Shades of Green: are Pricing and Ownership of Green Bonds affected by their "Greenness"?

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Marco Spinelli,
MSc in Financial Markets
EDHEC Business School
393 Promenade des Anglais
06200 Nice, France
marco.spinelli@edhec.com

Supervisor: Prof. Gianfranco Gianfrate
EDHEC Business School

Abstract

With the growth of green bonds as an asset class, the market has developed ad hoc verification frameworks to determine the expected environmental benefits of projects financed via green fixed income securities. We investigate the differential pricing of bonds whose shades of green have been labelled "dark", "medium" or "light" by CICERO, a leading provider of second opinions on green bonds. We find that on average dark-green bonds are not priced differently from otherwise similar non-green bonds. However, we find that the premium for dark-green bonds increases over time and has been particularly penalized in 2020, possibly because of lesser investor focus on assets' environmental footprint during the COVID-19 crisis. As far as responsible investors are concerned, we show that the ownership of dark-green bonds significantly differs from that of conventional or lighter-green bonds. Institutional investors committed to integrate sustainability in their investments have significantly higher stakes in dark-green bonds. While markets do not seem to price dark-green bonds differently from conventional bonds, the former are able to importantly attract climate-aware investors.

Keywords: climate change; green bond; carbon emissions; climate risk; shades of green; responsible investment.

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1. Introduction

While all countries committed under the Paris Agreement to limit global temperature rise to 1.5˚C-2˚C, the major question remains how the world can achieve this temperature goal. IPCC (2018) finds that "rapid, far-reaching and unprecedented changes in all aspects of society" must happen to ensure targeted temperature. Those changes will require profound transitions in land, energy, industry, buildings, transport, and cities.

The financial system will be crucial to support and to accelerate investments in the clean energy and technologies needed to decarbonise the economy. This is why the 196 participating countries in the Paris Agreement committed to “make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development” in order to hold the increase in the global average temperature to well below 2° C above pre-industrial levels.

IPCC (2018) estimates that those “finance flows” amount to about $2.4 trillion (roughly, 2.5% of the global Gross Domestic Product annually) between 2016 and 2035. Such enormous figure is also consistent with the analysis by the OECD (2017), according to which approximately $103 trillion of additional investments will be required between 2016 and 2030 to meet global development needs in a way that is climate compatible. Similarly, McKinsey (Woetzel et al., 2016) anticipates cumulative needs for about USD 49 trillion, excluding primary energy and energy efficiency, between 2016 and 2030. Batthacharya et al. (2016) estimates these infrastructural needs to be between USD 75 and 86 trillion, including primary energy and energy efficiency. All the estimates imply that a large portion of the global financial system needs to be activated to prevent the ultimate climatic collapse.

The IPCC report is an alarming warning and it implicitly confirms the unprecedented investment opportunity that can be unlocked when sustainable finance becomes mainstream. With banks having restricted lending capabilities and public budgets under strain in many countries, *private* sector sources of capital need to be engaged and green bonds are considered among the key instruments to

mobilize private financial resources towards the progressive decarbonisation of the global economy (World Bank, 2015; OECD, 2017).

Green bonds are a relatively new type of bonds defined by the International Capital Markets Association (ICMA) as "any type of bond instrument where the proceeds will be exclusively applied to finance or re-finance, in part or in full, new or/and existing eligible green projects". In other words, green bonds are conventional bonds – public debt issued by corporates, municipalities and other governmental entities – with a distinguishing feature: proceeds are used for environment-friendly projects, primarily related to climate change mitigation and adaptation.

The literature has already extensively investigated whether financial markets price differently green bonds from otherwise similar non-green bonds; however, the evidences are still mixed (MacAskill et al., 2021). Focusing on the secondary market, Zerbib (2018) finds a small negative premium showing that the yield of a green bond is lower than that of a conventional bond. On the primary market, Gianfrate and Peri (2018) find similar evidence of a relative advantage for the issuer of green bonds versus similar non-green bonds. However, the empirical support to the existence of a green premium (or "greenium") is far from unanimous: focusing on the same market – namely, the US municipal bonds - Baker et al. (2018) support the evidence of a greenium associated with green bonds compared against similar non-green ones, while Larcker and Watts (2020) do not find any evidence of such greenium.

This paper explores whether besides being green, for a bond the degree of greenness matters as well. Using the green labels released in second-opinions by the Center for International Climate Research (CICERO), a leading independent research institutions dedicated to environmental research, we quantify the 'green bond premium' as the difference between the yields of matched conventional and green-labeled bonds. On a cross-sectional average, dark-green and light/medium-green bonds experience no yield premium. However, we find that the premium for dark-green bonds evolves over time showing a descendent pattern but it has been particularly penalized in year 2020, possibly

because of the COVID-19 crisis and consequent lesser investor interest for assets' environmental footprint.

Importantly, we show that the shades of green do matter for responsible investors. Institutional investors who have signed the United Nations' Principles for Responsible Investment (UNPRI) have a significantly higher ownership of dark-green bonds than conventional bonds, while the light/medium green bonds do not feature significantly higher holdings of UNPRI investors. This finding supports the view that the shades of green do matter for climate-aware institutional investors even if the demand for dark-green assets does not translate in a tangible premium as far as the bond pricing is concerned.

The paper is structured as follows. Section 2 discusses the main contributions on green bonds pricing and ownership. In Section 3, the data is presented. Section 4 illustrates the methodology for the greenium estimation. Section 4 shows the findings about the relation between distance to default and emission levels. Section 5 presents some additional robustness tests. Finally, Section 6 discusses the main findings and concludes.

2. Literature review

Green bonds are a recent phenomenon with a widespread growth across countries started not earlier that 2013. Consequently, the scholarly literature on green bonds is limited. Ge and Liu (2015) examining how a firm's corporate social responsibility (CSR) performance is associated with the cost of its new bond issues in the US market, found that firms with better CSR performance are able to issue bonds at lower cost. Similar conclusions have been reached by Oikonomou, Brooks and Pavelin (2014). Bauer and Hann (2010), analyzing a large cross-industrial sample of US public corporations, found that environmental concerns are associated with a higher cost of debt financing and lower credit ratings, and proactive environmental practices are associated with a lower cost of debt. Stellner, Klein and Zwergel (2015) found only weak evidence that superior corporate social performance (CSP) results in systematically reduced credit risk. On the contrary, Menz (2010), focusing on the European corporate bond market, observed that the risk premium for socially responsible firms was, *ceteris paribus*, higher than for non-socially responsible companies, although this finding is only slightly significant. Zerbib (2019) has analysed the green bond advantage focusing on 135 investment grade green bonds issued worldwide. The paper shows that bondholders pay of 8 basis points (statistically significant) to buy green bonds after issuance. Evidences have been collected for non-corporate issuers as well. Karpf and Mendel (2017) investigated green and conventional bonds in the U.S. municipal bonds market and found that green bonds seem to be penalized by the market.

Flammer (2020) shows that corporate green bonds have become more prevalent over time, especially in industries where the environment is financially material to firm operations. The study documents that investors respond positively to the issuance announcement, and ex-post the issuers improve their environmental performance post issuance, also experiencing an increase in ownership by long-term and green investors.

However, the evidences about the existence of a green advantage in the primary market (when bonds are initially issued) and in the secondary market (when bonds are traded following the issuance) are

still mixed (MacAskill et al., 2021; Zerbib, 2019; Gianfrate and Peri, 2019). The paradigmatic contrasting evidences about the existence of a greenium come from the US municipal bond market. Baker et al. (2018) show that green US municipal bonds are issued at a premium to otherwise similar ordinary bonds on an after-tax basis and that green bonds appear more closely held than ordinary bonds; both pricing and ownership effects are stronger for bonds that received an external green certification. The opposite conclusion is reached by Larcker and Watts (2020) who find for the same market a null greenium, concluding that investors appear unwilling to forgo wealth to invest in environmentally sustainable projects.

More recently, scholars have started to specifically investigate the role of green certification and green labelling on the pricing of sustainable fixed-income securities.

According to the ICMA's Green Bond Principles, there are generally four types of green external reviews: second-party opinion, verification, certification, and green rating. Each bond can have just one or more types of green external review, and external reviewers are typically independent research institutions dedicated to environmental research such as the Center for International Climate Research (CICERO).

Bachelet et al. (2019) finds that certification of bonds' "greenness" affects the greenium apparently because reputation and green third-party verifications can reduce informational asymmetries and the risk of perceives green (bond)-washing.

The role and value of third-party certification of greenness are also relevant for financial regulation and policy considerations. Reed et al. (2019) argue that green bonds fall into the category of credence goods, as defined by Dulleck and Kerschbamer (2006): investors can find difficult to assess the benefit of such good before-and-after "consumption". Since the measurement of green bonds' impact is challenging ex-ante and ex-post for investors, independent certification by experts can guide guide investors by providing a benchmark for quality. However, Reed et al. (2019) criticize the current process for certification, and in particular the lack of a framework or transparency from third-party

auditors. In fact, issuers can shop around until they obtain a rating they like regardless of the true greenness of the project financed with the bonds' proceeds.

Dorfleitner et al., 2020 find that green bonds with a second-party opinion or other form of greenness certification enjoy a relatively higher green bond premium, thus supporting the view that credible independent certification is valuable for investors. In particular, investors trade green bonds with second-party opinion at prices that increase with the level of greenness evaluation of the bond: dark-green bonds have a higher premium. This evidence is interpreted as supporting the view that "shade-of-green methodology" adopted by several specialized independent reviewers is pricing-relevant in the market.

Our paper contributes to the existing literature by focusing on the pricing and ownership of dark-green bonds. There are three interrelated research questions that are addressed. First, we explore whether the shades of greenness really matter in the market pricing of bonds that have been confirmed as "dark-green" by a leading independent second opinion review. Second, we investigate whether this the greenium (if any) associated to the shades of green evolves over time and whether it was specifically affected in 2020 by the COVID-19 crisis. Finally, is the ownership of dark-green bonds different form the one of light/medium-green bonds and conventional bonds? In particular, we study whether investors who explicitly committed to integrate climate considerations in their portfolio decisions invest relatively more in the darker-green fixed-income securities.

3. Data and Methodology

3.1 Data

Our dataset relies on the Second Opinions produced by CICERO. CICERO, a Norwegian independent research company specialized in providing second opinions for green bonds issuances, is considered among the pioneers and leaders in the field (Dorfleitner et al., 2020). CICERO assesses how well a green bond aligns with a low-carbon resilient scenario. The objective of CICERO is therefore to determine whether a given activity or technology supports a low-carbon and climate resilient society in the long-term. In some cases, activities or technologies that reduce emissions in the short-term actually result in a prolonged use of high-emitting infrastructure – hence, an increase in net emissions - in the long term. The second opinions are graded *Light Green*, *Medium Green* or *Dark Green*. *Light Green* is allocated to projects that are climate-friendly but lack a long-term horizon; while the bond proceeds can deliver short-term GHG emission reductions, the project will still extensively rely mostly on fossil fuels. Also, these projects remain exposed to physical and transitional climate risks ad there is no evidence of appropriate strategies in place to protect the issuers from such risks. *Medium Green* is allocated to projects that incorporate a long-term vision to reduce emissions, but they are not ambitious in the scope of carbon footprint reduction. *Dark Green* is allocated to projects show ambitious but realistic carbon footprint reduction targets. Additionally, the issuers have a robust strategy to reduce or mitigate the exposure to other transitional and physical climate risks. Therefore, the *Dark Green* bonds have to be considered the best green assets available in the fixed income realm. Our research question will specifically explore whether the green bonds rated "dark green" by CICERO are actually priced differently from the other ones. The ratings are freely available on CICERO's website.

In order to estimate the green premium, we follow the methodology used by Zerbib (2019), which consist in matching each of the green bonds with two comparable, non-green bonds. This allows us to linearly extrapolate (or interpolate) the yield of a comparable, conventional bond with the same maturity as the green bond.

We started with a first database composed of 296 bonds rated Dark green and 3694 conventional bonds from the same issuers and a second databased composed of 255 bonds rated Light & Medium green and 2927 comparable conventional bonds. After the matching procedure, we are left with 71 Dark green bonds and 77 medium green bonds. These databases include all the descriptive information needed for the matching procedure: Rating CICERO, Issuer Name, Coupon, Maturity, Bloomberg Composite rating, Maturity type, Currency, Amount issued, Payment rank, ISIN, Coupon Type, BCLASS Level 4.

Our main price data source is Bloomberg. We obtained daily close ask yield, bid price, and ask price for each of the bonds included in the sample from January 2013 to November 2020. For the daily data we kept only the dates for which we have data on all the three bonds in each triplet.

In addition, we obtained from Bloomberg the ownership data of each bond included in our sample. For each fixed income security we obtained the holder name, amount held, and the percentage holding. The ownership data for our securities is composed by a total of 311 different owners.

We obtained the portion of the 2018 survey to the signatories of the United Nations' Principle for Responsible Investments (UNPRI) reporting their dealings with climate change risks and opportunities. The survey respondents have a cumulated Assets under Management (AuM) of about 71 trillion USD, considering that according to some estimate[1] the global AuM of such investors is about 79 trillion USD globally, the survey can be considered fairly representative (about 90% of the world total). Out of the 311 owners of the green bonds in our sample, 116 are UNPRI signatories. Moreover, from the survey we have disclosure of what tools and approaches are reportedly used by each UNPRI signatory to integrate climate risks considerations in its investment strategy and portfolio allocation.

[1] Boston Consulting Group, *Global Asset Management 2018*.

3.2 Methodology

The first step consists in matching our bonds, rated by CICERO, with comparable bonds that should ideally differ as little as possible apart from the green feature. As in Zerbib, 2019 we look for bonds from the same issuer, with the same currency, rating, maturity type, payment rank and coupon type. In addition, we exclude bonds whose maturity differs from the green bonds' maturity of more than 2 years and/or whose issue date differs from the green bonds' of more than 6 years. Lastly, we also exclude bonds whose amount issued is more than 4 times or less than ¼ that of the green bond. To increase the sample size, we also include bonds that are not rated. We end up with a total of 148 triplets of bonds.

After downloading daily close ask yields, ask prices, and bid prices we start construction our variables. First, we linearly extrapolate or interpolate the comparable yield that a conventional bond with the same maturity as the green bond is expected to have. In practice, we first identify the line that passes through the points defined by the yields and the maturities of our two conventional bonds (parameters m and q), and then we calculate the yield of the comparable bonds as:

$$\hat{y}^{CB} = m * Maturity^{GB} + q \qquad \text{(Eq. 1)}$$

Where CB stands for Conventional bond and GB stands for Green bond. Given this proxy, we are able to calculate the Ask yield difference between our green bond and a synthetic comparable bond with the same maturity for each date in which we have data:

$$\Delta\hat{y}_{i,t} = y_{i,t}^{GB} - \hat{y}_{i,t}^{CB} \qquad \text{(Eq. 2)}$$

Our sample comprises 56196 unbalanced daily observations for 360 bonds (148 green and 212 conventional). The average yield premium across all observation is of -3.42 bps and the distribution is slightly skewed to the left. The mean yield for dark green bonds is -8.29 bps whereas for medium green bonds is 2.34 bps.

To properly estimate the green bond premium, we proceed with a *within regression* as in Zerbib (2019). This is done for three main reasons: to bring out the bond-specific time-invariant unobserved effect without imposing any distribution; second, strict exogeneity holds and ensures unbiasedness and consistency of the estimator; third, the difference in liquidity proxy to be uncorrelated with the unobserved specific effects provides for a wide range of potential control parameters is not required (Zerbib, 2019). Thus, the green premium p_i is defined as the unobserved effect in the following regression:

$$\Delta\hat{y}_{i,t} = p_i + \beta\Delta Liquidity_{i,t} + \epsilon_{i,t} \quad \text{(Eq. 3)}$$

With

$$\Delta Liquidity_{i,t} = Liquidity_{i,t}^{GB} - Liquidity_{i,t}^{CB} \quad \text{(Eq. 4)}$$

To quantify the liquidity of a given bond we use the closing percent quoted bid-ask spread as a proxy. For the synthetic conventional bond, we use a distance weighted average of the liquidity of the two original conventional bonds:

$$Liquidity_{i,t}^{CB} = \frac{d_2}{d_1+d_2} BA_{i,t}^{CB1} + \frac{d_1}{d_1+d_2} BA_{i,t}^{CB2} \quad \text{(Eq. 5)}$$

With

$$d_1 = |\, Maturity^{GB} - Maturity^{CB1} \,|$$
$$d_2 = |\, Maturity^{GB} - Maturity^{CB2} \,|$$

Table 1 shows the descriptive statistics of our independent variable $\Delta Liquidity_{i,t}$. We can see that it is concentrated around zero with a low standard deviation which is also an indication of the good quality of the matching procedure.

Once obtained the green premium with the fixed effect regression we can study the determinants of the green bond premiums with a second regression:

$$\hat{p}_i = \alpha_0 + \alpha_1 \mathbf{1}_{Dark\ Green} + \sum_{j=1}^{N_{rating}-1} \alpha_{2,rating_j} \mathbf{1}_{rating_j} + \sum_{j=1}^{N_{sector}-1} \alpha_{3,sector_j} \mathbf{1}_{sector_j} + \sum_{j=1}^{N_{currency}-1} \alpha_{4,currency_j} \mathbf{1}_{currency_j} + \alpha_5 Maturity + \alpha_5 \log(Issue\ Amount) + \varepsilon_i$$

(Eq. 6)

4. Results

This section tests our questions of whether: (1) investors trade darker-green bonds at a premium in the secondary market; (2) the premium (if any) is variant over time; and (3) the ownership of darker-green bonds differs from the other kinds of bonds.

As a first step, because the variation of liquidity difference at the bond level explains part of the variation of yield difference, it is important to control for the liquidity difference when estimating the green bond premium (Zerbib 2019; Dorfleitner et al., 2020).

Table 1 – Descriptive statistics of the liquidity proxy

	Min	1st Quart.	Median	Mean	3rd Quart	Max	Std. Dev
$\Delta Liquidity_{i,t}$	-1.835%	-0.014%	0.008%	0.023%	0.046%	5.897%	0.149%

Table summurizing the distribution of the variable ΔLiquidity.

Table 1 shows that our difference in yield is significantly related to our liquidity proxy. We run different heteroscedasticity tests and we detect its presence. We also run a Wooldridge test which does not seem to detect any strong serial correlation. We test the significance of the relationship with different standard errors (e.g. Newey-West and Panel-corrected) but the results do not change. Despite the low R^2, ΔLiquidity is significant at the 99% level. This is consistent with what Zerbib, 2019 found.

Table 2 – Results of the regression first regression (Eq.3) over the whole sample

	Dependent variable: $\Delta\hat{y}_{i,t}$		
	Within	Newey-West Std. Errors	Panel-corrected Std. Errors
ΔLiquidity	-60.871***	-60.871***	-60.871***
	(1.768)	(7.765)	(5.759)
Observations	56196	56196	56196
Adj. R^2	.021		.021
F Statistic	1185.90***	61.45***	
	(df = 1; 56194)	(df = 1; 56194)	

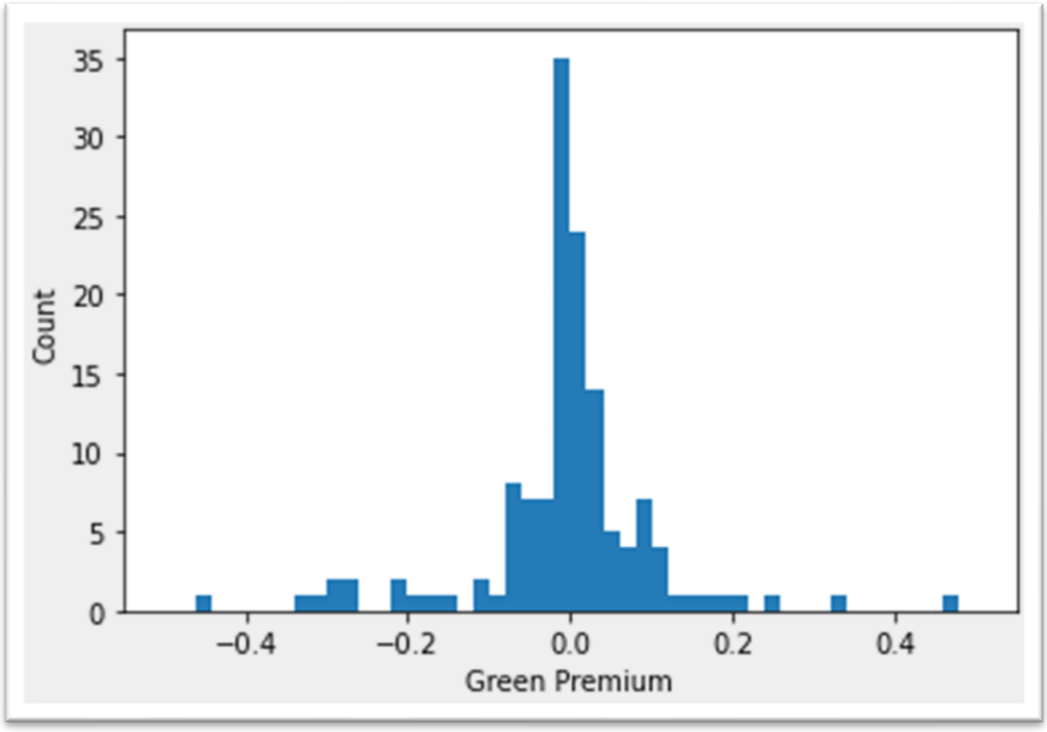
The independent variable $\Delta\hat{y}_{i,t}$ is the difference bertween Ask yields defined in Eq. 2. ΔLiquidity is our liquidity proxy defined in Eq. 4. Standard errors in parentheses. Notation of the significance levels: *p<0.1; **p<0.05; ***p<0.01.

Table 3 – Descriptive statistics of the green premiums (whole sample)

	Min	1st Quart.	Median	Mean	3rd Quart	Max	Std. Dev
$\hat{p}_i$	-0.4419%	-0.0274%	0.0016%	-0.0053%	0.0288%	0.4715%	0.1113%

Table summurizing the distribution of the variable $\hat{p}_i$ (fixed effect of the within regressions defined in Eq. 3)

Figure 1 – Distribution of the Green Premium (whole sample)



Histogram graph (50 buckets) summurizing the distribution of the variable p_i (fixed effect of the regressions defined in Eq. 3)

We computed the green premiums with the fixed effect regression in Eq. 3 for triplets of bonds with more than 20 observed days. We decided to remove the bonds triplets whose yield premiums higher than 50bps or lower than -50bps. These bonds were skewing the results. We obtain 138 green premiums, with mean -0.5 bps and a left skewed distribution. We calculate the significance of the results with the Wilcoxon test. The result is not significantly lower than 0 (p-value 0.473). In Table 4 there are the results of the Wilcoxon test by subgroup for each subgroup that has more than 10 observations. We can see that the only subgroups of bonds in Euro and bonds in USD have premiums significantly lower than 0 (at 5% and 10% respectively). Also, the sector subgroup of "Government Guarantee" has a negative yield premium with 99% confidence.

Table 4 – Significance of the Green Premium by subgroup

		Mean	Median	# GB	$\hat{p}_i < 0$
Shade of Green	Dark Green	-0.0095	-0.0023	64	0.279
	Medium & Light Green	-0.0016	0.0024	74	0.610
Currency	EUR	-0.0347**	-0.0100	18	0.033
	CNY	-0.0082	-0.0082	1	
	SEK	0.0265	0.0024	80	0.991
	NOK	-0.0021	0.0015	16	0.430
	USD	-0.0601*	-0.0279	11	0.074
	AUD	-0.0312	-0.0312	2	
	BRL	-0.3369	-0.3369	1	
	HKD	-0.1832	-0.2468	6	
	MYR	-0.0072	-0.0059	3	
Rating	AAA	-0.0262	-0.0014	27	0.286
	AA	-0.0619	-0.0169	5	
	AA-	0.0302	0.0302	1	
	A	-0.0247	-0.0044	4	
	BBB+	-0.0218	-0.0218	2	
	NR	-0.0460	-0.0026	26	0.255
	Null	0.0219	-0.0003	73	0.854
Sector	Government Owned, No Guarantee	-0.0392	-0.0051	26	0.111
	Banking	-0.0111	-0.0003	3	
	Diversified Manufacturing	-0.0019	-0.0019	1	
	Supranational	-0.0447	-0.0287	6	
	Local Authority	0.0186	0.0127	23	0.828
	Consumer Cyc Services	0.1695	0.1186	7	
	Other Industrial	0.0194	0.0033	15	0.940
	Government Guaranteed	-0.1130***	-0.1133	16	0.007
	Electric	-0.0025	-0.0050	19	0.166
	Mortgage Non Pfandbriefe	0.0153	0.0153	2	
	Treasury	-0.0144	-0.0144	1	
	Consumer Products	0.0285	0.0285	1	
	Other Financial	0.0294	0.0586	16	0.942
	PS Loan Non-Pfandbriefe	0.0328	0.0328	1	
	Finance Companies	-0.0030	-0.0030	1	

Mean and Median green premium calculated by subgroups. The subgroups are: Shades of Green (rating by CICERO), Curreny, Rating, and Sector. In addittion, for each subgroup with more than 10 observations we calculate the p-value of the Wilcoxon signed-rank test for the null hypothesis H_0: $\hat{p}_i \geq 0$. Details of the procedure can be found in Zerbib, 2019. In the last columns we report the number of green bonds for each subgroup. Notation of the significance levels: *p<0.1; **p<0.05; ***p<0.01.

To better understand whether Dark green bonds have a more negative yield premium than Medium & Light green bonds we run the regression in Eq. 6. Table 5 shows the results of these regressions. In general, the dummy variable representing Dark Green bond has a negative coefficient. However, the Shade of Green is not significantly explaining the variance in the dependent variable (the green premium) in model 1 and 3. It is significant with 90% confidence in model 2.

Table 5 – Second step regression with Green Premium as dependent variable

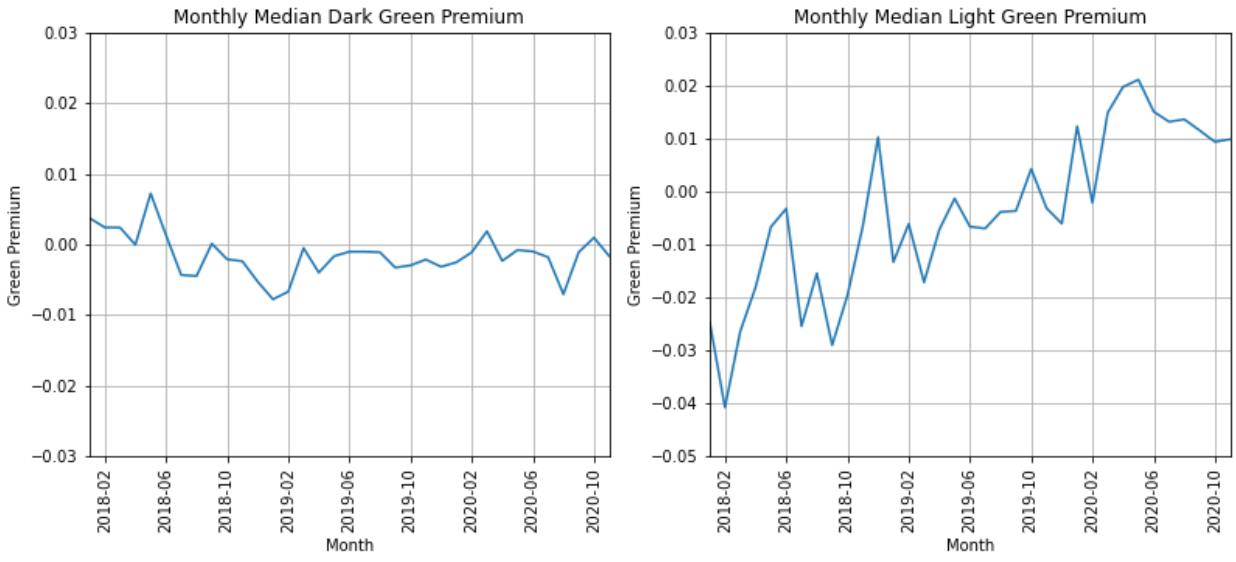
	Dependent variable: $\hat{p}_i$		
	1	2	3
Is_Dark_Green	-0.0364 (0.029)	-0.0439* (0.025)	-0.0079 (0.019)
Maturity_Ordinal	-0.0000 (0.000)		
Log_Amt_Out	0.006 (0.013)	0.0094 (0.012)	
Is_EUR	-0.0282 (0.082)	0.0644 (0.052)	
Is_SEK	-0.0156 (0.082)	0.0942** (0.038)	
Is_USD	-0.0908 (0.091)	0.0275 (0.051)	
Is_AUD	-0.089 (0.101)		
Is_BRL	-0.4252*** (0.131)		
Is_NOK	0.0052 (0.078)	0.0806** (0.044)	
Is_CNY	0.0389 (0.126)		
Is_HKD	-0.087 (0.099)		
Is_AAA	0.0913*** (0.038)	0.0576 (0.051)	
Is_AA	-0.0155 (0.071)		
Is_AA-	0.0647 (0.114)		
Is_A	0.0065 (0.064)		
Is_BBB+	0.0557 (0.084)		
Is_Null	0.0391 (0.030)	0.066 (0.046)	
Is_Government Owned, No Guarantee	-0.031 (0.104)	-0.0401 (0.035)	
Is_Banking	-0.0151 (0.12)		
Is_Diversified Manufacturing	-0.007 (0.141)		
Is_Supranational	-0.0105 (0.108)		
Is_Local Authority	0.0069 (0.098)	-0.025 (0.03)	
Is_Consumer Cyc Services	0.1545 (0.103)		
Is_Transportation Services	-0.0000 (0.000)		
Is_Other Industrial	0.0053 (0.103)	-0.0133 (0.036)	
Is_Government Guaranteed	-0.1342 (0.108)	-0.1274*** (0.04)	
Is_Electric	-0.0006 (0.103)	-0.0359 (0.036)	
Is_Mortgage Non Pfandbriefe	0.0145 (0.117)		
Is_Treasury	-0.0135 (0.138)		
Is_Consumer Products	0.0352 (0.133)		
Is_Other Financial	0.0059 (0.100)	-0.0445 (0.035)	
Is_PS Loan Non-Pfandbriefe	0.0285 (0.136)		
Constant	5.899 (10.781)	-0.244 (0.213)	-0.0016 (0.013)
Observations	138	138	138
Adj. R^2	.221	.203	-.006
F Statistic	2.821*** (df = 31; 106)	3.332*** (df = 15; 122)	0.098 (df = 1; 136)

The dependent variable $\hat{p}_i$ is the green premium calculated with the regression in Eq. 3. “Maturity Ordinal” is the Maturity date in ordinal format. “Log_Amt_Out” is the natural logarithm of the Amount Issued. “Is_EUR” is a dummy variable equal to 1 for bonds in EUR. “Is_SEK” is a dummy variable equal to 1 for bonds in SEK. “Is_USD” is a dummy variable equal to 1 for bonds in USD. “Is_AUD” is a dummy variable equal to 1 for bonds in AUD. “Is_BRL” is a dummy variable equal to 1 for bonds in BRL. “Is_NOK” is a dummy variable equal to 1 for bonds in NOK. “Is_AAA” is a dummy variable equal to 1 for bonds whose Bloomberg Composite Rating is AAA. “Is_AA+” is a dummy variable equal to 1 for bonds whose Bloomberg Composite Rating is AA+. “Is_AA” is a dummy variable equal to 1 for bonds whose Bloomberg Composite Rating is AA. “Is_AA-” is a dummy variable equal to 1 for bonds whose Bloomberg Composite Rating is AA-. “Is_A” is a dummy variable equal to 1 for bonds whose Bloomberg Composite Rating is A. “Is_Government Owned, No Guarantee” is a dummy variable equal to 1 for bonds whose BCLASS Level 4 is Government Owned, No Guarantee. “Is_Diversified Manufacturing” is a dummy variable equal to 1 for bonds whose BCLASS Level 4 is Diversified Manufacturing. “Is_Supranational” is a dummy variable equal to 1 for bonds whose BCLASS Level 4 is Supranational. “Is_Local Authority” is a dummy variable equal to 1 for bonds whose BCLASS Level 4 is Local Authority. “Is_Other Industrial” is a dummy variable equal to 1 for bonds whose BCLASS Level 4 is Other Industrial. “Is_Government Guaranteed” is a dummy variable equal to 1 for bonds whose BCLASS Level 4 is Government Guaranteed. Standard errors in parentheses. Notation of the significance levels: *p<0.1; **p<0.05; ***p<0.01.

We can also see from Figure 2 how the average Dark green premium and the average Medium & Light green premium seems to be evolving over time in our dataset. It appears that the Dark green premium is getting more and more negative over time (excluding the COVID-19 crisis) whereas the Light & Medium green premium seems to be stable (or even increasing) over the same time horizon.

Figure 2 – Evolution of Green Premiums over time

Dark Green Bonds Premium **Light & Medium Green Premium**



The left chart shows the median of green premiums for dark green bonds calculated monthly (by running Eq.3 for each month rather than over the whole life of the security). The right side shows the same but for Medium and Light Green bonds. It is worth noting that the number of bonds observed increases with time. The monthly green premium is calculated from June 2017 to November 2020 for all bonds available.

We firstly repeat the analysis with all the observations before 2020. We can see from both Table 6 and Figure 2 that the distribution looks more clearly left skewed and there is also a lower variance with less outliers. The Wilcoxon test on this dataset of 81 green bond premiums tells us that the mean

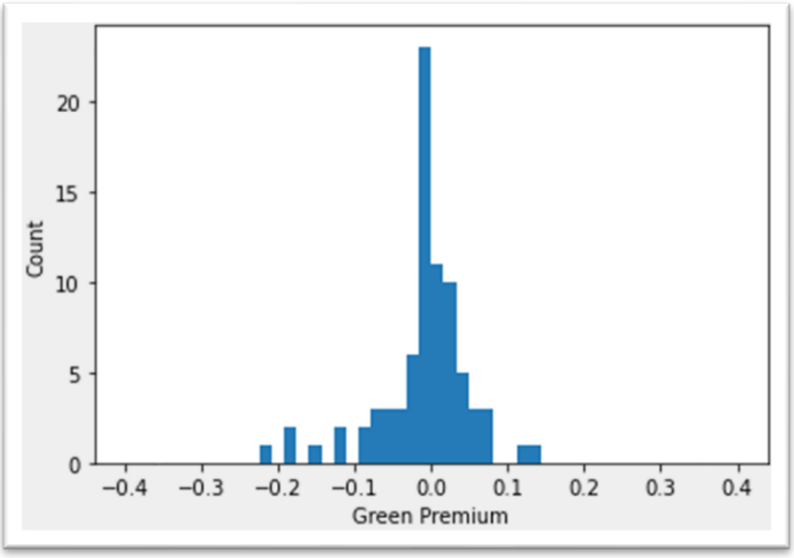
is still not significantly lower than 0 but the p-value decreases to 0.135. In this case also the subgroups: bonds in EUR and Government Owned, No Guarantee are significantly lower than zero with a 95% confidence level.

Table 6 – Descriptive statistics of the green premiums (before 2020)

	Min	1st Quart.	Median	Mean	3rd Quart	Max	Std. Dev
$\hat{p}_i$	-0.4163%	-0.0196%	-0.0029%	-0.0149%	0.0201%	0.1326%	0.074%

Table summurizing the distribution of the variable $\hat{p}_i$ (only for observations before 01/01/2020)

Figure 3 – Distribution of the Green Premium (before 2020)



Histogram graph (50 buckets) summurizing the distribution of the variable p_i (only for observations before 01/01/2020)

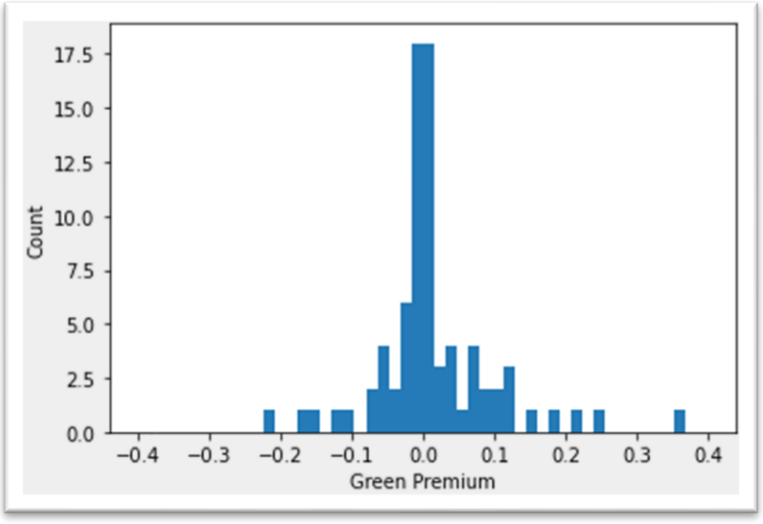
We can now study what happens to these 81 observations during 2020. As show in Table 7, the average green premium is slightly positive and Figure 4 shows that the distribution of observation is more symmetric around 0, with larger positive observations. It appears that the COVID-19 crisis had an effect on the green premium.

Table 7 – Descriptive statistics of the green premium (after 2020)

	Min	1st Quart.	Median	Mean	3rd Quart	Max	Std. Dev
$\hat{p}_i$	-0.5439%	-0.0173%	0.0016%	0.001%	0.0321%	0.3624%	0.118%

Table summurizing the distribution of the variable $\hat{p}_i$ (only for bonds that where already available before 01/01/2020 but only using observations after 01/01/2020)

Figure 4 – Distribution of the Green Premium (after 2020)



Histogram graph (50 buckets) summurizing the distribution of the variable p_i (only for bonds that where already available before 01/01/2020 but only using observations after 01/01/2020)

We finally investigate whether the ownership of dark-green bonds differs from that of otherwise similar green bonds. We are specifically interested in the role played by investors who have signed to UNPRI. Table 8 shows the average holding size of the top investors for the bonds included in our sample.

Table 9 – Descriptive statistics of Ownership Data (Top 20 Owners)

	Min	1st Quart.	Median	Mean	3rd Quart	Max	Std. Dev
All owners	0.120	2.358	5.645	11.010	14.668	68.850	13.518
UNPRI Owners	0.050	1.000	3.220	7.720	8.500	60.000	11.931

Table summurizing the distribution of the total Percentage Outstanding Owned by the Top 20 Owners (from Bloomberg) for the bonds in our sample. Data is in percentage. We have ownership data for 124 bonds.

To understand whether UNPRI signatories effectively prefer to hold green bonds we study the percent holding of investors of the tree categories of bonds that we have identified: Dark green, Medium & Light Green and Comparable conventional bonds. It turns out that UNPRI investors represent 75.2% of the top 20 holder's ownership of Dark green securities and 60.4% of Light & Medium green securities. Also, they hold 59.0% of the comparable conventional securities. This result seems to highlight that UNPRI investor prefer to hold green bonds but they also perform a thorough due diligence and end up holding a significantly higher percentage of Dark green bonds.

On the other hand, UNPRI investors seem to treat Light & Medium green bonds as equal to the conventional bonds. We have repeated the analysis also for bonds for which the top 20 owners represent at least more than 5% of the total ownership of the security and results do not change. Investors that are non-UNPRI hold only 24.8% of dark green bonds whereas hold 39.6% of L&M bonds and 41% of the conventional bonds. Table 9 shows that UNPRI investors have on average a significantly higher stake in dark-green bonds versus conventional bonds and light/medium-green bonds.

Table 9 – Bond Ownership by UNPRI Investors

	Dark green vs. Conventional	Light green vs. Conventional	Dark green vs. Light green
Mean Difference	16.24%***	1.37%	14.87%**
t-statistic	2.7144	0.2369	2.2676
p-value	0.0095	0.8135	0.0284

Table summarizing the Welch's t-test for mean differences: $t = \frac{\mu_1 - \mu_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$. Mean Difference is the difference between the average top 20 percentage ownership of UNPRI investors of the two categories: $(\mu_1 - \mu_2)$ where μ_1 corresponds to the first category appearing in the column title.

It is also worth looking at the growth in ownership of green bonds compared to conventional bonds rather than the absolute percentage ownership of these bonds. This analysis shows that non-UNPRI tend to hold more conventional bonds that green. Their percentage holding of dark-green bonds is 40% lower than their percentage holding of dark-green bonds. On the contrary, UNPRI investors have a 27% higher percentage ownership of dark-green bonds than of conventional bonds.

To get more granular results, we study how dark-green bonds' ownership is affected by the kind of climate-related investment tools/frameworks adopted by UNPRI signatories. We specifically observe from the UNPRI survey whether signatories reported the adoption of any of 14 different climate risk related tools. Table 10 shows the average ownership of dark, light/medium and comparable bonds of both the investors that replied True and False to the various questions about the adoption of the different tools.

The most interesting aspect that we can study is the growth in ownership with respect to the comparable bond for the two categories. In particular, we notice that the categories of True respondents that have the largest increase in ownership of dark-green versus light/medium green are: *Setting carbon reduction targets for portfolio, Target setting for emission risk reduction, Encourage internal/external portfolio managers to monitor emission risks, Formal contracts to integrate climate in external investments*. On the other hand, there are categories that have a higher percentage ownership of light/medium-green than dark-green, in particular: *Sought climate policy change with policymakers* and *Scenario testing*.

Table 11 shows that the UNPRI investors who answered True to the various questions on average prefer to hold green bonds over comparable conventional bonds: their percentage ownership of dark-green bond is 69% higher than their ownership of conventional bonds. On the other hand, for non-UNPRI investors, the percentage holding of dark-green bonds is 40% lower than the conventional bonds' one. This might explain why we do not find a strong evidence of green premium in our dataset. Non-UNPRI investors hold a larger share of conventional bonds counterbalancing the effect of the green bond excess demand attributable to UNPRI investors. As we saw this effect might have been accentuated by the COVID-19 crisis.

Table 8 – Percentage Ownership of the tree bond typologies for the respondents of the UNPRI Survey

	True Dark	True Light	True Comp	False Dark	False Light	False Comp
Setting carbon reduction targets for portfolio	0.1685	0.1180	0.0520	0.5838	0.4856	0.5379
Established climate change sensitive asset allocation strategy	0.0296	0.0271	0.0176	0.7227	0.5765	0.5724
Targeted low carbon/climate resilient investments	0.1583	0.1952	0.1167	0.5940	0.4083	0.4733
Reduce portfolio exposure to emissions intensive holdings	0.2574	0.1867	0.1495	0.4949	0.4169	0.4404
Used emissions data or analysis to inform investment decisions	0.1340	0.1512	0.1266	0.6183	0.4524	0.4634
Sought climate change integration by companies	0.2019	0.1825	0.1490	0.5504	0.4211	0.4410
Sought climate policy change with policymakers	0.1060	0.1789	0.1019	0.6463	0.4247	0.4881
Carbon footprinting	0.2426	0.2350	0.1491	0.5097	0.3686	0.4408
Scenario testing	0.0470	0.0650	0.0033	0.7053	0.5386	0.5866
Disclosure on emission risk	0.1609	0.1578	0.1017	0.5914	0.4458	0.4882
Target setting for emission risk reduction	0.1342	0.0930	0.0668	0.6182	0.5106	0.5231
Encourage internal/external portfolio managers to monitor emission risks	0.2510	0.1162	0.1261	0.5013	0.4874	0.4638
Formal contracts to integrate climate in external invest	0.0076	0.0042	0.0014	0.7447	0.5993	0.5885
Emissions risks monitoring/reporting are formalized into contracts when appointing managers	0.0000	0.0000	0.0000	0.7523	0.6036	0.5899

Table summurizing the mean percentage ownership of the UNPRI investors that have replied to diffent questions posed in the UNPRI survey. The second column is the percent holding of Dark Green bonds of the investors that replied True to the question in the first column. The third and fourth columns are the percent holding of Medium/Light Green bonds and Comparable bonds for the same investors respectively. The last 3 columns report the same statistics but for investors that replied False to the question in column 1.

Table 9 – Growth in percentage ownership of green bonds over conventional bonds for the respondents to the UNPRI survey and non-UNPRI (Null) investors

	True Dark	True Light	True Comp	False Dark	False Light	False Comp	Null Dark	Null Light	Null Comp
Mean	195%	201%	/	21%	-5%	/	-40%	-3%	/
Median	69%	55%	/	23%	-5%	/	-40%	-3%	/

The first 6 columns show the average growth in ownership of green bonds compared to conventional bonds. For each of the lines in Table 7 we calculate the growths as [True Dark/True Comp – 1] and [True Light/ True Comp – 1] (this procedure is repeated for both the True and False respondents). We then calculate the Median and Mean of each of the columns (14 datapoints per column). The last 3 columns report the same result but for non-UNPRI investors (Null response).

6. Conclusions

With the exponential growth of green bonds and a larger variety of sustainable fixed income securities available in the market, investors are exercising greater scrutiny on the green credentials of issuers. Several initiatives have been launched in order to set standards for the correct labelling and certification of bonds' greenness. The 'Green Bond Principles' (GBPs) promoted by ICMA are the most widely accepted standards to promote the integrity of the green bond market. the GBPs encourage green bond issuers to seek external reviews about the issuance process and use of proceeds. According to the GBPs, there are four types of external reviews: second-party opinion, verification, certification, and green rating. As an emerging practice, external reviewers are allocation a shade of green judgment to express the quality and quantity of the expected environmental benefits associated with each green bond issue.

However, the extent to which investors do care about the different shades of green of bonds is understudied. We study the bonds that received a second opinion by CICERO an independent research centre that attributes a shade of green label to bond issues on the basis of the environmental short to long term footprint of the project financed with the green bond issuance proceeds. By matching these green bonds with otherwise similar non-green bonds we find that there is no "greenium" for the dark-green nor for the light/medium green bonds. Hence, the yield and pricing of the bonds in the market do not seem affected by the greenness degree of the securities. Our findings are in line with Larcker and Watts (2020) who do not find consistent evidence of any greenium for US green municipal bonds. In terms of asset pricing, not only the green label does not have implications on the yield and price of the bonds, but also the shades of green are not reflected in differential pricing of sustainable fixed income securities.

Our sample is limited in size but the choice of focusing on one provider of shades of green labels grants internal data and measurement consistency. Along Dorfleitner et al. (2020), future research

should explore whether the shades of green labels granted by the various second-opinions providers are really meaningfully consistent and comparable.

We find that the dark-greenium is time-variant and increasing over time. This might be due to the fact that investors are getting more attentive and sophisticated in assessing the environmental benefits associated with green-labelled assets. Therefore, they are over time more willing to forgo a financial return (lower yield) in exchange for more climate-resilient assets.

We find strong evidence that investors committed to integrate sustainability in their portfolio decisions own relatively more dark-green bonds in way that is economically and statistically significant. This is confirmed by a granular analysis of the reported answers to the UNPRI survey about the adoption of specific tools and frameworks such as carbon footprinting and scenario analysis. Institutional investors who reported adopting climate-aware investing tools do actually hold more dark-green bonds in their portfolios. We are not able to establish a causal relationship between the bonds having obtained a dark-green second-opinion judgment by CICERO and the higher stake held by responsible investors. It is possible that climate-aware investors did carry a due-diligence autonomously and purchased more of the green bonds with strongest environmental credentials and objectives. However, our analysis reveals a strong preference of responsible investors for dark-green bonds, while the light/medium-green bonds appear to be treated like non-green bonds as far as ownership can tell.

In the last decade, green bonds have become increasingly appealing as an asset class to investors (Krueger et al., 2020). Our results also have policy implications as the shades of green do matter for investment decisions although they are not priced differently in the market. Independent external

reviews appear can help reducing information asymmetry between green bond issuers and investors.

Thus, the regulatory standard and frameworks should be encouraged and offer more granular assessment of the environmental quality of the projects financed via green bonds. An important step

would be the homogenization, disclosure and enhanced comparability of the assessment criteria and metrics adopted by independent green bond reviewers.

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