Advancing the European Clean Energy Transition: A Firm-Level Rating System Approach to Green Bonds

Nicolas Jean Marie SIMON

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Abstract

For the last two decades, Europe has been facing significant climate change challenges that require governments, and public and private companies to adopt sustainable actions. To solve this situation, the European Commission focuses on green bonds as the light bearer to support the EU taxonomy. Green bonds are debt instruments mobilizing capital to finance positive environmental projects and facilitate the clean energy transition. In our work, we want to investigate the ability of green bond issuances by European companies to reduce the global carbon emissions from 1998 to 2003. Using four models and six regressions for each of them based on firm characteristics, this study assesses whether or not green bond issuances advance the European clean energy transition. Our results show that green bond issuances by European firms lead to a 1.438% increase in global carbon emissions, which is statistically significant at the 10% level. While green bonds help reduce overall carbon emissions by 1.40%, they make no positive contribution when considering scope emissions, which increase by 2.38%. These results suggest that corporates are not effective enough to contribute to the European clean energy transition, thereby failing to align with the EU taxonomy purposes.

Keywords: Green Bonds, European Clean Energy Transition, EU taxonomy, Firm Level Rating System, Environmental projects

Autor: Nicolas Jean Marie Simon

Título: Avançando a Transição Energética Limpa na Europa: Uma Abordagem de Sistema de Classificação em Nível de Empresa para Títulos Verdes

Resumo

Nas últimas duas décadas, a Europa tem enfrentado desafios de mudança significativos que exigem que os governos e as empresas públicas e privadas adoptem medidas sustentáveis. Para resolver esta situação, a Comissão Europeia centrou-se nas obrigações verdes como o suporte para a taxonomia da UE. As obrigações verdes são instrumentos de dívida que mobilizam capital para financiar projectos ambientais positivos e facilitar a transição para energias limpas. No nosso trabalho, pretendemos investigar o impacto da emissão de obrigações verdes por uma empresa europeia na redução das emissões globais de carbono entre 1998 e 2003. Utilizando quatro modelos e seis regressões para cada um deles, com base nas características das empresas, este estudo avalia o impacto positivo ou negativo das obrigações verdes na transição europeia para as energias limpas. Após a sua execução, os nossos resultados mostram que a emissão de obrigações verdes por empresas europeias conduz a um aumento de 1,438% nas emissões globais de carbono, o que é estatisticamente significativo ao nível de 10%. Embora as obrigações verdes ajudem a reduzir as emissões normais de carbono em 1,40%, não contribuem positivamente quando se consideram as emissões de âmbito, que aumentam em 2,38%. Estes resultados sugerem que as empresas não são suficientemente eficazes para contribuir para a transição europeia para as energias limpas e para se alinharem com os objectivos da taxonomia da UE.

Palavras-chave: Obrigações Verdes, Transição Europeia para as Energias Limpas, Taxonomia da UE, Sistema de Classificação a Nível de Empresa, Projectos ambientais

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1. Introduction

Europe has been increasingly threatened by the devastating effects of climate change and as such there is an urgent need to move towards a more sustainable world. To deal with this phenomenon as effectively as possible, we must all strive to both identify and implement sustainable actions. With this in mind, political institutions, and public and private companies have turned to issuing green bonds. For many, these financial debt instruments are one of the levers with the capacity to address the future threats we all face. A green bond is a debt financing tool that allows us to mobilize capital to finance projects with positive environmental impacts. This financial instrument can only be used for the purpose of reconciling financial investments that are in line with the low carbon transition (European Commission, 2021 and IMF, 2023). The clean energy transition is the shift from traditional fossil fuel-based energy sources to cleaner and more sustainable alternatives (Clean Energy Transition Partnership,2023). Combining these two concepts gives us a mechanism to channel funds toward the transition to clean energy and a method to reduce greenhouse gas emissions (The Oxford Institute for Energy 2022).

In this thesis, we analyze the impact of a company issuing a green bond on global carbon emissions between 1998 and 2023, including both overall carbon emissions and emissions across different scopes. To achieve this, we make use of multiple regression analyses based on a rating system considering firms' characteristics (Ehlers, Mojon, and Packer, 2020). Transitioning from this overview of the dual benefits of green bonds to our specific focus, our research aims to address the following question:

"Based on a firm-level rating system, how could Green Bonds advance the European Clean Energy Transition?"

In an effort to answer this question, we check what the impact of a company's green bond issuance is on the level of carbon emissions. We based our method on earlier work by Ehlers, Mojon, and Packer (2020). In the context of my thesis, firm-specific characteristics as well as firm profitability are included as control variables. Through a thorough regression analysis, we can say that green bond issuances by European companies don't contribute to the advancement of the clean energy transition in reducing global carbon emissions.

In Appendix G, our results show that the issuing of a green bond increases global carbon emissions (overall and individual scopes) by 1.438%. This result is statistically significant at the 10% level. This result is obtained by summing the averages of all dependent variables. Additionally, and looking at my results from a different angle, a company issuing a green bond participates in the clean energy transition by reducing the standard carbon emissions by 1.40 % statically significant at a 10% level (Appendix G). On the other hand, we find that company green bond issuances do not contribute to the clean energy transition when considering the scope variables. Our results show that the issuing of a green bond increases the individual scope emissions by 2.38% statically significant at the 10% level (Appendix G).

The research contributes by empirically analyzing the impact of green bonds issued by European companies on global carbon emissions. This analysis provides valuable insights into the effectiveness of green bonds as a tool trying to advance the clean energy transition. Despite efforts to advance the low-carbon transition, it is still difficult for corporate-issued green bonds to effectively reduce overall carbon emissions and fully align with European targets.

Our work is organized as follows: Section 2 outlines surveys the earlier literature presenting the key concepts and theoretical approach of our study. Next, Section 3 describes the structure of the data and the methodology. Section 4 presents the empirical results and the main findings of my work. Then, Section 5 describes the robustness section and finally, Section 6 provides some final remarks.

2. Literature Review

In the context of my master's thesis, I have undertaken thorough research on my topic concerning how green bonds can facilitate the energy transition in Europe. I defined my keywords through various publications, references, and academic works. This work relied primarily on the research article titled "Green Bonds and Carbon Emissions: Exploring the Case for a Rating System at the Firm Level" by Ehlers, Mojon, and Packer (2020). This paper proposes a rating system that compares company data and carbon emissions (scopes 1, 2, and 3) in connection with green bond issuances between 2013 and 2023. Looking at different sources, we find multiple research papers discussing the same topic such as the research paper proposed by Mazzacurati (2021), titled “Environmental impact and liquidity of green bonds” and a report from the Institute for Climate Economics published by Nicole, Shislov and Cochran (2021).

2.1 Green bonds: a clean energy transition tool

The rapid emergence of green bonds represents a significant improvement in the field of finance and sustainable finance. In a world where environmental and social challenges are increasingly in the spotlight, green bonds serve as financial instruments to mobilize capital to finance environmentally beneficial projects World Bank (2022) and IMF (2020).

The importance of the transition to clean energy has been highlighted in several studies. This issue is crucial for achieving sustainability goals and mitigating climate change. It has been shown that green bonds are instruments that play a crucial role in financing the transition to clean energy by allocating investments to renewable energy projects and other environmentally beneficial initiatives (Maino, 2021; Bongaerts and Schoenmaker, 2020). The Oxford Institute for Energy (2021) as well as Smith et al. (2018) have presented analyses looking at the role, opportunities, and challenges of green bonds in terms of financing the low-carbon energy transition and also the significant growth in bond issuances targeting the EU taxonomy. They take into consideration the different investments involved with the alignment of international climate goals. To provide a deeper understanding of the topic, I choose to focus my study on the European market. Alamgir and Chang Cheng (2023) investigate the impact of green bond finance on renewable energy investment in the region. They also provide insight into how green bonds attract investments and mobilize capital to ensure a sustainable finance lifecycle. Several theoretical studies have complemented this earlier empirical work to provide a deeper understanding into the mechanisms through which green bonds can promote the alignment between investment and the clean energy transition. Nicol, Shishlov and Cochran (2018) explain this link by demonstrating the most appropriate pathway to combine financing and the clean energy transition to support investment and sustainability. Finally, Tang and Zhang (2020) and Flammer (2021) show that a positive correlation exists between market reactions and corporate green bond issuances.

The Climate Bonds Initiative provides a general and legal framework for all companies issuing green bonds, based on one main objective: to combine corporate finance, investment, and the energy transition in a single framework to ensure a better understanding of these issues.

2.2 The Climate Bonds Initiatives Framework and the EU Taxonomy

The Climate Bonds Initiatives provide a common framework for all companies issuing green bonds to address a common framework on reducing carbon emissions, the energy transition and the EU Taxonomy for all companies issuing green bonds. This initiative provides a guideline called the Climate Bonds Taxonomy (2021), to assist in the climate alignment of assets and projects. This is a helpful tool for investors, issuers, municipalities, and governments to understand the key investments aligning with the necessity to fight climate change. Several industries are committed to the Climate Bond Initiatives which are composed of 8 categories including Energy, Transport, Water, Buildings, Marine Resources, Industry, Waste, and ICT. Overall, this encompasses 283 companies within the energy sector; buildings represent more than 65 % of the green bond markets in 2021.

Focusing on investments, the main purpose of a business is to make money. The European Commission (2023) believes that the goal of a company is to do business in such a way that it aligns with these new goals, specifically in the context of adhering to the Paris Agreement objectives. The United Nations organized COP 2021 in Paris. This climate meeting brought together 195 countries with a common goal of reducing gas emissions. Three main objectives emerged from this meeting: to mitigate, adapt and mobilize finance.

Looking at mitigation, the Paris Agreement sets the objective of keeping 1.5°C within reach and securing the global net zero in 2050 with an overall goal of decreasing carbon emissions. All countries need to adhere to this legal framework to limit the global CO2 emissions issued by companies. Then, the second goal of the Paris Agreement concerns the adaptation of the countries most affected by climate change. COP 21 aimed to help and support these communities. Finally, the mobilization of finance was adopted by COP 2015. To align the purposes of 2015 and 2021, the United Nations leveraged $100 bn annually until 2020 to help developing countries mitigate and adapt to climate change. Tollivier, Keeley and Managi (2019) show that the combination of these three purposes tends to facilitate the clean energy transition. These authors explain that “Green bonds, a clean energy transition tool”, green bonds are debt instruments that play a role in financing the Paris Agreement purposes and contributing to the reduction of carbon emissions. The UN environment program quantifies COP 15 and the investment made by companies in green bond financing and valued these at around $ 200 bn. In addition, Eurostat (2023) shows that the emissions have decreased by 70 million tons (- 8,5 %) of CO2 after the COP 2021 to the third quarter of 2023.

It is clear that green bonds could play a vital role in financing the clean energy transition. One study shows that green bonds and carbon emissions are linked to a rating system with firm characteristics. Ehlers, Mojon and Packer (2020) show a positive correlation between companies that issue green bonds and the companies advancing the clean energy transition. In addition, they also show that companies that issue green bonds contribute most significantly to the reduction in carbon emissions after attracting more investors. Unfortunately, this study was done in 2020, immediately before COP21 and the Paris Agreement which means that we are unable to see any significant changes following these events and this framework. In this paper, we will look at companies that issued green bonds in the time both before and after the COP 2021. Using the previously mentioned paper as a starting point, we will extend this study to cover a more extensive period. By focusing on the impact of green bond issuances on firms’ carbon emissions, we will study the contribution of these green bond issuances to the clean energy transition in the European market.

3. Data and Methodology Section

3.1 Data and Variables Selection:

The purpose of my research is to focus on the effect of European green bonds on the clean energy transition at a firm level. For this, we have to check the way to show that the green bonds affect the low-carbon energy transition. To study the role of green bond issuances in the green transition, we started by extracting the European green bonds issued by each company between 2013 and 2023 from Refinitiv Eikon. We also downloaded several bond-specific characteristics including the offer price and the market price. Next, we merged this dataset with data on the firm characteristics of all the firms in my green bond issuance sample over the period between 1999 and 2023. The firm characteristic data was also downloaded from Refinitiv Eikon. Firm characteristics refer to company data such as the quick ratio, current ratio, financial leverage, structural credit leverage ratio, as well as total assets and logarithmic returns. Finally, we combine this with data covering carbon scopes (1, 2, and 3) and the total carbon emissions for each of the firms in the sample. After removing duplicates, our sample consisted of 193 unique firms. After further cleaning the sample to ensure that only firms with all relevant variables are included in the final sample, the sample is reduced to 90 unique firms. To conclude the data treatment and to avoid biases in our results, we take the natural logarithm of total assets, the market price of the bond issuance, our three scope variables as well as total emissions. Taking the natural logarithm allows me to reduce variation in these variables and better enables me to study the relationship between each firm's carbon emissions, the green bond issuance, and the previously mentioned firm characteristics. It is important to note that our three scope variables and our total emissions value contain negative values. To account for this, we use the following formulas to compute the natural logarithm of total emissions and the natural logarithm of the individual scope variables:

Logarithm Carbon Emissions

$$\text{Log Carbon Emissions}_i = \log(\text{Carbon Emissions}_i) + \log(\text{Min Carbon Emissions}_i) + \log(0.00001) \quad (1)$$

Logarithm Scope 1

$$\text{Log Scope } 1_i = \log(\text{Scope } 1_i) + \log(\text{Min Scope } 1_i) + \log(0.0001) \quad (2)$$

Logarithm Scope 2

$$\text{Log Scope } 2_i = \log(\text{Scope } 2_i) + \log(\text{Min Scope } 2_i) + \log(0.0001) \quad (3)$$

Logarithm Scope 3

$$\text{Log Scope } 3_i = \log(\text{Scope } 3_i) + \log(\text{Min Scope } 3_i) + \log(0.0001) \quad (4)$$

To complete the data selection process, we introduce a dummy variable for the regression analysis. This variable distinguishes periods with green bond issues (assigned a value of one) from those without (assigned a value of zero) over the period from 1998 to 2023.

This dummy variable allows us to examine whether companies that have issued green bonds in a given year subsequently reduce their carbon emissions and scope. It also allows us to assess whether issuing a green bond improves a company's financial performance after the issue.
In essence, by creating this dummy variable and incorporating it into our analysis, we aim to examine the impact of green bond issuances on both environmental outcomes and financial metrics, thereby enhancing our understanding of the broader implications of such actions for companies.

Table 1 presents summary statistics for the different variables used in our regression analysis. It is worth noting that all the variables are consistent in terms of the number of observations, which totals 1914, and in terms of the time period, which spans from 1998 to 2003. Looking at the dependent variables, we can see that their mean, standard deviation, minimum and maximum values are closely aligned. Conversely, the control variables show disparities in their respective mean, standard deviation, minimum and maximum values.

Table 1. Selected descriptive statistics, 1998 - 2023

	Observations	Mean	S. Deviation	Min	Max
Dependent variables					
LN[a] Carbon Total Emissions	1,914	2.09	0.13	2,00	4.54
LN[a] Carbon Scope 1	1,914	2.10	0.17	2,00	4.20
LN[a] Carbon Scope 2	1,914	2.09	0.14	2,00	3.56
LN[a] Carbon Scope 3	1,914	2.18	0.34	2,00	5.15
Explanatory variables					
Issued or not issued a Green Bond [b]	1,914	0.04	0.21	0,00	1.00
Control variables					
Quick Ratio	1,914	1.59	15.90	0.01	665.50
Leverage	1,914	3.44	31.79	0.03	1.33
Return on Assets	1,914	220.10	2.013	0.01	28.19
LN[a] Assets	1,914	3.87	1.30	-1.18	9.14
LN[a] Market Price	1,914	1.36	0.89	-5.96	4.54
Carbon Emissions	1,914	24.81	793.30	-181.90	34.56

Notes:

[a] represents a basic variable in its logarithmic form.

[b] represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0 when it does not.

Table 2 shows the European scope emissions issued by each country between 1998 – 2003. The variable "number of firms" represents the number of firms by country. From this point, we can observe that the three countries that have issued more green bonds are Sweden (21), Norway (9) and the United Kingdom (8). On the other hand, the three countries that have issued the fewest green bonds are Poland, Ireland and Portugal.

Then, our model displays the three scope emission variables. Our variable "Total Scopes" captures the sum of our three individual scope variables. One limitation of this model is that we cannot assume that a single company can't represent a country. This result can't be fully representative when we compare one single company with the country as a whole (Portugal and Ireland) and various companies with its country (Sweden and Norway). To limit the impact of this, we decided to rank the countries using a new variable called "Total Average Scopes". We can observe that the three countries that issued the highest value of emissions are: the United Kingdom (2356.37), Turkey (1808.47) and France (247.57).
On the other hand, the three countries issuing the fewest scope emissions are Portugal (-54.88), Ireland (-23.76) and Netherlands (-15.23). This means that the countries that emit the most scope emissions are the ones that are doing the least to reduce greenhouse gas emissions and combat climate change.

Table 2: Scopes classification by country, 1998 - 2023

Country	# of Firms	Scope 1	Scope 2	Scope 3	Total Scopes[a]	Total Average Scopes [b]
United Kingdom	8	-19.36	-13.02	18955.42	18923.03	2365.37
Turkey	2	5.645	-6.74	3618.03	3616.94	1808.47
France	7	2.2	-21.12	1751.94	1733.02	247.57
Czech Republic	1	82.87	6.53	77.73	167.13	167.13
Norway	9	36.51	-15.62	1063.45	1084.34	120.48
Austria	3	-48.19	-45.73	349.66	255.73	85.24
Sweden	21	259.02	15.68	1087.27	1361.98	64.85
Belgium	4	15.17	10.02	39.55	64.75	16.18
Switzerland	3	-0.87	8.84	11.35	19.31	6.43
Germany	7	-1.54	-6.548	5.22	-2.87	-0.41
Italy	7	-15.55	-15.38	8.16	-22.77	-3.25
Finland	7	-14.21	-19.59	-2.11	-35.92	-5.13
Denmark	2	15.36	-32.55	3.505	-13.69	-6.84
Spain	3	-20.76	22.21	-24	-22.55	-7.51
Poland	1	-3.97	4.55	-13.58	-13	-13,00
Netherlands	3	-7.42	-33.48	-4.79	-45.69	-15.23
Ireland	1	-17.85	-9.21	3.3	-23.76	-23.76
Portugal	1	-4.22	-40.71	-9.95	-54.88	-54.88

Notes:

[a] Total Scopes represent the sum of the three scopes per country and their firms

[b] Total Average Scopes represent the sum of the the three total scopes divided by the number of firms for each country

Table 3 reports the European total carbon emissions issued by each country between 1998 – 2003. "Number of firms" captures the count of firms by country. Next, we decided to create an additional variable called “Total Average Carbon” due to the same limitation mentioned above as presented in table 2. By doing so, we can deduce that the firms issuing the most carbon emissions are: Czech Republic (22.85), Belgium (21.34) and Sweden (18.18). On the other hand, the three countries issuing the fewest scope emissions are: Austria (-52.78), the United Kingdom (-16.20) and Italy (-15.56). The Czech Republic, Belgium and Sweden are the countries whose firms contribute the least to the EU taxonomy whereby countries aim to reduce gas emissions and also contribute to the low carbon transition. In contrast, Austria, the United Kingdom and Italy are the countries advancing the most in terms of the clean energy transition.

Table 3: Carbon emissions classification by country			
Country	# of Firms	Total Carbon	Total Average Carbon [a]
Czech Republic	1	22.85	22.85
Belgium	4	85.35	21.34
Sweden	21	381.74	18.18
Norway	9	112.49	12.50
Denmark	2	12.87	6.43
Spain	3	17.44	5.81
Poland	1	5.53	5.53
Germany	7	-10.75	-1.77
Switzerland	3	-9.92	-3.31
Turkey	2	-6.85	-3.42
Portugal	1	-6.93	-6.93
Netherlands	3	-24.63	-8.21
France	7	-75.46	-10.78
Finland	7	-101.66	-14.53
Ireland	1	-14.59	-14.59
Italy	7	-108.95	-15.56
United Kingdom	8	-129.55	-16.20
Austria	3	-158.35	-52.78

Notes:

[a] Total Average Carbon Emissions respesents the total carbon emissions divided by the number of firms for a given country

Table 4 shows the European Scope emissions issued by each industry in for all the countries in our sample over the period between 1998-2003. Within our model, we use a variable called "number of companies" to represent the number of companies by industry. We observe that the industries with the highest number of green bond issuers are Real Estate (30), Utilities (21), Industrial and Commercial Services (4), Telecommunication Services (4) and Natural Resources (4). Conversely, the sectors issuing the fewest green bonds are Natural Resources (1), Banking & Investment Services (1), Renewable Energy (2), Transport (2), Food & Beverages (2) and Food & Drug Retail (2).

The limitation mentioned above is once again evident when comparing a single company with its industry (e.g. Mineral Resources and Banking and Investment Services) and when comparing several companies within an industry sector (e.g. real estate and utilities).
The table shows that the top three industries with the highest scope emissions are Mineral Resources (10473.11), Renewable Energy (9738.48) and Transport (4014.16). Conversely, the three industries with the lowest scope emissions are Natural Resources (-74.24), Automobiles & Auto Parts (-39.08) and Food & Drug Retailing (-22.78). This highlights that industries with higher scope emissions are less proactive in reducing greenhouse gases and combating climate change.

Table 4 : Scopes Classification by Industry						
Industry Sectors	# Firms	Scopes 1	Scopes 2	Scopes 3	Total Scopes [a]	Total Average Scopes [b]
Mineral Resources	1	5443.52	287.45	4742.14	10473.11	10473.11
Renewable Energy	2	-14.04	-1.86	19492.88	19476.97	9738.48
Transportation	2	-181.02	-265.96	8475.31	8028.32	4014.16
Industrial & Commercial Services	4	101.72	40.1	12052.82	12194.65	3048.66
Telecommunications Services	4	-40.47	-132.61	2227.82	2054.73	513.68
Banking & Investment Services	1	-17.25	-48.77	577.19	511.16	511.16
Cyclical Consumer Products	3	114.36	-45.76	1340.25	1408.85	469.61
Real Estate	30	168.11	-16.68	5009.12	5160.55	172.01
Industrial Goods	4	33.33	-13.88	7.54	26.98	6.74
Utilities c	21	-18.93	-3.13	14.54	-7.53	-0.35
Chemicals	4	-46.29	16.08	9.47	-20.73	-5.18
Food & Beverages	2	5.34	-14.92	-8.42	-18	-9
Energy - Fossil Fuels	3	-28.74	-16.58	-14.46	-59.78	-19.92
Food & Drug Retailing	2	-70.32	-39.49	64.25	-45.56	-22.78
Automobiles & Auto Parts	3	-5.71	-72.16	-39.36	-117.24	-39.08
Applied Resources	4	-97.15	-126.6	-73.2	-296.96	-74.24

Notes:

[a] Total Scopes represent the sum of the three scopes per country and their firms

[b] Total Average Scopes represent the sum of the the three total scopes divided by the number of firms for each country

c Utilities is the sector that provide essential services such as electricity, natural gas, water, and sanitation.

Table 5 shows the total carbon emissions by industry in the European region between 1998 and 2003. The “number of enterprises” variable in the table above shows the number of enterprises per industry sector. It can be seen that the three most carbon-emitting industries are Mineral resources (343.36), consumer goods (111.59) and industrial and commercial services (48.12). On the other hand, the sectors with the lowest carbon emissions are Transportation (-184.10), Applied Resources (-104.49) and Food & Drug Retailing (-49.94). Our sample has an equal distribution of industries. We once again create a variable called "Total Average Scopes" and we see no difference between the "Total Carbon Emissions" and “Total Average Scoped”.

To summarize, we can observe that the industrial sectors with the highest total carbon emissions are the ones that emit the most gas and contribute the least to the development of the clean energy transition.

Table 5: Total carbon emissions classification by country

Classification scopes industry	# Firms	Total Carbon Emissions	Total Average Carbon [a]
Mineral Resources	1	343.35	343.35
Cyclical Consumer Products	3	111.59	37.19
Industrial & Commercial Services	4	48.12	12.03
Real Estate	30	15.72	0.52
Utilities [b]	21	-8.55	-0.40
Industrial Goods	4	-7.142	-1.78
Food & Beverages	2	-5.99	-2.99
Automobiles & Auto Parts	3	-14.70	-4.90
Renewable Energy	2	-10.05	-5.02
Energy - Fossil Fuels	3	-26.73	-8.91
Chemicals	4	-47.09	-11.77
Telecommunications Services	4	-48.17	-12.04
Banking & Investment Services	1	-22.20	-22.20
Food & Drug Retailing	2	-49.94	-24.97
Applied Resources	4	-104.49	-26.12
Transportation	2	-184.10	-92.05

Notes:

[a] Total Average Carbon Emissions respesents the total carbon emissions divided by the number of firms for a given country

[b] Utilities is the sector that provide essential services such as electricity, natural gas, water, and sanitation.

3.2 Regression Analyses

3.2.1 Cross-sectional study

In order to capture the effect of green bond issuances as a tool for advancing the clean energy transition, we base our analysis on the rating system at a firm level. To do this, I want to run a regression analysis to study if the issuance of green bonds could have a positive impact on the clean energy transition based on firms' characteristics (control variables). Using the methodology proposed in Elhers, Mojon and Packer (2020) as a basis for my work, I decide to bring a new approach to study this topic from a better angle. The purpose is to see whether the issuance of a green bond in a given year leads to the company decreasing its carbon emissions and the scopes emissions.

3.2.2 Dependent variables

To verify the impact of green bonds on the low-carbon transition, we identify 4 dependent variables to capture the impact of green bond issuances on carbon emissions. The first dependent variable that we decide to study using a regression analysis, is the logarithm of carbon total emissions. Next, we run a second regression using carbon scope 1 emissions as the dependent variable followed by both scope 2 and scope 3 emissions as dependent variables (See Appendix A).

3.2.3 Explanatory variables

In primarily basing our research on Elhers, Mojon and Packer (2020), we decide to introduce a dummy variable named" Issued or not issued a Green Bond" which takes value one in periods with a green bond issuance. The role of this variable is to study if a company could participate in the low-carbon transition after issuing a green bond in a given year. The purpose is to observe if after issuing a debt instrument, the carbon emissions and the scopes emissions vary in any significant way. Appendix A provides a summary of all the variables used in the regression analysis.

3.2.4 Control variables

We also include several firm controls to account for firm characteristics. This data was downloaded from Refinitiv Eikon. The quick ratio, ROA, Ln total assets, Ln Market Price, Total emissions and Credit Structural Leverage are included as control variables. We take the natural logarithm of both the Market price and total assets. A more detailed explanation of the use of these can be found in Appendix A. In addition, we explain each of the control variables in Appendix A.

3.3 Methodology

To study the impact of the issuing of a green bond by a company, we ran 4 models covering each of our 4 dependent variables. We run our results using both firm fixed effects (main results) and random effects (robustness). The first effect captures firm-specific effects assumed to be constant over time. On the other hand, we have the second effect which includes firm-specific effects as random variables that follow a specific distribution. To choose between the two, we used the Hausman test to identify which is best in our regression analysis. The Hausman test indicates that fixed effects should be used as the p-value is over 10 % significance level. On the other hand, the Hausman test should indicate random effects if the p-value is under a 10 % significance level.

In the fixed effects framework, we decided to exclude the control variable 'structural credit leverage' from the regression as it introduces bias due to its constancy. In this context, fixed effects involve the inclusion of indicator variables for each individual or firm, which means that constant variables cannot be captured. Consequently, the variable "structural credit leverage", being constant, does not vary between individuals and does not affect the regression results, making it non-informative and prone to bias.

On the other hand, in the random effects framework, this control variable does not introduce bias because random effects assume that individual effects are random and not constant. Therefore, even if the credit structural leverage variable is constant, it can still be included in the model through random effects, which means that it can contribute to explaining the variability of the regression results without introducing bias.

The final regressions for each model and its two effects are:

Ln Carbon Emissions:

Fixed Effects

$$\text{Ln Carbon Total Emissions}_i = a_i + b_1 \text{ Issued or Not Issued a Green Bond}_i + b_2 \text{ Leverage}_i + b_3 \text{ Quick Ratio}_i + b_4 \text{ ROA}_i + b_5 \text{ Ln Market Price}_i + b_6 \text{ } CO_2 \text{ Emissions}_i + \Sigma_I \quad (5)$$

Random effects

$$\text{Ln Carbon Total Emissions}_i = a_i + b_1 \text{ Issued or Not Issued a Green Bond}_i + b_2 \text{ Leverage}_i + b_3 \text{ Quick Ratio}_i + b_4 \text{ ROA}_i + b_5 \text{ Ln Market Price}_i + b_6 \text{ } CO_2 \text{ Emissions}_i + b_7 \text{ Credit Structural Leverage}_i + \Sigma_I \quad (6)$$

Ln Scope 1:

Fixed Effects

$$\text{Ln Scope 1}_i = a_i + b_1 \text{ Issued or Not Issued a Green Bond}_i + b_2 \text{ Leverage}_i + b_3 \text{ Quick Ratio}_i + b_4 \text{ ROA}_i + b_5 \text{ Ln Market Price}_i + b_6 \text{ } CO_2 \text{ Emissions}_i + \Sigma_I \quad (7)$$

Random effects

$$\text{Ln Scope 1}_i = a_i + b_1 \text{ Issued or Not Issued a Green Bond}_i + b_2 \text{ Leverage}_i + b_3 \text{ Quick Ratio}_i + b_4 \text{ ROA}_i + b_5 \text{ Ln Market Price}_i + b_6 \text{ } CO_2 \text{ Emissions}_i + b_7 \text{ Credit Structural Leverage}_i + \Sigma i \quad (8)$$

Ln Scope 2:

Fixed Effects

$$\text{Ln Scope 2}_i = a_i + b_1 \text{ Issued or Not Issued a Green Bond}_i + b_2 \text{ Leverage}_i + b_3 \text{ Quick Ratio}_i + b_4 \text{ ROA}_i + b_5 \text{ Ln Market Price}_i + b_6 \text{ } CO_2 \text{ Emissions}_i + \Sigma_I \quad (9)$$

Random effects

$$\text{Ln Scope 2}_i = a_i + b_1 \text{ Issued or Not Issued a Green Bond}_i + b_2 \text{ Leverage}_i + b_3 \text{ Quick Ratio}_i + b_4 \text{ ROA}_i + b_5 \text{ Ln Market Price}_i + b_6 \text{ } CO_2 \text{ Emissions}_i + b_7 \text{ Credit Structural Leverage}_i + \Sigma i \quad (10)$$

Ln Scope 3:

Fixed Effects

Ln Scope 3 i = a i + b_1 Issued or Not Issued a Green Bond i + b_2 Leverage i + b_3 Quick Ratio i + b_4 ROA i + b_5 Ln Market Price i + b_6 CO_2 Emissions i + Σ i (11)

Random effects

Ln Scope 3 i = a i + b_1 Issued or Not Issued a Green Bond i + b_2 Leverage i + b_3 Quick Ratio i + b_4 ROA i + b_5 Ln Market Price i + b_6 CO_2 Emissions i + b_7 Credit Structural Leverage i + Σi (12)

Table 6 : Correlation Matrix

Variables	Issued or not issued	Quick Ratio	Credit Structural Leverage	Leverage	ROA	Ln Assets	Ln Market Price
Ln Carbon Emissions	-0,02	-0,01	-0,02	-0,01	0,08	-0,06	0,34
Ln Scope 1	0,04	-0,01	0,00	-0,01	0,06	-0,05	0,24
Ln Scope 2	-0,02	-0,01	-0,04	-0,01	-0,03	0,04	0,22
Ln Scope 3	0,05	-0,01	0,03	-0,01	-0,02	0,01	0,07

Table 6 represents the correlation coefficients between different variables. Each cell indicates the correlation between the variable in the row and the variable in the column. The correlation coefficient ranges from -1 to 1, where -1 indicates a perfect negative correlation, 0 indicates no correlation, and 1 indicates a perfect positive correlation.

4. Results

4.1 Hausman Test: Logarithm Carbon Emissions

Prior to running our regressions, we have to choose which effects (fixed or random) are the most appropriate in our model. To do so, we use the Hausman test. If the p-value is over 10 %, we have to choose fixed effects in our model. On the other hand, if the p-value is under 10% then the best choice is to use random effects. To explain it with words, the decision to use fixed effects in our model suggests that we accept to capture firm-specific effects that are constant over time.

On the other hand, the decision to take random effects in our model signifies that we accept to capture firm-specific effects that are random variables (no constant variables). For the dependent variable LN carbon emissions scopes, we have to conduct a Hausman test between the fixed effects and random effects of our regression.

Table 7 displays the results of the Hausman test. We can deduce that we have to choose fixed effects. We find that the p-value is over 10%, so we have a p-value of 35.29 % above the 10% significant level. The best decision is to apply a fixed effects model.

Table 7 : Haussman Test - Logarithm Carbon Emissions Scopes

Variable	Fixed Effects	Random Effects	Difference	Std. Error
Dummy	-0.013533	-.0134024	-.0001306	.
LnAssets	.0015131	.0013686	.0001444	.0002182
Leverage	.0063205	-.0002611	.0065816	.0040182
QuickRatio	- .0126979	.0004628	-.0131607	.0080341
ROA	-4.83e-07	8.24e-07	-1.31e-06	9.40e-07
Ln Market Price	.0505259	.0495682	.0009577	.0010737
Total Carbon Emissions	.0000666	.000067	-3.54e-07	.
Results :		***Notes:***		
chi2(6)	6.67	(6) represents the chi square distribution with 6 variables		
Prob > chi2	0.3529	Prob > chi2 is the p value in this test		

4.2 Regression Analysis : Logarithm Carbon Emissions

Table 8 displays the main results of the regression analysis where the logarithm of carbon emissions serves as the dependent variable. The regression outcomes are presented with progressive company control variables. For each column from the left to the right side, we add one independent variable at a time. The independent variable "Issued or not issued a green bond" consistently carries a negative coefficient. This suggests a link between green bond issuances and lower carbon emissions.

To interpret our dummy variables, we take the coefficient found in the last column (6) and the first row. We have the presence of a dummy variable with a log. We should apply this formula: Exp ((b) – 1) = 100 * (Exp (-0.014) – 1) = -1,39 %. So, we can say that if the company issues a green bond then its level of carbon emissions decreases by 1.39% at the 10% level. In line with our research question, we can observe that the issuing of this debt instrument enables companies to finance the clean energy transition but in a small proportion.

For the independent variable LN Assets, the coefficients are consistently negative (-0,002) but not statically significant. It shows that there is not a clear association between Ln Total Assets and Ln Carbon. For the leverage, we can observe that the coefficients show mixed effects across specifications. In columns (2), the coefficient is zero and not statistically significant, while in (3), (4) and (5), it becomes positive. In column (6), it remains positive (0.006) but still carries no statistical significance. This indicates that the relationship between leverage and LN Carbon Emissions is inconsistent across models. For the quick ratio, we find all negative (but not statistically significant) coefficients. This means that we don't have a clear relationship between the quick ratio and our dependent variable. Moving to return on assets, we have only 0 as coefficients without statistical significance. This suggests that the independent variables don't have a significant impact on Ln Carbon Emissions. On the opposite side, we can observe that the natural logarithm Market Prices have positive coefficients (0.065*** and 0,051***) and are significant at the 1% level. It implies that companies with high market prices are potentially the higher carbon emissions issuer. Also, we can find that the independent variable total carbon emissions has a coefficient of 0 with a significance level of 1 %. In addition, the 41.60 % shows that this regression doesn't contain enough independent variables to explain our dependent variable.

Table 8: Fixed effects model - Logarithm Carbon Emissions Scopes

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]
Issued or not issued a Green Bond [c]	-0.010	-0.010	-0.010	-0.010	-0.016*	-0.014*
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.008)
LN [a] Assets	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Leverage		-0.000	0.009	0.009	0.006	0.006
		(0.000)	(0.014)	(0.014)	(0.013)	(0.010)
Quick Ratio			-0.018	-0.018	-0.013	-0.013
			(0.027)	(0.027)	(0.025)	(0.021)
Return on Assets				-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)
LN [a] Market Price					0.065***	0.051***
					(0.004)	(0.004)
Total Carbon Emissions						0.000***
						(0.000)
Constant	2.100***	2.100***	2.098***	2.098***	2.009***	2.013***
	(0.008)	(0.008)	(0.009)	(0.009)	(0.010)	(0.008)
Observations	1914	1914	1914	1914	1914	1914
R-squared	0.001	0.001	0.002	0.002	0.113	0.416
Adjusted R-squared	-0.485	-0.490	-0.493	0.499	0.067	0.385
Number of Firms	90	90	90	90	90	90

Standard errors in parentheses	***Notes:***
*** p<0.01, ** p<0.05, * p<0.1	[a] is the logarithm of the variable used
*,**,*** denote statistical significance at	[b] represents the dependent variable
the 10%, 5% and 1% levels, respectively.	[c] represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0, if not

4.3 Hausman Test – Logarithm Scopes 1 Emissions

Table 9 presents the Hausman test results. Based on our findings, we choose a fixed effects model. With a p-value of more than 10%, namely 42.17%, it exceeds the 10% significance threshold. Therefore, the use of fixed effects in our model is the optimal choice.

Table 9 : Haussman Test - Logarithm Scopes 1 Emissions

Variable	Fixed Effects	Random Effects	Difference	Std. Error
Dummy	.015621	.0159627	-.0003417	.
LnAssets	.0027725	.0024848	.0002878	.0001524
Leverage	-.0045489	-.0102343	.0056854	.0033756
QuickRatio	.00911	.0204766	-.0113666	.0067491
ROA	-8.74e-07	-3.85e-07	-4.89e-07	7.90e-07
Ln Market Price	.0366286	.0373128	-.0006842	.0008735
Total Carbon Emissio	-5.93e-06	-5.93e-06	-6.98e-09	.
Results :		***Notes:***		
chi2(6)	6.01	chi2(6) represents the chi square distribution with 6 variables		
Prob > chi2	0.4217	Prob > chi2 is the p value in this test		

4.4 Regression Analysis – Logarithm Scopes 1

Table 10 presents the main results of the regression analysis using the logarithm of emission scope 1 as the dependent variable. The regression results are presented with progressive fixed effects. We present our regression analysis in a scaled form to gradually add an independent variable. The dummy variable "issued or not issued a green bond" has only positive coefficients. We observe that from the first to the fourth column, the coefficients show a result of 0.019 with a significant level at 10%. Then, the last two columns show results of 0.016 with no significant level at 1%, 5% and 10%. There is a weak relationship between green bond issuances and Scope 1 emissions. To give an interpretation of our dummy variable, we refer to our coefficient located in the last column (6) and the first row. Since we have a dummy variable with a logarithm, we have to use this formula: Exp ((b) - 1) = 100 * (Exp (0.016) - 1) = 1.61%. We can say that when a company issues a green bond, its scope 1 emissions increase by 1.61%. Based on this, the issuance of green bond instruments facilitates the financing of the clean energy transition and doesn't advance the clean energy transition, albeit to a modest extent. Then the natural logarithm of total assets shows only positive coefficients (0.003) with no statistical significance level. This shows that in our model there is a small impact between our independent and dependent variables. For leverage, we observe that the coefficients show mixed effects across the specifications. In column (2), the coefficient is zero and statistically insignificant. From the third to the last column, all the coefficients are strictly negative and do not assume the presence of a significance level. The relationship between the leverage variable and its dependent variable is not clear.

For the quick ratio, we find positive but insignificant coefficients. This means that we have a weak relationship between the quick ratio and our dependent variable.

For our next variable, return on assets, we observe coefficients of 0 with no significance level. This suggests that the independent variable has no discernible effect on Ln carbon emissions. In contrast, we observe positive coefficients (0.035*** and 0.037***) with a significant level of 1% for the natural logarithm of market prices. This implies that companies with higher market prices potentially have higher emission levels. Furthermore, the independent variable total carbon emissions has a coefficient of 0 with a 1% significance level.

Furthermore, the R-squared value of 3.80 % suggests that this regression is missing a significant portion of the independent explanatory variables for our dependent variable.

Table 10: Fixed effects model - Logarithm Scopes 1 Emissions

VARIABLES	(1) LN [a] Scope 1 [b]	(2) LN [a] Scope 1 [b]	(3) LN [a] Scope 1 [b]	(4) LN [a] Scope 1 [b]	(5) LN [a] Scope 1 [b]	(6) LN [a] Scope 1 [b]
Issued or not issued a Green Bond c	0.019*	0.019*	0.019*	0.019*	0.016	0.016
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
LN [a] Assets	0.003	0.003	0.003	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Leverage		0.000	-0.003	-0.003	-0.005	-0.005
		(0.000)	(0.014)	(0.014)	(0.013)	(0.013)
Quick Ratio			0.007	0.006	0.009	0.009
			(0.027)	(0.027)	(0.027)	(0.027)
Return on Assets				-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)
LN [a] Market Price					0.035***	0.037***
					(0.004)	(0.005)
Total Carbon Emissions						-0.000**
						(0.000)
Constant	2.092***	2.092***	2.093***	2.093***	2.045***	2.045***
	(0.008)	(0.008)	(0.009)	(0.009)	(0.011)	(0.011)
Observations	1914	1914	1914	1914	1914	1914
R-squared	0.003	0.003	0.003	0.003	0.036	0.038
Adjusted R-squared	-0,467	-0,472	0,478	-0,483	-0,143	-0,124
Number of Firms	90	90	90	90	90	90

Standard errors in parentheses	***Notes:***
*** p<0.01, ** p<0.05, * p<0.1	[a] is the logarithm of the variable used
*,**,*** denote statistical significance at	[b] represents the dependent variable
the 10%, 5% and 1% levels, respectively.	c represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0, if not

4.5 Hausman Test – Logarithm Scopes 2 Emissions

Table 11 shows the results of our Hausman test when considering the logarithm of scope 2 emissions as our dependent variable. We can observe that the p-value is 18.60%, over the 10 % significant level. The logical choice is to use fixed effects in our model.

Table 11 : Haussman Test - Logarithm Scopes 2 Emissions

Variable	Fixed Effects	Random Effects	Difference	Std. Error
Dummy	-.0115231	-.0120292	.0005061	.
LnAssets	.0083919	.0080388	.0003531	.0004397
Leverage	.0099184	-.0051797	.0150981	.0072689
QuickRatio	-.0198918	.0102934	-.0301852	.0145335
ROA	1.56e-06	8.10e-07	7.46e-07	1.70e-06
Ln Market Price	.0118373	.0168377	-.0050004	.001994
Total Carbon Emissions	-4.62e-06	-4.59e-06	-3.05e-08	4.38e-08
Results :		***Notes:***		
chi2(6)	8.79	the chi square distribution with 6 variables		
Prob > chi2	0.1859	chi2 is the p value in this test		

4.6 Regression Analysis – Logarithm Scopes 2

Table 12 shows the results for the dependent variable logarithm scope 2 emissions. Our regression is displayed in scale. It takes a progressive fixed effects form, in which we add each independent variable step by step. To talk about our independent variable "Issued or not issued a green bond" we can observe in the table below that all the coefficients are negatives. It shows that the dummy variable corresponding to the logarithm scope 2 emissions plays an important role in our model.

To go deeper into the dummy variable analysis, we take the coefficient in the last specification (6) and first row. To measure the impact, we have to apply this formula: Exp ((b) - 1) = 100 * (Exp (0.012) - 1) = 1.19 %. From this result, we can explain that when a firm issues a green bond, its level of scope 2 emissions decreases by 1.19 %. To align with our research question, we can observe that the issuing of this debt instrument enables the financing of the clean energy transition but in a small proportion.

In our model, we display the natural logarithm of total assets which takes positives coefficients and with a significant level at 1%. This explains that there is a relationship between this independent and the logarithm of the scope 2 emissions variable. Then, the leverage carries positive coefficients (0.010 and 0.011). We can highlight a slight impact of this variable in our model but not enough to explain that the leverage could reduce the scope 2 emissions. In the same situation, we find that the quick ratio has negative coefficients with no statistical significance. Then, we can observe two similar independent variables total carbon emissions and return on assets with zero for all the coefficients. In contrast, we observe positive coefficients (0.010*** and 0.011***) with a significance level of 1% for the natural logarithm of market prices. This implies that companies with higher market prices potentially have higher scopes 2 emissions.

In addition, the R^2 of 1.2 % shows that this regression shows the independent variables are not explicative for our model.

Table 12: Fixed effects model - Logarithm Scopes 2 Emissions

VARIABLES	(1) LN [a] Scope 2 [b]	(2) LN [a] Scope 2 [b]	(3) LN [a] Scope 2 [b]	(4) LN [a] Scope 2 [b]	(5) LN [a] Scope 2 [b]	(6) LN [a] Scope 2 [b]
Issued or not issued a Green Bond c	-0.010	-0.011	-0.010	-0.010	-0.011	-0.012
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
LN [a] Assets	0.009***	0.009***	0.009***	0.009***	0.009***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Leverage		-0.000	0.011	0.010	0.010	0.010
		(0.000)	(0.015)	(0.015)	(0.015)	(0.015)
Quick Ratio			-0.021	-0.021	-0.020	-0.020
			(0.030)	(0.030)	(0.030)	(0.030)
Return on Assets				0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)
LN [a] Market Price					0.011**	0.012**
					(0.005)	(0.005)
Total Carbon Emissions						-0.000
						(0.000)
Constant	2.061***	2.062***	2.059***	2.059***	2.044***	2.044***
	(0.009)	(0.009)	(0.010)	(0.010)	(0.012)	(0.012)
Observations	1914	1914	1914	1914	1914	1914
R-squared	0.008	0.008	0.008	0.008	0.011	0.012
Adjusted R-squared	-0,417	-0,421	-0,424	-0,429	0,409	-0,402
Number of Firms	90	90	90	90	90	90

Standard errors in parentheses	***Notes:***
*** p<0.01, ** p<0.05, * p<0.1	[a] is the logarithm of the variable used
*,**,*** denote statistical significance at	[b] represents the dependent variable
the 10%, 5% and 1% levels, respectively	c represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0, if not

4.7 Hausman Test – Logarithm Scopes 3 Emissions

Table 13 shows the Hausman test and its results. We can conclude that we need to choose a fixed effect. We see that the p-value is above 10%, so we have a p-value of 83.11% above the 10% significant level. The best decision is to use fixed effects in our model.

Table 13 : Haussman Test - Logarithm Scopes 3 Emissions

Variable	Fixed Effects	Random Effects	Difference	Std. Error
Dummy	.0641555	.0648077	-.0006522	.
LnAssets	.0202478	.019476	.0007718	.0005793
Leverage	-.019876	-.0348572	.0149812	.0102762
QuickRatio	.039685	.0696325	-.0299476	.0205462
ROA	1.52e-06	8.44e-07	6.72e-07	2.40e-06
Ln Market Price	-.0204672	-.0170061	-.0034612	.0027268
Total Carbon Emissions	-2.16e-06	-2.37e-06	2.10e-07	6.25e-08
Results :		***Notes:***		
chi2(6)	2.82	chi2(6) represents the chi square distribution with 6 variables		
Prob > chi2	0.8311	Prob > chi2 is the p value in this test		

4.8 Regression analysis – Logarithm Scopes 3

Table 14 shows the results for the dependent variable log of Scope 3 emissions. Our regression is shown in scale. It takes the form of progressive fixed effects, where we add each independent variable step by step. Regarding our independent variable "Issued or not issued a green bond", we can see in the table below that all the coefficients are positive and significant at the 5% level. This shows that the dummy variable is somewhat correlated with the dependent variable. To analyze our dummy variable in more detail, we take the coefficient in the last specification (6) and the first row. To measure the impact, we have to apply this formula: Exp ((b) - 1) = 100 * (Exp (0.065) - 1) = 6.72%. From this result, we can explain that when a company issues a green bond, its scope 3 emissions increase by 6.72% at the 1% significant level. To align with our research question, we can observe that the issuing of green bonds enables firms to finance the clean energy transition throughout the scopes 3 emissions and don't contribute to reduce them.

In our model, we present the natural logarithm of total assets, which has positive, constant (0.020) and statically significant coefficients at the 5% level. There is a clear relationship between the level of total assets and Scope 3 emissions. This means that when a company increases its level of assets, we have an increase in the other indirect emissions that occur upstream or downstream in the company's value chain. For the next independent variable (leverage), we can see that all the coefficients are negative. We can see that a low level of leverage has an impact on reducing our Scope 3 emissions. For the quick ratio, we find practically the same coefficients (from 0.069 to 0.071), which means that the effect is important enough to have an impact on our regression model.

Then we can observe two similar independent variables, total carbon emissions and return on assets, with all coefficients equal to zero. For the natural logarithm of market prices, we can observe that the first variable is significant at the 10% level and has a negative coefficient of -0.017. In contrast, the coefficients in the last column lose their significative level at 10 % but stay the same (in size). In addition, we find that our independent variable can explain roughly 1.60% of the variation in the dependent variable based on the R^2.

Table 14: Fixed effects model - Logarithm Scopes 3 Emissions

VARIABLES	(1) LN [a] Scope 3 [b]	(2) LN [a] Scope 3 [b]	(3) LN [a] Scope 3 [b]	(4) LN [a] Scope 3 [b]	(5) LN [a] Scope 3 [b]	(6) LN [a] Scope 3 [b]
Issued or not issued a Green Bond c	0.064***	0.064***	0.063**	0.063**	0.063**	0.065***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
LN [a] Assets	0.020***	0.020***	0.020***	0.020***	0.020***	0.020***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Leverage		-0.000	-0.035	-0.035	-0.034	-0.035
		(0.000)	(0.030)	(0.030)	(0.030)	(0.030)
Quick Ratio			0.071	0.071	0.069	0.070
			(0.061)	(0.061)	(0.061)	(0.061)
Return on Assets				0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)
LN [a] Market Price					-0.017*	-0.017
					(0.011)	(0.026)
Total Carbon Emissions						-0.000
						(0.000)
Constant	2.128***	2.128***	2.136***	2.136***	2.118***	2.140***
	(0.037)	(0.037)	(0.038)	(0.038)	(0.056)	(0.058)
Observations	1914	1914	1914	1914	1914	1914
R-squared	0.012	0.012	0.012	0.013	0.015	0.016
Adjusted R-squared	-0,366	-0,371	-0,375	-0,38	-0,365	-0,37
Number of Firms	90	90	90	90	90	90

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 *,**,*** denote statistical significance at the 10%, 5% and 1% levels, respectively	***Notes:*** [a] is the logarithm of the variable used [b] represents the dependent variable c represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0, if not

5. Robustness

In this section, our purpose is to ensure the reliability and stability of our regression results, we conducted a series of robustness tests. These tests aim to validate the robustness of our findings. In addition, we attempt to address any potential concerns regarding the choice of the effects and the variables. To do so, we decide to take the random effects in our robustness section and replace two of our independent variables (Return on Assets and Quick Ratio) by two others (Return on Equity and Current Ratio). The main purpose is to observe if by using the random effects in our regression or alternating our choice of independent variables, we can obtain better results.

Table 15 displays the different robust tests considering the independent variables for this section and still the same 4 dependent variables. The dummy variable has all its coefficients statically significant at two different levels. Going deeper, the dependent variable LN Carbon emissions passes from 1 % to 5 % in terms of significance level between the main and the robust results. For Ln Scopes 1 and 2, these two coefficients become significant at the 10% level. In contrast, the LN of Scope 3 sees its level of significance level pass from 5 % to 10%. To interpret our coefficients, we apply this formula: Exp ((b) - 1) *100. For the LN Carbon emissions, we observe that when a company issues a green bond, the level of carbon emissions decreases by 1.41 % at a 5 % significant level. Then the second independent shows that when a company issues a green bond then the level of scope 1 emissions increases by 1.51 % at a 10 % significance level. For the third, we observe that when a company issues a green bond then the level of scope 2 emissions decreases by 1.21 % at a 10 % significance level. The last dependent variable scope 3 emissions, we find that when a company issues a green bond then the level of scope 3 emissions increases by 6,82 % at a 10 % significant level. To compute the average across all of them (Appendix G), we find that when a company issues a green bond then the global emissions increase by 1.4275 % (Appendix F) and for the main results, by 1.4375 % (Table 15). We can say that between the fixed effects and random effects. We find the same results within a margin of 0.010. For the two dependent variables that we replaced. We find that the return on equity is a better variable in our model explaining more than the return on assets. Also, we observe that the quick ratio presents better results than the current ratio.

Table 15: Robust effects (Random Effects + Variables ROA and Quick Ratio)

VARIABLES	(1) Ln[a] Carbon Emissions [b]	(1) Ln[a] Scope 1[b]	(1) Ln[a] Scope 2 [b]	(1) Ln[a] Scope 3 [b]
Issued or not issued a Green Bond c	-0.014**	0.015*	-0.012*	0.066*
	(0.006)	(0.008)	(0.007)	(0.035)
Ln[a] Assets	0.004	0.008**	0.009***	0.008
	(0.002)	(0.003)	(0.003)	(0.009)
Leverage	-0.000	0.010	0.004	0.035
	(0.014)	(0.012)	(0.011)	(0.027)
Return on Assets	-0.001	-0.001*	-0.000	0.003
	(0.001)	(0.001)	(0.001)	(0.002)
Quick Ratio	0.000	-0.021	-0.009	-0.071
	(0.028)	(0.024)	(0.021)	(0.054)
Ln[a] Market Price	0.050***	0.039***	0.017***	-0.020
	(0.016)	(0.012)	(0.007)	(0.026)
Total Carbon Emissions	0.000***	-0.000**	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Credit Structural Leverage	-0.040	-0.006	-0.051	0.136
	(0.042)	(0.069)	(0.047)	(0.197)
Constant	2.022***	2.053***	2.051***	2.143***
	(0.025)	(0.026)	(0.015)	(0.051)
Observations	1,914	1,914	1,914	1,914
Number of firms	90	90	90	90

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 *,**,*** denote statistical significance at the 10%, 5% and 1% levels, respectively	***Notes:*** [a] is the logarithm of the variable used [b] represents the dependent variable c represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0 if not

6. Conclusion

Our research provides an analysis of the effectiveness of green bonds as a tool in the European clean energy transition. To observe this, we start our study by providing a literature review. Green bonds play a pivotal role in mitigating climate change and advancing the clean energy transition. We observe companies issuing green bonds, have the desire to participate in this transition. Green bonds are considered a way of mobilizing capital towards a greener world, having greater respect for our environment and aligning with sustainable goals as the Paris Agreement's objectives. Some institutions provide a guideline for companies wanting to issue a green bond ensuring alignment with climate goals and guiding investments towards key sectors.

In the data and methodology section, we give a structure for investigating the impact of European green bond issuance on the clean energy transition. I decided to base my research on a system of rating green bonds on carbon emissions. To achieve this, our work relied primarily on the research article titled "Green Bonds and Carbon Emissions: Exploring the Case for a Rating System at the Firm Level" by Ehlers, Mojon, and Packer (2020). In my research, I collect data on European companies having issued a green bond and their firm characteristics between 1998 – 2023. We obtained a sample of 90 firms. To address biases and facilitate analysis, natural logarithms were applied to key variables, including total assets, market price, carbon emissions, and scopes 1, 2, and 3. The dummy variables (Issued a green bond or not) were introduced to distinguish periods with and without green bond issuances, enabling the examination of their impact on both environmental outcomes and financial metrics. The purpose is to observe when companies issue green bonds in a given year and subsequently reduce their carbon emissions and scope. It also allows us to assess whether issuing a green bond improves a company's financial performance. Our comprehensive approach aims to deepen understanding of the relationship between green bond issuance, carbon emissions, and the transition to clean energy.

In the results part, we conducted four Hausman tests to determine whether random or fixed effects are more appropriate for our regressions. After executing these tests, we find that the optimal effects to integrate into our models are fixed. Then, we ran six regressions for each dependent variable. For the first model, we find when a company issues a green bond then its level of carbon emissions decreases by 1.39% at the 10% level. For the logarithm scope emissions 1, we observe when a company issues a green bond, its scope 1 emissions increase by 1.61%. The next dependent variable shows when a firm issues a green bond, its level of scope 2 emissions decreases by 1.19 %. The last dependent variable explains when a company issues a green bond, its scope 3 emissions increase by 6.72% at the 1% significant level. In Appendix G, our results show that the issuing of a green bond increases the global carbon emissions (standard and scopes) by 1.438% statically significant at a 10% level. This result is obtained by summing the averages of all dependent variables. Additionally, and looking at my results from a different angle, a company issuing a green bond participates in the clean energy transition by reducing the standard carbon emissions by 1.40 % statically significant at a 10% level. On the other hand, we find that company green bond issuance does not contribute to the clean energy transition when considering the scope variables. It explains that the issuing of a green bond increases the scope emissions by 2.38% statically significant at the 10% level. We can say that based on a firm-level rating system, green bonds are not considered enough as a tool to advance the clean energy transition. Our results show that when a company issues a green bond its level of global carbon emissions increases by 1.438%. This leads to the same conclusion as shown in our guide research paper, titled "Green Bonds and Carbon Emissions: Exploring the Case for a Rating System at the Firm Level" by Ehlers, Mojon, and Packer (2020 In addition, in the robustness section, I find that using either fixed or random effects doesn't make a difference in the results. Random effects do improve my results slightly and some variables gain significance.

There were several limitations to our work. Firstly, our reliance on Datastream for data collection proved to be limiting, as the platform did not provide sufficient data to build a comprehensive database. In addition, we identified numerous other relevant independent variables that could have enriched our analysis and provided a more nuanced understanding of the issue. Secondly, the transformation of certain independent variables into logarithmic forms during the regression analysis may have limited the effectiveness of the model in capturing the full impact on global carbon emissions. Thirdly, the absence of certain independent variables relevant to the research posed a challenge as Datastream lacked information on certain countries, limiting the scope of our analysis. Addressing these limitations in future research could lead to more robust and insightful results.

To approach our work differently, we offer another study. We could observe the impact when a company issues a green bond focused on the European sectors or industries. The purpose is to conduct a separate analysis for industries of renewable energy, transport, real estate, or mineral resources. In doing this future research, we would understand how green bonds influence global carbon emissions and advance the low-carbon transition. By focusing on the industries, the purpose is to further investigate whether or not companies can advance the clean energy transition.

Additionally, future research could replicate the study using Bloomberg, a platform renowned for offering superior data compared to Datastream. Widely utilized by financial market professionals and researchers for its data quality, Bloomberg presents an opportunity to procure enhanced data for exploring new insights and overcoming the primary limitations of our current study. Moreover, the high-quality database may potentially lead to revisiting the conclusions drawn in the current analysis.

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Appendix A:

Table of Variables

Name	Definition	Sources
Dependent Variables		
LN Total Carbon Emissions	Logarithm of the sum of all greenhouse gas. emissions	Datastream
LN Scopes 1 Emissions	Logarithm of the emissions produced by a company's owned or controlled sources, such as vehicles and equipment.	Datastream
		Datastream
LN Scopes 2 Emissions	The logarithm of the greenhouse gas emissions generate indirectly by a company through the consumption of purchased electricity, heat, or steam.	Datastream
LN Scopes 3 Emissions	The logarithm of all indirect greenhouse gas emissions associated with a company's	
Explanatory Variable		
Issued or not issued a Green Bond	Take the value 1 when the company issues a Green Bond in year T and 0 when not	Datastream
Control Variables		
Quick Ratio	Difference between Current Assets and Inventories then divided by the Current Liabilities	Datastream
		Datastream
Return on Assets	The ratio of the net income to Total Assets	
		Datastream
LN Total Assets	Natural Logarithm of Total Assets	
		Datastream
LN Market Price	Natural Logarithm of the Current Price of the company concerned.	
		Datastream
Carbon Emission	Measure direct carbon emissions issued by a company.	
		Datastream
Credit Structural Leverage	The degree to which a company's debt levels impact its credit risk and financial stability	Datastream

Appendix B:

Table 8 bis: Random effects model - Logarithm Carbon Emissions Scopes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]	LN [a] Carbon Emissions [b]
Issued or not issued a Green Bond c	-0.010	-0.010	-0.010	-0.010	-0.016*	-0.013*	-0.013*
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.008)	(0.008)
LN [a] Assets	-0.003	-0.003	-0.003	-0.003	-0.002	0.001	0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Leverage		-0.000	-0.006	-0.006	0.000	0.000	-0.000
		(0.000)	(0.012)	(0.012)	(0.011)	(0.010)	(0.010)
Quick Ratio			0.012	0.013	-0.001	-0.000	0.000
			(0.024)	(0.024)	(0.023)	(0.019)	(0.019)
Return on Assets				0.000	0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)	(0.000)
LN [a] Market Price					0.062***	0.050***	0.050***
					(0.004)	(0.003)	(0.003)
Total Carbon Emissions						0.000***	0.000***
						(0.000)	(0.000)
CreditStructuralLeverage							-0.034
							(0.054)
Constant	2.100***	2.100***	2.101***	2.101***	2.015***	2.016***	2.023***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.011)	(0.015)
Observations	1914	1914	1914	1914	1914	1914	1914
Number of firms	90	90	90	90	90	90	90

Standard errors in parentheses	***Notes:***
*** p<0.01, ** p<0.05, * p<0.1	[a] is the logarithm of the variable used
*,**,*** denote statistical significance at	[b] represents the dependent variable
the 10%, 5% and 1% levels, respectively	c represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0, if not

Appendix C:

Table 10 bis: Random effects model - Logarithm Scopes 1 Emissions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	LN [a] Scope 1 [b]	LN [a] Scope 1 [b]	LN [a] Scope 1 [b]	LN [a] Scope 1 [b]	LN [a] Scope 1 [b]	LN [a] Scope 1 [b]	LN [a] Scope 1 [b]
Issued or not issued a Green Bond [c]	0.020*	0.020*	0.020*	0.020*	0.020*	0.016	0.016
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
LN [a] Assets	0.003	0.003	0.003	0.003	0.003	0.003	0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Leverage		0.000	-0.011	-0.011	-0.011	-0.010	-0.010
		(0.000)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Quick Ratio			0.022	0.022	0.021	0.021	0.020
			(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Return on Assets				-0.000	-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)	(0.000)
LN [a] Market Price					0.025	0.012	0.011
					(0.114)	(0.111)	(0.111)
Total Carbon Emissions						0.036***	0.037***
						(0.004)	(0.004)
CreditStructuralLeverage							-0.000**
							(0.000)
Constant	2.103***	2.103***	2.105***	2.105***	2.101***	2.055***	2.054***
	(0.019)	(0.019)	(0.019)	(0.019)	(0.029)	(0.029)	(0.029)
Observations	1,914	1,914	1,914	1,914	1,914	1,914	1,914
Number of Firms	90	90	90	90	90	90	90

Standard errors in parentheses	***Notes:***
*** p<0.01, ** p<0.05, * p<0.1	[a] is the logarithm of the variable used
*,**,*** denote statistical significance at	[b] represents the dependent variable
the 10%, 5% and 1% levels, respectively	[c] represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0, if not

Appendix D:

Table 12 bis : Random effects model - Logarithm Scopes 2 Emissions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	LN [a] Scope 2 [b]	LN [a] Scope 2 [b]	LN [a] Scope 2 [b]	LN [a] Scope 2 [b]	LN [a] Scope 2 [b]	LN [a] Scope 2 [b]	LN [a] Scope 2 [b]
Issued or not issued a Green Bond c	-0.010	-0.010	-0.010	-0.010	-0.010	-0.012	-0.012
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
LN [a] Assets	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***	0.008***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Leverage		-0.000	-0.005	-0.005	-0.005	-0.005	-0.005
		(0.000)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Quick Ratio			0.010	0.010	0.011	0.009	0.010
			(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Return on Assets				0.000	0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)	(0.000)
LN [a] Market Price					-0.043	-0.048	-0.049
					(0.066)	(0.063)	(0.061)
Total Carbon Emissions						0.016***	0.017***
						(0.005)	(0.005)
CreditStructuralLeverage							-0.000
							(0.000)
Constant	2.063***	2.063***	2.064***	2.064***	2.073***	2.052***	2.052***
	(0.013)	(0.013)	(0.014)	(0.014)	(0.019)	(0.019)	(0.019)
Observations	1914	1914	1914	1914	1914	1914	1914
Number of Firms	90	90	90	90	90	90	90

Standard errors in parentheses	***Notes:***
*** p<0.01, ** p<0.05, * p<0.1	[a] is the logarithm of the variable used
*,**,*** denote statistical significance at	[b] represents the dependent variable
the 10%, 5% and 1% levels, respectively	c represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0, if not

Appendix E:

Table 14 bis : Random effects model - Logarithm Scopes 3 Emissions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	LN [a] Scope 3 [b]	LN [a] Scope 3 [b]	LN [a] Scope 3 [b]	LN [a] Scope 3 [b]	LN [a] Scope 3 [b]	LN [a] Scope 3 [b]	LN [a] Scope 3 [b]
Issued or not issued a Green Bond [c]	0.064***	0.064***	0.063**	0.063**	0.063**	0.065***	0.065***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
LN [a] Assets	0.020***	0.020***	0.020***	0.020***	0.020***	0.020***	0.019***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Leverage		-0.000	-0.035	-0.035	-0.034	-0.035	-0.035
		(0.000)	(0.030)	(0.030)	(0.030)	(0.030)	(0.031)
Quick Ratio			0.071	0.071	0.069	0.070	0.070
			(0.061)	(0.061)	(0.061)	(0.061)	(0.061)
Return on Assets				0.000	0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)	(0.000)
LN [a] Market Price					0.095	0.101	0.101
					(0.212)	(0.213)	(0.214)
Total Carbon Emissions						-0.017*	-0.017
						(0.011)	(0.011)
CreditStructuralLeverage							-0.000
							(0.000)
Constant	2.128***	2.128***	2.136***	2.136***	2.118***	2.140***	2.140***
	(0.037)	(0.037)	(0.038)	(0.038)	(0.056)	(0.058)	(0.058)
Observations	1914	1914	1914	1914	1914	1914	1914
Number of Firms	90	90	90	90	90	90	90

Standard errors in parentheses	***Notes:***
*** p<0.01, ** p<0.05, * p<0.1	[a] is the logarithm of the variable used
*,**,*** denote statistical significance at	[b] represents the dependent variable
the 10%, 5% and 1% levels, respectively	[c] represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0, if not

Appendix F:

Table 15 bis : Robust effects (Random Effects + Variables ROE and Current Ratio)

VARIABLES	(1) Ln[a] Carbon Emissions [b]	(1) Ln[a] Scope 1[b]	(1) Ln[a] Scope 2 [b]	(1) Ln[a] Scope 3 [b]
Issued or not issued a Green Bond c	-0.013**	0.016*	-0.012	0.065*
	(0.006)	(0.008)	(0.012)	(0.034)
Ln[a] Assets	0.001	0.002	0.008***	0.019***
	(0.001)	(0.002)	(0.002)	(0.004)
Leverage	-0.000	-0.010	-0.005	-0.035
	(0.014)	(0.012)	(0.013)	(0.027)
Return on Equity	0.000***	-0.000***	0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
CurrentRatio	0.000	0.020	0.010	0.070
	(0.027)	(0.023)	(0.027)	(0.053)
Ln[a] Market Price	0.050***	0.037***	-0.049	-0.017
	(0.016)	(0.012)	(0.061)	(0.026)
Total Carbon Emissions	0.000***	-0.000**	0.017***	-0.000
	(0.000)	(0.000)	(0.005)	(0.000)
Credit Structural Leverage	-0.034	0.011	-0.000	0.101
	(0.043)	(0.070)	(0.000)	(0.193)
Constant	2.023***	2.054***	2.052***	2.140***
	(0.025)	(0.026)	(0.019)	(0.051)
Observations	1,914	1,914	1,914	1,914
Number of firms	90	90	90	90

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 *,**,*** denote statistical significance at the 10%, 5% and 1% levels, respectively	***Notes:*** [a] is the logarithm of the variable used [b] represents the dependent variable c represents the dummy variable taking the value of 1 when a company issues a bond in year t and 0 if not

Appendix G:

Measure of the global carbon emissions

	Coefficients	Exponential	Results		Average Standard Carbon Emissions	Average Scopes Emissions	Average Global Carbonn Emissions
Carbon Emissions	-0,014*	0,986097544	-0,013902456	-1,39*	-1,39%*	-	1,438% *
Ln Scopes 1	0,016	1,016128685	0,016128685	1,61	-	2,38% *	
Ln Scopes 2	-0,012	0,988071713	-0,011928287	-1,19	-		
Ln Scopes 3	0,065***	1,067159024	0,067159024	6,71***	-		

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1: *,**,*** denote statistical significance at the 10%, 5% and 1% levels, respectively