

Different Shades of *Green*: Using Natural Language Processing to Estimate Green Bond Premium

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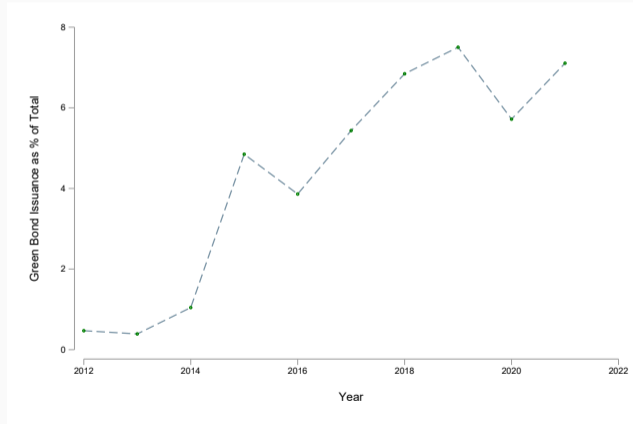
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Green financing: The green bond market

- Huge investments are needed to address climate change and transit to a low-carbon economy
- The **green bond market** is recently growing as a market where to raise green financing



- We know:
 - The **green label** to the debt instrument ensures that the issuer commits to finance projects with environmental benefits
 - Early stage evidence on a premium in the green bond market ([Baker, Bergstresser, Serafeim, and Wurgler 2018](#); [Zerbib 2019 JBF](#))
 - Recent evidence that green bonds do not trade at a premium ([Flammer 2021 JFE](#))
- **Little known** about the effects of the bond's *greenness* of the use of proceeds on its pricing
 - Is there heterogeneity among green bonds' use of proceeds?
 - Are investors overpaying for greener bonds?
 - Is there a premium for issuing greener bonds?

- Exploit cutting-edge Natural Language Processing (NLP) techniques to understand the motives for issuing green bonds and the pricing of green bonds instruments
 - Create the **Green Score** to quantify alignment to the Green Bond Principles standards
 - Use **within-issuer fixed effects** to control for issuer's unobservables and compare to conventional bond pricing

Evidence that issuing green bonds is associated with a premium that varies with the bonds' *greenness* of the use of proceeds and that is driven by interest cost savings

- **Premium** corresponds to a **decrease in the yield at issue by 12 percent**
- Evidence for the cost of capital motive to issue a green bond ([Flammer 2021 JFE](#))

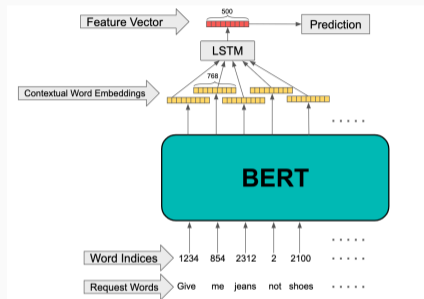
- **Green bonds:** Bloomberg Fixed Income database
 - Primary market data for green and conventional bonds, worldwide
 - Period: January 2012 - May 2021
 - All bonds issued by corporate, non-corporate, government, and supranational entities
- Hand-collected bond's prospectus, green finance framework, external reviewer's documentation; manually extract and match the use of proceeds
- We consider a **bond issuer** and a **common issuer** sample

▶ Summary statistics - Bond issuer

▶ Summary statistics - Common issuer

Using BERT to measure the bond's *greenness*

- **Challenge:** It is not easy to measure the bond's *greenness*
 - Each bond's prospectus has different text, financing purpose, transparency in language...
- We use the algorithm **BERT** to perform a **(con)textual analysis** of the green bonds' intended use of proceeds [▶ More](#)
 - Create the **Green score**, or the degree of similarity between use of proceeds and the Green Bond Principles scheme (**ICMA**) [▶ More](#)
 - Values range [0;1] (=1 a perfect alignment to the Green Bond Principles) [▶ More](#)



Results

Is there a premium for issuing greener bonds?

	Yield at Issue (pp)			
	(1)	(2)	(3)	(4)
Green Score	-1.814*** (0.338)	-0.853*** (0.126)	-0.432*** (0.111)	-0.475*** (0.113)
Industry FE	N	Y	Y	N
Currency FE	N	Y	Y	Y
Rating FE	N	Y	Y	Y
Issue size FE	N	Y	Y	Y
Year FE	N	N	Y	N
Industry \times Year FE	N	N	N	Y
Controls	Y	Y	Y	Y
R^2	0.146	0.700	0.731	0.740
Mean dependent variable	3.922	3.922	3.922	3.922
Observations	52,212	51,808	51,808	51,808

Companies that issue a green bond enjoy a premium that varies with the bond's *greenness* \rightarrow
 Lower yield at issue by 12.4% compared to the mean

Interest savings drive the premium for greener bonds

Panel A. Coupon Rate (pp)

	(1)	(2)	(3)	(4)
Green Score	-1.952*** (0.161)	-0.563*** (0.079)	-0.150** (0.069)	-0.150** (0.070)
Industry FE	N	Y	Y	N
Currency FE	N	Y	Y	Y
Rating FE	N	Y	Y	Y
Issue size FE	N	Y	Y	Y
Year FE	N	N	Y	N
Industry × Year FE	N	N	N	Y
Controls	Y	Y	Y	Y
R ²	0.015	0.733	0.776	0.783
Mean dependent variable	3.683	3.683	3.683	3.683
Observations	45,034	44,763	44,763	44,762

Panel B. Zero Volatility Spread (bps)

	(1)	(2)	(3)	(4)
Green Score	-0.617 (0.684)	0.538 (0.592)	0.723 (0.598)	0.863 (0.604)
Industry FE	N	Y	Y	N
Currency FE	N	Y	Y	Y
Rating FE	N	Y	Y	Y
Issue size FE	N	Y	Y	Y
Year FE	N	N	Y	N
Industry × Year FE	N	N	N	Y
Controls	Y	Y	Y	Y
R ²	0.993	0.993	0.993	0.993
Mean dependent variable	122.091	122.091	122.091	122.091
Observations	41,360	41,100	41,100	41,099

Annualized yield at issue ↓ as a consequence of ↓ interest cost

Do firms enjoy a green premium when compared to their conventional bonds?

	Yield at Issue (pp)			
	(1)	(2)	(3)	(4)
Green Score	-1.439*** (0.212)	-1.198*** (0.143)	-0.921*** (0.163)	-0.222*** (0.076)
Issuer FE	N	N	N	Y
Currency FE	N	Y	Y	Y
Rating FE	N	Y	Y	Y
Issue size FE	N	Y	Y	Y
Year FE	N	N	Y	Y
Controls	Y	Y	Y	Y
R^2	0.043	0.453	0.485	0.675
Mean dependent variable	2.737	2.737	2.737	2.737
Observations	8,898	8,866	8,866	8,830

Greener bonds have lower annualized yields at issue by 8.03% as compared to conventional bonds issued by the same issuer

- We provide evidence of a green bond premium that varies with bonds' *greenness* of the use of proceeds
- Our novel measure, the Green score, assess the contextual similarity between the issuers' use of proceeds and the Green Bond Principles standards
- Bond issuers of greener bonds enjoy a decrease in the annualized yield at issue by 12 percent on average
- The green premium is primarily driven by cost savings rather than differentials in bonds' riskiness
- Additional results on firm heterogeneity, spillover effects on bond pricing

Appendix

Bond issuer sample: Summary statistics

	Obs.	Mean	Std. Dev.	Min.	Max.
Panel A: Bond issuer sample (issuing both green and conventional bonds)					
Green Score	58,500	0.02	0.12	0	0.88
Yield at Issue (yearly %)	57,848	3.92	3.26	0	16.84
Coupon Rate (yearly %)	54,627	3.68	2.92	0.05	13.50
Zero Volatility Spread (bps)	43,651	122.09	160.30	-92.90	873.20
Green Bond (0/1)	60,079	0.06	0.23	0	1
Price at Issue	53,823	99.58	1.86	85.14	101.88
Duration	49,213	4.89	5.16	0.02	25.07
G-Spread (bps)	43,252	127.99	158.37	-126	877
I-Spread (bps)	44,064	121.27	160.41	-104.80	867.60
Corporate (0/1)	60,079	0.48	0.50	0	1
Panel B: Green bond sample (green bonds issued by bond issuers)					
Green Score	1,780	0.70	0.09	0.18	0.88
Yield at Issue (yearly %)	1,137	2.45	2.18	0	12.88
Coupon Rate (yearly %)	3,201	2.46	2.26	0.05	13.50
Zero Volatility Spread (bps)	2,728	100.51	147.41	-92.90	873.20
Green Bond (0/1)	3,359	1	0	1	1
Price at Issue	2,420	99.82	1.28	85.14	101.88
Duration	2,995	4.71	4.45	0.02	25.07
G-Spread (bps)	2,780	110.29	142.74	-126	877
I-Spread (bps)	2,780	96.74	144.56	-104.80	867.60
Corporate (0/1)	3,359	0.54	0.50	0	1
Panel C: Conventional bond sample (conventional bonds issued by bond issuers)					
Yield at Issue (yearly %)	56,711	3.95	3.27	0	16.84
Coupon Rate (yearly %)	51,426	3.76	2.93	0.05	13.50
Zero Volatility Spread (bps)	40,923	123.53	161.02	-92.90	873.20
Conventional Bond (0/1)	56,720	1	0	1	1
Price at Issue	51,403	99.57	1.88	85.14	101.88
Duration	46,218	4.90	5.21	0.02	25.07
G-Spread (bps)	40,472	129.20	159.32	-126	877
I-Spread (bps)	41,284	122.93	161.29	-104.80	867.60
Corporate (0/1)	56,720	0.48	0.50	0	1

Common issuer sample: Summary statistics

	Obs.	Mean	Std. Dev.	Min.	Max.
Panel A: Common issuer sample (issuing both green and conventional bonds)					
Green Score	9,729	0.09	0.23	0.00	0.88
Yield at Issue (yearly %)	9,232	2.77	2.41	-1.44	23.50
Coupon Rate (yearly %)	9,393	2.56	2.33	-0.07	22.62
Zero Volatility Spread (bps)	7,825	59.15	81.35	-1655.90	1110.10
Green Bond (0/1)	10,121	0.16	0.37	0	1
Price at Issue	9,572	99.42	5.34	8.42	128.98
External Certification (0/1)	10,121	0.03	0.18	0	1
Duration	8,275	5.39	5.53	0	53.44
G-Spread (bps)	8,009	72.77	144.79	-9427.50	1116.20
I-Spread (bps)	8,062	59.87	145.85	-9438.70	1104.60
Corporate (0/1)	10,121	0.59	0.49	0	1
Panel B: Green bond sample (green bonds issued by common issuers)					
Green Score	1,214	0.70	0.10	0.18	0.88
Yield at Issue (yearly %)	718	1.93	1.91	-0.28	11.99
Coupon Rate (yearly %)	1,528	1.69	1.80	-0.07	12.25
Zero Volatility Spread (bps)	1,357	56.46	90.66	-947	1110.10
Green Bond (0/1)	1,606	1	0	1	1
Price at Issue	1,289	99.34	5.53	29.50	107
External Certification (0/1)	1,606	0.20	0.40	0	1
Duration	1,438	5.57	4.87	0	53.44
G-Spread (bps)	1,386	73.41	135.38	-3570.90	1110
I-Spread (bps)	1,394	54.56	135.16	-3582.40	1102.70
Corporate (0/1)	1,606	0.51	0.50	0	1
Panel C: Conventional bond sample (conventional bonds issued by common issuers)					
Yield at Issue (yearly %)	8,514	2.84	2.43	-1.44	23.50
Coupon Rate (yearly %)	7,865	2.73	2.38	0	22.62
Zero Volatility Spread (bps)	6,468	59.71	79.26	-1655.90	1109.60
Conventional Bond (0/1)	8,515	1	0	1	1
Price at Issue	8,283	99.44	5.31	8.42	128.98
Duration	6,837	5.35	5.66	0	38.71
G-Spread (bps)	6,623	72.63	146.69	-9427.50	1116.20
I-Spread (bps)	6,668	60.98	147.97	-9438.70	1104.60
Corporate (0/1)	8,515	0.61	0.49	0	1

- We use pre-trained word embedding vectors to convert each word to its unique vector representation
- **This conversion is based on the context of each word in a specific sentence**
- Word embedding vectors [→] sentence vectors [→] document vectors
- BERT creates the cosine similarity between two vectors, which determines whether the vectors are pointing in the same direction and have similar sentiment

$$\text{CosSim}(C_{ji}) = \frac{u_{ji} \cdot g_i}{|u_{ji}| |g_i|} = \frac{\sum_d u_{j id} \cdot g_{id}}{\sqrt{\sum_d u_{j id}^2} \sqrt{\sum_d g_{id}^2}} \quad (1)$$

where:

- g is document vector for Green Bond Principles
- u are the document vectors for generated from individual sentence vectors (i) for each (j^{th}) document of "Use of Proceeds"
- d enumerates the elements of u and g

2. Use of Proceeds - Eligible Assets

Vasakronan's Green Finance Instruments raise funds for eligible new projects and existing buildings as well as renewable energy projects ("Eligible Assets") with environmental benefits.

Eligible Assets comprise a selected pool of assets funded, in whole or in part, by Vasakronan that promote the transition to low-carbon and climate resilient growth (the "Green Asset Pool").

Eligible Assets target climate change mitigation and adaptation, and include sustainable property development as well as high-performing existing buildings that are sustainably operated and maintained.

Vasakronan is aware that potentially, the greatest opportunity to reduce the built environment's impact on the climate, is through enhancing the operations and maintenance of existing buildings by lowering energy consumption, shifting to renewable energy sources and by combating emissions from transportation and travel to and from buildings.

List of Eligible Assets, the Green Asset Pool

(1) New construction and major renovations of buildings owned and managed by Vasakronan and/or its subsidiaries that have an energy performance¹ at least 25 percent below the maximum permitted in the building regulation (Swedish BBR code) valid at the time of approval by the Green Finance Committee (see Section 3 below) and that have or will receive a certification of either:

- » LEED New Construction or Core and Shell, minimum certification level "Platinum"
- » BREEAM New Construction, minimum certification level "Outstanding"

Green Bond Principles

- **Terrestrial and aquatic biodiversity conservation** (including the protection of coastal, marine and watershed environments);
- **Clean transportation** (such as electric, hybrid, public, rail, non-motorised, multi-modal transportation, infrastructure for clean energy vehicles and reduction of harmful emissions);
- **Sustainable water and wastewater management** (including sustainable infrastructure for clean and/or drinking water, wastewater treatment, sustainable urban drainage systems and river training and other forms of flooding mitigation);
- **Climate change adaptation** (including efforts to make infrastructure more resilient to impacts of climate change, as well as information support systems, such as climate observation and early warning systems);
- **Circular economy adapted products, production technologies and processes** (such as the design and introduction of reusable, recyclable and refurbished materials, components and products; circular tools and services); **and/or certified eco-efficient products;**
- **Green buildings** that meet regional, national or internationally recognised standards or certifications for environmental performance.

While the GBP's purpose is not to take a position on which green technologies, standards, claims and declarations are optimal for environmentally sustainable benefits, it is noteworthy that there are several current international and national initiatives to produce taxonomies and nomenclatures, as well as to provide mapping between them to ensure comparability. These may give further guidance to Green Bond issuers as to what may be considered green and eligible by investors. These taxonomies are currently at various stages of development. Issuers and other stakeholders can refer to examples in the [sustainable finance section](#) of ICMA's website.

Word clouds for Green Bonds Principles and use of proceeds



(a) Green Bond Principles



(b) Use of Proceeds

▶ Back

Spillover effects for conventional bonds' pricing overtime

