Green-labeled bonds and sustainable bonds: A missing puzzle piece

L.T. Ho [a], C. Gan [a], W. Yang [b] and S. Jin [a]

[a] Department of Financial and Business Systems, Faculty of Agribusiness and Commerce, Lincoln University, Christchurch, New Zealand; [b] Department of Global Value Chains and Trade, Faculty of Agribusiness and Commerce, Lincoln University, Christchurch, New Zealand
Email: Linh.Ho@lincoln.ac.nz

Abstract: Climate change and environment-related problems are major concerns globally. Stakeholders including governments, corporates, investors, and customers, play different roles in building a sustainable world. Their tasks are challenging because of limited financial resources. To finance activities that benefit the environment and minimise the severe impact of climate change, green-labeled bonds are one of the resolutions. With the green features, this type of fixed-income asset can signal investors and customers that the green bonds' issuers are doing "good" for the future. However, there are other bonds that also hold similar green features as green-labeled bonds, but they are not readily recognised in the bond market. This paper describes a procedure to classify a new category for green-unlabeled bonds and call this as sustainable bond. The performance of green-labeled and sustainable bonds are compared. Evaluating the bond performance underpins the greenium fundamental of green bonds, and provides insight into applications of the new sustainable bond category in the economy.

The Green Instrument Indicator (GII) is used to screen all green-labeled bonds (green bonds, hereafter) in the universal debt market on Bloomberg. Green bonds are issued by corporate, municipal, government, supranational, and multinational issuers. Sustainable bonds comprise all green-unlabeled bonds in the debt market that are identified and classified as climate bonds, sustainability bonds, and Environmental, Social, and Corporate Governance (ESG) bonds. We use three screening steps to identify sustainable bonds. First, we select climate bonds classified in the Bloomberg Industry Classification System (BICS). Second, we expand the screening criteria to the use of proceeds to screen sustainability bonds. Third, ESG bonds are selected using the management of proceeds (ESG) criterion. Based on data from 1 January 2012 to 30 November 2021, we obtained 4295 green bonds and 2955 sustainable bonds (1422 climate, 861 sustainability, and 672 ESG). Thus, 7250 bonds are used in this study.

We find that, in the short term, green-labeled bonds do not outperform green-unlabeled counterparts in terms of bond liquidity. In the long term, our result shows that green-labeled bonds are traded at 20 bps lower in terms of bond yields than green-unlabeled bonds. The result indicates the existence of a greenium effect between the two groups of green bonds: labeled and unlabeled. Our finding expands the current literature on the greenium phenomenon between green and vanilla bonds to the greenium effect that also holds within the green bond group. The pricing difference can be explained by a green label representing less information asymmetry on the greenness of bonds with lower potential environmental risk. Therefore, some investors prefer to pay a higher price for green labels. For the relationship between bond performance and bond features, our results reveal that the type of bond ownership plays a key role in explaining the performance of green bonds.

Keywords: *Sustainable bonds, green bonds, green-unlabeled bonds, green-labeled bonds, bond performance*

1. INTRODUCTION

Sustainable investment emerged in 1971 and has rapidly accelerated the interest of investors and organisations in the last several years (2017–2022). The negative externalities such as global warming and climate change that come with economic growth are one of the crucial challenges of this time. Thus, there is a need to reform the financial system to serve the needs of inclusive environmentally sustainable development progress. However, the lack of information is one of the obstacles that pause this progress (CFA Institute 2020). With the increase in demand for green finance and investment, especially in New Zealand and Australia, it is important to identify sustainable financial tools such as green-featured bonds and evaluate the performance of sustainable investments in the short and long term.

Green-labeled bonds (green bonds, hereafter) can signal investors that green bond issuers attempt to protect the environment and combat climate change. However, there are other bonds that hold the same green features as green bonds, but they are not readily recognised in the bond market. Therefore, this study attempts to explore green-unlabeled bonds by classifying a new bond category: sustainable bond. We compare the performance of green and sustainable bonds using the characteristics of the green bond ownership and investment grade.

The novelty of this study is twofold. First, a new sustainable bond category for green-unlabeled bonds is classified. The sustainable bond consists of three types of bonds: climate, sustainability, and ESG. Identifying sustainable bonds and evaluating their performance enable investors to recognise the green-alike assets and signal applications of the new sustainable bond category in the economy. Second, our study extends the research scope in green bond performance. We focus on both corporate and government green bonds while most previous studies mainly investigate the performance of either corporate (Russo et al. 2020; Zhou and Cui 2019) or municipal green bonds (Partridge and Medda 2020), not both together. We expand the sample size to 83 issuance countries and entities while previous studies only consider one country such as the United States (US) (Partridge and Medda 2020), China (Zhou and Cui 2019), or a limited number of countries (33 countries in Russo et al. 2020)). Further, we compare the green bond performance by bond ownership and investment grade. This comparison has not been investigated for green-featured bonds in the literature.

Based on data from 1 January 2012 to 30 November 2021, we obtained 7250 bonds (4295 green bonds and 2955 sustainable bonds). Our results show that both green and sustainable bonds attract higher interest from corporates than governments. The numbers of both green and sustainable bonds grew over time, especially during the COVID-19 period. Using generalized least squares (GLS) random-effects regression models, we find that green bonds underperform sustainable bonds in terms of bond liquidity and yield. Government bonds are more liquid than corporate bonds in the short term. Corporate green bonds and non-investment grade bonds are preferred as long-term debt assets because of higher expected returns.

The remainder of the paper is organised as follows. Section 2 provides the background of green finance and develops the hypotheses. Section 3 describes the methodology to classify green and sustainable bonds and investigate the bond performance. Section 4 presents the results and discussions. Section 5 concludes the paper.

2. BACKGROUND

The importance of green finance has steadily blossomed over the past few years and has emerged as a key topic in the new policy dynamic promoting sustainable development. It involves improving the natural environment and solving pollution, global warming, climate change issues, etc. Green finance products consist of existing and emerging green products, and other green financial solutions (Hayes and Jafri 2020). The existing green products comprise green bonds and green equity funds.

Empirically, there is growing attention on the topic of green-labeled bonds. Green-labeled bonds are identified using labeling standards. The labeling standards identify green bonds using the Green Bond Principles (GBP), self-labeled on Bloomberg, and the Climate Bonds Standard developed by the Climate Bonds Initiative (CBI). The latest version of Climate Bonds Standard in 2019 (CBI 2019a) provides a Green Bond Framework using the core components of the GBP. Both bond issuers and investors benefit from the Climate Bonds Standard because it enhances the strengthened disclosure and green definitions, and ensures green debt products meet the labeling requirements and the goals of the Paris Climate Agreement (CBI 2019b). Although the labeling standards are updated frequently, not all bonds with green features are recognised. Green-unlabeled bonds indicate green or climate-aligned bonds that have not been identified and labeled although they meet the criteria of the latest Climate Bonds Standard of 2019 and the latest Climate Bonds Taxonomy of 2021.

A green label is an indicator of a bond's environmental risk, which is similar to the credit rating used to assess credit risk in the conventional bond market. Compared with green-unlabeled bonds, green-labeled bond issuers may signal relatively lower environmental risk because they are required to disclose more information about

their greenness to receive a label, third-party opinion, external assessment, and certificate (Hyun et al. 2021). Although green-unlabeled bonds do not have an official tag, they are issued by institutions that engage in business activities aligning with environmental concerns. However, studies on the performance of green-labeled and unlabeled bonds are limited. Pham (2016) conducted a volatility analysis using S&P green bond indices from 2010 to 2015. The author's results demonstrate that the green-labeled bond sector experiences a greater volatility clustering effect than green-unlabeled bonds. Using propensity score matching, Hyun et al. (2021) explore the pricing difference between green-labeled and unlabeled bonds. Although the two types of green bonds have similar characteristics, green-labeled bonds are traded at 24-36 bps lower, in terms of yield, than their unlabeled counterparts. Given the scarcity of existing studies, whether green-labeled bonds can generate higher returns and economic benefits than green-unlabeled bonds is catching researchers' attention.

The green bond markets are exposed to significant challenges of inconsistency in evaluating the green performance of firms, different definitions of corporate greenness, and lack of data (Gilchrist et al. 2021). The performance of green bonds is evaluated using different measurements of daily returns and bond yields. For example, using daily returns of green bonds, Yousaf et al. (2021) find that green bonds outperform the securities markets and serve as a safe haven asset during the S&P500 index's downturns and the COVID-19 pandemic period. Using bond yields, Partridge and Medda (2020) find that green municipal bonds outperform their conventional counterparts in the US from 2014 to 2018, and the significant green premium (greenium) presents in the secondary municipal bond market.

Existing studies mainly focus on the pricing and the performance of green bonds compared with conventional bonds. Pricing differences relate to the concept of green premium, negative premium, or greenium. According to EIB (2021), greenium occurs when the green bond yield is lower than the vanilla (non-green) bond yield. However, the greenium phenomenon is ambiguous. For instance, using the yield term structure, Karpf and Mandel (2018) find that green bond returns, on average, are 23 basis points (bps) lower than conventional bond returns. Baker et al. (2018) show that green bonds are issued at a premium with lower yields (after tax) than conventional bonds. EIB (2021) shows mixed evidence of greenium in the literature from 2015 to 2021. Among the 30 studies investigated by EIB (2021), 13 show evidence of greenium and 12 studies have mixed results of a positive and negative premium. Tang and Zhang (2020) find no evidence of the greenium phenomenon between corporate green bonds and comparable conventional bonds. Partridge and Medda (2020) show that there is no statistically significant difference in terms of liquidity between green and conventional bonds.

In addition, green bonds are issued across various institutions, industry types, and investment classes. There is a dearth of studies that break green bonds into different categories to examine the impact of bond characteristics on bond performance. For example, MacAskill et al. (2021) summarise that most studies advocate the existence of a green premium, especially for investment-grade bonds and government bonds (Hachenberg and Schiereck 2018; Zerbib 2019). Bachelet et al. (2019) explore the difference in green premium and liquidity among different issuer characteristics. The authors' results indicate that private green bonds have a positive premium and a much narrower liquidity advantage than their brown (non-green) bond counterparts, whereas institutional green bonds exhibit a negative premium and are significantly more liquid. Therefore, we explore whether green bonds' characteristics can explain some of the performance divergence, including the broader categories of green bonds, the characteristics of green bond ownership, and the specific investment grade, that might determine green bond performance. Therefore, we hypothesize the following relationships:

H1: Green-labeled bonds outperform green-unlabeled bonds.
H2: Government green bonds outperform corporate green bonds.
H3: Investment-grade green bonds outperform non-investment-grade green bonds.

3. METHODOLOGY

According to ICMA (2021a), the four core components of the GBP are: the use of proceeds; the process for project evaluation and selection; the management of proceeds; and reporting. The ICMA also developed two other guidelines: the sustainability-linked bond principles (SLBP) (ICMA 2021a), and the social bond principles (SBP) (ICMA 2021b). To capture any non-green-labeled but climate-aligned bonds, Partridge and Medda (2020) use the 'use of proceeds' information in the official statement of each bond. If a bond's use of proceeds meets the green labeling requirement of the GBP (2016 version), the bond is classified as a climate-aligned bond. The screening method of Partridge and Medda (2020) results in a bond database that consists of both green-labeled and non-green-labeled (climate) bonds in transport, water, energy, waste, and pollution control, and multi-sector categories. However, the use of proceeds is only one of four core components of the GBP. Therefore, it is important to expand the screening criteria to the other GBP components such as the management of proceeds. The expansion in screening criteria for the inclusion of both green-labeled and green-

unlabeled bonds supports issuers and investors in labeling green products and services, managing investment portfolios, completing reports, and satisfying external reviews.

We use data from Bloomberg from 1 January 2012 to 30 November 2021. To obtain data for both green-labeled and green-unlabeled bonds, we first screen all active corporate and government bonds using the Bloomberg SRCH (search) function for fixed-income assets. After screening for green-labeled bonds (to form the green bond group) using the Bloomberg Green Instrument Indicator (GII), we obtain 4325 securities as of 30 November 2021. With few issuances in 2008 (3 green bonds) and 2009 (5 green bonds) and no issuances in 2010 and 2011, our sample period is from 2012 to 2021 to minimise zero and blank data. After excluding all green bonds issued before 2012 and any upcoming issuances in 2022, the final sample of the green bond group has 4295 green-labeled bonds.

Next, to screen green-unlabeled bonds, all green-labeled bonds are excluded using the Bloomberg SRCH function to avoid any duplication of data, and the three-step screening procedure is used. First, we follow Partridge and Medda (2020) and select all bonds classified in the BICS industries of renewable energy, biotechnology, waste and environment services and equipment to screen for climate bonds. Second, we expand the screening criteria to the use of proceeds (sustainability bond/loan) to screen sustainability bonds. Third, ESG bonds are selected using the management of proceeds (ESG) criterion. The climate, sustainability, and ESG bonds form a new sustainable bond category. After excluding all bonds issued before 2012, we obtain 2955 sustainable bonds (1422 climate, 672 ESG, and 861 sustainability).

The GLS random-effects regression models are used to compare the performance of green and sustainable bonds between corporate and government bonds, investment-grade and non-investment-grade bonds, in the short and long term. GLS can control for heterogeneity (Russo et al. 2020) caused by observing the bond performance daily over the 10-year period because it can estimate unknown parameters given the correlation between the residuals in a linear regression model. To accommodate the time-invariant variables in our data (bond type, bond class, and bond grade), we use random-effects models because they are generalized more easily for data with more than two data levels than fixed-effects models (Rodrıguez 2012). Next, we conduct a random-effects linear regression with a first-order autoregressive process AR(1) to account for the panel data structure (T=2587 < N =7250 panel dataset) and autocorrelation. The variance inflation factor (VIF) analyses show all VIF values are less than the maximum threshold of 10 (Chatterjee & Price 1991), suggesting that potential multicollinearity among the independent variables has marginal effect on our estimates. We use the two-stage least squares (2SLS) with an instrumental variable approach to account for potential endogeneity for robustness check which shows consistent results in our analyses. To evaluate the bond performance in the short and long term, bond liquidity (*Liquidity*) and yield to maturity (*YTM*) are used as the dependent variables, respectively. Table 1 presents the variables' description and data sources. Equations (1) and (2) are the four-group-factor models of green bond performance:

$$Liquidity_{it} = \alpha + \beta_j Control_{j,it} + \mu Return_{it} + \gamma_j Bond_{j,it} + \theta_j Market_{j,it} + \varepsilon_{it} \quad (1)$$

$$YTM_{it} = \alpha + \beta_j Control_{j,it} + \mu Return_{it} + \gamma_j Bond_{j,it} + \theta_j Market_{j,it} + \varepsilon_{it} \quad (2)$$

Table 1. Variables description

No.	Variable	Group factor	Description	Note
1	Liquidity	Dependent	Closing yield-based bid-ask spread (short-term bond performance).	(1)
2	YTM	Dependent	Bid Yield to Maturity (YTM) (long-term bond performance).	(2)
3	Coupon	Control	Coupon rate in percentage.	(2)
4	Size	Control	Natural logarithm (ln) of issue amount in USD.	(1)
5	Term	Control	Term to maturity in years.	(2)
6	Return	Return	Daily return on bond investment = (Last ask price$_t$ – Last ask price$_{t-1}$)/Last ask price$_{t-1}$	(1)
7	Green	Bond	Dummy variable = 1 for Green-labeled bond, otherwise 0.	(1)
8	Climate	Bond	Dummy variable = 1 for Climate bond, otherwise 0.	(1)
9	ESG	Bond	Dummy variable = 1 for ESG bond, otherwise 0.	(1)
10	Sus	Bond	Dummy variable = 1 for Sustainability bonds, otherwise 0.	(1)
11	Class	Bond	Dummy variable = 1 for Corporate bond (including MULT and SNAT), otherwise 0.	(1)
12	Grade	Bond	Dummy variable = 1 for Investment-grade bond (Baa3 or BBB- & above), otherwise 0.	(1)
13	Industry	Bond	Category variable showing 11 BICS Level 1 industries. Communications=1, Consumer Discretionary=2, Consumer Staples=3, Energy=4, Financials=5, Government=6, Health Care=7, Industrials=8, Materials=9, Technology=10, and Utilities=11.	(1)
14	Economy	Market	Dummy variable equal to 1 for high income economy, otherwise 0.	(3)

Note: (1) Authors' calculations based on Bloomberg data; (2) Bloomberg; and (3) Authors' calculations based on the World Bank data.

4. RESULTS

A total of 7250 green and sustainable bonds are issued by 81 different countries and two international entities, viz., SNAT (supranational issuer) and MULT (multinational issuer or multinational enterprise). SNAT and

MULT are considered corporate bonds according to the Bloomberg screening criteria. Table 2 shows the total number of corporate bonds issued from 2012 to 2021, is more than six times that of government bonds. Both green and sustainable bonds attract higher interest from corporates than governments. The numbers of green-alike bonds rapidly increase over time, especially during the COVID-19 period (2020-2021). In terms of the income category, no green bonds are issued in the low-income economies. Most green and sustainable bonds are issued in the upper middle- and high-income economies. More green bonds are issued in the upper middle-income economies (747) than in the lower middle income economies (63). The numbers are about the same for sustainable bonds (446 and 372 in the lower and higher middle-income economies, respectively).

Table 2. Description of the green and sustainable bonds

Category	Bonds	Climate	ESG	Sus	Sustainable (unlabeled)	Green (labeled)	Total
		(1)	(2)	(3)	(4) = (1) + (2) + (3)	(5)	(6) = (4) + (5)
All	**Total**	**1422**	**672**	**861**	**2955**	**4295**	**7250**
Type	Corporate	1420	382	681	2483	3775	6258
	Government	2	290	180	472	520	992
Period	2012-2016	383	7	15	405	267	672
	2017-2019	524	89	159	772	1444	2216
	2020-2021	515	576	687	1778	2584	4362
Grade	Investment	245	402	534	1181	1858	3039
	Non-Investment	1177	270	327	1774	2437	4211
Region	East Asia & Pacific	358	342	411	1111	1226	2337
	Europe & Central Asia	261	184	181	626	2105	2731
	Latin America & Caribbean	102	19	47	168	186	354
	Middle East & North Africa	2	0	0	2	13	15
	North America	354	41	92	487	413	900
	South Asia	345	4	2	351	39	390
	Sub-Saharan Africa	0	4	6	10	34	44
	Unclassified Region	0	78	122	200	279	479
Income	Low	0	0	2	2	0	2
	Lower middle	348	5	19	372	63	435
	Upper middle	355	16	75	446	747	1193
	High	719	573	643	1935	3206	5141
	Unclassified	0	78	122	200	279	479
Industry	Communications	0	1	14	15	25	40
	Consumer Discretionary	0	24	53	77	173	250
	Consumer Staples	0	4	16	20	45	65
	Energy	775	0	0	775	273	1048
	Financials	0	243	399	642	1825	2467
	Government	0	369	300	669	816	1485
	Health Care	279	7	7	293	12	305
	Industrials	368	22	20	410	252	662
	Materials	0	0	14	14	96	110
	Technology	0	0	5	5	39	44
	Utilities	0	2	33	35	739	774

Note: ESG stands for Environmental, Social, and Corporate Governance. Sus stands for Sustainability. The industry category is based on the Bloomberg Industry Classification Systems (BICS) Level 1. Municipal bonds are excluded because they are issued only in the US.
Source: Authors' calculations using data from Bloomberg.

Table 3 presents the regression results of bond liquidity and bond yield. The wider a bid-ask yield spread is, the less liquid a bond is in the short term. Therefore, the significant positive coefficients of green dummy variable in model (1) provide strong evidence that green bonds are less liquid than sustainable bonds in the short term, which does not support our H1. The coefficients of ESG and Sus (-0.0472 and -0.0426, respectively) in model (2) confirm that ESG and sustainability bonds are more liquid than other bond types in the short term. In the long term, the negative impact of green labeling on bond performance persists. The results for bond yield in models (3) and (4) show green bonds underperform all types of sustainable bonds. The finding signals that holding a green bond that is readily recognised on the debt market with a label is expected to yield a lower return than holding a green-but-unlabeled bond in the long term. In line with Hyun et al. (2021), we find that the yield spread between green-labeled and green-unlabeled bonds in model (3) is about -20 bps. The result indicates the existence of a greenium effect between the two groups of green bonds: labeled and unlabeled. Our finding expands the current literature on the greenium phenomenon between green and vanilla bonds on the greenium effect that also holds for the green-featured bond groups.

For the impact of bond ownership on green bond performance, the findings are mixed. In the short term, the significant coefficients of the class dummy variable in model (1) indicate that government green bonds are more liquid than corporate green bonds. However, the results in models (3) and (4) suggest corporate green

bonds actually yield a higher expected return (YTM) than government green bonds in the long term. Therefore, we reject H2. Interestingly, we find that the corporate-government liquidity difference falls in the range of 1-2 bps in the short term, and the corporate-government yield premium is 18 bps to 23 bps in the long term. Therefore, we conclude that the characteristics of bond ownership play a key role in the performance of green and sustainable bonds. Corporate green bonds perform better than government green bonds in the long term.

Table 3. Regression results

	GLS RE				RE AR(1)			
Variable	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Liquidity	Liquidity	YTM	YTM	Liquidity	Liquidity	YTM	YTM
Coupon	0.0149***	0.0127***	0.820***	0.824***	0.0153***	0.0131***	0.823***	0.828***
	(0.000739)	(0.000753)	(0.0108)	(0.0111)	(0.000764)	(0.000787)	(0.0115)	(0.0119)
Size	-0.00587***	-0.00611***	-0.141***	-0.140***	-0.00598***	-0.00617***	-0.134***	-0.133***
	(0.000785)	(0.000773)	(0.0114)	(0.0114)	(0.000813)	(0.000809)	(0.0123)	(0.0122)
Term	-0.00299***	-0.00316***	0.00474	0.00540	-0.00300***	-0.00315***	0.00491	0.00555
	(0.000300)	(0.000296)	(0.00439)	(0.00438)	(0.000311)	(0.000310)	(0.00471)	(0.00471)
Industry	0.000945	0.000325	-0.0222**	-0.0225***	0.000911	0.000311	-0.0229**	-0.0228**
	(0.000595)	(0.000589)	(0.00864)	(0.00867)	(0.000616)	(0.000616)	(0.00928)	(0.00932)
Return	0.000029	0.000029	0.00589*	0.00589*	-0.000252***	-0.000252***	-0.0675***	-0.0675***
	(0.000209)	(0.000209)	(0.00318)	(0.00318)	(0.000048)	(0.000048)	(0.000260)	(0.000260)
Class	0.0115***	0.00202	0.182***	0.228***	0.0114***	0.00207	0.178***	0.225***
	(0.00352)	(0.00361)	(0.0513)	(0.0532)	(0.00365)	(0.00378)	(0.0551)	(0.0573)
Grade	-0.00648**	-0.00212	-0.137***	-0.133***	-0.00622**	-0.00206	-0.159***	-0.158***
	(0.00268)	(0.00267)	(0.0390)	(0.0395)	(0.00279)	(0.00280)	(0.0421)	(0.0425)
Economy	-0.0351***	-0.0365***	-0.338***	-0.341***	-0.0341***	-0.0355***	-0.321***	-0.322***
	(0.00311)	(0.00307)	(0.0454)	(0.0453)	(0.00323)	(0.00321)	(0.0488)	(0.0488)
Green	0.0282***		-0.199***		0.0281***		-0.184***	
	(0.00252)		(0.0366)		(0.00262)		(0.0396)	
Climate		0.00226		0.165***		0.000927		0.137**
		(0.00365)		(0.0537)		(0.00380)		(0.0569)
ESG		-0.0472***		0.374***		-0.0471***		0.361***
		(0.00387)		(0.0569)		(0.00408)		(0.0622)
Sus		-0.0426***		0.104**		-0.0421***		0.102*
		(0.00338)		(0.0500)		(0.00357)		(0.0547)
Constant	0.184***	0.233***	3.428***	3.157***	0.185***	0.233***	3.299***	3.038***
	(0.0154)	(0.0154)	(0.224)	(0.227)	(0.0159)	(0.0161)	(0.240)	(0.243)
Observations	1,618,275	1,618,275	1,602,379	1,602,379	1,618,275	1,618,275	1,602,379	1,602,379
Number of id	4,102	4,102	4,069	4,069	4,102	4,102	4,069	4,069

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. GLS RE: The Generalized Least Squares random-effects regression. RE AR(1): The random-effects linear regression with a first-order autoregressive AR(1) process.
Source: Authors' calculations.

In terms of the investment grade, our results support H3 that investment-grade green bonds outperform non-investment-grade bonds in the short term (see Table 3). Investment-grade green bonds have tighter bid-ask spreads, meaning that they are more liquid in the debt market than non-investment-grade green bonds. However, in the long term, the performance of investment-grade green bonds is less attractive than the non-investment-grade green bonds with an expected yield difference of -13 bps to -16 bps. This finding emphasizes that bond investors' demand for higher income (higher coupon rate) and greater expected return (higher YTM) to compensate for higher risk caused by the uncertainty of receiving future cash flows in the long term. In other words, when a green bond is closely attached to green features, it pays higher coupon rates to compensate for environmental and climate risks. Thus, the bond has a greater credit spread and lower credit rating or even falls in the non-investment-grade bond category. As a result, a non-investment grade bond is more preferred and traded as a long-term debt asset.

5. CONCLUSIONS

This study helps stakeholders to recognise green-unlabeled bonds by classifying a new bond category, sustainable bond. Identifying sustainable bonds and evaluating their performance enable investors to recognise the green-alike assets and signal applications of the new sustainable bond category in the economy. Using the GLS random-effects regression models, we compare the performance of 4295 green bonds and 2955 sustainable bonds by bond ownership and investment grade. The results show that both green and sustainable bonds attract higher interest from corporates than governments. The numbers of both green and sustainable bonds grew over time, especially during the COVID-19 period. Green bonds underperform sustainable bonds in terms of bond liquidity and yield. The result indicates the existence of a greenium effect between the two

groups of green bonds: labeled and unlabeled. Although government bonds are more liquid than corporate bonds in the short term, corporate bonds and non-investment grade bonds outperform in the long term.

Our findings provide valuable insights for investors, governments, and bond issuers. Expanding the screening criteria for green-unlabeled bonds supports stakeholders in identifying and labeling green-alike assets, managing investment portfolios, completing reports, and satisfying external reviews. For investors, although green-labeled bonds trade at a premium, a green label indicates less information asymmetry and low environmental risk exposure and protects investors from green-washing.

We investigated only the nexus between bond features and their performance. Future studies could examine the performance of green and sustainable bonds across industries and geographic regions. It is also interesting to investigate the short-term and long-term effects of the COVID-19 pandemic and political sanctions (e.g., the Russia-Ukraine war) on the green bond markets. These future research directions will trigger interesting applications of investors' curiosity such as whether green and sustainable bonds can be added to investment portfolios to hedge downside risk, and which types of green and sustainable bonds in which industries can have resilience effects to form a diversified portfolio.

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