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The Green Bond Premium: A Comparative Analysis[1]

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Abstract

The paper aims to analyze the presence of a premium on Green Bonds (GBs greenium), financial instruments issued with the specific purpose of contributing to the ecological transition, to facilitate the transformation of our economic system into a low carbon economy, resilient to climate change and resource efficient. The study, starting from the indications provided by Zerbib (2019), was carried out in four steps: the first, to determine the actual existence of a differential between the GB yields compared to a sample of traditional bonds; the second step, based on a panel analysis, to demonstrate that the differential is not due to typical market factors, but rather to the nature of GBs; the third step, characterized by a cross-section analysis, that has the objective to verify whether the characterizing components of the GBs, identified in the qualitative variables of currency, issued quantity, rating and type of issuer, are determinants of the "greenium" factor. Lastly, the evolution of the "greenium constant" over time is calculated to draw some final conclusions. The analysis period is from 2017 to 2022 for a total of 248 weekly observations.

The analysis shows that greenium does not seem to be present for all categories of issuers. One of the possible reasons may be linked to the different degree of transparency observed by the different issuers. Finally, considering the time frame of the analysis (2017-2021) we can assert that the premium for GBs has undergone an evolution, over time, due to some triggering factors. The first is certainly the growth of interest in green finance. Secondly, the pandemic (as seen also by estimates made over time and by the presence of a structural break) played its role as protagonist, bringing with it an increase in the value of the differential for both government and corporate bonds, precisely in the period due to the first lockdown, characterized by a strong instability of the markets. Estimates have also shown that, for government bonds, the increase in greenium was not driven by liquidity shocks, unlike corporate bonds. This result reflects the importance that investors attach to the disclosure of information that is provided at the time of issue and during the life of the bond.

JEL Codes: G15; H23; Q56.
Keywords: Green Bonds; Greenium; Yields; Sustainable Transition.

1 Although the paper is the result of a common effort, M. De Leonardis wrote Sections 5–6, G. Ferri wrote Sections 1 and 8, M. Intonti wrote Sections 2–3-8, L. Serlenga wrote Sections 4-7.

1. Introduction

The paper aims to analyze the presence of a premium on Green Bonds (GBs), or greenium, as a negative differential of yield (where GBs are generally characterized by a lower return than their corresponding plain vanilla bonds), or as a positive differential of price compared to traditional bonds (where GBs are characterized by a price higher than similar traditional bonds) (Barclays, 2015; Bloomberg, 2017.

The paper focuses on the following issues:

1. the determinants of greenium;
2. the influence of variables such as issued amount, rating, currency, issuer type;
3. the growing trend of greenium as investor confidence in the quality of GBs grows (assessable through issuance information and issuer status) and the extent of the same growth in both government bonds and private issuers.

Based on the literature on the subject, we identify and verify three significant research hypotheses:

HP1: Ceteris paribus, the greenium exists, in its formulation of yield differential, where traditional bonds pay higher returns because the systematic risk is assessed differently by investors and for the positive environmental impact of GBs.

HP2: The increase in GB emissions results in a reduction in the greenium linked to the increased risk of greenwashing.

HP3: The gap between the greenium of the government GBs and that of the GBs of other issuers during pandemic.

2. Green bond standards and disclosure

GB are financial instruments issued with the specific purpose of contributing to the ecological transition, to facilitate the transformation of our economic system into a low carbon economy, resilient to climate change and resource efficient (European Central Bank, 2019). Through their issuance there is a typical "win-win" situation in which both the issuer and the investor contribute, with mutual advantage, to the pursuit of a sustainable future (Eurosif, 2018). Therefore, GB are sustainable finance instruments, useful for achieving the Sustainable Development Goals (SDGs) of the UN 2030 Agenda, in particular those of an environmental nature, and aimed at pursuing the actions identified in the EU's Action Plan on Sustainable Finance, where a European GB emission standard has recently been implemented.

The provision of adequate and transparent information tools is a key element in increasing investor confidence, reducing the risk of greenwashing and making the GB market efficient, to the benefit of the environmental objectives that these emissions are intended to pursue.

For this purpose, on January 2020 the European Commission issued the "EU Green Bond Standard" (GBS), a standardized GB model to which issuers can voluntarily join with the objective of qualitatively standardizing the information provided by issuers to investors and contributing to the market achieving a higher level of effectiveness, transparency and reliability. Although no obligation exists in the drafting of the information to the public, except for the government GB, most issuers comply with the GBS Framework (GBF), which is required to attach the document proving the outcome of the external review. According to the Usability Guide of the EU Technical Expert Group in Sustainable Finance (European Commission, Technical expert group on sustainable finance (TEG), 2019), to be fully prepared, the GBF must follow the following template:

- Section 1 Strategy and rational: this section outlines the sustainable development objectives pursued by issuing GBs, summarized in summary with the 17 Sustainable Development Goals (SDG);
- Section 2 Process for selection of Green Projects: inside it is required to indicate the necessary procedures for each project to comply with Taxonomy (for example, the forecasting of committees, the use of Technical Screening Criteria (TSC) and the identification of criteria for exclusion of projects);

- Section 3 Green Projects: this part of the GBF is dedicated to the description of the projects or project categories against which the financial resources will be channeled;
- Section 4 Management of Use-of-Proceeds: the information contained therein concerns the specification of the amount of funds raised and the modalities chosen for their administration;
- Section 5 Reporting: at the final stage, the issuer indicates the frequency and way the reports are published, making public the results of the investments.

The last two sections can be further explored in the Allocation Report and the Impact Report, documents that are not mandatory by the European Commission, but with high information content, both qualitative and quantitative. The first aims to inform the market in a clear, direct and precise way about the areas of investment and the individual projects in which the issuer intends to use the financial resources collected; the second, on the other hand, highlights the estimates, and sometimes also the Key Performance Indicators (KPI), which will be used later to verify the conformity of the results with the forecast ex ante.

The above-mentioned European GB model follows the international standard called Green Bond Principles of the International Capital Market Association, which contains non-binding procedural guidelines that define and specify the appropriate approach to issuing a GB, provide issuers with guidance on the key components for issuing a relevant GB; assist investors by promoting and providing access to the information needed to assess the positive impact of their investments in GB; and help the underwriters of securities by directing the market in disclosing useful information to facilitate multiple transactions (ICMA, 2018).

The key components are:

1. Use of Proceeds
2. Process for Project Evaluation and Selection
3. Management of Proceeds
4. Reporting Activity ("Reporting"), with External Review.

As we will see, the disclosure of the GBs represents a key element in triggering a process of increasing investor's confidence, which leads to the underwriting of bonds in the awareness that the risk of greenwashing can be minimized through adequate transparency and accountability tools.

3. Literature review

The international literature on the topic of GB focuses, in a first phase before 2015, on the topic of the growth of the market of sustainable bonds (Wood and Grace, 2011; Bovelette, 2015; Elliott and Zhuang, 2014). Below, instead, it highlights an increase in the number of statistical and econometric papers, aimed at analyzing and possibly confirming the existence of a differential in yield and price between GBs and traditional bonds.

Particularly significant, on the topic of greenium, appears the contribution of Zerbib (2019), in which the author uses three methods to analyze the data: the matching method (to link the yields and prices of green and brown bonds to each other), a panel regression analysis (to determine the GB premium) and a cross-section analysis (to understand which bond characteristic is most decisive in creating a premium on yield or price). The objective of the analysis is to try to explain the "greenium", using an econometric model able of highlighting the difference in price and yield that characterizes two bonds, one green and one brown, in the awareness that the phenomenon can be calculated both as a negative yield differential and as a positive differential with respect to the price.

This study is part of a broader picture of work on the subject which seems to lead to different results. The deviations between the results could be caused by the used methods, by the year of publication and, closely related to the previous one, by the evolution of the GB market mentioned above.

Among the studies on the theme, the CBI (2016) uses a matching method on the bonds traded on the primary market, not showing any type of negative premium on the yield. Instead, the study of Barclays (2015), through an OLS regression on the bonds traded on the secondary market finds a greenium of -17 bps, much greater than the result found two years later by Zerbib (2019). In the same period, the study of Ehlers (2017), through an initial matching method and subsequent analysis of the yield curve of the green and brown bond pairs, reaches a result of approximately -18 bps both in the primary market and in the secondary. Interesting are even the studies of Baker (2018) that uses a large sample composed of 2083 GBs in a period between 2010 and 2016 and, through a regression on bond yields, comes to a result of -5,7 bps in the primary market, and to a similar result also in the secondary. Lastly, Fatica, Panzica and Rancan (2019) study, characterized by a dataset containing 1397 GBs, with the same method used by Baker in the previous year, but achieving non-homogeneous results. For this reason, the authors state that "greenium" does not appear to be present for all categories of issuers. One possible reason is that while non-financial corporations can report the greenness of projects for which the proceeds of the bond are more transparently, this may be harder for financial institutions. Since investors have shown interest in buying and investing in green products, asymmetric information on the sustainability of the underlying projects is crucial to influence their market prices. In this line, Bour (2019), reproduced the same Zerbib's model using, as a dependent variable, the number of documents in support of the project that the companies would have completed through the GB emission. The results are statistically significant and particularly interesting from a financial point of view. In fact, companies and governments that attached a coherent and complete documentation regarding the destination of the funds raised, showed a higher value of the greenium.

4. Methodology and dataset construction

The study, starting from the indications provided by Zerbib (2019), was carried out in four steps: the first, necessary to determine the actual existence of a differential between the GB yields compared to a sample of traditional bonds. The second step, based on a panel analysis, is intended to demonstrate that the differential is not due to typical market factors, but rather to the nature of GBs. To do this, the liquidity factor was used as an independent variable of the model (Abudy, 2016). A third step, characterized by a cross-section analysis, that has the objective to verify whether the characterizing components of the GBs, identified in the qualitative variables of: 1) the currency, 2) issued quantity, 3) rating and 4) type of issuer, are determinants for the "greenium" factor. Lastly, the evolution of the "greenium constant" over time is calculated to draw some final conclusions.

The data needed to perform the econometric analysis were collected from the database provided by Thomson Reuter Eikon: Refinitiv Workspace and selected by the "Green Bond Guide", an area containing over 70,000 GBs issued by both government and corporations. The GBs used in the sample are approved by the CBI.

The composition of the dataset was made through four main phases:

1) All GBs having the following characteristics have been identified:
    i) issue amount over US $100 million;
    ii) higher rating than BBB- issued by Fitch.
2) Traditional bonds were selected that owned:
    i) Same GB issuer;
    ii) Same maturity (with a gap of up to two years of difference between the GB and the traditional);
    iii) Same rating;
    iv) Similar amount emitted (certainly more than 100mln);
    v) Same currency.
3) The final dataset, composed of 32 GBs and 2 traditional bonds for each sustainable bond, is divided as follows, based on the Refinitiv Eikon database, maintaining the same proportions of the GB universe issued in 2021 and censored by the database: 13 government bonds, 14 corporate bonds and 5 bond agencies. The sample consists of 96 bonds: 32 green and 64 brown. The analysis period is from 28 April 2017 to 21 January 2022 for a total of 248 weekly observations.
4) Finally, a dataset panel has been created, containing:

- Changes in yields over time;
- Changes in liquidity over time;
- The rating;

• The quantity emitted;
• The type of issuer;
• The currency.

5. Green bond premium analysis

The premium of green bonds (the greenium) is defined as "a negative difference between sustainable bond yields and traditional bond yields based on the difference in residual liquidity" (Zerbib, 2019). Based on this definition, the differential was calculated using the following model.

$$(1)\ \Delta\tilde{y}_{i,t} = pi + \beta\Delta Liquidity i,t + \epsilon i,t$$

Where:
$\Delta\tilde{y}i,t$ is the yield differential over time between the ask yields of sustainable bonds and the conventional bond yield calculated by interpolation;
pi: it is the greenium;
$\Delta Liquidity i,t$: is the change in liquidity calculated as the difference between the liquidity of the GB and the liquidity of the conventional bond, using the Bid-Ask spread as a proxy.
ϵi,t: is the error term.

$\Delta\tilde{y}i,t$ is the difference between the yield of the sustainable bond and the yield of the conventional bond created by the interpolation of the two traditional bonds. The interpolation, in this case, occurred by calculating the average between the yields of the conventional bonds used, chosen from GBs with similar maturities. To this purpose, if conventional bonds with different maturities of GBs had been chosen, it would have been necessary to create a model that would linearly regress the two conventional bonds with the maturity of the GBs, so as to interpret the value of the yield at the maturity of the two conventional bonds, with the yield curve of the GBs.
The difference between the yields of the securities pairs is calculated as follows:

$$(2)\ \Delta\tilde{y}_{i,t} = y_{i,t}^{GB} - y_{i,t}^{CB}$$

Where:
• yi,t^{GB} is the yield of the GB title "i" at time t;
• yi,t^{CB} is the yield of the traditional title (conventional, constructed by interpolation) "i" at time t.
Below are the descriptive statistics and the graph.

Table 1: Descriptive Statistics $\Delta\tilde{y}_{i,t}$

Average	Median	Minimum	Maximum
-0.102	-0.052	-3.22	1.99

Results obtained from the formulation $\Delta\tilde{y}_{i,t} = y_{i,t}GB - y_{i,t}CB$

Source: authors' elaboration

Figure 1 - The distribution of returns over time

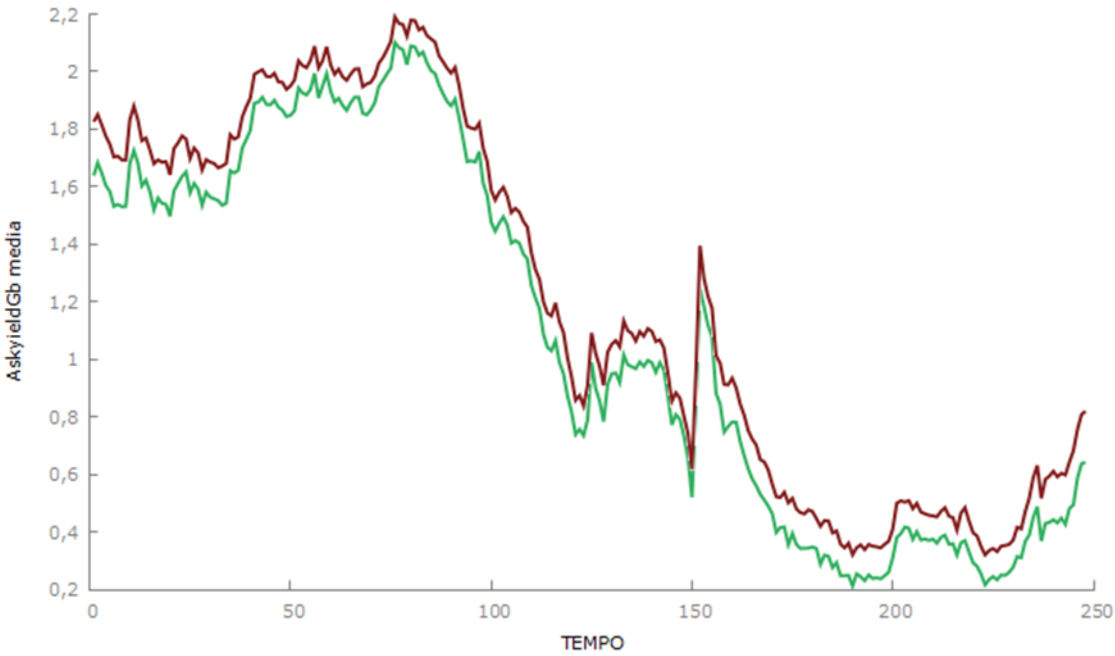

Figure (1): The graph shows the average values, over time, of the yields of sustainable bonds (in green) and conventional bonds calculated by interpolation (in red), divided by type of issuer.

Source: authors' elaboration

Although the above graph clearly shows a difference between the distribution of GB yields (in green) and traditional bond yields (in red), as a negative spread for GBs, it is not possible to define the yield differential result (on average equal to -10bps) as "greenium". The reason is due to the lack of sufficient data to demonstrate that this spread stems from the nature of GBs and not from factors linked to market developments.

It was therefore necessary to verify whether the spread of liquidity between these two types of bonds was impactful in determining the differential, using a second model of analysis. An interesting first point to note about the liquidity of the sampled bonds is the difference in issuance between the two types of bonds. Table 2 shows the average of emissions from different types of issuers. It is easy to see that the emissions of conventional bonds 1 and 2 are higher than those of GB. This could be a trigger for greenium. Although the matching procedure captures part of the liquidity effects through matching based on maturities and emission amounts, it does not capture its entirety. A first step in determining the GB premium is therefore to control the remaining liquidity.

For the calculation of residual liquidity, a methodology widely recognized by the literature was applied: the Bid-Ask Spread (Beber et al., 2009; Dick-Nielsen et al., 2012; Chen et al., 2007).

In order to be more homogeneous in variables, the difference between bid and ask yield was used instead of bid and ask price (Zerbib, 2019). This choice was made on the basis of previous studies on the calculation of the high or low frequency liquidity value approximation. The detected data are in an intermediate position between low frequency and high frequency measurements (characterized more precisely by intraday measurements) (Fong et al., 2017).

Table 2: The average of emissions

Media Emissioni (Mln)	**Green Bond**	**Bond Conv.1**	**Bond Conv.2**

Corporate	677	707	689
Government	842	1644	1070
Agency	894	864	1004

Notes: The table shows the average values of the issues of sustainable and conventional bonds, broken down by type of issuer. Data is taken from Refinitiv Workspace

Source: authors' elaboration

Liquidity is therefore calculated as follows:

$$(3)\ \Delta Liquidity i,t = Liquidity i,t^{GB} - Liquidity i,t^{CB}$$

Dove:

- $Liquidity i,t^{GB}$ is the measure of liquidity referred to a GB;
- $Liquidity i,t^{CB}$ is the measure of liquidity referred to a conventional bond.

The liquidity of the conventional bond is calculated as follows:

$$(4)\ Liquidity_{i,t}^{CB} = \frac{d_2}{d_1+d_2} Liquidity_{i,t}^{CB1} + \frac{d_2}{d_1+d_2} Liquidity_{i,t}^{CB2}$$

Where:
d1 = |Green Bond maturity - CB1 maturity|;
d2 = |Green Bond maturity - CB2 maturity|.

Where:

$$(5)\ Liquidity_{i,t} = \frac{Ask\ Yield_{i,t} - Bid\ Yield_{i,t}}{(Ask\ Yield_{i,t} + Bid\ Yield_{i,t})/2}$$

$$(6)\ Liquidity_{i,t}^{\widehat{CB}} = \frac{d_1}{d_1+d_2} \frac{Ask\ Yield^{CB1}{}_{i,t} - Bid\ Yield^{CB1}{}_{i,t}}{(Ask\ Yield^{CB1}{}_{i,t} + Bid\ Yield^{CB1}{}_{i,t})/2} + \frac{d_2}{d_1+d_2} \frac{Ask\ Yield^{CB2}{}_{i,t} - Bid\ Yield^{CB2}{}_{i,t}}{(Ask\ Yield^{CB2}{}_{i,t} + Bid\ Yield^{CB2}{}_{i,t})/2}$$

By definition, a premium for sustainable bonds is present if the regression result shows a negative and statistically significant constant (Zerbib, 2019).

Table 3: Determination of the greenium

	$\Delta \hat{y} i,$
Constant	-0.131^{***}
Δ***Liquidity***$_{i,t}$	0.160 (0.188)

OBS	7936
R^2	0.705

Note: results of panel analysis fixed effect:

$\Delta \tilde{y}i,t = pi + \beta\Delta Liquidityi,t + \epsilon i,t$

∗p<0.1; ∗∗p<0.05; ∗∗∗p<0.01

Source: author's elaboration

The results obtained by the regression "panel with fixed effects" clearly show the presence of a statistically significant greenium, of the value of -13bps, found in the constant of the model. The slope, identified in the residual liquidity variable, appears to be close to 0 and not statistically significant. The above data shows, at the same time, a correct choice of bonds and an effective matching procedure for the sampled bonds. In fact, data highlights that liquidity is not, in this case, the determinant of the yield differential itself, and therefore of the greenium.

Below, our study focused on the construction of a model that would allow to understand, among some qualitative variables considered relevant in literature, which is more impactful on the determination of the differential just calculated. Following Zerbib's (2019) definition, greenium is the sum of time-invariant constants for each single triplet of regression.

The distribution of constants was necessary to develop the model described above.

Table 4 shows the descriptive statistics for this distribution.

Table 4: Descriptive statistics Greenium (pi)^^	
Average	-0.138
Median	-0.200
Minimun	-1.99
Maximum	0.837

Note: this table summarizes the greenium values of each individual bond. Premium calculated as fixed-effect panel regression of the model $\Delta \tilde{y}_{i,t} = pi + \beta\Delta Liquidityi,t + \epsilon i,t$

Source: author's elaboration

The analyzed model is then configured as follows:

$$(7)\ \widehat{p_i} = a + \gamma_1 IssueAmount_1 + \gamma_2 Rating_i + \gamma_2 Currency_i + \gamma_2 IssueType_i + \epsilon i$$

Where $\hat{p}_i$ is the distribution of the constant that comes from the regression panel fixed effect described in the initial model; $\gamma_1 IssueAmount_1, \gamma_2 Rating_i, \gamma_2 Currency_i, \gamma_2 IssueType_i$ are all the dummy variables vectors and ϵi is the error term.

The analysis was carried out in two parts, one related to the characteristics of the GB and one augmented. In the first, the augmented one, all the dummy variables in the model are analyzed (excluding one per group to avoid problems related to the perfect collinearity).

In the second part of this analysis 10 tests were carried out using, as independent variables, groups of always different dummies, that represent qualitative variables related to bonds. Breuch-Pagan test has been run for non-heteroschedasticity on all tests reported.

In order to estimate which characteristics of sustainable bonds are most impactful on the composition of the differential, some of the most important characteristics for a bond have been selected and, once transformed into dummy variables, have been inserted as independent cross-section variables with the time-invariant constant pi as a dependent variable. The characteristics are summarized in Table 5.

Table 5: The determinants of greenium

Variable	Unit	Description
Amount Issued	0-1	- Divided into three families:Under 500(mln) - From 500 to 1000 (mln) - Over 1000(mln)
Rating	0-1	Divided into three families: - Under BBB+ - From A- to AA- e - Over AA
Currency	0-1	- EUR - USD
Type Of Issuer	0-1	- Divided into three families Corporate - Government - Agency

Source: authors' elaborations on Refinitiv data

Table 6: OLS regression results, Greenium determinants

		Dependent Variable: p_i^{FE}										
		Augmented	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*
		OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	Const	−0.660** (0.291)	−0.179 (0.134450)	−0.038	−0.747*** (0.259)	−0.114*** (0.162933)	−0.283 (0.206)	0.937* (0.475)	0.007 (0.200)	0.271 (0.205)	−0.981*** (0.291)	−0.484* (0.242)
Amount issued	Under 500 (mln)						0.0595 (0.187)			−0.322 (0.221)		
	From 500 to 1000 (mln)	−0.055 (0.216)	−0.068 (0.219)						−0.048 (0.205)	−0.409* (0.238)	−0.048 (0.205)	
	Over 1000 (mln)	0.279 (0.314)	0.242 (0.227)						0.303 (0.242)		0.303 (0.242)	
Rating	Under BBB+			−0.132 (0.258)		0.515 * (0.301)					0.327 (0.310)	
	From A- to AA-	−0.174 (0.306)						0.112 (0.289)	−0.192 (0.267)		0.135 (0.344)	−0.102 (0.248)
	From AA to AAA	−0.344 (0.342)		−0.143 (0.224)	**-0.582**** **(0.259)**	0.459 (0.315)	−0.678*** (0.287)	0.070 (0.914)	−0.327 (0.310)			−0.471 (0.296)
Currency	USD							−0.0454740 (0.593594)				
	EUR	0.030 (0.239)				0.167 (0.186)	0.190 (0.199)					
Type of Issuer	Corporate	**0.643*** **(0.331)**				−0.514 (0.311)		-0.063 (1.0075)		−0.069 (0.185)	**0.661**** **(0.303)**	**0.501*** **(0.280)**
	Government	**0.928***** **(0.322)**			**0.676**** **(0.263)**		**0.792***** **(0.298)**		0.253 (0.3174)		**0.914***** **(0.296)**	**0.926***** **(0.297)**
	Agency					**−1.00***** (0.310)		1.537* (0.854)	−0.661** (0.303)	**−0.734***** (0.256)		
Obs		32	32	32	32	32	32	32	32	32	32	32
R^2		0.336	0.336	0.015	0.215	0.299	0.216	0.297	0.335	0.301	0.335	0.277
F statistic		1.735	1.735	0.224	2.562	2.220	1.864	0.123	1.722	2.241	2.105	2.592

$*p<0.1$; $**p<0.05$; $***p<0.01$

Notes: The table above shows the results of all the tests carried out. Each test is attributable to an OLS regression with dependent variable the distribution of the time-invariant constantpi = a + $\gamma 1 IssueAmount_1 + \gamma 2 Rating_i + \gamma 2 Currency_i + \gamma 2 IssueType_i + \epsilon_i$*. From column (a) to column (k) there are the results of the tests on the variation of the "greenium" upon the occurrence of some qualitative variables, in column (l), however, the results of the structural analysis are reported.*

Source: authors' elaboration

6. The greenium over time pre- and post-pandemic

In order to provide a complete overview of the greenium phenomenon, the differential is identified over time, to verify its evolution and draw some conclusions.
The objective of the estimates in the following section is to understand if greenium has changed significantly in the preceding and subsequent periods of pandemic, due to the shock of rates resulting from the sudden increase in economic instability (Fatica & Panzica, 2021). In addition, the type of issuer (corporate and government) has been considered in the model setting, composing models, as follows:

$$\Delta\tilde{y}_{c,t} = p_c + \beta\Delta Liquidity_{c,t} + \beta_2 PostPandemic_{c,t,} + \epsilon_{c,t}$$

Where:

$\Delta\tilde{y}_{c,t:}$ it is the yield differential between the ask yields of sustainable bonds and the conventional bond yield calculated by interpolation of corporate bonds;

p_t: is a greenium;

$\Delta Liquidity_{c,t}$ is the change in liquidity calculated as the difference between the liquidity of GB and the liquidity of conventional corporate bonds, using the Bid-Ask spread as a proxy.

$\beta_{2Pre/PostPandemic,t}$, is a dummy variable valued at 1 if the sample is estimated in post-pandemic times and 0 in the antecedents;

ϵc,t,: is the error term.

E $\Delta\tilde{y}_{g,t} = p_g + \beta\Delta Liquidity_{g,t} + \beta_2 PostPandemic_{g,t,} + \epsilon_{g,t}$ (for government bonds)

The results of six regressions are collected in the table 7. The first two concern the calculation of the pre- and post-pandemic greenium without distinction by type of issuer, the next four concern the calculation of the pre- and post-pandemic differential of corporate and government bonds.

Table 7: Determination of the greenium pre and post Covid - 19

	Issuer Type	*Pre Pandemic*	*Post Pandemic*
Greenium	*General*	-0.1697***	-0.1196***
		(0.007)	(0.006)
	Corporate	-0.1140***	0.0066
		(0.0067)	(0.0071)
	Government	-0.1782***	-0.1803***
		(0.035)	(0.033)
Liquidity	*Corporate*	0.2480***	0.2480***

		(0.023)	(0.022)
	Government	0.161**	0.161**
		(0.074)	(0.074)
Pre/Post Pandemic Dummy Variable	*Corporate*	0.120***	-0.121***
		(0.007)	(0.007)
	Government	-0.002	0.0016
		(0.009)	(0.009)

*p<.05, **p<.01, ***p<.001.

Source: authors' elaborations

The estimates see a greater amount of the differential for government bonds both in the period before the pandemic and in the following period (-0.1782 and -0.1803 respectively) as well as a lower liquidity impact (0.161). The coefficient of the dummy variable implies that for government bonds, greenium has been found to behave fairly stable. The results see values close to 0 and not significant for government bonds unlike corporate bonds that are higher and related to the performance of the differential itself.

It was therefore necessary to show graphically the performance of the premium and liquidity of government and corporate bonds throughout the sample. To calculate the value of the differential in every single moment of time, therefore, 248 linear regressions have been estimated, one for every moment, in this case the weeks between 28 April 2017 and 22 January 2022 and from the results we drew the values of the constant for each estimate.

The estimated model is the following:

$\Delta\tilde{y}_t = p_t + \beta\Delta Liquidity_t + \epsilon_t$

where:

$\Delta\tilde{y}_t$: is the yield differential for every single moment of time between the ask yields of sustainable bonds and the conventional bond yield calculated by interpolation

p_t: Greenium

$\Delta Liquidity_t$: is the change in liquidity calculated as the difference between the liquidity of the GB and the liquidity of the conventional bond, using as approximation the Bid-Ask spread.

ϵt: is the error term

The above graph shows in green the evolution of the greenium over time and in red the independent variable of the liquidity calculated using the approximation of the Bid - Ask Spread.

The division of the phenomenon into two main moments is clear. The first of constant decrease in the period between 2017 and the beginning of 2019, the second, after a maintenance phase, of sudden growth during the first months of 2020, the same characterized by the rotation of the pandemic and the first lockdown. The opposite effect, on the other hand, for the liquidity that sees a sudden growth in that very time. In fact, most government and non-government bonds suffered a serious deterioration in liquidity during the most acute phase of the Covid-19 crisis, peaking around the third week of March 2020.

Before estimating the evolution of the differential for the two different types of issuer, it is necessary to provide an overview of the phenomenon through two regressions carried out on the bonds belonging to the two types of issuer. The results, shown in the table below, see a much more important greenium for government bonds (-0.199), a result consistent with the previous OLS regression

Fig 2. – Greenium and liquidity over time

Source: authors' elaborations

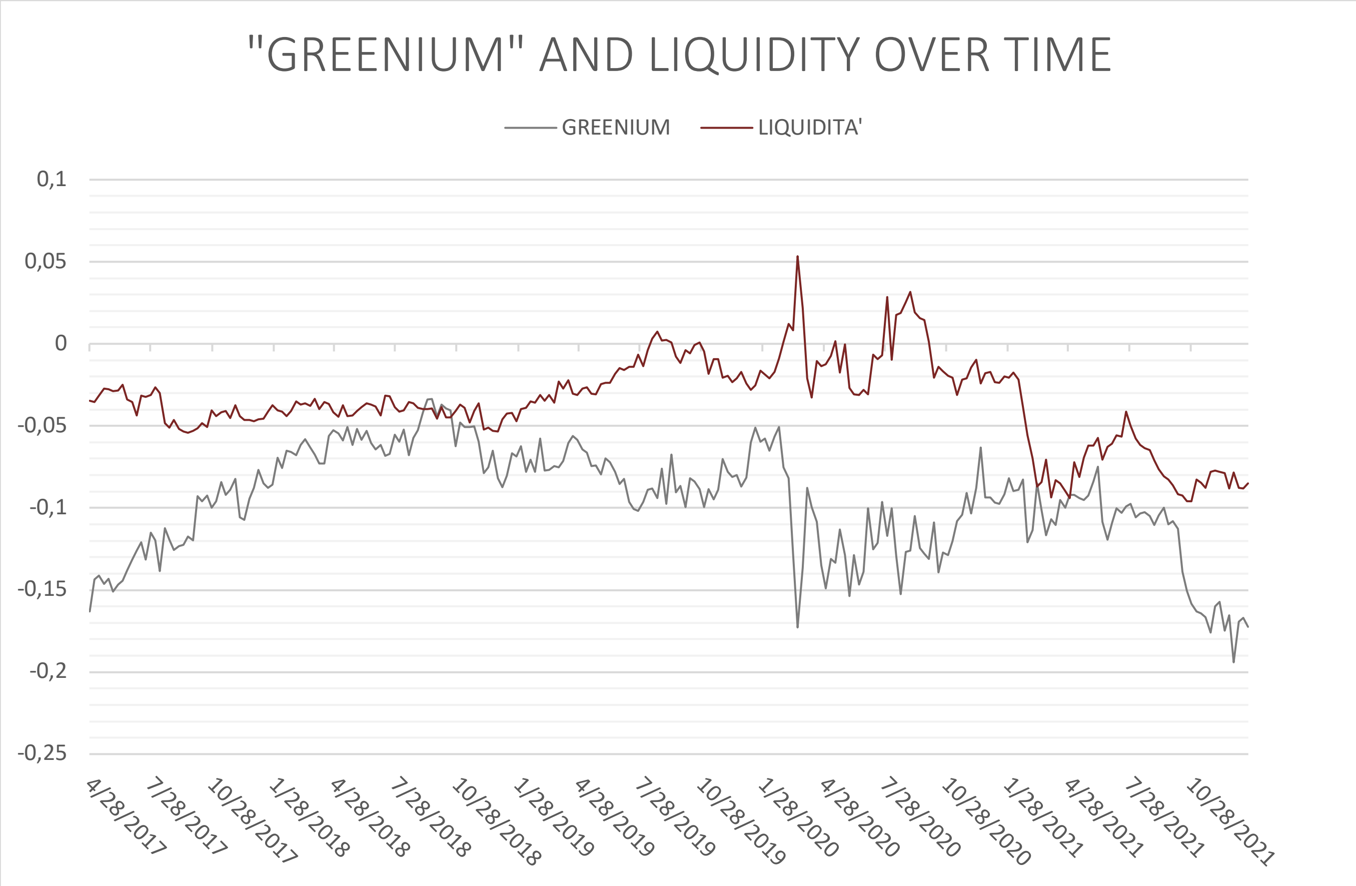

Table 8: Greenium's determination by issuer's type

CORPORATE		GOVERNMENT & AGENCY	
	$\Delta\hat{y}_i,$		$\Delta\hat{y}_i,$
Constant	-0.060^{***}	**Constant**	-0.199^{***}
Δ***Liquidity***$_{i,t}$	0.156^{***} (0.022)	Δ***Liquidity***$_{i,t}$	0.183^{**} (0.080)
OBS	3472	**OBS**	4464
$\mathbf{R^2}$	0.663	$\mathbf{R^2}$	0.718

Note: Results of the fixed effect panel analysis carried out using the type of issuer as a filter (Corporate and Government + Agency): $\Delta\tilde{y}i,t = pi + \beta\Delta Liquidityi,t + \epsilon i,t$

**p<.05, **p<.01, ***p<.001.*

Source: authors' elaborations

The following is the explanatory graph of the evolution of the differential and liquidity over time by type of issuer, using the same methodology applied for the determination of the differential in the

Fig 3. – Greenium in corporate bonds

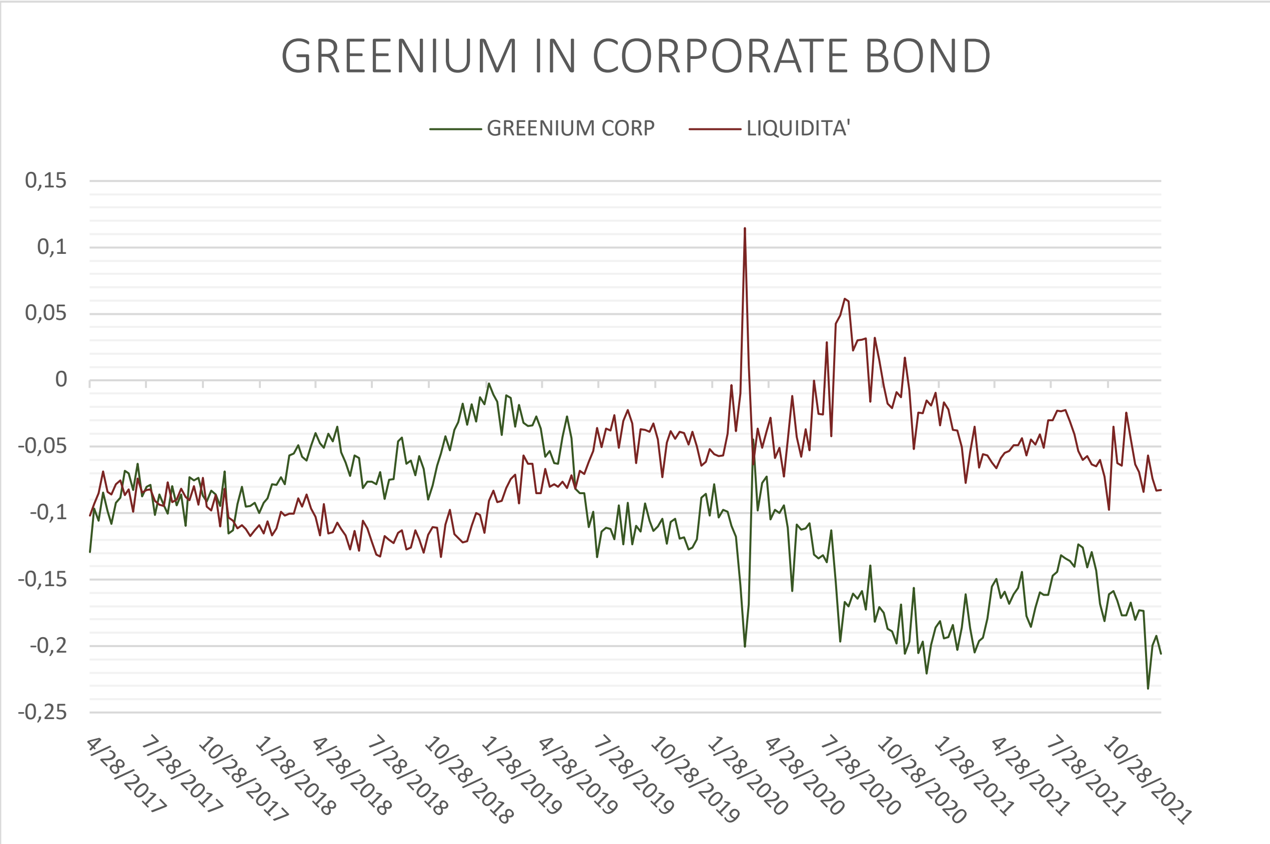

Table 1: The figure shows the evolution of the greenium (in green), and of the liquidity (in red) of corporate bonds calculated through OLS regression for each single instant of time of the yield and liquidity differential of government bonds

Source: authors' elaborations

more general case. Finally, here is a graph that compares the two differentials over time, which is necessary to draw some conclusions

Fig. n 4. – Greenium in government bonds

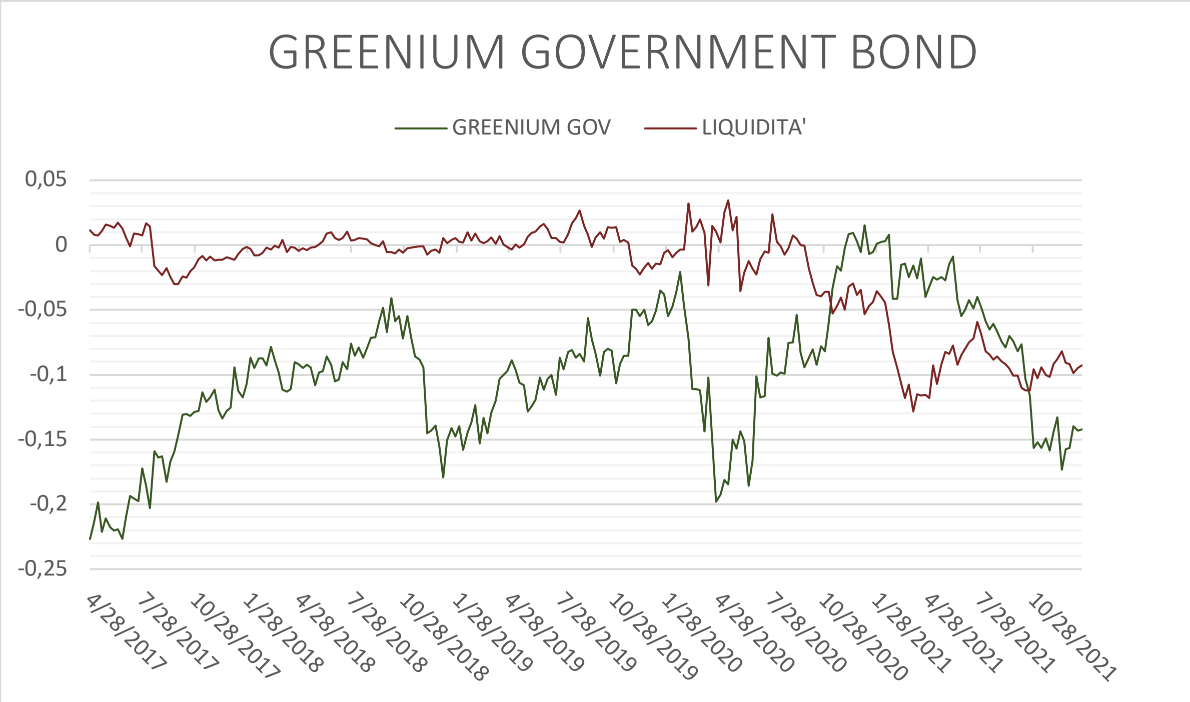

Figure n. 4: The figure shows the evolution of the greenium (in green), and of the liquidity (in red) of government bonds calculated through OLS regression for each single instant of time of the yield and liquidity differential of government bonds

Source: authors' elaborations

Fig. n. 5. – Greenium in government vs corporate bonds

Source: authors' elaborations

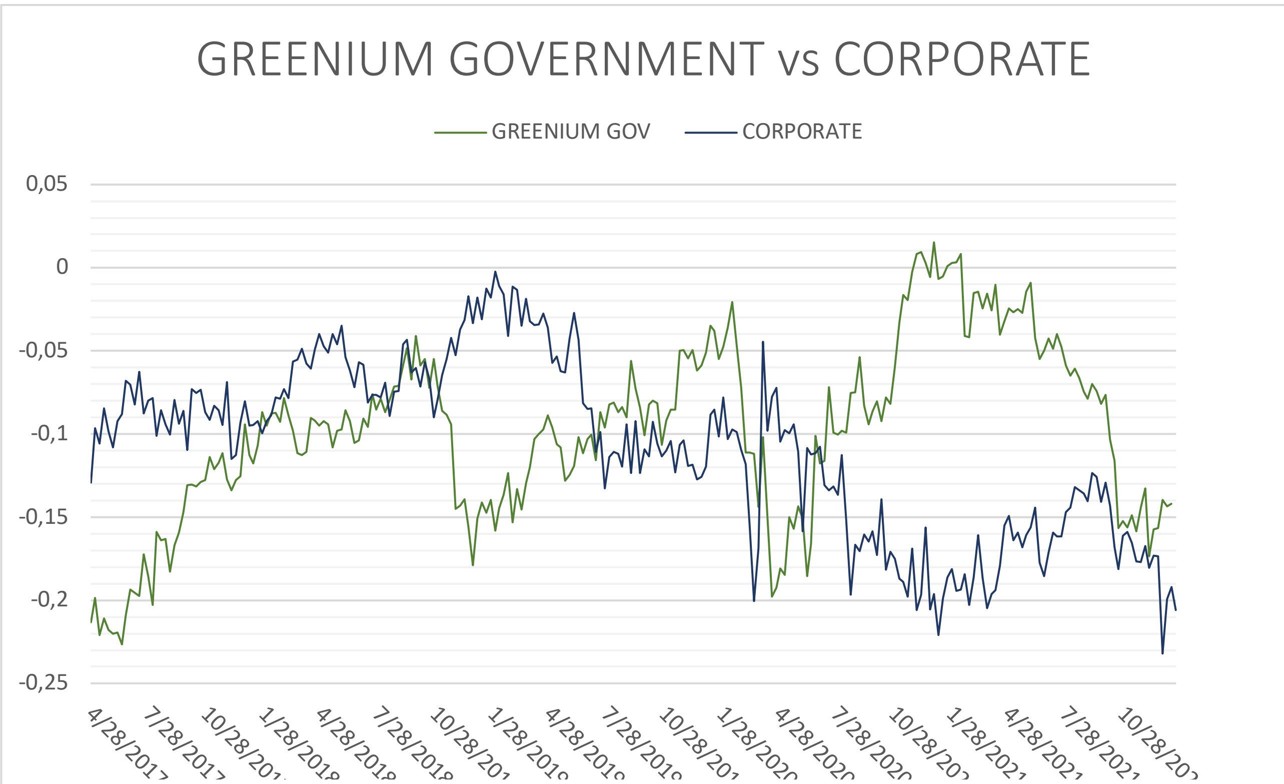

Figure n. 5: The figure shows the evolution of the greenium for government bonds (in green), and for corporate bonds (in blue) taken from the previous analyzes

Lastly, a test was performed to estimate the presence of a structural break between the two-time intervals (pre and post pandemic). The test is characterized by a regression panel containing an independent variable calculated as an iteration between liquidity and temporal dummy (Pre_Pandemic) as well as the dummy variable itself. In order to understand which of the two types of issuers suffered the most from the rotation of the lockdown and the interest rate crisis, there were two regressions, the first for corporate bonds and the second for government bonds. The results are summarized in the table below

The model for corporate bonds is structured as follows:

$$\Delta\tilde{y}_{c,t} = p_c + \beta\Delta Liquidity_{c,t} + \beta_2 PrePandemic_{c,t,} + \beta_3 IterationPrePandemic_{c,t,} + \epsilon_{c,t}$$

With:

$$IterationPrePandemic_{c,t,} = \Delta Liquidity_{c,t} * PrePandemic_{c,t,}$$

Table 9: Structural Break determination pre / post Covid - 19

		Corporate	***Government***
	Greenium	-0.092***	-0.1602***
		(0.007)	(0.035)
	Liquidity	0.383***	0.107
		(0.025)	(0.074)
	IterationPrePandemic	-0.074***	-0.032***
		(0.006)	(0.005)
	PrePandemic dummy	0.113***	-0.06***
		(0.007)	(0.009)
F Statistic	*b[DummyPretPandemic_1]=0* *b[IterationPrePandemia]=0*	210.39	49.0085

*p<.05, **p<.01, ***p<.001.

Source: authors' elaborations

The model for corporate bonds is represented as follows:

$$\Delta\tilde{y}_{c,t} = p_c + \beta\Delta Liquidity_{c,t} + \beta_2 PostPandemic_{c,t,} + \beta_3 IterationPostPandemic_{c,t,} + \epsilon_{c,t}$$

With:

$$IterationPostPandemic_{c,t,} = \Delta Liquidity_{c,t} * PostPandemic_{c,t,}$$

Table 10: Structural Break determination pre / post Covid - 19		
	Corporate	***Government***
Greenium	0.021^{***} (0.007)	-0.1927^{***} (0.039)
Liquidity	0.310^{***} (0.022)	0.167^{**} (0.080)
IterationPrePandemic	0.074^{***} (0.006)	-0.059^{***} (0.005)
PrePandemic dummy	-0.113^{***} (0.007)	0.03^{***} (0.009)
F Statistic *b[DummyPostPandemic_2]=0 b[IterationPostPandemic]=0*	44,5032	49,0085

*p<.05, **p<.01, ***p<.001.

Source: authors' elaborations

7. Results

From the elaborations carried out it is possible to draw some considerations: the first is that, in the greenium determinant's analysis, unlike what emerges in Zerbib, 2019 and despite the negative influence of the ratings on the premium for GBs, the result on the bonds that have a lower rating is not statistically significant (c).
What we can highlight, however, is a positive influence on the greenium of government bonds compared to the other types *(d) (f) (j) (k)* of 0.67, 0.79, 0.91 and 0.92 respectively. This interesting result could be due to the nature of government bonds, which in many cases are safer than corporate or agency bonds.
A second interesting result that comes from the analysis concerns the rating. It seems that bonds with a higher rating have a negative influence on the greenium, even if they are linked to government bonds. Finally, in no case analyzed, present and not in the table shown, does the currency significantly influence the greenium. The augmented analysis (a) has results similar to that variable. Government bonds correspond to the highest influence on greenium compared to other types, in this case 0.97 while corporate bonds 0.64. The other factors included do not appear to be statistically significant although a positive influence on bonds with an issue exceeding 1000 mln (0.27) and a negative influence on bonds with a rating above AA of 0.33 can be observed.
The conclusions we can reach, therefore, are in line with Serena, Panzica and Fatica, 2019 and Climate Bonds Initiative, 2017: "Greenium does not seem to be present for all categories of issuers". One of the possible reasons may be linked to the different degree of transparency observed by the

different issuers. In particular, States seem to be more attentive to the dissemination of information at the time of issue and subsequent reporting, in order to maintain a high reputation and rating.
The last part concerns, however, the evolution of greenium over time. The regressions carried out for every moment of time have outlined a quite clear evolution of the amount of the differential: in the period between 2017 and 2020 the value tends to increase (and therefore decrease), subsequently, during the pandemic, the value of the differential decreases (and therefore increases) vertiginously. Estimates reported in Table 7, from regressions show that, in general, government bonds have a broader differential than the corporate ones in the sample, respectively -0.1782 and -0.1803 pre- and post-pandemic bonds and 0.11 and 0.006 pre- and post-pandemic bonds. It is therefore evident that the turnaround of the pandemic affected the greenium, making it lower (and thus higher) in government bonds, while having the opposite effect on corporate bonds, this result is similar to Hande et al., 2019.
In government bonds, moreover, the variation and evolution of the differential has not been found to be dependent on changes in liquidity caused by the interest rate crisis. The liquidity ratio, in fact, is very small and not significant for government bonds in the period before the pandemic and still lower than for corporations in the following period (0.383 pre-pandemic and 0.310 post-pandemic). The coefficients of the Iteration and the pre and post pandemic dummy are statistically significant at a level of significance of 0.01 showing that, in the period after the pandemic crisis, the yield differential decreased for corporate bonds and remained stable for governmental ones (-0.113 and 0.03). The significance of the coefficients therefore shows the presence of a structural break between observation 150 and 151, corresponding to the dates 6 March 2020 and 13 March 2020.
The results are confirmed by the tests on linear restrictions which, in each regression performed, have a value of the F statistic higher than the critical value, rejecting the null hypothesis that all coefficients could have null value.

8. Conclusions

The analysis allows us to draw some interesting conclusions.
The work had its starting point in the analysis of the differential yield between GBs and conventional bonds created by interpolation, that was found to be -10bps. A panel analysis was then carried out and led us to understand whether this differential was due to the liquidity of the bonds. After creating the model and choosing the most suitable proxy of liquidity, the analysis of data found a negative greenium of 13bps, therefore close to the measurement based exclusively on the yield differential.
The result of the regression allows us to state that, in the sample analyzed, the difference between GB yields and traditional plain vanilla bonds is 13 basis points based on the liquidity value of these financial instruments, where the liquidity is calculated through bid-ask spread.
These two results lead us to make some considerations on the greenium and the reasons for its existence. In many market segments, demand over supply is higher for GBs than for conventional bonds. This discrepancy in the microstructure of the market can be attributed to an excess demand for investments due to the characteristic of GBs where the increasing demand for GBs is left unsatisfied by an insufficiently large volume of GB issues.
A negative premium due to excess demand for GBs investments supports the results of the Stakeholder Theory that can be summarized, in this specific case, as better environmental performance lowers the cost of capital. One of the channels involved is the increase in the size of the bond holder base, which exerts greater downward pressure on GB yields than on conventional bond yields. This situation, fueled by public and private initiatives to redirect investment towards low carbon emissions, reflects the strong interest of investors willing to finance the green transition.
Through the second cross section analysis it was possible to evaluate what characteristics of the bonds impacted more or less positively on the greenium. From this last analysis it was clear that government GBs differ from corporate GBs. This result explains that investors attach greater importance to the green aspect of the bond and are more determined to acquire it when documentation is linked to it that minimizes the risk of information asymmetry about the use of the proceeds (Akerlof, 1970).

Government GBs, by nature, have precise documentation on the use of finance (Doronzo et al., 2021), especially in the last period, unfortunately, also characterized by fictitious sustainable investments that diminish investor confidence. To an increase of security on the use of money there is an increase of greenium, in line with the findings emerged in Fatica, Panzica and Rancan (2019).
Finally, considering the time frame of the analysis (2017-2021) we can assert that the premium for GBs has undergone an evolution, over time, due to some triggering factors. The first is certainly the growth of interest in green finance, which has seen an increasing audience of investors interested in green issues and who are increasingly seeking guarantees that their funds would have been used for environmental reasons. Secondly, however, the pandemic (as seen also by estimates made over time and by the presence of a structural break) played its role as protagonist, bringing with it an increase in the value of the differential for both government and corporate bonds, precisely in the period due to the first lockdown, characterized by a strong instability of the markets. Estimates have also shown that, for government bonds, the increase in greenium was not driven by liquidity shocks, unlike corporate bonds. This result reflects the importance that investors attach to the amount of information that is provided at the time of issue and during the life of the bond. The greater the certainty that the investment is really green, the greater the greenium, the less the impact of liquidity. For government bonds both in the period before and after the first lockdown it appears to be greater the value of the differential and smaller (and in the period before the pandemic, not significant) the value of the liquidity impact of the bid-ask Spread).

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