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Do the Shades of Green Matter? The Pricing and Ownership of "Dark-green" Bonds

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Abstract

With the growth of green bonds as an asset class, the certification of the climate footprint of projects financed via those bonds is becoming more sophisticated. We investigate the pricing of the bonds with the highest climate impact rating, namely the "dark-green" bonds. We find that on average dark-green bonds are not priced differently from otherwise similar non-green or light-green bonds. However, we show that the ownership of dark-green bonds significantly differs from that of other 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, they 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

Green bonds are a relatively new type of bond 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 exclusively to finance environment-friendly projects, primarily related to climate change mitigation and adaptation initiatives.

The literature has already extensively investigated whether financial markets price green bonds differently from otherwise similar non-green bonds. However, the empirical evidence about the existence and magnitude of a green premium (or "greenium") is far from unanimous (MacAskill et al., 2021). In 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. In 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. Baker et al. (2018) in their study of US municipal bonds find a greenium associated with green bonds in comparison to similar non-green ones; for the same market Larcker and Watts (2020) find no greenium at all.

This paper explores whether the degree of greenness matters for the pricing and ownership of bonds. Using the green labels released in second opinions by the Center for International Climate Research (CICERO), a leading independent research institution dedicated to environmental research, we quantify the "green bond premium" as the difference between the yields of matched conventional and green-labelled bonds. On a cross-sectional average, dark-green and light/medium-green bonds experience no yield premium.

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 in the 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 into a tangible premium as far as the bond pricing is concerned.

Our paper is structured as follows. Section 2 discusses the role of finance and green securities in channelling public and private resources to the financing of the transition towards a low carbon economy; the main contributions on green bonds pricing and ownership are also discussed. In Section 3, the data is presented. Section 4 illustrates the methodology for the greenium estimation and shows the findings about the relation between distance to default and emission levels. Section 5 presents some additional robustness tests. Section 6 discusses the main findings and concludes.

2. Literature review

While most countries committed under the Paris Agreement to limit global temperature rise, how the world achieves that ambitious goal is still being debated by economists and policy-makers. The Intergorvemental Panel on Climate Change (IPCC) in 2018 found that "rapid, far-reaching and unprecedented changes in all aspects of society" must happen to ensure that temperature targets are achieved. Those changes will require profound transitions in land, energy, industry, buildings, transport, and cities. The financial system will be crucial to support and accelerate investments in the clean energy and technologies needed to decarbonise the economy. This is the reason 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℃ above pre-industrial levels.

IPCC (2018) estimates that those "finance flows" will amount to about US$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), which estimates US$103 trillion of additional investments will be required between 2016 and 2030 to meet global development needs in a way that is climate compatible. McKinsey (Woetzel et al., 2016) anticipates cumulative needs for about US$49 trillion, excluding primary energy and energy efficiency, between 2016 and 2030. Bhattacharya et al. (2016) estimate these infrastructural needs to be between US$75 trillion and US$86 trillion, including primary energy and energy efficiency. All the estimates imply that a large portion of the global financial system will need 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 considered among the key instruments to mobilise private financial resources towards the progressive decarbonisation of the global economy (World Bank, 2015; OECD, 2017).

Green bonds are assumed to be the financial instrument that will play a major role in financing the transition towards a low-carbon economy. The literature has already explored the extent to which green bonds are priced differently from otherwise similar bonds. Zerbib (2019) has analysed the green bond advantage by focusing on 135 investment grade green bonds issued worldwide. The paper shows that bondholders pay 8 basis points (statistically significant) to buy green bonds after issuance. Evidence has been collected for non-corporate issuers as well. Karpf and Mandel (2017) investigated green and conventional bonds in the US municipal bonds market and found that green bonds seem to be penalised 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 the issuers improve their environmental performance post issuance, also experiencing an increase in ownership by long-term and green investors.

However, the evidence 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) is still mixed (MacAskill et al., 2021; Zerbib, 2019; Gianfrate and Peri, 2019). The paradigmatic contrasting evidence 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.

Bachelet et al. (2019) find that certification of bonds' "greenness" affects the greenium apparently because reputation and green third-party verifications can reduce informational asymmetries and the risk of perceived 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), where investors can find it 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 investors by providing a benchmark for quality. However, Reed et al. (2019) criticise 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.

Deng et al. (2020) use Chinese green bonds to study the relationship between greenness and green bond prices. Because bond proceeds in China are not entirely used for green projects, the fraction of proceeds used for green project is an alternative measure for bond greenness. Deng et al. (2020) show that the bonds whose proceeds are fully used for green projects do enjoy a greenium. On the other hand, Tang and Zhang (2020) study the ownership of green bond issuers and find that institutional investors increase their equity holding of green bond issuers after green bond issuance announcement.

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 specialised 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 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 from that of light/medium-green bonds and conventional bonds? In particular, we study whether investors who have explicitly committed to integrate climate considerations in their portfolio decisions invest relatively more in the dark-green fixed-income securities.

3. Data and Methodology

3.1 Data

Our dataset relies on the Second Opinions produced by CICERO. The Norwegian independent research company specialises in providing second opinions for green bonds issuances, and is among the pioneers and leaders in the industry (Dorfleitner et al., 2020). CICERO assesses how well a green bond aligns with a low-carbon resilient scenario 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 in the long-term.

Also, these projects remain exposed to physical and transitional climate risks and 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 that 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 are the best fixed-income securities in terms of climate impact and resilience. Our research specifically explores whether the green bonds rated "dark green" by CICERO are priced differently from ones that are similar except for the degree of greenness. The ratings are freely available on CICERO's website.

To estimate the green premium, we follow the methodology used by Zerbib (2019), which matches 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.

Our initial dataset comprises 296 bonds rated Dark green and 3694 conventional bonds from the same issuers. A second dataset includes 255 bonds rated Light & Medium green and 2927 comparable conventional non-green bonds. Bond prices are from Bloomberg and 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. As for the daily prices, 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 bonds includes a total of 311 distinct ultimate owners.

We obtained the portion of the 2018 survey of UNPRI signatories that reports their dealings with climate change risks and opportunities. The survey respondents have a cumulated Assets under Management (AuM) of about US$71 trillion. Considering that some estimates[1] put the global AuM of such investors at about US$79 trillion, the survey can be considered a fair representation (about 90% of the world total). 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 risk considerations in its investment strategy and portfolio allocation.

3.2 Methodology

The first step consists of 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. We also include bonds that are not rated, ending up with a total of 148 triplets of bonds.

We linearly extrapolate or interpolate the comparable yield that a conventional bond with the same maturity as the green bond is expected to have. Empirically, we first identify the interpolating line for 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:

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

$$\hat{y}^{CB} = m * Maturity^{GB} + q$$

(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:

$$\Delta\hat{y}_{i,t} = y_{i,t}^{GB} - \hat{y}_{i,t}^{CB}$$

(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 it 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 reasons: first, to bring out the bond-specific time-invariant unobserved effect without imposing any distribution; second, to ensure strict exogeneity along unbiasedness and consistency of the estimator; and third, to grant that the difference in liquidity proxy is uncorrelated with the unobserved specific effects, so that 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:

$$\Delta\hat{y}_{i,t} = p_i + \beta\Delta Liquidity_{i,t} + \epsilon_{i,t}$$

(Eq. 3)

With

$$\Delta Liquidity_{i,t} = Liquidity_{i,t}^{GB} - Liquidity_{i,t}^{CB}$$

(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:

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

(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 $\Delta Liquidity_{i,t}$: it appears to be concentrated around zero with a low standard deviation which is also an indication of the good quality of the matching procedure.

Once we have 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

In this section we test 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 that of bonds similar except for the shade of green.

As a first step, because the variation of liquidity difference at the bond level explains part of the variation of yield difference, it is appropriate 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 summarising 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 (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 the results of Zerbib (2019).

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

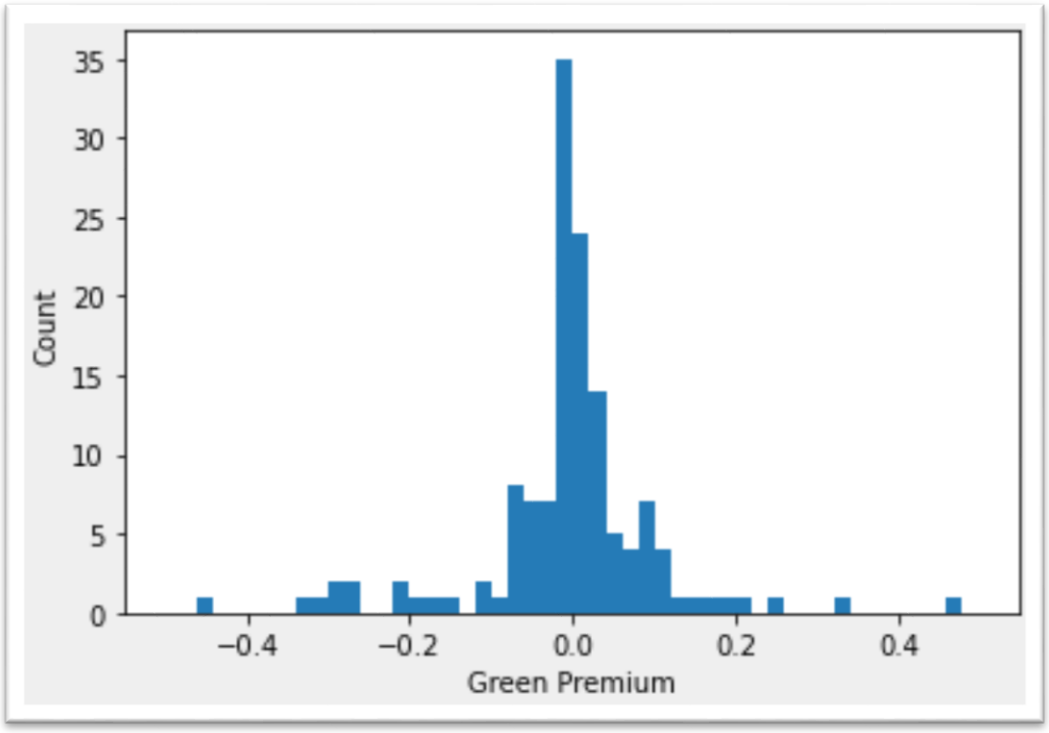
The independent variable $\Delta\hat{y_{i,t}}$ is the difference between Ask yields defined in Eq. 2ΔLiquidity is our liquidity proxy defined in Eq. 4. Standard errors in parentheses. Notation of the significance levels: *p<0.1; **p<0.05; ***p<0.01.

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



Histogram graph (50 buckets) summarising 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 removed the bonds triplets whose yield premiums were higher than 50bps or lower than -50bps. 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 issued in Euro and bonds issued 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	$\hat{p}_i < 0$	# GB
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), Currency, Rating, and Sector. In addition, 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

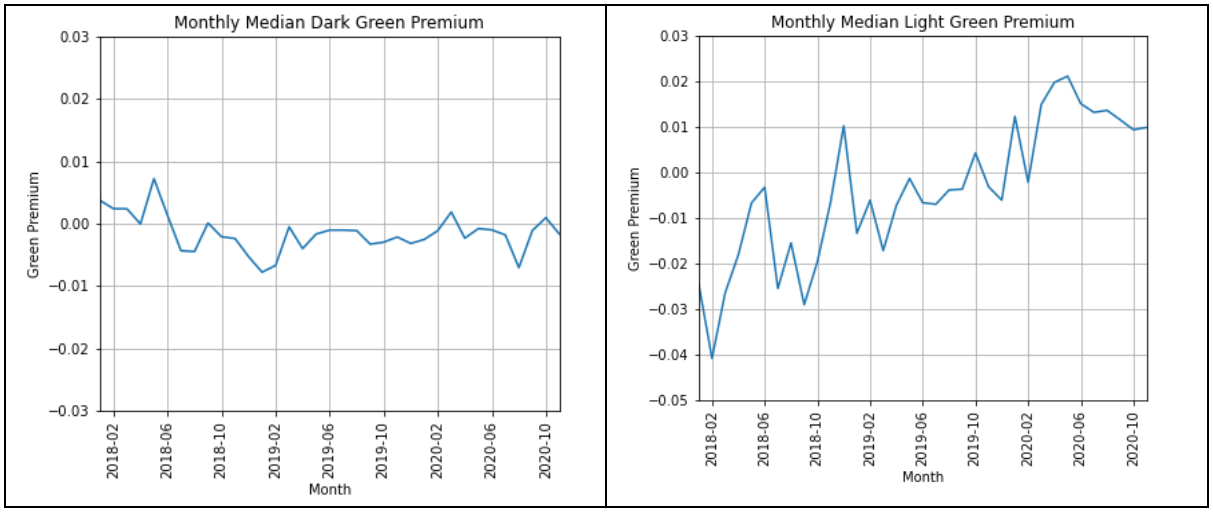
	Dependent variable: $\hat{p}_i$		
	1	2	3
Is_Dark_Green	-0.0364 (0.029)	-0.0439* (0.025)	-0.0079 (0.019)
Maturity_Ordinal	-0.0000 (0.000)		
Log_Amt_Out	0.006 (0.013)	0.0094 (0.012)	
Is_EUR	-0.0282 (0.082)	0.0644 (0.052)	
Is_SEK	-0.0156 (0.082)	0.0942** (0.038)	
Is_USD	-0.0908 (0.091)	0.0275 (0.051)	
Is_AUD	-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 that the median Dark green premium remains stable over time while the median Medium & Light green premium seems to increase.

Figure 2 – Evolution of Green Premiums over time



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.

First we 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

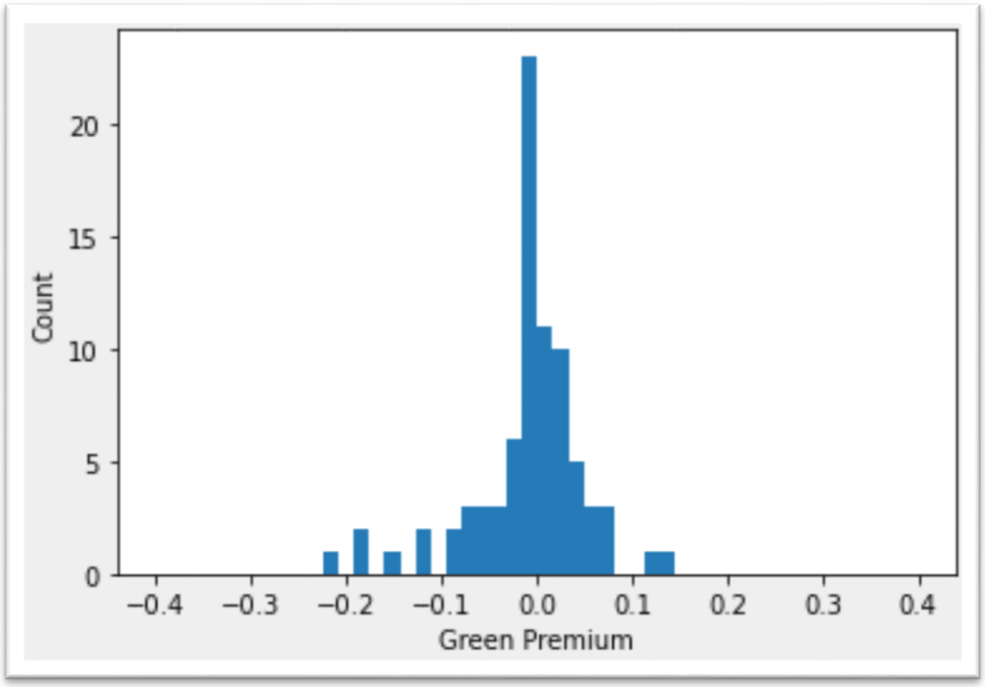
tells us that the mean is still not significantly lower than 0 but the p-value decreases to 0.135. In this case also the subgroups: bonds in EUR and Government Owned, No Guarantee are significantly lower than zero with a 95% confidence level.

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 summarising 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) summarising the distribution of the variable p_i (only for observations before 01/01/2020)

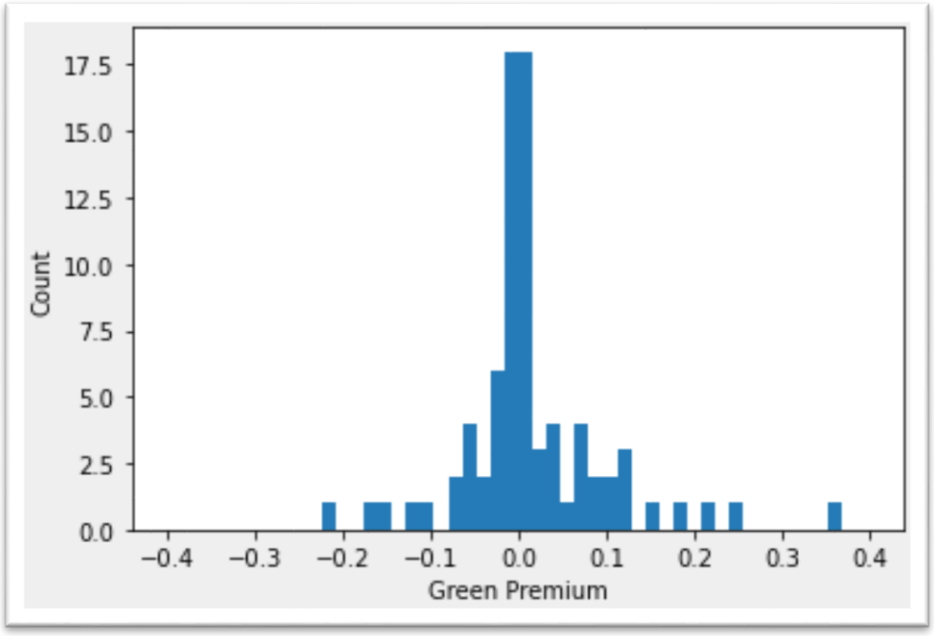
We can now study what happens to these 81 observations during 2020. As shown in Table 7, the average green premium is slightly positive and Figure 4 shows that the distribution of observation is more symmetric around 0, with larger positive observations. It appears that the COVID-19 crisis has an effect 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 summarising the distribution of the variable $\hat{p}_i$ (only for bonds that were 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) summarising 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 up to UNPRI thus committing to integrate climate concerns in their investment decisions (Gibson et al., 2020; Kim and Yoon, 2020). Table 8 shows the average holding size of the top investors for the bonds included in our sample.

Table 8 – 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 summarising 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 three categories of bonds that we have identified: Dark green, Medium & Light Green and Comparable conventional bonds. 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 supports the view that UNPRI investors prefer to hold dark green bonds rather than similar conventional bonds. On the other hand, UNPRI investors seem to treat lighter 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 5% of the total ownership and the results do not change. Investors that are non-UNPRI hold only 24.8% of dark green bonds but 39.6% of lighter green 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 lighter 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 summarising 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 investors 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. In contrast, UNPRI investors have a 27% higher percentage ownership of dark-green bonds than of conventional bonds.

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 allocating 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 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, it is not only the green label that 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 only on a single provider of second-opinion grants internal empirical validity and measurement consistency. Along the lines of Dorfleitner et al. (2020), future research should explore whether the shades of green labels granted by the alternative second-opinions providers are indeed meaningfully consistent and comparable.

We find strong evidence that investors committed to integrate sustainability in their portfolio decisions own relatively more dark-green bonds 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 out due-diligence autonomously ending up purchasing relatively more of the bonds with the strongest environmental credentials. 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 indicates.

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 can help in reducing the information asymmetry between green bond issuers and investors. Thus, better regulatory standard and frameworks should be encouraged. In particular, the shades of green approach could offer a more granular assessment of the environmental quality of the projects financed via green fixed-income securities. Important elements in that direction would be the homogenisation, the disclosure and the enhanced comparability of the assessment criteria and metrics adopted by independent green bond reviewers.

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