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In Search of Greenium. Analysis of Yields in the European Green Bond Markets

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Abstract

The green bond market shows good potential to help mobilize financial sources towards sustainable investments. Green bonds are similar to conventional bonds but are specifically created to raise money to finance climate or other environmental projects. The relevance of the paper is underpinned by mixed evidence on the existence of ‘greenium in various corporate bond markets and lack of a clear understanding of the green bond yields’ determinants. The objective of the paper is to explore the existence and determinants of greenium in Europe. Our sample included 3,851 green and conventional bonds in the European debt markets over the period from 2007 to 2021. The results showed that the climate corporate bonds in Europe are priced at discount to the same-risk conventional corporate bonds. The magnitude of greenium in whole European green bond market was around 4 bps. However, we did not find the significant greenium in the green bond markets of the UK, France, Netherlands, and Germany. The conclusions of the research could lead to a better understanding of the green bond market for investors, regulators, and potential issuing companies.

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1. Introduction

The environmental agenda has become the most acute and significant topic of the last decade. According to “The Global Risks Report 2022” [15], the top-3 most severe risks on a global scale over the next 10 years are environment related risks like “climate action failure”, “extreme weather” and “biodiversity loss”. The green bond market and so-called green investment naturally complement countries' climate change mitigation strategies. Green bonds are aimed to finance or refinance projects helping to address climate and environmental issues. Governments as well as companies issue them in order to finance the switchover to a more sustainable and low-carbon economy. According to Climate Bond Initiative (CBI) reports [6] green bond market in the period 2015-2020 grew by an average of 50 % per year (globally and at EU level).

However, it is still a marginal market and represented about 3 to 3.5% of overall bond issuance in 2022 [3]. Researchers and practitioners who work and investigate in green bond market have revealed the notion of negative premia to the green bonds' yield or greenium. Greenium leads to a lower yield for the buyer, but allows you to get a reduced interest rate for the issuer of green debt instruments [1, 8, 13, 17]. The greenium is an important incentive for issuers to issue more green-labeled bonds. The papers which explored the nature of greenium summarized the numerous determinants of yield discounts [6, 8, 10]. However, the literature review indicates that some studies showed absence of greenium for green bonds in comparison to conventional ones and claimed that greenium is only a marketing tool to sell these types of debt instruments [9, 12]. Another controversy is that the mixed results were found for corporate bond markets. Some researchers showed unlike green bond issued by government arms or financial institutions, corporate bonds showed absence of greenium [1]. Lastly, the studies investigated greenium globally or in the US or Chinese bond markets while the coverage of the EU green market is insufficient

Thus, the objective of this study is to investigate the existence of greenium and determine its key determinants in European corporate debt capital markets. To achieve this objective, we will solve the following tasks: (1) to identify and study of key factors which determine the yield in European corporate debt market in general and local markets of Great Britain, France, Netherlands, and Germany in the period of 2007-2021; and (2) to investigate the greenium at these markets during above mentioned timespan. The choice of local markets was underpinned by the large volume of corporate green bonds issued at these markets. The paper contributes to the literature in various ways. Firstly, it investigates the presence of greenium and its main determinants in the underexplored European corporate green bond markets in Europe. Secondly, we investigate the presence of greenium in several local European debt markets with the largest volumes of green bonds: Great Britain, France, Netherlands and Germany. Thirdly, our research was conducted with the use of sample comprising more recent periods (2019-2021) while many papers investigated earlier time periods. The results of the study can be used by investors to develop strategies for managing portfolios of green bonds and by issuers of green bonds to choose the placement market.

2. Materials and methods

2.1. Data

We followed the approach of [8] and made a sample comprising of corresponding issues of green and conventional bonds made as of February 2022 from Bloomberg database. Data sampling was carried out based on (1) the year of issue: from 2007 to 2021; (2) geographic location: Europe; (3) industry: only those industries were selected in which there were green bond issues; (4) availability of data on the current yield and credit rating of the issue. We chose this timespan to cover the entire history of green bond issuance. The first green bond was issued in 2007 by the European Investment Bank and since that time the total volume of [3] of green bonds have increased to US\$1.6 trillion.

Macroeconomic data was downloaded from the World Bank Database. The initial sample contains 4035 European both conventional and green bonds from 33 European countries for the period from 2007 to 2021. The share of green bonds in the sample was about 11%. Issues of conventional bonds with a rating not corresponding to green bond ratings were excluded from the sample. In addition, observations with an enormous amount outstanding compared to the rest of the sample, with a negative coupon, as well as outliers in the dependent variable (current yield minus the risk-free ECB rate) were removed. After processing the data and removing all missing data and outliers, the sample size was 3852 bonds with a green bonds' share of about 12%.

2.2. Model

Based on a literature review, a multiple OLS regression model was chosen for analysis. The regression equation looks as follows:

$$\begin{aligned} Yield_i = & \beta_0 + \beta_1 Green_i + \beta_2 Coupon_i + \beta_3 \ln(Amount\ Outstanding)_i + \beta_4 Tenor_i + \beta_5 Industry_i \\ & + \beta_6 Coupon\ type_i + \beta_7 Coupon\ frequency_i + \beta_8 Payment\ rank_i \\ & + \beta_9 \ln(Min\ denomination)_i + \beta_{10} Credit\ rating_i + \beta_{11} ESG\ Rating_i \\ & + \beta_{12} Bid-Ask\ Spread_i + \beta_{13} \ln(Debt-to-EBITDA)_i + \beta_{14} Revenue\ growth_i \\ & + \beta_{15} GDP\ growth_i + \beta_{16} CPI_i + \beta_{17} gr_year + \varepsilon_i \end{aligned} \quad (1)$$

The dependent variable in our analysis (Yield) is the current ask yield of bond issue.

Green – dummy variable equals to 1 if bond issue is defined as Green and 0 otherwise. Variable of main interest in this research.

Coupon is the yearly coupon rate of bond issue measured in percentage points. The influence of this variable on bond risk premium is considered to be positive *ceteris paribus*.

$\ln(\text{Amount Outstanding})$ is the logarithm of outstanding amount of issue measured in US dollars. In practice, larger companies have more opportunities to borrow large amount of money in the market due to their reputation and stable revenue and cash flows. Therefore, the influence of the amount outstanding on the yield is negative.

Tenor is the number of years till maturity of bond issue measured in years. We expect that the more years to maturity the issue has the riskier it is and the higher the yield of this bond.

Industry is a set of dummy variables equals to 1 if the issuer operates in the particular industry (utilities, industrials, financials) and 0 otherwise.

Coupon type is a dummy variable equals to 0 if the issue has fixed type of coupon and 1 otherwise. We assume that nonfixed coupon leads to greater uncertainty and as a result to greater risk, so the yield should be higher for this type of bond issues. Therefore, we expect the positive influence of this variable.

Coupon frequency is a categorical variable which is equal to 1 if coupon is paid annually and 0 otherwise.

$\ln(\text{Min denomination})$ is the logarithm of minimum piece of bond measured in US dollars which is traded in the market and could be bought per one person of legal entity. The logic as in the case of the size of bond issue, the larger the company and the issue, the larger the minimum trading piece the less risky the issue.

Credit rating is the numerical value of the top three rating agencies' (S&P, Moody's, Fitch) ratings of the bond issue. To obtain the resulting variable, the ratings were transferred into numeric equivalent (Appendix A). The final value was calculated as the minimum between S&P, Moody's and Fitch ratings. The greater credit quality of the company reflects in higher rating of the whole company as well as of its bond issues and as a result the less a risk-premium demanded by the market.

ESG Rating is a dummy variable equals to 1 if the bond issue has ESG Rating and 0 otherwise. The existence of ESG rating leads to lower risk-premium, therefore the influence is assumed to be negative [1, 5].

Bid-Ask Spread is a proxy of a liquidity measure which is calculated as the difference between ask and bid price for this issue as of February 2022. A higher liquidity of bond issue reflects high investors' demand, and this leads to decreasing yield. This leads to a conclusion that the higher bid-ask spread means lower liquidity and higher yield, therefore there is a positive dependence between bond yield and bid-ask spread.

$\ln(\text{Debt-to-EBITDA})$ is the logarithm of issuers debt ratio which reflects the amount of company's income available to cover its obligations before covering interest, tax, depreciation and amortization expenses. The low ratio indicates healthy position of the issuer's business. On the contrary, the high ratio shows a high debt load and potentially lack of cash available to fulfill all of company's financial obligations. Therefore, the higher the ratio, the higher risk yield of the bond.

Revenue growth is the measure of percentage increase (decrease) in revenue of the bond issuer over the time.

GDP Growth is the gross domestic product growth rate which corresponds to the country of bond's issue and to the year of its issue, measured in percentage points.

CPI is the consumer price index which also corresponds to the country of bond's issue and to the year of its issue, measured in percentage points.

Gr_year is the categorical variable indicating the number of years elapsed since the first issue of green bonds in 2007 (0 if year of issue equals to 2007, 1 if year of issue equals to 2008, etc.).

3. Results

Table 1 presents the descriptive statistics of the final sample. To achieve more precise results, data were cleaned from outliers. Variables Amount outstanding, Min denomination and Debt to EBITDA ratio were transformed into logarithmic form in order to decrease the scale of data.

Table 1. Descriptive statistics of data.

Variables	N	mean	sd	min	max
Yield	3,852	2.75	1.92	0	25
Debt to EBITDA	3,852	26.38	211.6	0	5,74
Mod Duration	3,852	4.78	4.797	0.0025	68.09
ESG Rating	3,852	0.15	0.36	0	1
Credit rating	3,852	12.97	4.95	4	18
Green	3,852	0.12	0.32	0	1
Coupon	3,852	2.85	1.87	0	12.50
Amount Outstanding	3,852	3.146e+08	3.670e+08	86,66	3.000e+09
Bid-Ask Spread	3,852	0.798	1.55	0	63
Min Denomination	3,852	460,95	2.251e+06	0.041	4.451e+07
Tenor	3,851	11.43	8.74	1.51	100.00
Revenue Growth	3,852	11.65	95.88	-94.28	2,34
Utilities_dummy	3,852	0.32	0.47	0	1
GDP Growth	3,852	0.59	3.55	-10.82	25.18
CPI	3,852	1.31	0.96	-4.48	7.96
Coupon type	3,852	0.86	0.35	0	1
Coupon frequency	3,852	0.62	0.49	0	1
Fin_dummy	3,852	0.37	0.48	0	1
Industrials_dummy	3,852	0.09	0.29	0	1
gr_year	3,852	9.82	3.17	0	13

In order to form the final set of variables the correlation analysis was conducted. Modified Duration would be excluded due to high correlation with Tenor (0.8), which could cause multicollinearity problem in the model (Appendix B). The analysis is divided into two parts: an analysis of the presence of a green premium in the entire sample and in samples of individual countries, such as the UK, France and the Netherlands, since these countries have the largest samples of GB and CB in our dataset. Table 2 presents the results of the final specification of the models. In order to correct for heteroscedasticity robust standard errors were used. All variables included are significant on at least 10% significance level. There is no multicollinearity in models, all variance inflation factors (VIF) are less than 2 (Appendix C).

Table 2. The results of model (1) estimation.

VARIABLES	(1) full Yield	(2) Britain Yield	(3) France Yield	(4) Netherlands Yield	(5) Germany Yield
Green	-0.0386**	0.0842	0.00181	0.0483	-0.0132
ESG Rating	-0.0396*	-0.114	-0.0540	0.0366	0.0443
Coupon	0.975***	1.022***	0.934***	0.928***	1.010***
Ln (Amount Outstanding)	0.0246*	0.0941**	-0.0255*	0.0171	-0.0548
Tenor	-0.0250***	-0.0409***	-0.0171***	-0.0302***	-0.00489
Utilities_dummy	-0.148***	-0.152	-0.0724*	-0.0586	-0.288
Finacial_dummy	-0.126***	-0.0875	-0.0435	0.00309	-0.239
Industrials_dummy	-0.0638	0.0379	0.0434	0.0112	-0.357
Coupon type	-0.119**	-0.438	-0.0985	-0.0118	-1.263
Coupon frequency	-0.000606	-0.0526	-0.0371	-0.168***	0.153
Credit rating	0.00463**	0.00836	-0.000827	0.0130	-0.00188
Ln (Min Denomination)	-0.00199	0.0301**	0.0218	0.00651	0.0121
Bid-Ask Spread	0.0304***	0.107	0.0366***	0.0816	-0.123
Revenue Growth	-0.000120	-0.000928	0.000484	-0.000830	-0.00303
GDP Growth	0.00603**	0.0121	0.00691**	0.00386	0.0150

CPI	-0.0239***	-0.0684**	-0.0454**	-0.00897	-0.120
Constant	-0.0179	-1.294	0.738**	0.0138	2.481
Observations	3,851	541	509	342	255
R-squared	0.893	0.859	0.961	0.965	0.682
Robust pval in parentheses	*** p<0.01, ** p<0.05, * p<0.1				

All five models are with high goodness-of-fit: (1) models are significant by F-test and (2) explanatory variables explain no less than about 60% of the yield variance.

4. Discussion

4.1. Entire European green market

Table 2 demonstrated that the green bond premium dummy variable is significant at the 5% level. Therefore, we can infer that green bonds in entire European bond markets are priced at discount to the same risk as conventional bonds. The magnitude of greenium is around 4 bps (green bonds are priced tighter than conventional bonds). This finding match conclusions of the most studies on the topic which confirm the existence of greenium such as [1, 8, 11, 13]. The magnitude of greenium if closed to those in other papers. For instance, [17] reported a negative premium of 2bps in the world bond secondary market from 2013-2017. Similarly, [16] reported a lower yield (credit spread) of 34 bps than corresponding conventional bonds in the Chinese green bond market. The variable ESG rating dummy is also significant, however at a 10% level. It means that the greenium increases to around 78 bps if the green bond has the ESG rating. This finding coincides with that of [7] that the green bonds with ESG rating commanded a higher negative premium in comparison to unrated green bond issuances. Dummies belonging to the utility industry and financial industry are also significant at 1%. It means that bonds issued by utility or financial corporate can command higher greenium by 149 bps or 125 bps respectively. This result is consistent with [5] that the greenium is more pronounced for corporate issuers in the utility and power sectors. Interestingly, the dummy of companies belonging to the industrial sector turned out to be insignificant in our research. We explain this by the fact that the concept of the industrial sector is too broad and includes many subsectors for which the magnitude of the greenium is very different. An additional more granular analysis of the greenium by industrial subsectors is needed.

As expected, the size of the coupon and related variable of credit rating are significant at 1% and 5% respectively. The larger the coupon size and the lower the credit rating of the bond issue, the greater the yield of the bond. Bond liquidity has a positive effect on the yield; the higher the bid-ask spread (tighter spreads usually indicate a larger volume of trading) the higher the yield. Similarly, other variables which reflect other “conventional” bond characteristics such as tenor or coupon type have the expected signs. Variable coupon leads to greater uncertainty and as a result greater risk, so the yield is higher for this type of bond issue. The more years to maturity the issue has the riskier it is and the higher the yield spread of this bond. All of these confirm the traditional bond evidence [14].

However, the sign at the variable Amount Outstanding (significant at 10% level) is different from our initial expectations. We assumed that the influence of the amount outstanding on bond yield was negative because larger companies had more opportunities to borrow a substantial amount of money in the bond market due to their reputation and stable revenue and cash flows. Hence, investors consider them less risky and demanded lower yields in comparison to smaller issuers [8, 14]. Conversely, in Table 2 the sign at Amount Outstanding is positive. We argue that the variable Amount Outstanding should be considered as one of the proxies of liquidity of the bond. The research of the European Commission [4] on the Determinants of European market liquidity showed a reduction in liquidity in the European corporate bond market over the last few years with a sharp fall in bonds turnover and the rising role of buy-and-hold type investors (investment funds, insurance corporations, etc.). In this setting, larger bond issuances are treated as less risky and thus more attractive for buy-and-hold investors. This leads to lower liquidity and higher yield for issues with large amounts.

Both macroeconomic variables – Consumer Price Index (CPI) and the growth in Gross Domestic Product are significant at 5% and 1% respectively. The sign at the GDP growth variable is positive which contradicts our original expectations. We argue that GDP growth in the European economies increases demand for stocks by reducing demand for bonds (especially in a low-interest rate environment). Moreover, positive sign at GDP growth is supported by the

finding of [2]. They argued that issuers from countries with higher GDP growth benefited from higher bond yields. This thesis is supported by macroeconomic theory as more developed countries with lower yields in the economy due to low risk for investors always demonstrate lower GDP growth and vice versa. Increase in CPI negatively affects bond yields. This is again contrary to our initial expectations. However, the evidence of inverse dependency between CPI and corporate bond yields coincides with the finding of [11]. Moderate inflation encourages companies' capital investments (CAPEX). The growth in CAPEX on the one hand drives consumption and economic growth, but, on the other hand, makes fixed income payments unattractive. The latter decreases bond yields [11].

4.2. Individual European green market

In all individual bond markets, we did not find sustainable evidence of greenium. Moreover, the variables ESG rating dummy were insignificant in all markets. Thus, the existence of ESG rating is not the key determinant of yield there. In all markets, the size of the coupon explained the most of variance in yields. The positive signs at the variables are in line with our expectations. In the UK market, the amount outstanding was significant at a 5% level however the sign was against our expectations. We explained that by low liquidity. Other significant determinants of yield in the UK market were bond tenor and CPI (the sign was against our expectations, see explanations above). In France, we found that bonds issued by utility companies were priced tighter than the other bonds. This served as indirect evidence of the greenium of green bonds issued by companies from the electric power sector. Other significant determinants of yields in this market except for the coupon are (1) amount outstanding; (2) tenor; (3) bid-ask spread; (4) GDP growth; and (5) CPI. Interestingly, the constant is significant at the 5% level. This may be due to regulatory measures of the green bond market in France or some other drivers of supply and demand for bonds. More research is needed on this issue. In Netherlands and German markets all variables related to determinants of green bonds were insignificant. In the Netherlands market except for coupon, there were the following significant drivers of yield: (1) tenor and (2) coupon frequency. Interestingly, in the German market, only the size of the coupon was the significant driver of yield. We explain our findings by the low liquidity of bond markets in two of these sovereigns. It is most likely that many of the institutional investors in these markets follow the buy-and-hold strategy. This thesis is supported by the outcome of the research of the European Commission [4]. More research is needed on this issue as well.

5. Conclusion

This paper aimed to investigate the presence and direction of the risk premium in the European green bond market, as well as to identify the main determinants of the greenium in this market. For this purpose, we conducted the regression analysis on the sample of 3852 both conventional and green bonds from 33 European countries for the period from 2007 to 2020. The period under review covers the entire period of existence of green bonds in Europe since the first issue in 2007. Analysis showed the existence of statistically significant negative green premium of around 4 basic points in the whole European market and the absence of significant greenium in the green bond markets of the UK, France, Netherlands and Germany. The novelty of our research lies primarily in the fact that we analyzed the size of the greenium and its main determinants in the European corporate bond market. An analysis of the literature showed that in most papers, global bond markets, US markets or Chinese markets were chosen as the market under study. Conversely, the markets of state and municipal bonds were mainly studied in Europe, while the markets of green corporate issuers remained on the sidelines. Additionally, we expanded the period of analysis to 2007-2021 while earlier studies considered the period before 2019.

Limitations of our study include (1) the limited number of countries included in the sample; (2) the choice of linear regression as a methodology for estimating the value of greenium; (3) the limited number of green bonds included in the sample. In particular, our sample was limited to corporate bonds only. Given the controversial result for green bond markets in individual European countries more detailed analysis of yield drivers in these markets should be performed. Additional focus should also be placed on regulatory and tax incentives in selected European green bond markets as a such stimulus may be key drivers of greenium there. Furthermore, in-depth studies of individual European bond markets can deploy other methodologies such as matching method analysis or yield curve analysis.

Appendix A. Transformation of Rating Scales

Fitch	Moody's	S&P	Category
AAA	Aaa	AAA	1
AA+	Aa1	AA+	2
AA	Aa2	AA	3
AA-	Aa3	AA-	4
A+	A1	A+	5
A	A2	A	6
A-	A3	A-	7
BBB+	Baa3	BBB+	8
BBB	Baa2	BBB	9
BBB-	Baa1	BBB-	10
BB+	Ba3	BB+	11
BB	Ba2	BB	12
BB-	Ba1	BB-	13
B+	B3	B+	14
B	B2	B	15
B-	B1	B-	16
CCC+	Caa3	CCC+	17
CCC	Caa2	CCC	18
WD	NR	NR	19

Appendix B. Correlation matrix

	ModDurMid	ESG Rating	Green	Coupon	Bid-Ask Spread	Tenor	RevenueGrowth	Energy_dummy	Utilities_dummy	Industrials_dummy	GDPGrowth	CPI	ln_minden	ln_amout	ln_finlev	Coupon type	Coupon frequency	Credit rating
ModDurMid	1,00	0,09	-0,02	-0,03	0,32	0,80	0,00	-0,02	0,13	-0,02	-0,09	0,02	-0,01	0,17	-0,02	0,08	0,10	-0,11
ESG Rating		1,00	-0,02	-0,05	0,00	0,09	0,02	-0,02	0,04	-0,01	-0,01	-0,01	-0,03	0,24	-0,33	0,11	0,07	-0,31
Green			1,00	-0,04	-0,02	-0,03	-0,01	0,01	0,05	-0,01	-0,09	-0,04	0,10	0,03	0,01	-0,12	0,00	0,04
Coupon				1,00	0,10	0,14	0,00	0,14	-0,06	0,01	0,07	0,20	-0,01	-0,05	0,02	-0,04	-0,30	0,08
Bid-Ask Spread					1,00	0,38	0,05	0,12	0,07	0,02	-0,04	0,12	-0,03	-0,01	0,01	-0,03	-0,08	0,01
Tenor						1,00	0,00	0,01	0,24	-0,03	-0,04	0,07	0,00	0,16	-0,02	0,03	-0,07	-0,08
RevenueGrowth							1,00	0,03	0,00	-0,02	-0,04	-0,01	-0,05	0,01	0,02	0,00	-0,01	-0,02
Energy_dummy								1,00	-0,09	-0,04	-0,01	-0,03	-0,01	-0,10	0,00	0,00	-0,08	0,04
Utilities_dummy									1,00	-0,22	-0,05	0,01	0,00	0,15	-0,03	0,04	0,13	-0,08
Industrials_dummy										1,00	-0,01	-0,05	0,01	0,00	-0,02	0,05	0,02	0,00
GDPGrowth											1,00	0,21	-0,01	-0,08	-0,02	0,06	-0,06	-0,03
CPI												1,00	0,02	0,00	-0,01	-0,04	-0,17	-0,01
ln_minden													1,00	-0,01	0,01	0,04	0,01	-0,12
ln_amout														1,00	-0,20	0,17	0,05	-0,49
ln_finlev															1,00	-0,05	-0,04	0,23
Coupon type																1,00	0,16	-0,30
Coupon frequency																	1,00	-0,12
Credit rating																		1,00

Appendix C. Variance inflation factors (VIF)

Full		Britain		France		Netherlands		Germany	
Variable	VIF	Variable	VIF	Variable	VIF	Variable	VIF	Variable	VIF
Fin_dummy	1.84	Fin_dummy	2.21	Utilities_dummy	1.87	Utilities_dummy	1.80	Credit rating	3.26
Utilities_dummy	1.80	Utilities_dummy	2.06	Credit rating	1.68	Coupon	1.72	ESG Rating	2.57
Credit rating	1.65	Tenor	1.81	Fin_dummy	1.68	Coupon frequency	1.70	Fin_dummy	1.70
ln amount	1.49	BidAskSpread	1.57	ln amount	1.51	Fin_dummy	1.63	ln amount	1.64
gr_year	1.32	ln_amount	1.49	ESG Rating	1.50	Tenor	1.61	Utilities_dummy	1.60
Tenor	1.32	industrials_dummy	1.45	gr_year	1.45	BidAskSpread	1.47	GDPGrowth	1.57

industrials_dummy	1.32	gr_year	1.37	Revenue growth	1.44	gr_year	1.38	gr_year	1.57
BidAskSpread	1.21	CPI	1.26	Coupon	1.37	ln_amount	1.25	Tenor	1.51
GDPGrowth	1.19	Credit rating	1.26	industrials_dummy	1.32	Credit rating	1.25	BidAskSpread	1.48
Coupon frequency	1.18	Coupon frequency	1.22	Tenor	1.30	Green Dummy	1.15	Coupon	1.30
Coupon	1.17	GDPGrowth	1.21	BidAskSpread	1.25	industrials_dummy	1.14	ln_minden	1.30
Coupon type	1.15	ESG Rating	1.20	Coupon frequency	1.25	GDPGrowth	1.13	Coupon type	1.29
CPI	1.14	Coupon	1.20	GDPGrowth	1.22	CPI	1.13	industrials_dummy	1.29
ESG Rating	1.14	ln_minden	1.17	Coupon type	1.21	Revenue growth	1.12	CPI	1.26
Green Dummy	1.08	Revenue growth	1.08	ln_minden	1.17	ESG Rating	1.11	Coupon frequency	1.21
ln_minden	1.05	Coupon type	1.07	CPI	1.13	Coupon type	1.10	Revenue growth	1.16
Revenue growth	1.01	Green Dummy	1.06	Green Dummy	1.08	ln_minden	1.08	Green Dummy	1.16
Mean VIF	1.30		1.39		1.38		1.34		1.58

References

- [1] Bachelet, Maria Jua, Leonardo Becchetti, and Stefano Manfredonia. (2019) “The green bonds premium puzzle: The role of issuer characteristics and third-party verification.” *Sustainability* **11.4**: 1098.
- [2] Cavallo, Eduardo A., and Patricio Valenzuela. (2010) “The determinants of corporate risk in emerging markets: an option-adjusted spread analysis.” *International Journal of Finance & Economics* **15.1**: 59-74.
- [3] CBI report: Sustainable Debt Global State of the Market. (2022) (https://www.climatebonds.net/files/reports/cbi_global_sotm_2021_02h_0.pdf)
- [4] European Commission (EC). (2017b) “Drivers of corporate bond market liquidity in the European Union”, doi:10.2874/499825; ISBN 978-92-79-59845-6 European green bonds Report)
- [5] Gianfrate, G., Peri, M. (2019) “The green advantage: Exploring the convenience of issuing green bonds.” *Journal of Cleaner Production*, **219**: 127–135
- [6] Hyun, S., Park, D., Tian, S. (2021) “Pricing of green labeling: a comparison of labeled and unlabeled green bonds.” *Finance Research Letters* **41**:101816
- [7] Immel, M., Hachenberg, B., Kiesel, F., & Schiereck, D. (2021) ”Green bonds: shades of green and brown.” *Journal of Asset Management* **22(2)**: 96-109.
- [8] Ivashkovskaya, Irina, and Anna Mikhaylova. (2020) “Do Investors Pay Yield Premiums on Green Bonds?” *Journal of Corporate Finance Research* **14.2**: 7-21.
- [9] Larcker, David F., and Edward M. Watts. (2020) “Where's the greenium?” *Journal of Accounting and Economics* **69.2-3**: 101312.
- [10] MacAskill, S., Roca, E., Liu, B., Stewart, R.A., Sahin, O., (2021) “Is there a green premium in the green bond market? Systematic literature review revealing premium determinants.” *Journal of Cleaner Production*, **280.2**: 124491
- [11] Nanayakkara, Madurika, and Sisira Colombage. (2019) “Do investors in green bond market pay a premium? Global evidence.” *Applied Economics* **51.40**: 4425-4437.
- [12] Partridge, Candace, and Francesca Romana Medda. (2020) “The evolution of pricing performance of green municipal bonds.” *Journal of Sustainable Finance & Investment* **10.1**: 44-64.
- [13] Preclaw, Ryan, and Anthony Bakshi. (2015) “The cost of being green. Report, Barclays Credit Research.”
- [14] Sheng, Qiaoyan, Xuan Zheng, and Nian Zhong. (2021) “Financing for sustainability: Empirical analysis of green bond premium and issuer heterogeneity.” *Natural Hazards* **107.3**: 2641-2651.
- [15] The Global Risks Report 2022 (https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2022.pdf)
- [16] Wang, Q., Zhou, Y., Luo, L., Ji, J. (2019) “Research on the factors affecting the risk premium of China’s green bond issuance.” *Sustainability* **11.22**: 6394.
- [17] Zerbib, Olivier David. (2019) “The effect of pro-environmental preferences on bond prices: Evidence from green bonds.” *Journal of Banking & Finance* **98**: 39-60.