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The Efficiency of Environmental Project Financing with Green Bonds in the Energy Sector: Evidence from EU Countries

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Abstract

This paper investigates whether the issue of green bonds by energy companies allows lowering the cost of funding for their environmental projects. We use empirical data on green bond placement in the energy sector and comparable conventional bond yield curves to prove the existence of the green bond yield discount. The sample includes 37 plain vanilla green bond issues and comparable yield curves of EU energy companies for 2017–2020 with total volume EUR 25 bn. We demonstrate that green bonds have a 4.7 bps lower average yield compared to conventional bonds. This green bond discount is statistically significant at a 5% level and does not depend on issue size or debut status of the issue. We draw three main conclusions: (1) energy companies may lower cost of funding by issuing green bonds, making environmental projects more economically attractive, (2) the green bond discount is present for both inaugural and subsequent green bond issues, which makes it reasonable to finance all environmental projects with green bonds, (3) the green bond discount does not depend on the issue size, which makes green bonds an appropriate choice for financing capital-intensive projects.

Keywords: green bonds, energy companies, responsible investment, ESG policy, environmental impact

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Introduction

Energy is a strategically important segment of the global economy that impacts countries' sustainable development and national security. Global energy consumption reached 14.2 billions toe (tonnes of oil equivalent) in 2021 and has a tendency to increase in the foreseeable future [1]. The energy sector is the major contributor to climate change and produces 35% of global greenhouse gas (GHG) emissions worldwide [2]. The total energy-related GHG emissions have grown to 40 Gt of CO_2 equivalent in 2021 [3]. Therefore, reducing emissions is the key priority for energy companies, and they actively implement environmental projects in order to achieve their decarbonization aims.

The key financial issues energy companies face when implementing environmental projects are: (1) high capital intensity, (2) long payback period, (3) low return on investment (ROI) [4]. It forces energy companies to seek new financial instruments that allow attracting cheaper funding in the long-term. Green bonds could be the solution for energy companies since they usually have long maturity periods and significant amounts like plain vanilla bonds, but they may additionally offer a discounted interest rate due to a sufficient interest from investment community.

The global green bond market has grown to an adequate volume during the last several years. Since 2015, the amount of outstanding green bonds has increased more than 10-fold from $40bn to $500bn, attracting notable investor demand in global markets.

One of the reasons is the widespread adoption of the "responsible investment" concept by investors, which implies that the environmental impact is closely correlated with a company's long-term performance. Eco-friendly investments hedge investors against the risks of environmental hazards and potential penalties that governments tend to impose on polluting companies. This tendency has led to the appearance of a new investor type with a separate green mandate which is mostly focused on green bonds.

Another driver of the green bond segment growth is governmental support. The most common ways of governmental support are (1) mandatory disclosure of green investments by institutional investors, (2) tax exemption and coupon subsidies for green bonds, (3) subsides for green bond verification costs and (4) creation of dedicated green funds. An example of efficient regulation in the European market is Article 173 of the French Energy Transition Law that obliges publicly listed companies and institutional investors to disclose carbon emissions of their projects and investment portfolios. It stimulates active investment into green bonds, so that they appear in the investors' above-mentioned carbon reporting.

Energy companies comprise a significant portion of the green bond market issuance since they play a major role in the transition to the green economy. Almost 1/3 of the total annual green bonds issued in 2019 has been used for energy projects including solar, wind, geothermal, bioenergy and small hydropower plants. Many European energy and utilities companies, including A2A, Alliander, E.ON, Enel, Hera, Iberdrola, Innogy, Iren, Tennet Holding, Terna, etc., are now active green bond issuers.

The primary aim of this study is to determine the efficiency of financing environmental projects in the energy sector with green bonds compared to a similar senior unsecured public debt instrument – plain vanilla bonds. The nature of environmental projects in the energy sector with a long payback period and low rates of return implies that the primary efficiency indicator is the cost of funding.

The results may be useful in the pricing of green bonds' primary placements for both energy companies (issuers) and investors.

The remaining article is outlined as follows. Section second presents a literature review that has helped in building hypotheses. Section three provides details related to the sampling method and variable adoption. Section four presents the results and their statistical explanation. Section five contains a discussion of the results and their comparison to other authors' results. Section six concludes the existing study and provides further recommendations.

Literature overview and hypotheses statement

There are only a few papers on green bond pricing, and they do not have a common consensus regarding the "green premium" – the additional price premium (discount in yield) that investors are willing to pay for the green label compared to conventional bonds.

R. Preclaw and A. Bakshi (2015) [5] have conducted research based on secondary global bond market data for 2014–2015 with OLS-regression. The authors identified a 17-bps lower yield of the green bonds compared to ordinary bonds. G. Gianfrate and M. Peri (2019) [6] have analyzed European companies' bond yields in the secondary market for 2013–2017 with propensity score matching. They found a significant 20-bps discount of corporate green bond yields compared to conventional bonds. O.D. Zerbib (2019) [7] studies EUR and USD bond yields for 2013–2017 with matching and two-step regression methods. Author concludes that green bonds have 2-bps lower yields compared to conventional bonds. Q. Sheng et al. (2021) [8] in their research also calculated a significant 8-bps green bond discount in yield compared to conventional bonds and highlighted the importance of third-party verification. Authors have drawn these results by analyzing data on Chinese companies' primary bond placements with propensity score matching.

On the other hand, Climate Bonds Initiative [9] identified neither a premium, nor a discount in yield based on US and Eurobond primary market data for the respective period. Authors used the secondary market yield curve bootstrapping and subsequently compared it to the primary placement green bond yields in order to identify a premium or a discount. In addition, there are some papers that identify a premium in green bonds' yield. Among them is the research study by A. Karpf and A. Mandel (2018) [10] who have identified an 8-bps greater green bond yield based on 2010–2016 US muni bonds data.

The analysis of results drawn by different authors on this topic and their applicability for the purposes of this study is shown in Table 1.

Table 1. Results of existing research on greenium and their applicability

Research, source	Data	Results	Applicability
M.J. Emets (2020) [11]	Sample of 318 green and 1 695 conventional bonds	47 bps greenium	Energy sector is not isolated; Low descriptive power of OLS model (0.5–0.6); Dynamics of systematic factors (like base rates) is not considered
G. Gianfrate and M. Peri (2019) [6]	Sample of EU bonds secondary market for 2013–2017	20 bps greenium	Secondary market data is poorly applicable to issuers
R. Preclaw and A. Bakshi (2015) [5]	Sample of Eurobonds secondary markets for 2014–2015	17 bps greenium	Secondary market data is poorly applicable to issuers; Sample period is too narrow for drawing reliable conclusions
A. Mikhailova and I. Ivashkovskaya (2020) [12]	Sample of 2,450 primary placements in 2008–2020	23% spread compression for green bonds	Energy sector is not isolated
Q. Sheng et al. (2021) [8]	Sample of primary placements in Chinese market	8 bps greenium	Energy sector is not distinguished
O.D. Zerbib (2019) [7]	Sample of USD and EUR nominated bonds for 2013–2017	2 bps greenium	Energy sector is not distinguished; Sample is primarily focused on sovereign and muni-bonds
A. Karpf and A. Mandel (2018) [10]	Sample of US muni-bonds secondary market for 2010–2016	–8 bps greenium (Green bond rates are higher)	Energy sector is not isolated; Secondary market data is poorly applicable to issuers; Sample is focused on muni-bonds

Source: Composed by author.

As shown in Table 1, the results of existing research on greenium may be not suitable for assessing green bond efficiency for the energy sector companies since: 1) samples are based on different bond market segments (sovereign bonds, muni-bonds), 2) research is based on secondary market data, which is not applicable to primary issuance by energy companies, 3) the energy sector is not isolated in the results, 4) research methods have low precision or omitted variables (i.e., base rate dynamics).

This paper contributes to the literature corpus by using more granular bond issue filtering, a wider timeframe, focusing on the European energy segment and introducing a theoretical model that explains the green bond premium.

Additionally, there are three segments of literature that explore the impact of environmental and social projects on the pricing of other instruments (equity and ordinary debt).

The first segment studies the impact of CSR (Corporate Social Responsibility) on a company's equity value. There are numerous works on this topic, examples are M. Statman and D. Glushkov, 2009 [13], N. Semenova and L.G. Hassel, 2016 [14]. The consensus here is that CSR positively affects equity performance. However, the concept of CSR covers a wider scope than environmental impact: it also includes social responsibility. Therefore, the above-mentioned results are not directly applicable to the green bond market.

The second segment comprises papers exploring the link between a company's environmental impact and equity value. Notable works include R. Heinkel et al. (2001) [15], M.P. Sharfman and C.S. Fernando (2008) [16], S. Chava, 2014 [17]. Just as in the previous section, authors reached a consensus that the positive environmental impact of a company's business positively affects equity value. The findings, however, are applicable only to equity capital with a pricing mechanism that is sufficiently different from bonds.

The third segment focuses on companies' cost of debt and CSR. There is no consensus among authors on this topic. One group of authors (B.C. Magnanelli and M.F. Izzo (2017) [18], K.-M. Menz (2010) [19]) concludes that CSR improvement leads to a higher cost of debt, implying inefficient spending of funds on CSR. Another group of authors (C. Stellner et al. (2015) [20], I. Oikonomou et al. (2014) [21], H. Ghouma et al. (2018) [22]) estimates that CSR improvement leads to a lower cost of debt. The results are also not directly applicable to green bonds since they do not cover green bonds issued by brown companies (transition bonds).

The pricing of inaugural and subsequent green bond issues may be different, reducing their efficiency for the issuer. On the one hand, issuers usually pay a premium in the interest rate for the debut issues to attract an extensive investor community [23]. On the other hand, green bonds signal investors about the green transformation of a company, and subsequent green bonds may lose their efficiency and reduce the green bond discount since it would not present new information to investors. We expect the green bond discount to be present for both inaugural and subsequent green bond issues, so that energy companies have a reason to use green bonds to finance all environmental projects.

Green bonds are usually smaller compared to conventional bonds, since their use of proceeds is limited to specific projects. Some researchers state that the issue size sufficiently impacts bond yield at the primary placement [24; 25]. That might cause the green bond discount to decrease for the large green bond issues used to finance capital intensive environmental projects. On the other side, we expect the green bond discount to be stable across all issue sizes so as to ensure their efficiency for energy companies.

In order to identify whether issuing a green bond allows energy companies to lower the cost of funding for their green projects, the following hypotheses were set forth:

Hypothesis I: Green bonds have lower yields compared to conventional bonds – the green bond discount is present.

Hypothesis II: The green bond discount is present not only for the inaugural green bond issue, but for the subsequent issues as well.

Hypothesis III: The green bond discount does not depend on issue size.

Data and empirical methodology

We define the green bond discount (GBD) as the difference in yield between a green bond and a conventional bond.

The following methodology was applied in identifying the green bond discount in yield:

1) Plain vanilla green bond placements were selected.
2) Conventional bond curves were structured for each green bond issue using the Nelson-Siegel approach.
3) The green bond discount was calculated for each observation.
4) Factors impacting the green discount were tested with regression analysis.

Plain vanilla green bond selection

A significant portion of green bond issuance is not plain vanilla, meaning they cannot be directly compared to conventional bonds. The following selection criteria were applied:

- Global bonds issued by European Energy companies denominated in Euro.
- Senior unsecured debt.
- Fixed-coupon issues.
- No embedded options.
- Non-structured notes / Asset-based securities / Perpetual bonds / CPI-linkers.
- Use of proceeds: environmental purposes (according to ICMA rules) verified by an external entity.

Conventional bond curve formation

First, for each of green bond placements, conventional comparable bonds were selected among plain vanilla issues with the following priority:

- Issuer's non-green bonds.
- Non-green bonds from similar European energy sector issuers in Euro having the same credit rating assigned by at least two of three leading rating agencies (Moody's, S&P, Fitch).

The curves were bootstrapped only for those green bond issues where the number of comparable conventional bonds exceeded 5.

Curve formation process follows Nelson – Siegel [26] methodology. The equation (11) is fitted for each comparable green bond issue, so as to minimize the residual sum of squares. Four parameters (β_0, β_1, β_2, β_3) are estimated for the i-th green bond issue on the sub-sample of conventional bonds (j) with yield to maturity r_{ij}, and duration m_{ij}

$$\begin{cases} r_{ij} = \beta_0 + \left(\beta_1 + \beta_2\right) \cdot \left(\dfrac{1 - \exp\left(- \dfrac{m_{ij}}{\beta_3} \right)}{\dfrac{m_{ij}}{\beta_3}} \right) - \beta_2 \cdot \exp\left(- \dfrac{m_{ij}}{\beta_3} \right) + \varepsilon_{ig} \\ \sum_{g=1}^{n} \text{å}_{ig} \to \textit{minimize}. \end{cases} \qquad (1)$$

As a result, for each green bond issue (i) we formed a conventional bond curve with the following functional view:

$$r_i(m) = \beta_0 + (\beta_1 + \beta_2) \cdot \left(\frac{1 - \exp\left(-\frac{m}{\beta_3}\right)}{\frac{m}{\beta_3}} \right) - \beta_2 \cdot \exp\left(-\frac{m}{\beta_3}\right). \quad (2)$$

In the equation above (12), m is bond duration, $r_i(m)$ is the modelled conventional bond yield for the i-th green bond and $\beta_{0,1,2,3}$ are fitted curve parameters for the i-th green bond.

Deriving the green bond discount (greenium)

Once the conventional bond yield curves are fitted, the green bond discount is determined as follows:

$$GBD_i = r_i - r_i(m_i). \quad (3)$$

Where GBD is the green bond discount, r_i is a green bond yield at issuance and m_i is a green bond duration at issuance.

Regression of the green bond discount

We have used the following empirical models (14–16) to test the significance of the standalone green bond discount and the impact of issue size and debut status on the green bond discount

$$GBD_i = \beta_0 + \varepsilon_i \quad (4)$$

$$GBD_i = \beta_0 + \beta_1 \bullet DEBUT_i + \varepsilon_i \quad (5)$$

$$GBD_i = \beta_0 + \beta_1 \bullet DEBUT_i + \beta_2 \bullet VOLUME_i + \varepsilon_i, \quad (6)$$

Where $DEBUT_i$ – dummy variable that indicates whether the i-th green bond issue is inaugural (1) or not (0);

$VOLUME_i$ – the issue size of the i-th green bond, in millions of EUR.

Data sources

The research is based on the data of primary bond placements of EU energy companies nominated in EUR. European Union is the largest contributor to global decarbonization. The share of renewable energy sources in Europe's total energy mix has doubled from 20% in 2000 to 40% in 2021, which is the record among all regions [1]. One of EU's members – Norway – produces 99% of energy from renewable sources. It shows that EU energy companies are the most active in implementing environmental projects.

On the other side, European issuers have the largest share in the global green bond market. Since 2014 to 1H2022 European issuers have placed over $865 billion worth of green bonds, which comprise 45% of the global bond market [27]. Most of them are nominated in EUR.

The links among different variables in bond pricing are not constant or linear across the markets and currencies due to different regulation, investor structure, and taxation, therefore, we focus on the most representative segment of the global market – EU energy companies' bonds denominated in EUR.

The data on green bond issues has been taken from the Cbonds database. All EU energy sector bonds denominated in EUR have been pulled. The initial sample size comprised 102 observations. However, when all the filters described in the "Plain vanilla green bonds selection" section were applied, only 37 observations remained.

The data on green bond primary placement results (tenor, issue size, coupon, price, yield etc.) has been pulled from Cbonds, Bloomberg databases and issuance documents: Prospectus and Final terms. The data on secondary market quotes for comparable conventional bonds has been taken from Cbonds and Bloomberg databases.

Descriptive statistics of the green bond discount (GBD) in yield for primary bond placements of energy companies is presented in Table 2.

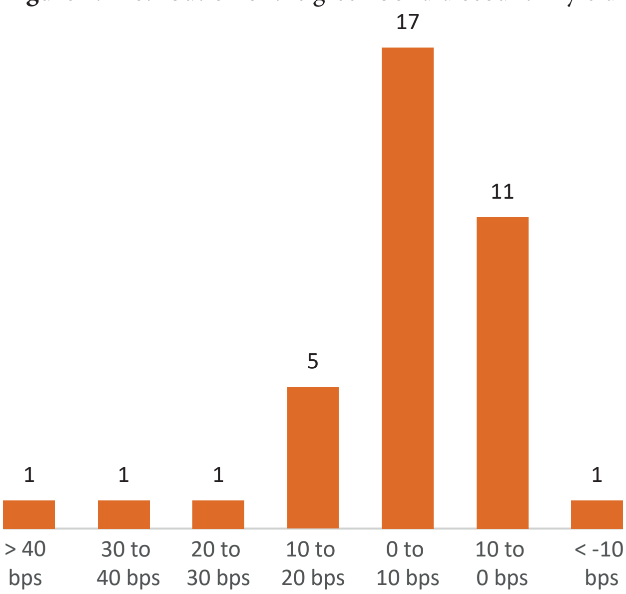
Table 2. Descriptive statistics of the green bond discount

Statistics	Value
Sample size	37 green bond issues
Average GBD	4.68 bps
Median GBD	2.83 bps

Source: Authors' calculation.

The distribution of the green discount in yield for primary bond placements of energy companies is depicted in Figure 1.

Figure 1. Distribution of the green bond discount in yield



Source: Authors' calculation.

Results

The results of the green bond discount regression analysis are presented in Table 3.

Table 3. Regression analysis of the green bond discount

	Dependent variable: Green bond discount		
	(1)	(2)	(3)
DEBUT		5.457	7.723
		(4.564)	(4.757)
VOLUME_MNEUR			0.013
			(0.009)
Constant	–4.678**	–6.596**	–16.357**
	(2.192)	(2.705)	(7.238)
Observations	37	37	37
R^2	–	0.039	0.095
Adjusted R^2	–	0.012	0.042
Residual Std. Error	13.331 (df = 36)	13.252 (df = 35)	13.048 (df = 34)
F Statistic		1.430 (df = 1; 35)	1.789 (df = 2; 34)
Note: *p**p***p<0.01.			

As shown in Table 3, the negative constant green bond discount is sufficient with 90% confidence in all three models, confirming Hypothesis I, which states that green bonds have lower yields compared to conventional bonds.

Models 2 and 3 show that the Debut factor cannot be considered statistically sufficient for determining the green bond discount size. It confirms Hypothesis II, which states that the green bond discount is present for both inaugural and subsequent green bond placements.

Model 3 shows that the VOLUME factor (issue size) has insufficient influence on the green bond discount size, which also confirms Hypothesis III.

F-statistic levels in models 2 and 3 indicate that the above-mentioned variables do not affect the green bond discount even cumulatively, which also confirms the sustainability of the green bond discount.

Discussion

The presence of a small green discount in yield indicates that investors are ready to forego only a small portion of return in exchange for the green label. One of potential reasons is that the share of responsible investors in the market is not sufficient to drive the yields sufficiently lower than conventional bonds.

At the moment, the pricing of green bonds is a little tighter than that of conventional bonds. It means that issuing a green bond may lower the cost of funding for green projects, making them even more attractive for energy companies.

Additionally, green bond issuance brings other sufficient benefits for the energy companies:

- It signals investors, denoting the transformation towards a low-carbon business model.
- It demonstrates the efficiency of the current ESG-policy to the shareholders as the company attracts market investments for its ESG-projects.
- It widens the investor base since the company attracts funds from market investors, including those with a specific green mandate, leaving other investors' limits unused.

The results of this research are mostly consistent with O.D. Zerbib [7], Q. Sheng et al. [8], and N. Mikhailova and I. Ivashkovskaya [12], which indicate a 2–8 bps greenium on an extensive sample of placements in Chinese and global primary bond markets. Authors that have based their research on secondary market data [6], [5] have obtained even higher greeniums of 17–20 bps. It can be explained by the fact that green bonds have stronger price dynamics in the secondary market following issuance.

The results would be useful in forming the environmental financing strategy for both European and Russian energy companies, since Russia has a green bond infrastructure (green project taxonomy, green listing sector at the Moscow Stock Exchange) that is fully compatible with the European market. The results are also of interest to investors because they are instrumental in identifying the fair pricing of green bonds at primary placements.

The key obstacle for this paper is the relatively small sample size – 37 green bond issues, which is caused by small size of energy companies' green bond market.

Conclusions

This paper analyses the problem of green bonds' efficiency for the financing of environmental projects by energy sector companies. For this purpose, a two-step approach was applied on the sample of European energy companies' green bonds nominated in EUR (as the largest segment of the green bond market). In the first step, we formed comparable conventional bond yield curves for each green bond issue and calculated the green bond discount. In the second step, we applied regression analysis to test for the significance of the standalone green bond discount and the impact of the debut status and issue size on it.

The main result of this research is that it confirms the efficiency of financing environmental projects by energy sector companies with green bonds in the following three aspects:

1) The research identifies an average green bond discount of 4.7 bps and confirms its statistical significance. Therefore, energy companies may lower the cost of funding by issuing green bonds, making environmental projects more economically attractive.
2) The research confirms that the debut status of the issue does not have a sufficient impact on the green bond discount. In other words, the green bond discount is present for both inaugural and subsequent green bond issues, which makes it reasonable to finance all environmental projects with green bonds.
3) This research confirms that issue size does not have a sufficient impact on the green bond discount, thus, that green bonds are appropriate for financing capital-intensive projects.

Further research in this area may be aimed at exploring the relationship between the green bond discount and the ESG-rating or at the extrapolation of the results of this research to other bond markets (for example, Chinese market or the US market).

References

1. Total energy consumption. Enerdata. URL: https://yearbook.enerdata.net/total-energy/world-consumption-statistics.html (accessed on 23.10.2022).
2. Pachauri R.K., Meyer L., eds. Climate change 2014: Synthesis report. Geneva: Intergovernmental Panel on Climate Change; 2015. 151 p. URL: https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf (accessed on 23.10.2022).
3. Energy related greenhouse gas emissions, 2000-2021. IEA. 2022. URL: https://www.iea.org/data-and-statistics/charts/energy-related-greenhouse-gas-emissions-2000-2021 (accessed on 23.10.2022).
4. Karaeva A.P., Magaril E.R., Kiselev A.V., Cioca L.-I. Screening of factors for assessing the environmental and economic efficiency of investment projects in the energy sector. *International Journal of Environmental Research and Public Health*. 2022;19(18):11716. https://doi.org/10.3390/ijerph191811716
5. Preclaw R., Bakshi A. The cost of being green. Barclays. Sep. 18, 2015. URL: https://www.environmental-finance.com/assets/files/US_Credit_Focus_The_Cost_of_Being_Green.pdf (accessed on 09.08.2020).
6. Gianfrate G., Peri M. The green advantage: Exploring the convenience of issuing green bonds. *Journal of Cleaner Production*. 2019;219:127-135. https://doi.org/10.1016/j.jclepro.2019.02.022
7. Zerbib O.D. The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking & Finance*. 2019;98:39-60. https://doi.org/10.1016/j.jbankfin.2018.10.012
8. Sheng Q., Zheng X., Zhong N. Financing for sustainability: Empirical analysis of green bond premium and issuer heterogeneity. *Natural Hazards*. 2021;107(3):2641-2651. https://doi.org/10.1007/s11069-021-04540-z
9. Green bond highlights 2017. London: Climate Bonds Initiative; 2018. 6 p. URL: https://www.climatebonds.net/files/reports/cbi-green-bonds-highlights-2017.pdf (accessed on 10.11.2019).
10. Karpf A., Mandel A. The changing value of the 'green' label on the US municipal bond market. *Nature Climate Change*. 2018;8(2):161-165. https://doi.org/10.1038/s41558-017-0062-0
11. Emets M.I. Modeling the green bond yield on bond offering. *Finansy i kredit = Finance and Credit*. 2020;26(12):2858-2878. (In Russ.). https://doi.org/10.24891/fc.26.12.2858
12. Mikhaylova A., Ivashkovskaya I. Do investors pay yield premiums on green bonds? *Journal of Corporate Finance Research*. 2020;14(2):7-21. https://doi.org/10.17323/j.jcfr.2073-0438.14.2.2020.7-21
13. Statman M., Glushkov D. The wages of social responsibility. *Financial Analysts Journal*. 2009;65(4):33-46. https://doi.org/10.2469/faj.v65.n4.5
14. Semenova N., Hassel L.G. Industry risk moderates the relation between environmental and financial performance. Sustainable Investment Research Platform Working Papers. 2008;(2). URL: http://web.abo.fi/fak/esf/fei/redovisa/kurser/Lasse/Mistra%20wp/sirp%20wp%2008-02%20Semenova%20and%20Hassel.pdf (accessed on 10.11.2019).
15. Heinkel R., Kraus A., Zechner J. The effect of green investment on corporate behavior. *The Journal of Financial and Quantitative Analysis*. 2001;36(4):431-449. https://doi.org/10.2307/2676219

16. Sharfman M.P., Fernando C.S. Environmental risk management and the cost of capital. *Strategic Management Journal*. 2008;29(6):569-592. https://doi.org/10.1002/smj.678

17. Chava S. Environmental externalities and cost of capital. *Management Science*. 2014;60(9):2223-2247. https://doi.org/10.1287/mnsc.2013.1863

18. Magnanelli B.S., Izzo M.F. Corporate social performance and cost of debt: The relationship. *Social Responsibility Journal*. 2017;13(2):250-265. https://doi.org/10.1108/SRJ-06-2016-0103

19. Menz K.-M. Corporate social responsibility: Is it rewarded by the corporate bond market? A critical note. *Journal of Business Ethics*. 2010;96(1):117-134. https://doi.org/10.1007/s10551-010-0452-y

20. Stellner C., Klein C., Zwergel B. Corporate social responsibility and Eurozone corporate bonds: The moderating role of country sustainability. *Journal of Banking & Finance*. 2015;59:538-549. https://doi.org/10.1016/j.jbankfin.2015.04.032

21. Oikonomou I., Brooks C., Pavelin S. The effects of corporate social performance on the cost of corporate debt and credit ratings. *The Financial Review*. 2014;49(1):49-75. https://doi.org/10.1111/fire.12025

22. Ghouma H., Ben-Nasr H., Yan R. Corporate governance and cost of debt financing: Empirical evidence from Canada. *The Quarterly Review of Economics and Finance*. 2018;67:138-148. https://doi.org/10.1016/j.qref.2017.06.004

23. Cai N., Helwege J., Warga A. Underpricing in the corporate bond market. *The Review of Financial Studies*. 2007;20(6):2021-2046. https://doi.org/10.1093/rfs/hhm048

24. Hotchkiss E., Jostova G. Determinants of corporate bond trading: A comprehensive analysis. *The Quarterly Journal of Finance*. 2017;7(2):1750003. https://doi.org/10.1142/S2010139217500033

25. Richardson S., Palhares D. (Il)liquidity premium in credit markets: A myth? *The Journal of Fixed Income*. 2019;28(3):5-23. https://doi.org/10.3905/jfi.2018.1.065

26. Nelson C.R., Siegel A.F. Parsimonious modeling of yield curves. *The Journal of Business*. 1987;60(4):473-489. https://doi.org/10.1086/296409

27. Market data. Climate Bonds Initiative. URL: https://www.climatebonds.net/market/data (accessed on 23.10.2022).

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