The lower output then translates into decreased public revenues and increased public debt. The issues concerning financing of rebuilding public infrastructure after occurring disasters is dealt in *Bevan and Adam (2016)*[11], who conclude that budget reallocation may be damaging while tax increase, if feasible, may be a workable option.

The objective of increasing energy efficiency is addressed with policy measures financed through different sources and their impact is studied in the economic literature. Environmental taxes can improve energy efficiency in short and long term, as evidenced by *He et al. (2021)*[12] for the OECD countries. *Li et al. (2023)*[13] investigate the effect of green bonds and green taxes

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[6] Li, Ch., Faridi, M. and Nazar, R., (2023) How does green finance asymmetrically affect greenhouse gas emission? Evidence from the top-ten issuance countries, *Borsa Istanbul Review 23-4*, pp. 887-894.
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[12] He, P. et al. (2021) The lond and short-term effects of environmental tax on energy efficiency: Perspective of OECD energy tax and vehicle traffic tax, *Economic Modelling, Vol. 97*, April 2021, pp. 307-325.
[13] Li, Y. et al. (2023), Assessment of environmental tax and green bonds impact on energy efficiency in the European Union, *Economic Change and Restructuring, 2023 56 (2),* Springer.

on energy efficiency in the European Union member states and confirm that green financing is a more efficient tool than green taxation for improvement of energy efficiency in the EU. Their study also found a positive impact of GDP growth on energy efficiency, which is explained by the growing ability of the government, the private sector and the banking sector to allocate resources to green projects. The green bond issuance promotes reduction of CO2 emissions, especially where the proceeds are used for energy efficiency projects as confirmed by *Al Mamun, Boubaker and Ngyuen (2022)*[14].

Interesting insights about the causality between the GDP growth and some of the explored variables are present in *Achaempaong (2018)*[15]. Based on data for 116 countries for the period 1990-2014, the research examines the causal relationship between economic growth, CO2 emissions and energy consumption and finds that economic growth has no causal effect on energy consumption while energy consumption one-directionally causes economic growth. The research also documents a bi-directional causality in the link economic growth – CO2 emissions with some regional variations.

Research Methodology

Having in mind the specifics outlined above, as well as the discussions in the relevant scientific literature, the main objective of the current research is to identify is there a significant difference between countries issuing green bonds[16] and those that do not issue green bonds[17], as far as it concerns the results of their climate-related policies and the sources of financing of the said policies.

To be able to give an answer to the main research question we formulate the following research hypotheses and questions:

Hypothesis 1. Countries which increase their green bond emissions demonstrate an increased speed of improvement of the variables, related to their environmental policies.

Hypothesis 2. Countries which increase their overall debt show an increased speed of improvement of the variables related to their environmental policies.

Hypothesis 3. Countries demonstrating higher growth rates show an increased speed of improvement of the variables related to their environmental policies.

Hypothesis 4. Countries which increase the fiscal burden of ecological taxes show an increased speed of improvement of the variables, related to their environmental policies.

To each of the above hypotheses we attach the following research questions: Does this concern all countries or some of them? Does this concern all or only some of the policy indicators? Do the countries that issue more green bonds show greater speed of improvement of the parameter? Can a substantial difference be identified in the results dependent on we use for

[14] Al Mamun, M., Boubaker, S. and Ngyuen, D. (2022) Green Finance and Decarbonization: Evidence from around the world, *Finance Research Letters 46 (5)*.
[15] Acheampaong, A., (2018) Economic Growth, CO2 emissions and Energy Consumption: What causes what and where? *Energy Economics Vo. 74,* August 2018, pp. 677-692.
[16] According to Eurostat data these are Belgium, Denmark, Germany, Ireland, Spain, France, Italy, Latvia, Lithuania, Luxembourg, Hungary, Netherlands, Austria, Poland, Slovenia, and Sweden.
[17] According to Eurostat data these are Bulgaria, Czechia, Estonia, Greece, Croatia, Cyprus, Malta, Portugal, Romania, Slovakia, Finland, and Iceland.

the assessment the variables calibrated as per the overall debt or as per the GDP growth? Is there a substantial difference between countries issuing green bonds and those which do not issue such?

We restrict our research as we accept that the EU countries, by following their environmental policies aim at achieving results that can be measured by the so-called EU environment policy indicators. We chose among the policy indicators that are related to the Sustainable Development Goals (SDG), and more precisely to Goal 7 (Affordable and clean energy, referred to as sdg_07) and Goal 13 (Climate action, referred to as sdg_13). The methodology operates under the assumption that this specific set of indicators enables the examination of the primary effects of green economy policy financing within the European Union, delineated by country[18]. These indicators represent the target effect, and the advancements in them reflect the effects of each EU country's policy approach. We compiled a dataset, Panel [A], for each EU member state spanning the period 2015-2022, featuring the following policy indicators as specified above:

1. *Primary energy consumption* (representing the Eurostat classification [sdg_07_10]).
2. *Final energy consumption* (representing the Eurostat classification [sdg_07_11]).
3. *Net greenhouse gas emissions* - as per the Eurostat classification [sdg_13_10].
4. *Net greenhouse gas emissions of the Land use, Land use change and Forestry (LULUCF) sector* - as per the Eurostat classification [sdg_13_21].
5. *Climate related economic losses* - as per Eurostat classification [sdg_13_40].

For achieving these objectives EU economies employ various sources of financing to a different degree. As there is not accurate statistical data for the public and private expenditures used for financing of these policies, we accept that a major part of the financing stems from:

- Green bonds, representing a financial instrument targeted at climate-related projects.
- A part of the country's total public debt, directed at environmental policies.
- Through the economic growth, represented by the growth of GDP, by the developed incentives for the economic agents to use a part of their growing earnings in times of economic expansion for environmental policies.
- Through fiscal revenues form environmental taxes, as we accept that the fiscal revenues are directed to environmental policies, and they incentivize economic agents to finance similar initiatives with their own resources so that they reduce their ecological tax burden.

Further to that, Panel [B] contains data on financial instruments, respectively the independent variables acting as catalysts of change within this methodology. This dataset covers each EU

[18] The territorial coverage focuses on the following EU Member States and Associated Member States: Belgium, Bulgaria, Czechia, Denmark,Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, Iceland, Norway, Switzerland, according to the data available in the Eurostat classification.

member state for the period 2019-2022 and includes the following indicators[19], representing the different sources of financing:

1. *Total green bonds issued by individual EU member governments annually, presented as a percentage of GDP at market prices*, based on Eurostat data and our calculations (GB/GDP).
2. *Cumulative total green bonds issued by individual EU member governments annually from 2019-2022, presented as a percentage of total government debt*, based on Eurostat data and our calculations (GB/Debt).
3. *Year-on-year change in total debt, as a percentage*, based on Eurostat data and our calculations (dDebt).
4. *Year-on-year change in GDP, as a percentage*, based on Eurostat data and our calculations (dGDP).
5. *Share of environmental tax revenues in total revenues from all taxes and social contributions,* representing Eurostat classification [ten00141]) (Etax)

The data analysis is structured, following the individual indicators in Panel [A] and includes an assessment of the relationship between each of the indicators in Panel [B] and those in Panel [A]. It examines changes in the indicators over both the medium-term (2015-2022) and short-term (2019-2022) periods by country. The assessment is conducted based on correlation analysis which seeks dependencies between each indicator from Panel [B] and the change in the indicator from Panel [A]. Moreover, the contribution of each indicator from Panel [B] to the change in the indicator from Panel [A] has been evaluated. A summary on the effects of the different funding sources aimed at achieving results in the different policy indicators has been outlined. The data for the indicators from Panels [A] and [B] are publicly available at Eurostat, as of January 2024.

Research Results

Policy effects on energy consumption

The EU policy aims at reducing both primary and final energy consumption indicators which are intertwined with economic characteristics and influenced by the growth intensity dynamics. Country by country, structural differences between economies are also important, requiring a tailored policy approach to managing indicator values at the level of the individual economy.

In line with the common policy, most countries in the sample have successfully achieved a decline in primary energy consumption (refer to Table 1). However, certain countries, including Croatia, Cyprus, and Malta, diverge from this change, showing an increase in the indicator. Bulgaria demonstrates weak but constant pace of increasing energy consumption variables as

[19] In the tables, the indicators from panel [B] are presented with their codes - GB/GDP; GB/Debt; dDebt; dGDP; Etax, respectively.

in the short run the final energy consumption is stabilized and has no change. In general, the assessment is that the implemented policies have an effect, particularly in the short term.

The conclusion is similar for the final energy consumption indicator (see Table 1). Some countries like Bulgaria, Croatia, Malta, and Romania exhibit a deterioration of the indicator (an increase in values). Despite these variations, the overall changes closely resemble those observed in the primary energy consumption indicator, although the differences justify distinguishing between the two indicators.

Overall, the assessment indicates that the implemented policies show results. Notably, the speed of achieving the desired outcome concerning final energy consumption is significant, considering primary energy consumption. This is probably due to the possibility of restructuring some energy sources used for meeting energy needs relatively more quickly than those used for manufacturing and production, for example.

Table 1. Medium- and short-term change of indicators - Primary energy consumption and Final energy consumption, by country, annualised, in million tonnes (equivalent), 2015-2022 (change indicated - see legend)

Indicator / Country	Primary energy consumption			Final energy consumption		
	_15_22	**_19_22**	**Trend**	**_15_22**	**_19_22**	**Trend**
Belgium	-1,09%	-6,61%	↓↓	-7,22%	-6,70%	↓
Bulgaria	5,00%	5,00%	↑	4,21%	0,00%	↑
Czechia	-2,03%	-2,77%	↓↓	2,89%	-1,58%	↕
Denmark	-4,76%	-5,33%	↓↓	-5,63%	-6,29%	↓↓
Germany	-12,10%	-8,80%	↓	-4,56%	-5,40%	↓↓
Estonia	-2,08%	-2,08%	↓	0,00%	-3,45%	↓↓
Ireland	2,88%	-2,72%	↓	6,19%	-3,23%	↕
Greece	-10,68%	-6,28%	↓	-3,01%	-0,62%	↓
Spain	-4,23%	-6,14%	↓↓	0,87%	-6,13%	↓↓

France	-16,12%	-12,91%	↓	-6,68%	-5,01%	↓
Croatia	3,75%	1,22%	↑	4,55%	0,00%	↑
Italy	-6,57%	-4,52%	↓	-3,61%	-2,95%	↓
Cyprus	8,70%	0,00%	↑	5,88%	-5,26%	↕
Latvia	0,00%	-6,52%	↓↓	5,26%	-2,44%	↕
Lithuania	8,62%	0,00%	↑	10,20%	-3,57%	↕
Luxembourg	-7,32%	-15,56%	↓↓	-7,50%	-15,91%	↓↓
Hungary	2,58%	-2,85%	↓	5,17%	-1,61%	↕
Malta	12,50%	0,00%	↑	16,67%	0,00%	↑
Netherlands	-4,92%	-12,07%	↓↓	-10,70%	-12,32%	↓↓
Austria	-4,73%	-6,50%	↓↓	-4,36%	-7,07%	↓↓
Poland	9,32%	-1,70%	↓	16,21%	-1,76%	↕
Portugal	-4,15%	-5,88%	↓↓	4,38%	-2,34%	↕
Romania	0,65%	-3,43%	↓	9,59%	0,42%	↑
Slovenia	-1,59%	-4,62%	↓↓	0,00%	-4,08%	↓
Slovakia	-1,90%	-3,13%	↓↓	0,93%	-3,57%	↑
Finland	-3,21%	-5,92%	↓↓	-3,72%	-8,63%	↓↓
Sweden	-2,97%	-7,21%	↓↓	-2,52%	-1,59%	↓

Source: Eurostat and calculations generated through our research

Legend: ↓ - downward trend; ↓↓ - downward change with a tendency to further decrease; ↑ - upward change; ↑↑ - upward change with a tendency to increase; ↕ - no persistent change.

Regarding the potential sources of financing policies related to primary energy consumption, the analysis reveals a significant negative correlation between the quantity and value of issued green bonds and the value of the indicators. Essentially, countries issuing more green bonds tend to achieve reductions in both primary and final energy consumption, as evident in Table 2. In fact, over half of the countries which have issued green bonds exhibit a correlation coefficient in relation to the indicator, highlighting a strong link between the bonds and the observed effects. This relationship is particularly pronounced with regards to the total value of green bonds issued by individual EU member governments as a percentage of GDP (GB/GDP). The assessment of green bond magnitude relative to GDP provides a calibrated indicator, amplifying the strength of dependence based on the size of the economy.

The analysis also highlights the significant influence of changes in the overall debt of individual countries on the indicators. This holds true not only for countries without green bond issuance, where total debt serves as a crucial financing source for their green policies, but also for countries with green bond issuance. In both cases, the role of general government debt is crucial. This can be attributed to the nature of certain policies, which are horizontally structured, making it challenging to segregate activities for financing exclusively through green bonds. Interestingly, this influence is more pronounced for final energy consumption compared to primary consumption.

It is curious to explore the effect of economic growth on this policy indicator. Most of the countries in the sample confirm the intuitive logic that economic growth generates increase in energy consumption, as for nearly half of the economies the link is substantial. In some of them (Bulgaria, Croatia, Italy, and Norway) the increased values of GDP are strongly related to primary energy consumption. To a certain degree this can be attributed to the energy intensity of the economic sectors that generate the economic growth for the respective economies. A small number of countries (Luxembourg, Netherlands, Sweden, and Iceland) manage to achieve a reduction in the primary energy consumption in parallel with economic growth, although the link policy indicator – source of financing is weak.

Once again, economic growth plays a part in the worsening of the energy consumption indicator. Notably, the Czech Republic and Luxembourg stand out as exceptions, showing no such dependence. The group of countries where this dependence is not observed comprises only the Czech Republic and Luxembourg.

One of the important factors related to the possibilities for financing green policies and activities is the share of revenue from environmental taxes in the total revenue from all taxes and social contributions. Correlation coefficients indicate that in nearly half of the countries, there is a strong connection between the size of these taxes and energy consumption.

It is logical for such fiscal revenues to be utilised for the implementation of green policies. In this case, correlation coefficients are expected to have a negative value, as is the case, for example, in Bulgaria and Lithuania. However, these instances appear to be more of an anomaly rather than the prevailing pattern, as in the majority of countries, the coefficients have a positive value.

Table 2. Correlation coefficients of the indicators - Primary energy consumption and Final energy consumption, by country, against dependence factors

Indicator / Country	Primary energy consumption					Final energy consumption				
	GB/GDP	GB/Debt	dDebt	dGDP	Etax	GB/GDP	GB/Debt	dDebt	dGDP	Etax
Belgium	-0,4115	-0,3512	-0,6940	0,6209	0,2454	-0,5326	-0,4900	-0,6293	0,4856	0,2677
Bulgaria			-0,3095	0,9651	-0,8277			-0,4715	0,6300	-0,8456
Czechia			-0,3536	0,5831	0,1360			0,1491	0,4913	-0,4163
Denmark	-0,2243	-0,2243	-0,5753	0,1228	0,1370	-0,3449	-0,3449	-0,5024	0,0611	0,1106
Germany	-0,7389	-0,7220	-0,6140	0,0942	0,8449	-0,6494	-0,6273	-0,7041	0,2193	0,8816
Estonia			-0,7867	0,6120	0,8579			-0,3639	-0,0804	0,9914
Ireland	-0,8986	-0,4650	-0,8015	0,1719	0,6421	-0,9126	-0,4727	-0,8298	0,1134	0,7058
Greece			-0,8988	0,4390	0,1793			-0,8453	0,6835	0,2785
Spain	-0,2674	-0,2077	-0,9999	0,5573	0,7490	-0,1718	-0,1134	-0,9953	0,6442	0,6720
France	-0,6566	-0,6065	-0,5611	0,3090	0,8983	-0,1500	-0,0560	-0,8867	0,7980	0,7026
Croatia			-0,9091	0,9745	-0,0318			-0,8601	0,9363	-0,0318
Italy	0,1796	0,1686	-0,7841	0,7465	0,2726	0,3528	0,3464	-0,8762	0,8209	0,3217
Cyprus			-0,7233	0,5919	0,6084			-0,6545	0,5393	0,6084
Latvia	-0,1320	-0,1560	-0,3941	0,0025	-0,4424	0,3461	0,3300	-0,2963	0,4875	-0,7116
Lithuania	0,1227	0,1411	-0,6392	0,4519	-0,9707	-0,3989	-0,4079	-0,5876	0,3138	-0,6934

Luxembou rg	-0,8237	-0,8224	0,1984	-0,0192	0,9390	-0,8237	-0,8224	0,1984	-0,0192	0,9390
Hungary	-0,5255	-0,5222	-0,3513	0,5973	-0,0156	-0,2149	-0,2086	-0,2859	0,7849	-0,1890
Malta			-0,8932	0,6955	0,3117			-0,9227	0,3380	0,7450
Netherland s	-0,7637	-0,5207	-0,8520	-0,0630	0,7693	-0,7250	-0,4718	-0,8714	-0,0563	0,8028
Austria	-0,4678	-0,4678	-0,8282	0,2527	0,7565	-0,5096	-0,5096	-0,7707	0,2493	0,6757
Poland	0,0898	0,1494	-0,6467	0,4583	0,9396	0,0743	0,2167	-0,7613	0,5105	0,8603
Portugal			-0,4398	0,3454	0,9945			-0,6967	0,6817	0,9056
Romania			-0,6130	0,1831	0,1954			-0,4940	0,3716	-0,1774
Slovenia	-0,3819	-0,3958	-0,7948	0,1904	0,7756	0,1395	0,1399	-0,9918	0,6772	0,5502
Slovakia			-0,3865	0,6239	-0,4939			-0,4420	0,6923	-0,4939
Finland			-0,9112	0,2065	-0,1205			-0,8532	0,0662	-0,1065
Sweden	-0,9406	-0,8987	-0,6564	-0,0340	0,2459	-0,5445	-0,4575	-0,7140	0,5802	-0,4091
Iceland				-0,0222	0,6421				0,3062	0,3558

Source: Calculations generated through our own research

Legend: Factors for which the obtained correlation value shows a significant strength of dependence on the indicators are highlighted in grey.

Note: Where there are gaps in the data for individual countries and/or years, the results for the respective country are not reported.

A summary of the relationship between the energy consumption indicators and the examined dependence factors can be derived from the presented data (see Table 2):

- In general, debt instruments (green bonds and general debt) act as catalysts for improving indicator values. It is evident that debt financing, irrespective of its green classification, stands out as a key factor in realising the policies focused on curbing energy consumption.

- Overall, GDP growth is associated with energy-intensive factors, and growth is related with a deterioration (increase) in the value of the indicators.
- There is an observation of decreasing of environmental taxes, presumably associated with positive results concerning the indicator. In rare cases, in select countries, fiscal revenues display a negative correlation with primary energy consumption, indicating that this factor has a substantial limitation in its contribution to the financing of relevant green policies.
- It can be observed that a relatively weaker elasticity of energy resources, used as a raw material (primary energy consumption), compared to those used for energy needs (final energy consumption) exists. In this sense it is expected that the primary energy consumption variable will be subject to slower and discreet changes over time, and probably associated with more costs for the society, compared to final energy consumption.

A major negative factor is the growth of economies, which puts a spotlight on the search for balance between positive economic processes and the associated environmental consequences. Addressing this question necessitates a closer look at the economic structures of individual countries and the magnitude of energy intensity prevalent in their leading sectors.

The high correlation between energy consumption indicators and fiscal taxation could be seen as a significant factor with the potential to influence changes in energy consumption. Despite the diverse approaches adopted by the countries in the sample, an overarching escalation in environmental taxes fails to yield positive results on the examined indicators. Instead, the pronounced interdependence offers an opportunity to strategically mitigate the specific tax burden, prompting a quest for alternative ways to finance these policies.

Policy effects on total greenhouse gas emissions and net carbon absorption

The EU policy is linked to a commitment to reduce the total greenhouse gas emissions indicator values. Conversely, regarding carbon sinks from the land use, changes in land use and forestry sector are expected to increase their magnitude. Clearly, for both indicators, the dynamics depend on the characteristics of the economy and are affected by the intensity of its growth.

Most countries in the sample, following the common policy, manage to achieve a downward change in the values of Net greenhouse gas emissions (see Table 3). However, for some countries (such as Croatia, Italy, Lithuania, Poland, etc.), the overall change is towards deterioration of the indicator (increasing values) for the given period. In general, the overall changes are towards reducing greenhouse gas emissions, with short-term changes significantly outperforming long-term ones in this regard.

Nearly half of the countries in the sample maintain positive values of net carbon sinks indicator, while the remaining half experience negative values. The difference can be largely attributed to factors such as the availability of potential for such sinks, including the size and characteristics of forest stands, among other similar factors.

The change in the magnitude of carbon absorption is linked to long-term policy, and in practice the number of countries with a significant improvement in the indicator and a shift from negative to positive values is relatively small (e.g. Czech Republic, Germany, and Finland).

Table 3. Medium- and short-term change of indicator changes - Total GHG emissions and Net GHG absorption, by country, on an annual basis, in million tonnes of CO2 (equivalent), 2015-2022 (change indicated - see legend)

Indicator / Country	Net greenhouse gas emissions			Net greenhouse gas emissions of the Land use, Land use change and Forestry (LULUCF) sector		
	_15_22	_19_22	Change	_15_22	_19_22	Change
Belgium	-5,71%	-7,48%	↓↓	-64,24%	-46,67%	↓
Bulgaria	-4,35%	0,00%	↓	12,01%	-4,39%	↑
Czechia	5,17%	-1,61%	↑	-218,82%	734,30%	↕
Denmark	-19,80%	-16,49%	↓	29,18%	-36,05%	↕
Germany	-16,07%	-10,48%	↓	-144,43%	-152,22%	↓↓
Estonia	-26,42%	-31,18%	↓↓	-1208,27%	27,70%	↓
Ireland	-2,08%	-6,62%	↓↓	25,94%	17,15%	↑
Greece	-24,47%	-17,44%	↓	801,43%	10,74%	↑
Spain	-15,87%	-17,19%	↓↓	5,67%	-3,51%	↑
France	-6,25%	-7,69%	↓↓	-58,50%	-13,21%	↓
Croatia	9,09%	0,00%	↑	-3,39%	5,43%	↕
Italy	1,52%	1,52%	↕	-34,45%	-39,18%	↓↓

Cyprus	-2,88%	-9,01%	↓↓	-21,33%	-22,16%	↓↓
Latvia	12,70%	22,41%	↑↑	70,52%	-489,79%	↕
Lithuania	30,77%	-3,77%	↑	-30,67%	9,10%	↓
Luxembourg	-19,71%	-16,50%	↓	43,26%	151,00%	↑↑
Hungary	7,27%	-4,84%	↑	41,06%	49,58%	↑↑
Malta	-36,11%	-11,54%	↓	-114,29%	50,00%	↓
Netherlands	-15,70%	-13,56%	↓	-20,84%	3,13%	↓
Austria	-8,43%	-22,45%	↓↓	36,64%	-311,38%	↕
Poland	9,78%	2,02%	↑	-39,98%	-45,32%	↓↓
Portugal	-15,00%	-23,88%	↓↓	17,70%	72,18%	↑↑
Romania	2,94%	-5,41%	↑	-3,80%	2,18%	↕
Slovenia	-27,06%	-31,87%	↓↓	-538,05%	-396,86%	↓
Slovakia	-4,62%	-10,14%	↓↓	46,35%	61,17%	↑↑
Finland	21,92%	-13,59%	↑	-102,34%	-127,05%	↓↓
Sweden	-12,50%	-63,16%	↓↓	-12,97%	17,66%	↓
Iceland	-13,94%	-11,99%	↓	-1,38%	-0,13%	↓
Norway	-13,70%	-19,23%	↓↓	-14,88%	16,68%	↓
Switzerland	-19,70%	-11,67%	↓	1063,94%	72,45%	↑

Source: Eurostat and calculations generated through our research.

Legend: ↓ - downward change ↓↓ - downward change with a tendency to further decrease; ↑ - upward change; ↑↑ - upward change with a tendency to increase; ↕ - no persistent change.

The potential funding sources for policies aimed at managing greenhouse gas emissions are characterised by a noteworthy negative correlation between the quantity and value of issued green bonds and the value of the indicator. In practice, this means that countries issuing more green bonds generally achieve a reduction in greenhouse gas emissions through them (see Table 4). More than half of the countries issuing green bonds have a negative correlation coefficient with the indicator, demonstrating a strong connection between the bonds and the realised effect.

One plausible explanation for this is that a significant proportion of issued green bonds directly aim to fund projects and initiatives specifically geared towards improving this indicator.

It's worth noting that unlike the two indicators related to energy consumption discussed above, in the context of greenhouse gas emissions, there isn't a significant preponderance of the factor, whether calibrated against GDP or against the total debt of the countries.

Despite being an important factor with a clearly expressed impact, the strength of this dependence is relatively low in most economies in the sample. This can be explained by the fact that countries issuing green bonds structure their measures related to greenhouse gas management as projects financed through green bonds, while other countries use a portion of their total debt as a source of funding for similar activities.

The overall dependence of the amount of government debt on the indicator does not provide a straightforward answer to the question of its correlation with the indicator. Indeed, in some countries, there is a significant positive correlation (e.g. Czech Republic and Malta), indicating successful use of government debt to implement carbon absorption policies. Conversely, in countries like Estonia, Greece, and Slovenia, there is a strong negative correlation – an increase in government debt is associated with a deterioration in the indicator. This correlation may stem from countries issuing debt to address other societal needs while carbon absorption policies remain on the periphery of their interests.

Economic growth is not a factor in the deterioration of the GHG indicator. Poland is the only exception among the sampled countries to exhibit such a dependence. Contrary to the intuitive expectation that economic growth leads to increased energy consumption (as mentioned earlier) and subsequently higher greenhouse gas emissions, this pattern is not affirmed in the majority of the countries.

One of the important factors related to the possibilities for financing green policies and activities lies in the proportion of revenues from environmental taxes compared to the overall income from all taxes and social contributions. Correlation coefficients, related to GHG emissions reveal that for almost all countries there is a strong similarity in the ecological taxes and the GHG variable dynamics.

Table 4. Correlation coefficients of indicators - Total GHG emissions and Net GHG absorption, by country, against dependence factors

Indicator / Country	Total greenhouse gas emissions					Net removals of greenhouse gases				
	GB/GDP	GB/Debt	dDebt	dGDP	Etax	GB/GDP	GB/Debt	dDebt	dGDP	Etax
Belgium	-0,7566	-0,7320	-0,1909	-0,7591	0,7926	0,9308	0,8966	0,3842	0,5847	-0,9423
Bulgaria			-0,1231	-0,0860	0,9911			0,5942	0,6087	-0,2853
Czechia			-0,5839	-0,5735	0,7433			0,9939	0,1665	-0,9961
Denmark	-0,4669	-0,4669	0,4056	-0,8099	0,9673	-0,7650	-0,7650	0,1480	-0,5493	0,6103
Germany	-0,8390	-0,8016	-0,3791	-0,4827	0,0307	0,9135	0,9062	-0,0830	0,8165	0,3814
Estonia			-0,1963	-0,2095	0,9958			-0,8939	0,9847	0,2160
Ireland	-0,4399	-0,8069	-0,4385	-0,6974	0,9994	-0,0774	0,9712	-0,1441	0,7793	-0,9936
Greece			-0,6510	-0,6092	-0,7524			-0,7476	-0,2058	-0,2048
Spain	-0,9376	-0,9175	-0,2975	-0,6099	0,8918	0,9201	0,8908	0,4557	0,4672	-0,9582
France	-0,8267	-0,8208	0,0843	-0,7261	0,4883	0,1194	0,1354	0,1306	-0,4301	-0,0225
Croatia			0,0219	-0,5084	0,7763			-0,2454	-0,0670	0,7906
Italy	-0,1945	-0,1716	-0,1443	-0,5316	0,7107	0,9860	0,9854	0,0038	0,6921	-0,8665
Cyprus			0,6630	-0,7571	0,9211			-0,4433	0,3539	-0,6514
Latvia	0,7075	0,7367	-0,2803	0,9561	-0,8210	0,8402	0,8613	-0,0962	0,9953	-0,9540
Lithuania	-0,3637	-0,4425	0,7268	-0,6620	1,0000	-0,6079	-0,6522	0,5006	-0,4643	0,9611
Luxembourg	-0,5133	-0,5117	0,5245	-0,8942	0,4096	-0,6506	-0,6483	0,6434	-0,4861	0,8312

Hungary	-0,6315	-0,6344	-0,1862	-0,7186	0,6934	-0,8324	-0,8337	-0,3265	-0,5602	0,8466
Malta			-0,1062	-0,8657	0,9082			0,8578	-0,0717	-0,9205
Netherlands	-0,3606	-0,2478	-0,3180	-0,7245	0,8394	0,9952	0,9739	0,2667	0,3569	0,7912
Austria	-0,6319	-0,6319	-0,0790	-0,8065	0,5377	-0,7896	-0,7896	-0,1566	-0,7606	0,6788
Poland	-0,4547	-0,2272	0,0274	0,1041	-0,9558	-0,3283	-0,7258	0,5602	-0,0119	0,3425
Portugal			0,2973	-0,6180	0,8351			0,0114	-0,4746	0,9984
Romania			-0,0603	-0,0802	0,7089			0,3619	-0,4949	0,3758
Slovenia	-0,7174	-0,7182	-0,5319	-0,1927	0,9873	-0,5353	-0,5365	-0,7142	0,0412	0,9247
Slovakia			-0,2825	-0,4126	1,0000			0,0663	-0,6692	0,9961
Finland			0,0671	-0,2720	0,9327			0,0162	0,3751	0,8342
Sweden	-0,6421	-0,7765	0,2500	-0,7961	0,9927	-0,7322	-0,8587	0,1495	-0,6817	0,9502
Iceland				-0,7245	0,9652				-0,2144	-0,9921
Norway				-0,8355					-0,8595	
Switzerland				-0,9490	0,9983				-0,2026	0,0560

Source: Calculations generated through our own research.

Legend: Factors for which the obtained correlation value shows a significant strength of dependence on the indicators are highlighted in grey.

Note: Where there are gaps in the data for individual countries and/or years, the results for the respective country are not reported.

We can draw the following conclusions regarding the relationship between the indicators of greenhouse gas emissions and absorptions from the considered dependence factors (refer to Table 4):

- Debt instruments, including green bonds and total debt, serve as catalysts for improving the value of GHG indicators. It is evident that debt financing, whether green or not, is a key factor in achieving policies aimed at reducing greenhouse gas emissions. Certain countries that issue green bonds to fund initiatives for enhancing carbon sequestration, demonstrate exceptionally positive outcomes. Countries such as Germany, Italy, and the Netherlands channel their efforts in this aspect of their policies through comprehensive project packages financed in the bond market. Simultaneously, the influence of other examined factors is notably weaker in these cases, particularly in terms of environmental tax revenues.
- The high correlation values of green bond financing signify that a substantial portion of activities funded through green bonds is directed towards the management of greenhouse gases.
- The strength of dependence of changes in total debt is highly significant and fiscal taxation associated with environmental taxes presents an almost equal effect. Regarding taxes, the impression is reinforced that it is not the revenues from them that act as a source for improving the indicator; rather, the heightened indicator is followed by an increase in the tax burden.
- The growth of GDP is associated with greenhouse gas emissions, resulting in a decrease in emissions. This is an important observation that demonstrates the long-term effects of implementing policies to reduce greenhouse gases.

Based on the results obtained and the observations made so far, a comprehensive evaluation of the effectiveness of the factors considered in the context of greenhouse gas emissions can be made. The most substantial contribution to achieving policies related to the reduction of the indicator is the magnitude of green bonds issued as a share of total debt. The logical explanation is likely that a significant portion of activities contributing to these policies is implemented with public resources, primarily sourced from government debt. In cases where countries have issued green bonds, the effects are positive but of secondary importance.

There is also a notable correlation with the factor related to environmental taxes, and in this case, the connection is positive. The explanation is that a substantial part of tax revenues is directly linked to carbon emissions. In this sense, high values of total carbon emissions logically lead to an increase in revenue from environmental taxes.

Policy effects on the indicator of economic losses from weather and climate events

A fundamental challenge associated with the indicator economic losses from weather and climate events (see Table 5.) is the episodic and unpredictable nature of such events, compounded by difficulties in localisation. Common strategies for managing this indicator involve the formulation of comprehensive or sector-specific strategies, plans, and programs, where funding is often provided partially or with specific prioritisation. Consequently, the occurrence of adverse weather and climate events causing economic losses emerges as a basic factor contributing to the increase in the value of the indicator, in some of the economies in the sample. This is notably observed in countries like Belgium, Spain, Hungary, Slovakia, Sweden, and others.

However, countries with a heightened increase in losses due to weather and climate events can be clearly distinguished from those where the indicator shows improvement (i.e., a decrease in value).

Table 5: Average value, change and correlation coefficients of the indicator - Economic losses due to weather and climate events, by country, on an annual basis, in million euro, for the period 2015-2022 (change indicated - see legend)

Indicator / Country	Average value	Change over the period[20]	Trend	GB/GDP	GB/Debt	dDebt	dGDP	Etax
Belgium	3 062	297,54%	↑↑	-0,2009	-0,1961	-0,3311	0,6022	
Bulgaria	291	-96,69%	↓			-0,2940	0,7418	
Czechia	289	16,13%	↑↑			0,9634	0,1173	
Germany	9 666	275,39%	↑↑	0,3785	0,3461	-0,0612	0,6719	0,5833
Ireland	155	-15,90%	↓	0,9947	-0,1430	0,9970	-0,8800	
Greece	322	-62,96%	↓			0,7098	-0,8070	-0,4165
Spain	2 912	5650,00%	↑↑	0,5340	0,5899	-0,3248	0,5487	0,8850
France	4 502	977,20%	↑↑	0,6697	0,7514	-0,5371	0,6041	0,3464
Italy	5 949	472,67%	↑↑	0,6244	0,6421	-0,3705	0,2557	0,9818
Luxembourg	102	219,64%	↑↑	-0,4607	-0,4612	-0,9354	0,6311	0,5284
Netherlands	423	2607,41%	↑↑	0,3951	0,1632	0,6949	0,3663	-0,9986
Austria	469		↕	-0,5789	-0,5789	-0,4427	0,2400	0,1793

[20] Regarding reported data period.

Poland	185	-61,43%	↓	0,9819	0,9624	0,7855	-0,9358	
Portugal	493	12633,33 %	↑↑			-0,3130	0,5461	0,9989
Romania	825	-68,82%	↓			-0,0199	0,4704	
Slovenia	86	-16,94%	↓	-0,1736	-0,1452	-0,6328	0,2601	0,9520
Slovakia	41	156,67%	↑↑			-0,5955	0,7346	-0,5129
Finland	47	-49,46%	↓			0,4881	-0,9476	
Sweden	76	176,47%	↑↑	-0,9535	-0,9829	-0,5247	-0,6417	0,7822
Switzerland	177	125,00%	↑↑	-0,8676			0,1489	-0,9682

Source: Eurostat and calculations generated through our research

Legend: ↓ - downward change; ↓↓ - downward change with a persistent tendency to further decrease; ↑ - upward change; ↑↑ - upward change with a persistent tendency to increase; ↕ - no persistent change

Factors for which the obtained correlation value shows a significant strength of dependence on the indicator are marked in grey.

Note: Where there are gaps in the data for individual countries and/or years, the result obtained for that country is not reported.

Analysing the correlation coefficients to understand the relationship between economic losses from weather and climate events and the examined factors (see Table 5.), we can draw the following conclusions:

- Countries issuing green bonds generally exhibit a significant positive correlation with losses from weather and climate events. The expected negative correlation (i.e., a negative correlation coefficient) is not observed in this case. Regardless of securing targeted funding through green bonds, the strength of dependence does not favour a reduction in losses but rather indicates the opposite change.
- Countries such as Spain, France, Italy, and others experience increasing economic losses despite the widespread use of their green bonds. One possible explanation for this dependency could be that these countries allocate the resources mobilised through their green bonds to different projects. Another explanation could be that the effect of the policy on the indicator has a significant time lag, meaning positive effects are yet to be realised. Thus, the observed positive correlation (effectively a negative result of

increased losses) seems to be more a result of unfortunate developments in meteorological and climatic events in specific locations. In this case, the practical explanation boils down to simply having bad luck.

- The change in countries' total debt has a generally negative correlation, indicating that a portion of countries' overall generated debt does contribute to reducing losses from climate events. Nevertheless, within the sample of countries, there are some (such as the Czech Republic, Ireland, Greece, the Netherlands, etc.) where the factor has a negative dependence, while the correlation is statistically strong and significant.
- The growth of GDP and environmental taxes also fails to provide satisfactory results for making statistically significant conclusions.

Conclusions

Green finance in essence involves using financial tools to efficiently allocate funds toward initiatives and investments that promote energy efficiency, renewable energy consumption, and the preservation and restoration of natural environment.

Countries that do not use debt bonds finance their respective activities with the overall national debt and revenues from specific environmental taxes.

The empirical results and the observations allow us to formulate the following conclusions, related the initial hypotheses:

Hypothesis 1. Countries which increase their green bond emissions demonstrate an increased speed of improvement of the variables, related to their environmental policies.

Overall, countries that issue green bonds demonstrate positive dynamics of the environmental policy indicators. Despite some exclusions, a notable distinction between countries with green bond emissions and those without green bonds can be made. This is not the case with the other sources of financing, and if it concerns environmental taxes a clear answer to the question cannot be given.

Hypothesis 2. Countries which increase their overall debt show an increased speed of improvement of the variables related to their environmental policies.

Overall, the hypothesis is rejected, despite minor exclusions. We can conclude that the increase of the overall debt has a relatively weak similarity with the policy indicators’ dynamics, except for a small group of countries.

Hypothesis 3. Countries demonstrating higher growth rates show an increased speed of improvement of the variables related to their environmental policies.

The hypothesis is rejected for most countries, with some minor exceptions. This is specifically valid for energy consumption variables.

Hypothesis 4. Countries which increase the fiscal burden of ecological taxes show an increased speed of improvement of the variables, related to their environmental policies.

A clear distinction between countries for which the hypothesis holds and countries for which is rejected can be observed. This distinction and grouping of countries are not linked to the availability or the lack of green bond emissions.

For all four hypotheses a clear dependence and grouping of countries cannot be established for the weather and climate related economic losses indicator.

In addition, in view of the possibilities for further research regarding some highlights in our empirical analysis, the following can be noted. In financing the green transition, factors such as per capita fossil fuel use and variations in population size and the degree of economic growth should be considered. It is not surprising that the primary issuers of green bonds in Europe are countries with developed economies and high GDP per capita. Developing countries require additional financial resources to achieve equity in the future green transition.

One of the main reasons for the inefficacy of international environmental agreements and domestic policies is the lack of adequate capital for progress in environmental projects. This challenge is prevalent in underdeveloped countries where governments prioritise spending and investments in projects with quick returns and low risk due to limited financial resources. The private sector in these countries also aims to invest in projects with high and rapid returns at low risk, but this process naturally varies across different countries.

Substantial differences exist among individual countries. Countries exhibit distinct attitudes toward various policy implementation tools, and certain policies likely enjoy greater priority depending on the specific country. Most countries in the sample concentrate on indicators such as energy consumption and carbon emissions. Notably, emissions from green bonds target actions to reduce harmful emissions, promote consumption of energy from renewable sources, and enhance energy efficiency.

In the end we may derive the general conclusion that a clear distinction between countries that issue green bonds and those that do not issue green bonds exists, regarding the outcomes of their environmental policies and sources of financing. Despite that, there is a lack of uniform approach adopted by the EU countries regarding the framework of financing of environmental policies.

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