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GREENWASHING IN THE CORPORATE GREEN BOND MARKETS

Key points:

- *Green bonds are debt instruments that the proceeds are committed to fund assets or projects that would bring positive environmental benefit, but whether the corporate issuers will deliver on their promise to reduce greenhouse gases (GHG) emissions is far from certain. Some firms may just reap the benefits from issuing green bonds without taking tangible actions to cut down GHG emissions, acting inconsistently with the initiative of the green bond issuance. Investors may take these mixed signals as evidence of greenwashing behaviour. This does not only impede progress in combating climate change, but could also pose financial stability implications. Specifically, a widespread of greenwashing issuers may trigger an abrupt sale and repricing of green bonds, as well as set off a chain of spillover effects on other green asset classes.*

- *Based on a novel dataset, we found that greenwashing is not uncommon in the global green bond market, as about one-third of corporate green bond issuers are found to have a poorer environmental performance after their initial green bond issuance. Nevertheless, we found that greenwashing behaviour has, to some extent, been penalised by market participants, as greenwashing firms are found to be less likely to issue green bonds again, or have to pay higher issuance costs even if they are able to re-issue green bonds.*

- *Besides, our finding shows that the establishment of well-defined green bond taxonomies and improvements in environmental disclosure requirements could further mitigate greenwashing behaviour. These would be important policy implications for policymakers to consider when designing relevant regulations to mitigate greenwashing and foster a healthier green bond market development.*

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1. INTRODUCTION

"It's now or never, if we want to limit global warming to 1.5℃; without immediate and deep emissions reductions across all sectors, it will be impossible"

-Jim Skea, Intergovernmental Panel on Climate Change, 2022.

Greenhouse gases (GHG) from human activities have been recognised as the most significant driver of climate change since the mid-20th century (United States Environmental Protection Agency, 2022). As climate change continued to intensify over past decades, there are growing evidences that the Earth has been taking revenge against us, as climate disasters including heat waves, droughts, hurricanes and floods have inflicted humanitarian crisis and economic damage with increasing frequency, scale, as well as intensity (United Nations Office for Disaster Risk Reduction, 2018; World Economic Forum, 2019). The impacts of climate change on natural and human systems could become irreversible if the world still does not take immediate action (The Intergovernmental Panel on Climate Change, 2022). Fortunately, human beings have assembled to battle against global warming. For instance, the Paris Agreement, which is the first binding international treaty on climate change, would require transformation of economic sectors to achieve carbon neutrality by mid-century (United Nations, 2022). [1]

In financial industry, regulators and financial institutions have also been contributing to this goal by designing various financial innovations to facilitate efforts to combat global warming. One notable innovation is green bonds, which are debt instruments that the proceeds are committed to fund assets and/or projects that would bring positive environmental benefit (Climate Bonds Initiative (CBI), 2020; International Capital Market Association (ICMA), 2021). Being the two most reputable organisations that offer best practice guidelines of debt instruments, CBI and ICMA define projects bringing positive environmental benefits as those that can foster a low carbon or a net-zero emissions economy (CBI, 2021; ICMA, 2021). CBI also stated that, as of early 2022, climate change is the environmental objective with most coverage across well-developed taxonomies in the world (CBI, 2021). All these suggest that

[1] The Paris Agreement was adopted by 196 Parties at 2015 United Nations Climate Change Conference in Paris. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels, so as to achieve a climate neutral world by mid-century.

reducing GHG emission, so as to tackle climate change, is a crucial environmental objective of green bonds.[2] [3]

Yet, whether green bond issuers would deliver on their promise to reduce GHG emission is far from certain. Some firms may just reap the benefits from issuing green bonds without taking tangible actions to cut down GHG emissions, acting inconsistently with the initiative of the green bond issuance. Investors may take these mixed signals as evidence of "greenwashing" behaviour (Rajwanshi, 2019; Lau et al, 2022). Not only would greenwashing impede the progress in combating climate changes, but it could also pose financial stability implications. Given that investors have taken account of environmental or sustainability factors in their investment goals (see for example, Hartzmark and Sussman, 2019; Chan et al, 2020), the unveiling of a firm's greenwashing behaviour may lead to an abrupt sale and repricing of its green bonds by investors. If a large number of green bond issuers are identified as greenwashing firms, this may trigger a massive capital exodus and hence sharp price correction in the green bond market. Furthermore, this may also set off a chain of spillover effects on other green asset classes, such as green equities, green index funds, ESG/SRI funds. As investors have become more concerned about the sustainability challenges facing the world today and accorded more importance to pro-environmental motives in their investment, these possible implications on financial stability could become increasingly pronounced and frequent.

Empirical research on the actual environmental contribution and financial stability implications of the green bond market development remains in its infancy. Therefore, this paper contributes to the literature by filling this gap. Three research questions will be studied as follows. First, we would study to what extent greenwashing behaviour prevails in the global green bond market. In specific, we will identify greenwashing firms in the sampled green bond issuers if they do not see an improvement in their environmental performance after their issuance of green bonds. Second, we would examine to what extent

[2] Green bonds belong to one out of five themes of sustainable debt (Climate Bonds Initiative, 2021). The other four are social bonds (proceeds to be used in social projects), sustainability bonds (proceeds to be used in both green and social projects), sustainability-linked bonds (bonds' payoffs are linked to entities' pre-set sustainability performance target) and transition bonds (proceeds to be used to finance activities that would result in short-term or long-term decarbonisation). Except for social bonds, the other three themes are also targeted to environmental improvement. Yet, they are not included in this study as data are limited due to market immaturity (sustainability bonds are captured by CBI since 2020; sustainability-linked bonds and transition bonds are captured since 2021).

[3] Existing literature also echoes this suggestion. For example, Fatica and Panzica (2021) find that 80% of the proceeds raised by green bonds are used to fund projects with the purpose of climate change mitigation.

the market could identify and penalise those greenwashing firms. Finally, we would evaluate whether policy measures such as green bond taxonomies and disclosure requirement are effective in mitigating greenwashing behaviour.

We observe that greenwashing is not uncommon in the global green bond market, as about one-third of corporate green bond issuers are found to have a poorer environmental performance after their initial green bond issuance. Next, we find that greenwashing behaviour have been penalised by market participants to some extent, as greenwashing firms are found to be less likely to issue green bonds again and have to pay higher issuance costs even if they are able to re-issue green bonds, reflecting investors' lower willingness to invest in their bonds. Finally, we find that establishing a green bond taxonomy and enhancing environmental disclosure requirement in an economy could discourage green bond issuance by greenwashing companies there. By mitigating greenwashing behaviour, these policies could help contain risks to financial stability and foster a healthier development of green bond markets.

The remainder of the article is organized as follows. Section 2 examines our hypotheses and empirical methodology. Section 3 describes the data sources and the key features of our sample. Section 4 discusses the estimation results. Policy implications and conclusions are presented in section 5.

2. HYPOTHESES AND METHODOLOGY

This section examines the hypotheses and the empirical methodology used to answer our three research questions.

Hypothesis 1: Greenwashing behaviour exists for some corporate green bond issuers.

This hypothesis acts as a pre-requisite for the analysis in this article. If greenwashing behaviour does not prevail in the market, the related financial market instability implications would not be derived. Having said that GHG emission reduction represents a crucial objective of green bonds, we would determine whether greenwashing firms exist based on data of firms' GHG emission intensity. We hypothesize that some corporates do greenwash.

To test this hypothesis, we compare the change in average GHG emission intensity of a green bond issuer before and after initial issuance. If the issuer does greenwash, one would not expect any improvement in its environmental performance after green bond issuance (Flammer, 2021). In other words, if the average GHG emission intensity did not drop after the green bond issuance, the issuer could be classified as a greenwashing firm. On the contrary, if the average GHG emission intensity did drop after the green bond issuance, the issuer could be classified as a green firm.

We expect to observe the existence of some greenwashing firms in the markets. In other words, some corporates would exhibit a rise in average GHG emission intensity since their initial green bond issuance.

Hypothesis 2: Greenwashing behaviour is observed and penalised by market participants.

When greenwashing behaviour is observed, the market participants, especially those placing heavy weight on pro-environmental benefits, may penalise the greenwashing firms by selling the green bonds issued by those firms or refraining from buying more green bonds by them. The direct consequence is that this will lower the demand for green bonds by greenwashing firms, thereby making them more difficult or costly to re-issue green bonds.
To test this hypothesis, we will first evaluate the following model.

Model 2a:

$$Pr\left(D_i^{Seasoned} = 1 \middle| X\right) = \Phi(\beta_0 + \beta_1 D_i^{GW} + controls + industry\ fixed\ effects + time\ fixed\ effects + \varepsilon_i)$$

where Pr represents the probability function, $D_i^{Seasoned}$ equals 1 if the issuer of bond i is a seasoned issuer, meaning that the issuer has issued green bonds for more than once, while $D_i^{Seasoned}$ equals 0 otherwise. Φ is the cumulative standard normal distribution function. D_i^{GW} equals 1 if the issuer of bond i is classified as a greenwashing firm and equals 0 otherwise. $controls$ captures a battery of control variables, including both bond-specific and firm-specific factors that could affect corporates' debt financing decision. Essentially, bond size (in natural logarithm scale), currency denomination, market capitalization (in natural logarithm scale), return on assets, and price to book ratio are included. $industry\ fixed\ effects$ captures time-invariant unobserved factors

that could affect green bond re-issuance decisions while $time\ fixed\ effects$ captures entities-invariant unobserved factors that could affect green bond re-issuance decisions. ε is the error term.

If greenwashing firms are observed and penalised by the market, we expect that β_1 would be negative, implying that those firms are less likely to issue green bonds again as compared to green firms.[4] On the other hand, if greenwashing behavior is not observed (hence not penalised), we should not expect any difference in terms of likelihood for green bond re-issuance between these two types of firms.

Yet, even if we observe a negative association between greenwashing behavior and probability for a repeated issuance, it may not be sufficient to conclude that a lower likelihood of repeated issuance must be due to investors' punishment over the greenwashing behavior. In contrast, this may solely reflect that greenwashing firms have changed their preferred capital structure with less debt issuance due to some unobserved factors, irrespective of the market demand for their green bonds. If this is the case, one should expect the issuance cost of greenwashing firms would not deviate much from that of green firms in repeated issuance. Hence, we will then test the following model to investigate changes in issuance cost due to greenwashing behaviour.

Model 2b:

$$Greenium_i = \beta_0 + \beta_1 D_i^{GW} + \beta_2 D_i^{Repeated} + \beta_3 D_i^{GW} \times D_i^{Repeated} + industry\ fixed\ effects + time\ fixed\ effects + \varepsilon_i$$

where $Greenium_i$ refers to the difference in yields at issuance between a green bond i and a conventional bond with closest characteristics. $D_i^{Repeated}$ equals 1 if bond i is a repeated issuance, meaning that the issuer has issued a green bond before the green bond i is issued.

To construct $Greenium$, we matched every green bond to a conventional bond with the same issuer, same currency denomination, same credit rating, same maturity. Also, the conventional bonds must have their issue dates within one year from that of the green bond, and the same restriction is applied into the maturity dates. Finally, the bond size of the conventional bond cannot be smaller than 25% of the green bond or larger than 400% of the green

[4] We rule out the possibility that greenwashing firms are observed yet are not penalised by the market participants due to the existence of sustainability-conscious investors (see for example, Hartzmerk and Sussman, 2019; Krueger, Sautner and Starks, 2020; Chan et al, 2020).

bond. Similar matching method has also been adopted by Bachelet, Becchetti and Manfredonia (2019), Zerbib (2019) and Lau et al. (2022).

Theoretically, the greenwashing behaviour would arise only after the initial green bond is issued. If the market participants do discriminate against the greenwashing behaviour, we would expect greenwashing firms to see a positive value of β_3 in model 2b. This implies that the yield difference between a repeated green bond and a conventional bond will be larger for repeated green bonds issued by greenwashing firms. In this case, even if the greenwashing firms are able to issue repeated green bonds, they would have to bear a higher issuance cost. If this result (as well as that in model 2a) realised as expected, we would conclude that market participants could identify and penalise greenwashing firms. In contrast, if the market participants could neither observe nor penalise greenwashing behaviour, we would not expect β_3 in model 2b to be significantly different from zero.

Hypothesis 3: Greenwashing behaviour can be mitigated by the establishment of a green bond taxonomy and enhancement on environmental disclosure requirement.

The lack of global standardization in definition and measurement of green projects is commonly blamed for the pervasiveness of greenwashing behaviour in the market (The International Organization of Securities Commissions, 2021; Flood, 2022; Network for Greening the Financial System, 2022; Walton, 2022). As such, unscrupulous issuers might use the loopholes to take advantages of investors' favourable view of green products, yet without actually making any real impact towards environmental conservation (2º Investing Initiative, 2020). Therefore, implementation of government policies on setting up well-delineated green bond taxonomies may help mitigate greenwashing behaviour (Climate Bonds Initiative, 2021; Network for Greening the Financial System, 2022), as issuers have to follow what the taxonomies described in their use of proceeds, or else their bonds could not be classified as green bonds, regardless of their own labelling. Thus, the advantages reaped by greenwashing firms via green labels should be reduced.[5] Therefore, we hypothesize that the availability of a green bond taxonomy in a jurisdiction could

[5] Green taxonomy, not only benefit green bond market development, could also bring a greater good to the overall green finance markets. For example, Lee (2020) shows that a green taxonomy establishment could improve the robustness of green finance markets.

lower the probability of observing green bonds issued by greenwashing firms there.

To test this hypothesis, we will evaluate the following model.

Model 3a:

$$\Pr\left(D_i^{GW} = 1 \middle| X\right) = \Phi(\beta_0 + \beta_1 D_i^{Taxonomy} + controls + \varepsilon_i)$$

whereas $D_i^{Taxonomy}$ equals 1 if the national/regional government has implemented individual national policies on setting up certain eligibility, principles and/or standards in classifying green bonds, and equals 0 otherwise. In other words, this dummy variable indicates whether there exists a green bond taxonomy in the jurisdiction that the bond issuance takes place.

Furthermore, a loose environmental disclosure requirement also contributes to the formation of a hotbed of greenwashing behaviour, since greenwashing firms might again use the loopholes to simply provide misleading information regarding their environmental performance (de Silva Lokuwaduge and De Silva, 2022; Ferguson and Sparr, 2022). Therefore, a more comprehensive environmental disclosure requirement may help investors identify misleading information provided by the greenwashing issuer, which in turn helps them discriminate against the issuers. As such, we hypothesize that a more comprehensive environmental disclosure requirement is negatively associated with the probability of observing green bonds issued by greenwashing firms.

To test this hypothesis, we will test the following model.

Model 3b:

$$\Pr\left(D_i^{GW} = 1 \middle| X\right) = \Phi(\beta_0 + \beta_1 Disclosure_i + controls + \varepsilon_i)$$

whereas $Disclosure$ is measured by Trucost's weighted carbon disclosure ratio. It represents how comprehensively a company discloses relatively to the company's overall carbon impact (S&P Global, 2019). In order to avoid the endogeneity issue that firms could simultaneously choose the amount of

disclosure and GHG emission intensity, $Disclosure$ equals to the average disclosure score one year before the first issuance of green bond in our setting. [6]

In both models, $controls$ refers to a battery of control variables that potentially affect the greenwashing decisions. These include the dummy variable of whether the bond is listed on exchanges, time to maturity, firm size (in natural logarithm scale), and dummy variable of whether the firm is a financial firm.

We expect that β_1 in model 3a to be negative, implying that greenwashing behaviour could be mitigated by national/regional efforts in setting up green bond taxonomies. We also expect β_1 in model 3b to be positive, implying that greenwashing firms would also be mitigated when the disclosure is more comprehensive.

Besides, we expect that the coefficients for listing dummy, maturity and firm size to be negative, and the coefficient for financial firm dummy is positive. The rationale is that bonds which are listed on exchanges and firms with larger size should arouse more investors' concerns, thereby raising the expected cost of greenwashing. For maturity dummy, as environmental projects are generally long-term, it would be doubtful that a short-term green bond is sufficient to support a green project with significant environmental impact. For financial firm dummy, as it is relatively difficult for investors to identify a clear link between the green bonds issued by a financial institution and a specific green investment project, we expect the risk of greenwashing is higher for financial corporates (See Lau et al (2022), Fatica, Panzica and Rancan (2021) and Gianfrate and Peri (2019)).

3. DATA

We describe the data that are used in the analysis in this section.

a. Data sources

Bond-level data. We sourced the green bond data from four main green bond data providers, namely, Bloomberg, CBI, Dealogic DCM and

[6] The environmental disclosure requirements are generally mandatory in most of the economies in or sample. In fact, more and more economies in the world have set up or have been setting up compulsory environmental impact disclosure requirement for corporates (Carrots & Sticks, 2020).

Thomson Reuters Eikon. CBI is an international non-profit organization working to mobilise global capital for climate action through promoting investment in projects and assets necessary for a rapid transition to a low carbon and climate resilient economy. Bloomberg, Dealogic DCM and Thomson Reuters Eikon are the widely used financial data and service providers. In our setting, we identified green bonds as those classified by at least one of the four main green bond data providers.

Bonds issued by non-corporates, including bonds issued by government, development banks, and supranational organizations, as screened by the issuer's Bloomberg Industry Classification System, are excluded. To avoid duplication among data sources, bonds without International Securities Identification Number (ISIN) are excluded. Besides, we also exclude bonds issued by non-listed corporates since detailed firm-level and environmental data are available for listed companies only.

The above criteria yield a total of 1888 corporate green bonds, with the total issuance size about $591.14 billion, issued by 643 listed companies between 2013 and 2021. A battery of bond-level data, including issuance size (in terms of US Dollars), currency denomination, date of issuance, date of maturity, yield to maturity, listing of exchanges, existence of green bond certification, are also extracted. Majority voting rule was used whenever there are inconsistencies among various data source.[7]

Environmental data. We sourced the annual data of GHG emissions from Trucost.[8] Following the Greenhouse Gas Protocol (The Greenhouse Gas Protocol, 2022), a comprehensive global standardised framework was established to measure and manage GHG emissions. Trucost, a subsidiary of S&P Global that has been assessing risks relating to climate change, natural resource constraints, and broader ESG factors since 2000, provides annual data of all three scopes of GHG emissions for corporates. Trucost also provides firms' comprehensiveness of GHG disclosure. Ranging from 0% to 100%, the disclosure ratio is measured by the proportion of GHG emission

[7] For instance, assuming that two data sources reported the size of issuance to be $100 million while one data source reported to be $80 million, the value of $100 million would be taken. In the case that if there are inconsistency between two data sources, third-party securities database such as Clearstream and Euroclear would be referenced and act as the tie-breaker.

[8] GHG refers to the seven GHG covered by the Kyoto Protocol, i.e., carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride and nitrogen trifluoride (The Greenhouse Gas Protocol, 2022).

disclosed by the firm to total GHG emission estimated by Trucost. For example, if the firm's total GHG emission is estimated to be 100 tonnes of CO_2 equivalent while it reported as 10 tonnes of CO_2 equivalent, then the disclosure ratio would be equal to 10%. Thus, the higher the disclosure ratio, the more comprehensive is the firm disclosing its GHG emission data.

Scope 1 measures GHG emissions from sources that are owned or controlled by the company. Scope 2 measures GHG emissions from generation of purchased electricity consumed by the company. Scope 3 measures other GHG emissions from sources not owned or controlled by the company, yet they arise as a consequence of the company's activities. In practice, Scope 1 and Scope 2 GHG emission data are more widely used in the literature in the assessment of firms' GHG emissions performance due to a more comprehensive standardization and assessment. Therefore, this article adds up Scope 1 and Scope 2 GHG emissions to form the aggregate GHG emissions.[9] For the sake of comparability among firms, the aggregate GHG emissions is normalised by company's revenue. We matched the GHG emissions data to green bond issuers via the issuers' tickers. Since not all the firms present their GHG emission data, issuers without GHG emission data are excluded in our final sample. After merging the data, our final sample contains 371 firms, totalling 1371 green bonds.

Accounting data. To have a better model specification, we obtained other annual firm-level data from S&P Capital IQ which provides a wide variety of firm-level data. The main variables used in the analysis include firm size (as measured by natural logarithm of market capitalization), profitability (as measured by return on assets), and valuation (as measured by the price to book ratio).

b. Summary statistics

Table 1 describes the summary statistics of the sample.

Table 1: Summary statistics

Stat	Obs	Mean	Median	St. Dev.
Panel A: Bond-level data				
Size ($mn)	1371	335	140	437
Maturity (years)	1371	7.63	5.76	7.00
Yield at issuance (%)	1371	2.71	2.09	2.61
Listing (1/0)	1371	0.75	-	-

[9] Apart from academic literature, Basel Committee on Banking Supervision (Basel Committee on Banking Supervision, 2021) also documented that bank respondents look at Scope 1 and Scope 2 emissions data relatively more than Scope 3 emissions data.

Taxonomy (1/0)	1371	0.72	-	-
Greenium (%)	191	-0.25	-0.08	1.04
Panel B: Environmental data				
$\Delta Aggregate$ (tCO_2e/$mn)	371	-2.59	-0.86	248.10
Disclosure ratio	371	48.43	49.47	40.05
Panel C: Accounting data				
Firm size ($bn)	1371	855.21	347.24	4093.19
Profitability (%)	1371	1.00	1.60	4.75
Valuation	1371	3.90	1.28	6.78

Panel A describes several characteristics of green bonds. It can be seen that the average issuance size of green bond is about $335 millions. The average maturity is 7.63 years. Average yield at issuance is 2.71%. About 75% of the green bonds are listed in exchanges and about 72% of green bonds are issued by issuers domiciled at economies with national/regional policies on green bond taxonomy. Finally, the average and median Greenium is 25 basis points and 8 basis points respectively, implying that generally issuance cost of green bonds is lower than that of their conventional counterparts. The negative Greenium is in line with existing literature on green bonds pricing. Given that not all the green bonds are able to match with a conventional counterpart, the number of observations regarding Greenium is smaller than other bond level data. Specifically, among the 1371 green bonds, 191 of them are able to match with their conventional counterparts.

Panel B reveals the difference in average GHG emission intensity since the firm's initial green bond issuance, compared to the average GHG emission intensity before the initial green bond issuance over the period 2013-2021.[10] The negative values of median reflect that more than half of the firms exhibit a reduction in the two scopes of GHG emission intensity, though the magnitude of the reduction is relatively insignificant. Besides, as reflected by the large standard deviation compared to the value of mean, there is a large variation in terms of the changes in environmental performance. These might indicate that there is a tendency of greenwashing behaviour in some firms. In addition, it is also found that the average disclosure score is only about 48%, with a large standard deviation. These figures show that the environmental disclosure requirement is relatively loose across jurisdictions, such that most of the corporates do not adequately disclose their environmental impact.

[10] For instance, assuming a green bond was issued in 2017, we would compare the average GHG emission intensity during 2017-2021 with that during 2013-2016.

Finally, panel C briefly describes other firm-level accounting data. The average firm size is about $855.21 billion in terms of the market capitalization. Average profitability is about 1% in terms of return on assets, while the average price to book value is 3.9.

4. EMPIRICAL ESTIMATION

This section presents the empirical estimation of our hypotheses introduced in section 2.

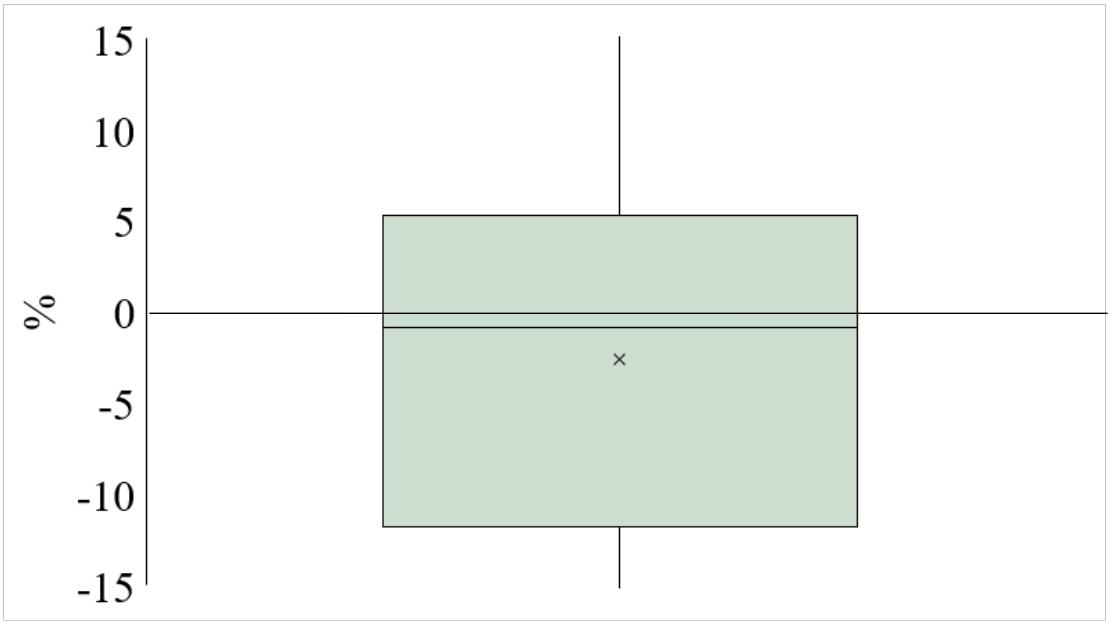
a. To what extent greenwashing behaviour prevail in corporate green bond markets.

As shown in the previous section, while more than half of the corporates in our sample see a reduction in GHG emission intensity, the magnitude of decline is relatively small. Besides, the large dispersion suggests that some corporates see a deterioration in the performance of GHG emission reduction, suggesting the existence of greenwashing in some firms.

Chart 1 reveals the distribution of change in aggregate GHG emission intensity before and after the corporates issue their initial green bond between 2013 and 2021. As shown from the values of median, the chart suggests that the typical firm sees a reduction in average GHG emission intensity since their initial green bond issuance, which is in line with Flammer's finding that generally green bonds yield improvements in environmental performance (Flammer, 2021). Yet, it could also be seen that there are still a number of firms landing on the positive territories of the vertical axis, implying that these firms actually have a higher GHG emission intensity after their initial green bond issuance.[11] As these firms' GHG emission performances are inconsistent with the initiative of green bond issuance, these mixed signals could be taken as hard evidence that these firms are indeed greenwashing.

[11] Out of 371 firms, 149 of them see an increase in average aggregate GHG emission intensity after their initial green bond issuance.

Chart 1: Change in average aggregate GHG emission intensity



Source: Author's calculation based on Trucost.

Note: The horizontal line inside the box represents the median value.

With the evidence that some firms are using green bonds as a greenwashing tool, next we would explore whether the market participants would identify and penalise this behaviour. The major findings are presented below, and the technical details of the empirical models used are all available in Appendix A.

b. To what extent the market could identify and penalise the greenwashing behaviour.

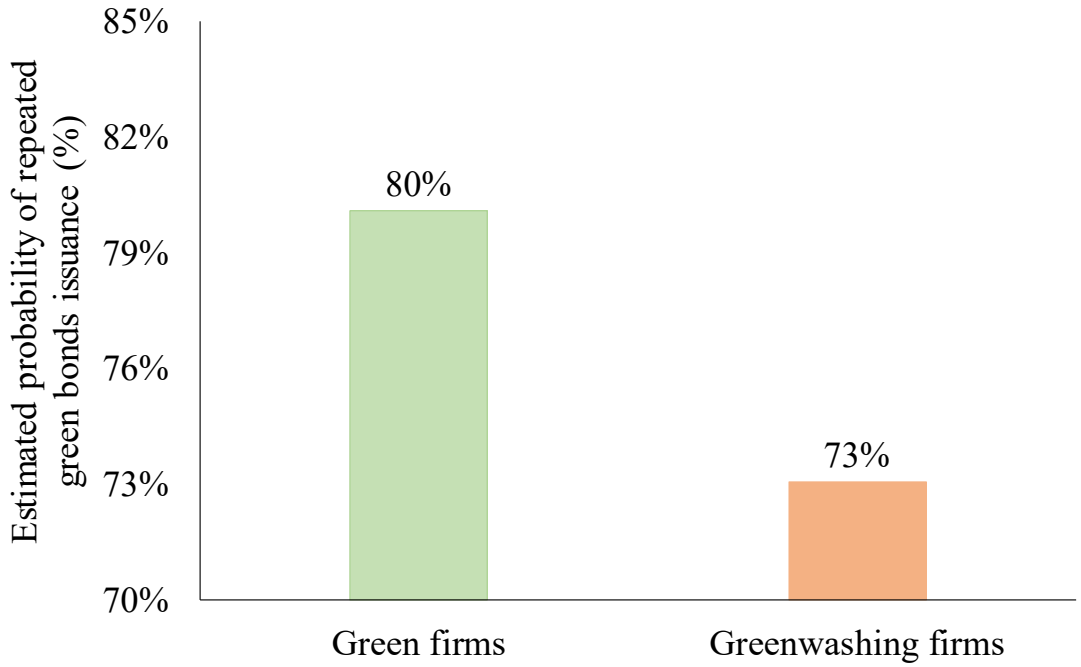
Given that we have identified the greenwashing firms in the preceding part, we would define the greenwashing dummy $D_i^{GW} = 1$ if the firm sees an increase in average aggregate GHG emission intensity since its initial green bond issuance (indicated as a greenwashing firm), and $D_i^{GW} = 0$ otherwise (indicated as a green firm).

Chart 2 reports the estimation result of model 2a. It could be seen that the likelihood of re-issuing green bonds is 73% for a typical firm if it is labelled as a greenwashing firm, about 7 percentage points lower than that for a green firm.[12] As mentioned previously, the lower likelihood to re-issue green

[12] Because the probit regression is nonlinear, the effect of the change in the explanatory variables depends on the initial value of the explanatory variables. A typical firm is defined as a hypothetical company with

bonds by a greenwashing firm could be explained by two reasons. First, as greenwashing behaviour is a nuisance to investors, they would be less willing to invest in green bonds issued by firms which are revealed to be greenwashing. With less demand for their green bonds, greenwashing firms could face higher issuance costs which would deter them from issuing green bonds again. Second, greenwashing firms may decide not to issue seasoned green bonds due to their own capital structure strategy, regardless of market receptiveness to their reissuance. As the latter case cannot be ruled out, we would proceed to study the market reaction to reissuance in the next part, with a view to drawing a conclusion on whether the market has been punishing greenwashing behaviour.

Chart 2: Estimation result of model 2a



Note: This bar chart depicts the estimated probabilities of repeated green bond issuances for green and greenwashing firms, by taking a typical firm (median values for all explanatory variables) for illustration.

To analyse market reaction to green bond reissuance by greenwashing firms, we could compare how reissuance costs of green bond will change for greenwashing and green firms, with estimation results displayed in Chart 3. Contrary to the green firms that can enjoy a larger Greenium on their repeated green bond issuance (more negative value of Greenium), it is observed that the repeated green bonds issued by greenwashing issuers are subject to

median values for all the explanatory variables (other than the greenwashing dummy) in the specified model. For more details, please refer to Stock and Watson (2012).

higher costs of issuance. Such higher issuance costs for green bonds by greenwashing firms reflect less favourable reception by investors, which should in turn dis-incentivise some greenwashing firms from re-issuing green bonds. This empirical evidence suggests that the lower likelihood for greenwashing firms to re-issue green bonds in model 2a could be attributed to investors' punishment, rather than simply the firms' internal capital structure decision.[13]

Chart 3: Estimated result of model 2b

Note: The bar chart depicts the impact of a typical firm to be a green firm versus a greenwashing firm on the Greenium of repeated green bond issuance. The Greenium is larger if the value is more negative.

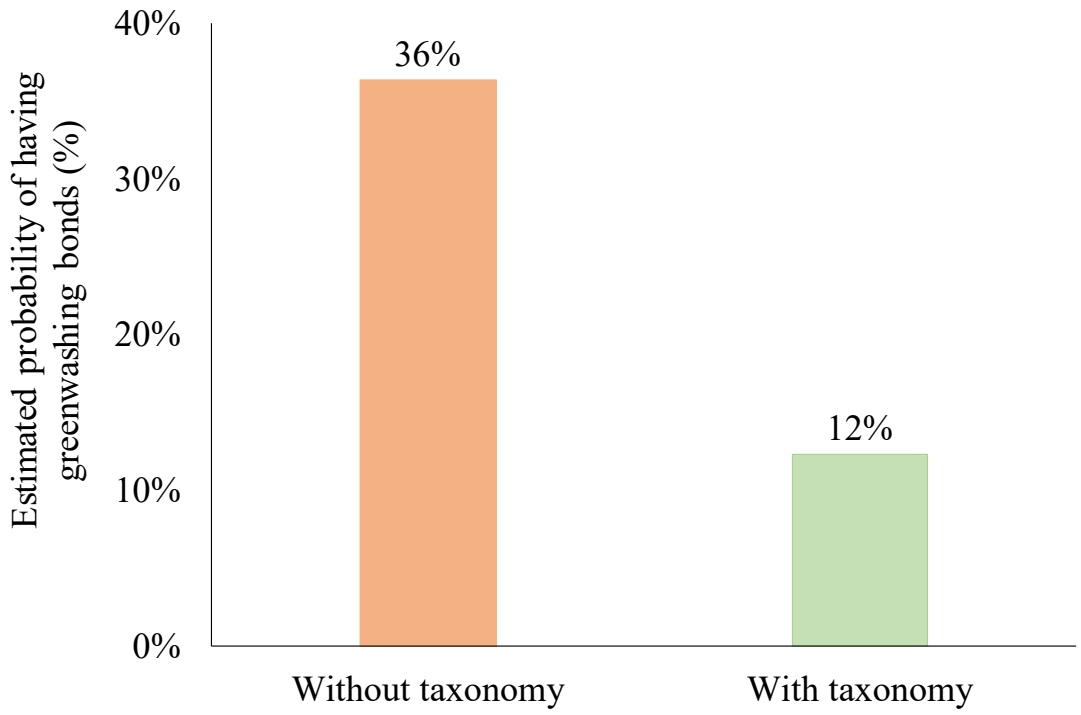
To recap, the above results show that greenwashing behaviour is observed and penalised by the market participants. As a result, greenwashing firms would find it harder to re-issue green bonds; and even if they could re-issue, the issuance costs would generally be higher.

c. Evaluation of greenwashing mitigation measures.

[13] Another evidence of the punishment exerted by the market is that in fact, the debt to capital ratio for greenwashing firm without repeated green bond issuance is not significantly lower than that of green firms. For example, the debt to capital is 1.29 for greenwashing firms without repeated green bond while the debt to capital ratio is 1.30 for green firms. This reflects that the demand for debt financing for greenwashing firms remains, yet they do so without using green bonds. This further suggests that the market has punished the greenwashing behaviour, such that greenwashing firms find it harder to re-issue green bonds.

This section will first evaluate the effectiveness of government effort in setting up green bond taxonomies on mitigating greenwashing behaviour. Chart 4 displays the estimation result of model 3a, which suggests that the probability of having greenwashing bonds in economies with a green bond taxonomy is lower, by 24 percentage points than those without. This result infers that a green bond taxonomy, which provides clearly-delineated standards for investors to better identify genuine green projects, would be instrumental in mitigating greenwashing behaviour.

Chart 4: Estimation result of model 3a

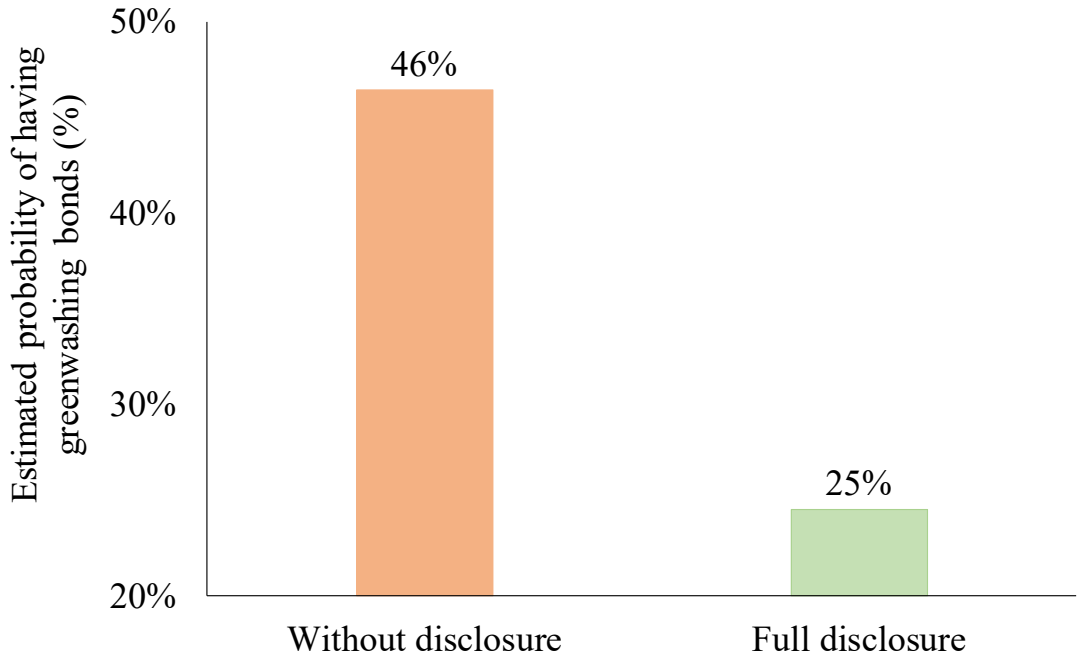


Note: This bar chart depicts the impact of having green bond taxonomies versus no green bond taxonomy on change in probability to have greenwashing green bond in an economy.

We will then turn to evaluate the effectiveness of environmental impact disclosure requirement in mitigating greenwashing behaviour. Chart 5 shows the estimation result of model 3b. It could be seen that a more comprehensive environmental disclosure is negatively associated with the probability of having greenwashing bonds in the economies. Specifically, it is estimated that the likelihood to have greenwashing green bond issued by firms with full disclosure is about 21 percentage points lower than those without. This suggests that a more stringent environmental disclosure requirement, which

should help investors make more informed decisions, could be useful in mitigating greenwashing behaviour.

Chart 5: Estimation result of model 3b



Note: This bar chart depicts the impact of having environmental performance disclosure on change in probability to have greenwashing green bond in an economy.

To sum up, the above results show that imposition of green bond taxonomies and more stringent environmental disclosure requirement, which should make issuers to disclose more accurately, could effectively mitigate greenwashing behaviour in corporate green bond markets.

5. CONCLUSION

Could corporate green bonds help tackle climate change? Yes, this is confirmed by the lower average aggregate GHG emission intensity since the corporates started issuing green bonds. However, sufficient progress may not have been made. Leveraging on multiple data sources, we reveal that some corporates merely use green bonds as a greenwashing tool, as reflected by a higher aggregate GHG emission intensity. This greenwashing behaviour might pose risks to financial stability, as well as impede the green bond market development and thus suffocate the progress in tackling climate change.

Nevertheless, the market seems to be able to observe and penalise some of these greenwashing behaviour. We have shown that green bonds issued by greenwashing firms are less welcomed by investors, thus lowering their re-issuance probability. Even if greenwashing firms could re-issue green bonds, such a lukewarm reception from market participants would impose a higher cost on their re-issuance.

Finally, this paper also provides empirical support on how a well-defined green bond taxonomy and a stricter requirement on environmental impact disclosure could mitigate greenwashing behaviour. These would be important policy implications for policy makers to consider when designing relevant regulations to curb this unscrupulous behaviour and foster a healthier development of green bond markets.

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Appendix A: Estimation results of the econometric models

This appendix covers the technical details of various empirical analyses discussed in Sections 4. The panel regression model used in each case is described below:

Table A1: Estimation result of model 2a

This Table shows the estimation result of model 2a.

$$Pr\left(D_i^{Seasoned} = 1 \middle| X\right) = \Phi(\beta_0 + \beta_1 D_i^{GW} + controls + industry\ fixed\ effects + time\ fixed\ effects + \varepsilon_i)$$

D_i^{GW} is the greenwashing dummy, classified by aggregate of Scope 1 GHG emission intensity and Scope 2 GHG emission intensity. Bond size and market capitalisation are in natural logarithm scale. Return on asset represents net profits to total assets in percentage form. Price to book is the market price per share divided by book value per share. The sample includes all bond-level observations from 2013 to 2021. Standard errors are reported in parentheses. The negative and statistically significant coefficient of D_i^{GW} in suggests that greenwashing firms were less likely to have repeated green bond issuance.

Dependent variable: $Pr\left(D_i^{Seasoned} = 1 \middle\| X\right)$	(1)
D_i^{GW}	-0.23**
	(0.10)
Bond size	-0.10**
	(0.05)
Market capitalization	0.10***
	(0.03)
Return on assets	-0.02
	(0.01)
Price to book	0.05**
	(0.02)
Constant	4.54
	(214.98)
Industry fixed effects	Yes
Time fixed effects	Yes
Currency denomination dummy	Yes
Observations	1230

Note: **p<0.05; ***p<0.01.

Table A2: Estimation result of model 2b

This Table exhibits the estimation result of model 2b.

$$Greenium_i = \beta_0 + \beta_1 D_i^{GW} + \beta_2 D_i^{Repeated} + \beta_3 D_i^{GW} \times D_i^{Repeated} + industry\ fixed\ effects + time\ fixed\ effects + \varepsilon_i$$

D_i^{GW} is the greenwashing dummy, classified by aggregate of Scope 1 GHG emission intensity and Scope 2 GHG emission intensity. $D_i^{Repeated}$ is a dummy variable capturing whether the green bond is classified as a repeated issuance. The sample includes all matched bond-level observations from 2013 to 2021. Green bonds that cannot be matched with conventional counterparts are dropped. Standard errors are reported in parentheses. the positive and

significant coefficients of $D_i^{GW} \times D_i^{Repeated}$ suggest that repeated green bonds issued by greenwashing issuers are subject to higher costs of issuance.

Dependent variable: $Greenium_i$	(1)
D_i^{GW}	-0.29
	(0.28)
$D_i^{Repeated}$	-0.41*
	(0.24)
$D_i^{GW} \times D_i^{Repeated}$	0.72**
	(0.34)
Industry fixed effects	Yes
Time fixed effects	Yes
Observations	191
R^2	0.11

Note: *p<0.1; **p<0.05.

Table A3: Estimation result of model 3a

This Table shows the estimation result of model 3a.

$$\Pr(D_i^{GW} = 1|X) = \Phi(\beta_0 + \beta_1 D_i^{Taxonomy} + controls + \varepsilon_i)$$

D_i^{GW} is the greenwashing dummy, classified by aggregate of Scope 1 GHG emission intensity and Scope 2 GHG emission intensity. $D_i^{Taxonomy}$ is the dummy variable representing whether the issuer of green bond i is domiciled in an economy with a green bond taxonomy. $D_i^{Listing}$ is the dummy variable capturing whether the green bond i is listed on exchanges. Maturity measures the duration it takes for the bond to mature. Firm size is in natural logarithm scale. $D_i^{Financials}$ is the dummy variable capturing whether or not the issuer of green bond i belongs to financial corporates classified by the Bloomberg Industry Classification System (Bloomberg, 2015). The sample includes all bond-level observations from 2013 to 2021. Standard errors are reported in parentheses. The negative and significant coefficients of $D_i^{Taxonomy}$ suggests that the probability of having greenwashing bonds in economies with green bond taxonomy is lower.

Dependent variable: $\Pr(D_i^{GW} = 1|X)$	(1)
$D_i^{Taxonomy}$	-0.81***
	(0.08)
$D_i^{Listing}$	-0.24***
	(0.08)
Maturity	-0.00
	(0.01)
Firm size	-0.04**
	(0.02)
$D_i^{Financials}$	-0.03
	(0.09)
Constant	0.89***
	(0.23)
Observations	1346

Note: **p<0.05; ***p<0.01.

Table A4: Estimation result of model 3b

This Table shows the estimation result of model 3b.

$$\Pr(D_i^{GW} = 1 \big| X) = \Phi(\beta_0 + \beta_1 Disclosure_i + controls + \varepsilon_i)$$

D_i^{GW} is the greenwashing dummy, classified by aggregate of Scope 1 GHG emission intensity and Scope 2 GHG emission intensity. $Discloure$ measures the proportion of GHG emission disclosed by the firm to total GHG emission estimated by Trucost. The sample includes all bond-level observations from 2013 to 2021. Standard errors are reported in parentheses. The negative and significant coefficients of $Disclosure$ suggests that the probability of having greenwashing bonds in firms with higher environmental impact disclosure is lower.

Dependent variable: $\Pr(D_i^{GW} = 1 \big\| X)$	(1)
$Disclosure$	-0.60***
	(0.08)
$D_i^{Listing}$	0.06
	(0.08)
$Maturity$	-0.01**
	(0.01)
Firm size	-0.04**
	(0.02)
$D_i^{Financials}$	1.03***
	(0.22)
Constant	1.03***
	(0.22)
Observations	1346

Note: **p<0.05; ***p<0.01.