Journal of Banking and Finance 102 (2019) 19–32

Contents lists available at ScienceDirect

Journal of Banking and Finance

journal homepage: www.elsevier.com/locate/jbf

Environmental performance and the cost of debt: Evidence from commercial mortgages and REIT bonds☆

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ARTICLE INFO

Article history:
Received 9 March 2018
Accepted 28 February 2019
Available online 1 March 2019

Keywords:
Environmental performance
Commercial mortgage valuation
Corporate bonds
Commercial real estate
Real estate investment trusts (REITs)

ABSTRACT

The increasing societal focus on environmental issues leads to important questions about the relationship between corporate environmental (ESG) performance and firms' cost of capital, but research on this topic remains scant. The real estate sector offers an ideal testing ground to investigate the relationship in two distinct manners, while specifically addressing concerns about endogeneity. We first investigate the spreads on commercial mortgages collateralized by real assets, some of which are environmentally certified. We then study spreads on corporate debt of property companies (REITs), both at issuance and while trading in the secondary market. The results show that loans on environmentally certified buildings command lower spreads than conventional, but otherwise comparable buildings, varying between 24 and 29 basis points, depending on the specification. At the corporate level, REITs with a higher fraction of environmentally certified buildings have lower bond spreads in the secondary market. These results are robust to different estimation strategies, and signal that environmental risk is efficiently priced in the real estate debt market.

1. Introduction

There is an increasing societal focus on environmental issues, most importantly the carbon externality from energy consumption, and its effects on climate change. Despite an inconsistent regulatory response, there has been significant uptake in corporate action on environmental sustainability – a major aspect of the broader corporate social responsibility (CSR). Some firms, such as Unilever and Patagonia, have made CSR core to their business strategy. Other firms invest in CSR, but merely with the aim to be compliant with regulation. Such differentiation leads to important questions about the relationship between firms' environmental performance and their financial performance, the outcome of which is of interest to investors, corporations, and policy makers alike.

There is a significant body of academic research investigating this relationship, typically focusing on broad measures of CSR. Margolis et al. (2007) survey the literature over the 1972 to 2007 period and conclude that environmental performance and other elements of CSR tend to have a positive impact on financial performance. But even though there seems to be consensus regarding the impact of environmental performance on financial performance, it is rather challenging to disentangle the mechanism by which CSR affects corporate performance. One such mechanism relates to efficient use of resources and an overall increase in organizational effectiveness (Sharfman and Fernando, 2008). Another mechanism is that CSR or environmental performance may lead to an improved corporate image and an enhanced reputation, which could benefit companies on the labor, goods, and capital markets (Turban and Greening, 1997). Furthermore, it has been argued that CSR-related investments may lead to a reduction in operational risk (An and Pivo, 2018; Albuquerque et al., 2018), which could result in easier access to capital or a reduced cost of capital.

The literature that specifically investigates the impact of CSR and environmental practices on the cost of capital is quite limited, with the early literature documenting no discernable effect or even

☆ Kok is funded by a VIDI grant from the Netherlands Organization for Scientific Research (NWO). This paper benefitted from comments by seminar participants at the University of Cambridge, Maastricht University, Ozyegin University, the RWTH Aachen, and the University of Southern California, and by conference participants at the 2014 ARCS Conference at Cornell University, the 2014 Geneva Summit on Sustainable Finance, and the 2015 AREUEA meetings in Boston. We specifically thank Carol Alexander (the Editor), two anonymous referees, Jeroen Derwall, Franz Fuerst, Min Hwang, Volkan Kayaçetin, Thies Lindenthal, Juan Palacios Temprano, Paulo Rodrigues, Niko Szumilo, and Paul Smeets. We are also grateful for the research assistance provided by Noël van Heesewijk. All errors pertain to the authors.

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https://doi.org/10.1016/j.jbankfin.2019.02.015
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higher interest rate spreads for better CSR performance. For example, D'Antonio et al. (1997) investigate the performance of socially screened bond mutual funds, but find no relationship between CSR and yield differences on a risk-adjusted basis. Sharfman and Fernando (2008) conclude that the debt capacity for companies with a superior environmental performance is higher, but that their cost of debt is higher as well.

More recent papers contrast these early findings: Bauer and Hann (2010) document evidence that environmental performance is associated with reduced bond spreads. Goss and Roberts (2011) show that companies with a lower score from KLD – a CSR rating agency – have higher spreads on their bank loans. However, investments in CSR are only rewarded if the borrower also has a high credit rating. Attig et al. (2013) find that bonds issued by firms with strong CSR performance have better credit ratings, which usually leads to better financing terms. More recently, Chava (2014) analyzes the cost of equity and bank loans for companies with and without environmental concerns, and shows that firms without these concerns incur lower interest rates. Cheng et al. (2014) find fewer capital constraints for firms that perform well on the social and environmental aspects of CSR, and Oikonomou et al. (2014) document that strong CSR performance is associated with better credit ratings and lower cost of debt for firms in a broad range of industries.

While recent studies are directionally consistent in findings, questions remain about the mechanism of the documented effects. There are also lingering concerns about endogeneity issues that tend to hamper research in related fields: the direction of causality between environmental performance and cost of capital is hard to identify, due to potentially confounding factors. For example, a firm's cost of capital may be affected by the quality of its management, which may also affect the firm's environmental considerations.

This paper addresses some of the shortcomings in the literature, investigating the effect of corporate environmental performance on the cost of debt, not just at the corporate level, but also at the level of individual assets and the loans financing those assets. We examine the real estate sector, which provides a combination of companies whose sole activity is the management of a real estate portfolio – Real Estate Investment Trusts, or REITs – and assets which are unequivocally related to the debt they collateralize – corporate bonds and mortgages. We analyze the spread on the commercial mortgages that are collateralized by individual buildings and on bonds issued by REITs, a combination of analyses that is possible for REITs only.

The asset-level analysis examines different assets owned by the same firm and the mortgages underlying them, implying that firm characteristics cannot explain the cross-sectional effects, reducing endogeneity concerns. We also specifically address the issue of endogeneity in the corporate-level analysis. First, we employ a robust set of instruments in a two-stage model, using a weighted local measure of environmental certification for each REIT portfolio, as well as the lagged weights of environmental certification. In addition, we estimate a first-difference analysis on REIT corporate bond spreads after issuance. This time-series analysis allows us to investigate the effects of changes in REITs' portfolio allocation to environmentally certified buildings on changes in corporate bond spreads. The first-difference approach aims to isolate the impact of a change in the share of environmentally certified buildings in the portfolio of a given firm on the change in bond spreads, eliminating concerns regarding unobservable fixed effects.

In addition to the methodological advantages offered by analyzing commercial real estate, there is also the issue of environmental materiality. The sector plays a key role in the production – and therefore also the potential reduction – of greenhouse gas emissions. For instance, the Energy Information Administration (EIA) reports that buildings accounted for 41 percent of total U.S. energy consumption in 2014.[1] Moreover, the EIA expects the energy consumption in the commercial building sector to increase by 23 percent until 2040.[2] As the regulatory response to increasing energy efficiency in the real estate sector is mostly focused on market-based solutions, for example through improving information transparency, understanding the broader financial implications of investments in the energy efficiency of real estate is important for investors and policy makers.

As a proxy for the energy and environmental efficiency of buildings and portfolios, we employ the LEED and Energy Star certification systems – both widely accepted measures of environmental building performance. The estimation results show that the spreads of mortgages on environmentally certified buildings are significantly lower than those on conventional buildings, with the difference varying between 24 and 29 basis points, depending on the specification. This translates into a reduction of $147,000 to $206,000 in the annual interest payment of an average commercial mortgage in the sample. Importantly, these results are robust to tenant and building quality. The heterogeneity in a building's environmental performance is also reflected in mortgage spreads, similar to the heterogeneity in property pricing across certification types and levels as documented by Kahn and Kok (2014) and Holtermans and Kok (2017). A detailed analysis of buildings with different LEED labels shows that the decline in the interest expense is largest for "Gold" or "Platinum" labeled buildings, with a reduction in mortgage spreads of 66–68 basis points, respectively. The findings in the mortgage analysis are robust to firm-fixed effects. We also document that the relationship between the share of environmentally certified buildings in a REIT's portfolio and debt pricing is most evident during the post-crisis period.

At the corporate level, we assess the fraction of a REIT portfolio that is environmentally certified – again, as measured by LEED and Energy Star certification – and then evaluate the impact on REIT corporate bond spreads. Using a two-stage least square analysis that explicitly controls for endogeneity, we document that companies with a higher share of energy efficient and environmentally certified assets have significantly lower bond spreads. Our findings demonstrate that doubling a portfolio's share of environmentally certified buildings – increasing the allocation to certified buildings for an average REIT from 3 to 6 percent – lowers the bond spread by 21 to 74 basis points. In addition, REITs with property portfolios without any certified buildings have significantly higher bond yields in the secondary market. The first-difference analysis yields similar results.

One important concern in our analysis could be the selection of firms employing secured versus unsecured debt. The literature shows that firms might borrow through unsecured debt to signal their quality (Giambona et al., 2017). In our paper, this type of selection issue can affect our results. For this purpose, we create a control variable for firms using unsecured debt relatively often, similar to Riddiough and Steiner (2018). While our findings show that such firms indeed have lower bond spreads, we do not document a significant impact on mortgage pricing. Most importantly, the coefficients of the portfolio environmental certification share measures are robust to the inclusion of the unsecured debt selection variable.

This paper adds to the academic evidence on the economic implications of environmental performance in general, and for real estate in particular. There is empirical evidence that environmentally certified buildings have a higher and more stable occupancy

[1] Energy consumption by sector for 2014 retrieved from: http://www.eia.gov/totalenergy/data/monthly.

[2] EIA Annual Energy Outlook 2014. For details, please visit http://www.eia.gov/forecasts/aeo.

rate, and higher marginal rents and transaction prices (Eichholtz et al., 2010, 2013; Fuerst and McAllister, 2011; Holtermans and Kok, 2017), and that REITs with a higher share of environmentally certified buildings have better operational performance and lower systematic risk (Eichholtz et al., 2012). The reflection of environmental performance in the cost of debt that is required to finance real estate assets and firms, provides evidence of a market-based nudge for building owners and investors to adopt more energy-efficient investment practices in the commercial real estate market.

Our paper also contributes to the literature on the collateral role of real assets in corporate borrowing. Previous research mainly concentrates on distressed sales of collateral assets such as airplanes (Pulvino, 1998; Benmelech and Bergman, 2009) and properties (Benmelech et al., 2005; Campello and Giambona, 2013; Demirci et al., 2018), evaluating how asset characteristics, such as redeployability, affect the cost of borrowing. These papers show that the extent of asset redeployability affects the number of potential buyers for these assets, and accordingly increases the liquidation value and decreases the cost of debt to finance these assets. This paper evaluates a different characteristic of collateral assets that can potentially affect their liquidation value – the environmental efficiency. To our knowledge, this paper is the first that links explicitly the environmental characteristics of collateral assets to the cost of borrowing.

The remainder of the paper is organized as follows: we first discuss the concept of environmentally certified buildings, providing an overview of the literature concerning their financial performance. Section 3 presents and describes the data employed in the analysis and Section 4 outlines the method. Section 5 discusses the results, and the paper ends with conclusions and implications.

2. Environmental certification and real estate investments

It has been documented that the commercial and residential real estate sector can play a pivotal role in the reduction of global energy consumption, given its significant environmental footprint and the wide array of seemingly profitable energy efficiency measures and technologies at its disposal (Enkvist et al., 2007; Kahn et al., 2014). The real estate industry has responded to the societal debate and subsequent regulatory response in different ways. One particularly notable development is the establishment of environmental certification programs, both at the building and at the portfolio level. Information provision about the relative performance of assets and firms, comparable to the miles-per-gallon (MPG) sticker on cars or hygiene scorecards in restaurants, may lead to increased user awareness and increased market efficiency (Jin and Leslie, 2009; Sexton and Sexton, 2014).

In the U.S., the two leading certification programs at the asset level are LEED and Energy Star, which have been developed by the U.S. Green Building Council (USGBC) and the U.S. Environmental Protection Agency (EPA), respectively. The environmental performance of the built environment is increasingly relevant to a substantial part of the commercial real estate market, as the diffusion of the two certification programs has spread rapidly over the past decade. At the end of 2005, less than five percent of the building stock (by square footage) in the 30 largest office markets in the U.S. had been certified under the LEED and Energy Star program, but this increased to almost 40 percent at the end of 2015 (Holtermans et al., 2015). As of November 2016, the U.S. real estate market counted 20673 commercial buildings with a LEED certificate and 26938 commercial buildings with an Energy Star label.[3]

Comparable to investments in CSR for a general corporation, an important question is the extent to which social and environmental benefits of real assets generate economic and financial value for investors. Indeed, a survey by Pivo (2008) shows that REIT managers give more weight to “concern for risk and return” and “opportunities to outperform” than to “moral responsibility” when they consider sustainability investments in assets. However, this early survey also shows that managers’ main concern lies in the lack of information on the financial performance of environmentally certified buildings.

A growing body of literature aims to assess the economic implications of energy efficiency and sustainability of buildings. Capitalizing on the widespread adoption of environmental certification, the literature shows that certified commercial buildings generate significantly higher marginal rents and increased transaction prices as compared to conventional, but otherwise comparable buildings (Chegut et al., 2014; Eichholtz et al., 2010, 2013; Fuerst and McAllister, 2011).

More importantly for this paper, studies investigating the economic performance of environmentally certified real assets also show that these assets are less risky. That holds on the individual asset level, and at the portfolio level. Eichholtz et al. (2010, 2013) find higher and more stable occupancy rates for environmentally certified commercial buildings. This is important, since volatility in occupancy, rather than the rent level, determines the volatility of real estate cash flows, and is the key yardstick for systematic risk at the real estate asset level. For residential property, Hyland et al. (2013) show that environmentally certified homes keep their value better in down markets, also suggesting that they represent lower systematic risk, while Brounen and Kok (2011) document a significantly shorter time on the market when dwellings are on sale. Analyzing the implications of investments in environmentally certified real estate at the corporate level, Eichholtz et al. (2012) document that REITs owning a larger fraction of environmentally certified buildings display enhanced operating performance, and that REITs with larger fractions of environmentally certified space also exhibit significantly lower systematic risk (beta).

If cash flows from environmentally certified real estate are more stable than conventional buildings, this may affect the debt service capacity. A recent paper by An and Pivo (2018) documents that commercial mortgages collateralized by environmentally certified buildings have a lower default risk. Moreover, once a default occurs, the literature suggests that the loss-given-default may well be lower for a loan on a environmentally certified building than for a loan on a conventional building, since certified buildings are consistently found to be more valuable, and have a higher liquidity, suggesting that these buildings represent higher collateral quality. This is in line with the collateral quality literature on real assets (see Benmelech et al., 2005; Campello and Giambona, 2013; Demirci et al., 2018). The lower default risk and the likely reduced loss-given-default may translate into a lower required risk premium, and potentially also into a lower cost of debt.

3. Data

For the different empirical analyses that are the core of this paper, we combine data from a range of commercial and public sources: CoStar, Factset, SNL Real Estate, the Environmental Protection Agency, the U.S. Green Building Council, and the U.S. Treasury. This section describes how we use and combine the different datasets.

[3] The Green Building Information Gateway provides information on the number of buildings certified under the LEED program by the USGBC: http://www.gbig.org/search/advanced. The number of commercial buildings labeled by the EPA is retrieved from: http://www.energystar.gov/index.cfm?fuseaction=labeled_buildings.locator.

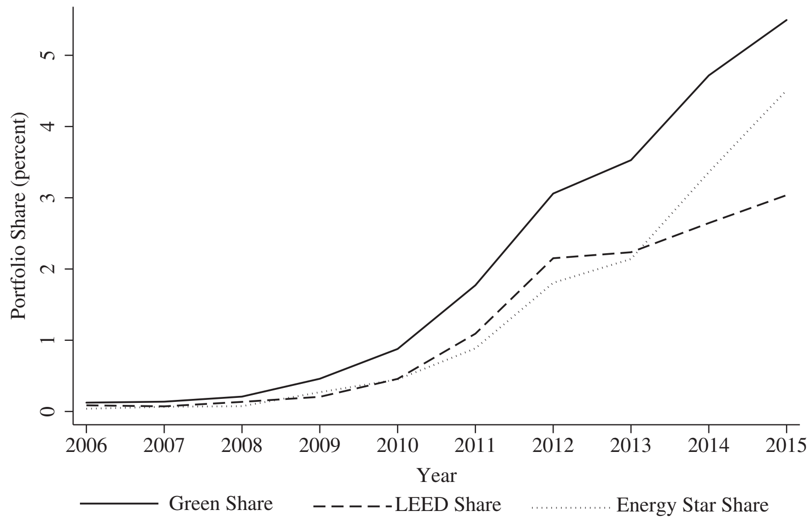

Fig. 1. Portfolio Weights of Environmental Certification over Time (2006–2015). The figure displays the average share of environmentally certified buildings in REIT portfolios over time. The solid line depicts the share of buildings in REIT portfolios with an Energy Star label, LEED certification or both. The dashed and dotted lines represent the share of buildings in REIT portfolios that are certified under the LEED or Energy Star program, respectively.

3.1. REITs and environmentally certified buildings

Our company-level analysis starts with the SNL Real Estate database. It contains 211 REITs for which we have complete information on individual asset holdings. For the 2006–2015 period, we identify LEED and Energy Star labeled buildings in the portfolios of REITs by matching the addresses of REIT-owned assets provided by SNL Real Estate with LEED and Energy Star data provided by the U.S. Green Building Council (USGBC) and the Environmental Protection Agency (EPA). Using GIS techniques, we transform all addresses into longitudes and latitudes, which enables us to geographically map the different datasets, identifying matching assets.

Fig. 1 presents the time series of the average overall share of environmentally certified space (by square footage) for the sample of REITs, as well as the LEED and Energy Star shares. Analogous to the green building adoption rates documented by Holtermans et al. (2015), the share of environmentally certified buildings is close to zero around 2006, but a continuing upward trend can be observed since that year. In 2015, the average share of environmentally certified buildings reached almost 5 percent of the total square footage of assets in REIT portfolios, with the LEED and Energy Star shares showing a comparable upward trend. In 2014, the cumulative Energy Star share slightly exceeded the cumulative LEED share, representing about 4 percent of the total square footage of REIT assets.

Fig. 2 further illustrates the total share of environmentally certified buildings for all REIT-owned assets in the U.S. (in square footage), measured by Core Based Statistical Area (CBSA) for the years 2006, 2010 and 2014. We observe a clear trend in the share of environmental certification of REIT assets over time. The average share of environmentally certified assets in REIT portfolios in each CBSA increased from 2.7 percent in 2006 to 8.2 percent in 2014.[4] Moreover, not only the share of assets with an Energy Star or LEED certification increased over time, but the geographical coverage also increased substantially. In 2006, REITs owned environmentally certified assets in just 42 different CBSAs, and this number increased to 224 CBSAs in 2014 (out of a total of 929 CBSAs in the U.S.).

In general, high-quality buildings are more likely to be certified (Eichholtz et al., 2010). Therefore, the impact of environmental certification can also capture unobservable building characteristics. SNL provides information regarding asset book value and building age, but to obtain a broader set of building quality characteristics, we match the SNL data with information from CoStar Property. CoStar Property collects data on building rents and transaction prices, combined with an elaborate set of building characteristics. We are able to cross-reference 2889 buildings from the SNL sample with the CoStar database, 101 of which are Energy Star or LEED certified. For these buildings, we obtain detailed information on the amenities that are present in the building. This includes information on whether the building has been renovated, and its distance to a transit stop. In this subsample, 36 percent of certified buildings are renovated, against 16 percent for the non-certified buildings. Certified buildings are also closer to a transit stop and have a higher likelihood of including amenities.

3.2. REITs and commercial mortgages

The SNL database contains financial information on the assets owned by U.S. REITs, including encumbrance data (the principal value of the debt) for each building in every year, provided that there is a commercial mortgage collateralized by these assets in a REIT portfolio. SNL provides information on the value of the encumbrance, the interest rate, the maturity date, a dummy variable indicating whether it is a fixed rate debt contract, and a “cross-collateralization” dummy indicating whether the debt contract is cross-collateralized by other assets.

The mortgage spread is calculated by subtracting the Treasury rate with the same or closest maturity from the mortgage rate. Time to maturity is calculated by the difference between the year of maturity and the derived year of origination.[5] Some commercial mortgage contracts are collateralized by multiple assets. First, we determine the assets serving as collateral for each debt contract, by grouping the debt contracts with exactly the same contractual

[4] This excludes CBSAs with a share of environmentally certified assets of zero.

[5] We need the exact date of origination in order to retrieve the Treasury rate corresponding to the date of origination. SNL does not provide the date of origination for mortgages, but since SNL reports loan data for every year, the year of origination can be derived from the first appearance of the debt contract in the database. Assuming that the day and month of origination are similar to the day and month of maturity, we derive the complete date of origination by combining this information with the year of the first appearance in the database.

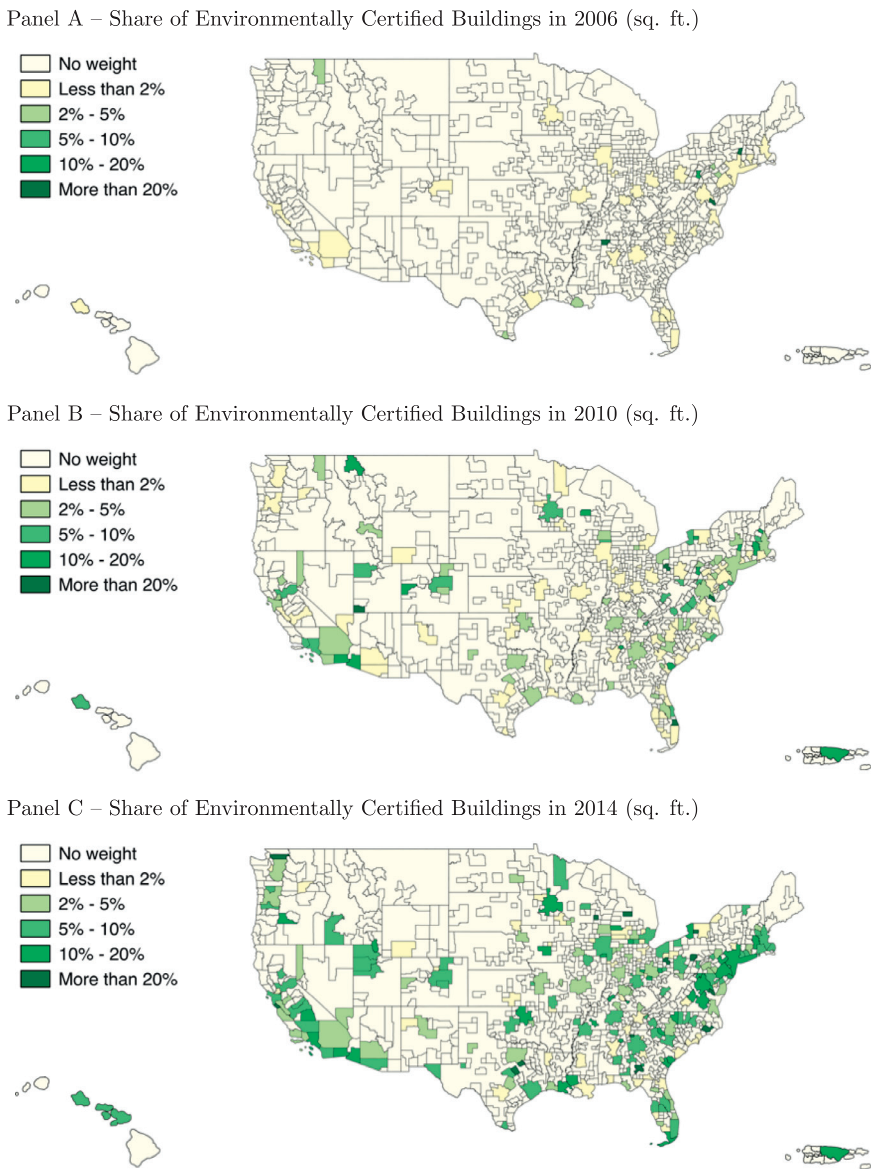

Fig. 2. Environmental Certification of REIT-Owned Assets by CBSA (2006, 2010, 2014). The share of environmentally certified buildings is calculated by Core Based Statistical Area (CBSA) and based on the total of square footage of certified buildings relative to the total square footage of assets owned by REITs in the CBSA. Hawaii, Puerto Rico and the U.S. Virgin Islands are enlarged for visibility. The state of Alaska is included in the estimation as well, but since the share of environmentally certified buildings in Alaska and its corresponding CBSA, Anchorage, is consistently zero, it is omitted from the figure.

terms by each year.[6] We then calculate the loan to value (LTV) ratio by dividing the encumbrance value by the total book value of the buildings collateralizing the corresponding contract in the year of origination.

Panel A of Table 1 presents the descriptive statistics for REIT mortgages and the buildings underlying these contracts. Our sample covers the period from 2006 to 2015. It includes 5596 buildings owned by 146 REITs collateralizing 2388 REIT mortgages, 191 of which are collateralized by Energy Star or LEED-certified buildings.[7] The average spread is 302 basis points for mortgages collateralized by environmentally certified buildings and 279 basis points for mortgages collateralized by non-certified buildings. The average time to maturity is slightly longer for mortgages collateralized by non-certified assets than mortgages collateralized by environmentally certified assets, seven years as compared to some six years, respectively. The average value of environmentally certified buildings is almost four times as high as the value of non-certified buildings: $167 million and $38 million, respectively. Environmentally certified assets have a somewhat higher LTV (50 percent) as compared to conventional assets (41 percent). Around 82 to 84 percent of the assets are financed with fixed rate mortgages. Cross-collateralization is more common among non-certified buildings: 39 percent, against 17 percent for environmentally certified buildings.

Importantly, we also introduce a proxy for tenant mix. In SNL, we observe the five largest tenants for each property in the sample, and we assess which of these companies are included in the S&P 500 index. We then create a dummy variable indicating whether the property has at least one tenant from the S&P 500 index.

[6] We group the contracts collateralized by different buildings by controlling for the same interest rate, the same encumbrance, the same date of maturity and the same company.

[7] Of the buildings in our mortgage sample 3 percent are Energy Star or LEED certified. Specifically, 2.1 percent of the buildings have an Energy Star label and similarly, 1.8 percent are certified under the LEED program. These numbers are in line with the numbers reported in Fig. 1.

Table 1
Descriptive Statistics (2006–2015).

Panel A – Commercial Mortgages and Collateral Assets

VARIABLES	Mean	Std. Dev. Non-Certified Collateral	Obs.	Mean	Std. Dev. Env. Certified Collateral	Obs.
Building Characteristics						
Renovated (1=yes)	0.16	0.36	2,788	0.36	0.48	101
Amenities (1=yes)	0.33	0.47	2,788	0.42	0.50	101
Transit Stop (1=yes)	0.22	0.41	2,788	0.49	0.50	101
S&P 500 Tenant (1=yes)	0.21	0.40	5,405	0.50	0.50	191
Asset Book Value (in $ million)	37.79	91.91	5,405	167.16	30.04	191
Less Than 10 Years Old (1=yes)	0.26	0.44	5,405	0.22	0.42	191
Mortgage Characteristics						
Mortgage Spread (in bps)	279.33	157.68	5,405	301.78	144.17	191
Encumbrance (in $ million)	83.66	107.87	5,405	119.35	187.23	191
LTV (fraction)	0.41	0.27	5,405	0.50	0.29	191
Time-to-Maturity (in years)	6.93	4.85	5,405	6.31	3.88	191
Cross-Collateralization (1=yes)	0.39	0.49	5,405	0.17	0.37	191
Fixed Rate (1=yes)	0.84	0.36	5,405	0.82	0.39	191
Firm Characteristics						
Secured Debt Ratio	0.78	0.28	5,405	0.69	0.28	191
Low Secured Debt Ratio (1=yes)	0.05	0.22	5,405	0.07	0.25	191
Total Assets (in $ billion)	3.94	5.86	5,405	8.17	9.44	191
Firm Q	1.27	0.26	5,405	1.27	0.27	191
Debt Ratio	0.53	0.14	5,405	0.55	0.11	191

Panel B – Corporate Bonds

		All Bonds	
Firm Characteristics			
Green Share (in percent)	3.09	6.18	1,628
Non-Green Dummy (1=yes)	0.19	0.39	1,628
Secured Debt Ratio	0.33	0.17	1,628
Low Secured Debt Ratio (1=yes)	0.05	0.22	1,628
Total Assets (in $ billion)	10.90	8.30	1,628
Firm Q	1.49	0.37	1,628
Debt Ratio	0.53	0.10	1,628
Equity Turnover	0.21	0.12	1,628
Bond Characteristics			
Bond Spread (in bps)	281.63	327.55	1,628
Moody's Rating	14.42	1.04	1,628
Debt Value (in $ million)	325.56	213.31	1,628
Time-to-Maturity (in years)	6.94	5.15	1,628
Callable (1=yes)	0.35	0.48	1,628
Convertible (1=yes)	0.01	0.11	1,628

Table 1 shows the descriptive statistics for REIT mortgage data in Panel A and corporate bond data in Panel B. Mortgage characteristics include LTV, year to maturity, indicator variables for fixed rate mortgages, a dummy for firms with low secured debt ratio, and whether there is any other asset collateralizing the mortgage. Asset book value and age are also included. The descriptive statistics of mortgage and building characteristics are by building and the descriptive statistics of green share and firm characteristics are by firm-years. In Panel B, green share is the ratio of total square feet of LEED or Energy Star certified assets to the total square feet of the REIT portfolio in year *t*. Bond characteristics include the debt value, year to maturity, equity turnover, a dummy for firms with low secured debt ratio, and an indicator variable for callable bonds. In both panels, firm characteristics cover the logarithm of total assets, debt-to-asset ratio and firm Q calculated as the ratio of market value of assets to book value of assets. All of the financial controls are observed at year t-1. The descriptive statistics of bond characteristics are by bond issue and the descriptive statistics of green share and firm characteristics are by firm-years.

Controlling for tenant quality can solve a potential endogeneity problem. Top-tier companies are more likely to prefer operating in environmentally certified buildings (Eichholtz et al., 2009) and the presence of such blue-chip tenants can decrease the cash-flow risk of a property, which may be reflected in the financing terms of a mortgage. Hence, failing to control for tenant quality may create an omitted variable problem. The measure confirms our suspicion: 50 percent of the environmentally certified buildings have at least one S&P 500 tenant as opposed to just 21 percent of the non-certified buildings.

The selection of secured versus unsecured debt by different borrowers can also influence our results. Giambona et al. (2017) find that firms choose unsecured debt to signal their quality as borrowers. So, lenders issuing loans to high-quality borrowers may be less interested in the quality of the assets on their balance sheets. This would imply that controlling for the level of unsecured debt taken out by a firm could weaken or mitigate the effect of environmental certification of assets held by REITs, since the certification can be regarded as an asset quality indicator. To evaluate whether the extent of unsecured debt affects the relationship between environmental certification and cost of debt, we create a dummy variable for firms in the lowest 5 percent of the secured debt ratio (to total debt). This cut-off corresponds to a secured debt ratio that is slightly higher than 0.20.[8]

3.3. REIT bonds

We retrieve corporate bond data for all U.S. equity REITs from FactSet. For each REIT bond, we observe the date of origination, the issue amount, the bond yield, the date of maturity, the bond rating by Moody's and whether the bond is callable and/or convertible. Importantly, we also retrieve secondary market data for the bond yield. We also collect financial characteristics of REITs from SNL for the year preceding the origination: total assets, firm Q, and the ratio of total debt to total assets (as well as the interest coverage ratio for the robustness checks).

[8] In unreported analyses, we try alternative cut-off values. Our findings on the impact of environmental certification is robust to using alternative cut-offs or using the secured debt ratio in the regressions directly.

Following (Anderson et al., 2003), we employ the credit rating data by first ranking ratings from low to high, creating a ranking variable that has a value of one for the lowest credit rating, increasing by one for each notch increase in the credit rating. The highest possible value is 23, corresponding to an AAA+ credit rating. In our sample, the ranking variable for Moody's rating ranges from 8 (B2) to 17 (A2).

We collect constant maturity treasury rates (CMT) from the U.S. Treasury.[9] Comparable to the mortgage analysis, we calculate the spread of the REIT bonds by subtracting the Treasury rate with the same or closest time to maturity from the yield of the bond on the REIT bond's origination date, and at the end of every year subsequent to origination if we have secondary market data.

Merging the SNL data with data from FactSet, we obtain a dataset of 390 bonds issued by 58 REITs during the 2006 to 2015 period. Panel B of Table 1 presents the descriptive statistics of the REIT corporate bond sample. The average bond spread is 282 basis points, including secondary market data. The average time to maturity is 7 years (approximately 10 years at issuance). Approximately one percent of the bonds issued are convertible, and 35 percent are callable. The value of total assets of an average REIT in the bond sample is $11 billion. The mean debt ratio is 53 percent, while the average firm Q is 1.49. As our analyses cover the secondary bond market as well as the primary market, we want to control for liquidity. Due to a lack of data on the liquidity of bonds, we employ equity turnover, and use that proxy to capture time variation in the liquidity of corporate bonds, following (Wang and Zhang, 2009). Gebhardt et al. (2005) also find that higher equity turnover correlates with the liquidity of bonds of the same firm. The average monthly equity turnover relative to shares outstanding is 21 percent.

4. Methodology

4.1. REIT commercial mortgages

First, we analyze the asset-level mortgage data, relating the presence of a label attesting to the environmental performance of an individual building or a small portfolio of buildings, to the mortgage collateralized by these assets. We estimate the following equation to assess the impact of the environmental performance of the collateral on the mortgage spread:

$$Mortgage\ Spread = f(Environmental\ Certification,\ Building,\ Mortgage,\ Firm\ Characteristics) \quad (1)$$

In the mortgage spread analysis, we control for building vintage (using an indicator for buildings less than 10 years old), the logarithm of the book value of the building, as well as year, state, and asset type-fixed effects. These control variables are similar to those employed by Titman et al. (2005) and An et al. (2011). In addition, we include indicator variables for building size, renovation, amenities, as well as distance to public transit stops. The match of our dataset with the CoStar database allows us to control explicitly for building quality, using the standard industry classification (Class A, Class B, and Class C).

We use the LTV ratio as one of the mortgage controls. Lenders may keep the LTV lower for riskier firms or assets and choose higher LTV for less risky firms or assets. To capture potential nonlinearity in the relationship, we also include the square of LTV in the regressions. In addition, we control for the time to maturity (in years) and include variables for fixed-rate mortgages and cross-collateralization. The quality of the borrowing firm is also likely to affect the mortgage spread. We therefore explicitly control for firm characteristics. Specifically, we include firm size, the debt ratio, and the market-to-book ratio. In addition to the characteristics of the borrower, the type of lender and other lender characteristics can potentially affect the mortgage spread. However, the data does not allow us to control explicitly for such lender details. Our inclusion of firm-fixed effects may alleviate some of the concerns about omitted variable bias, as these fixed effects may capture part of impact of unobserved lender characteristics, assuming borrowers sort into certain lender categories.

There could also be a selection effect by high-quality firms employing unsecured debt to signal their unobservable quality. We create a "low secured debt ratio" dummy to capture those firms aiming to signal their quality, similar to Riddiough and Steiner (2018).

4.2. REIT corporate bonds

In order to estimate the impact of energy efficiency on the bond spread of a REIT, we create a portfolio-level environmental performance measure following (Eichholtz et al., 2012). For each REIT, we calculate the dynamic portfolio share of environmentally certified assets, which is the ratio of the total square footage of certified space (measured by Energy Star or LEED) and the total square footage of the portfolio of a REIT, thus indicating the degree to which a REIT portfolio includes environmentally efficient assets:

$$Environmental\ Certification\ Share^{g}_{i,t} = \frac{\sum_l Sqft\ of\ Certified\ Buildings^{g}_{i,l,t}}{\sum_l Sqft\ of\ Buildings_{i,l,t}} \quad (2)$$

In this equation, i stands for REIT i, t stands for year t, l stands for building l and g is the environmental certification, which is either Energy Star, LEED, or both. In the multivariate analysis, we use the logarithm of the environmental certification share, complemented by an indicator variable taking the value of one for REITs with zero environmentally certified buildings. We then estimate the following equation, explaining bond spreads by the environmental certification share, as well as bond characteristics and a set of control variables:

$$Bond\ Spread = f(ln(Environmental\ Certification\ Share),\ Non-Green\ Dummy,\ Bond,\ Firm\ Characteristics) \quad (3)$$

In Eq. (3), we include a non-green indicator variable to circumvent the problem of taking the logarithm of zero. Property-type fixed effects address a possible relationship between a REIT's share of environmentally certified buildings and the property type it focuses on. Bond characteristics include the logarithm of the value of the bond, year to maturity, bond rating and variables indicating whether the bond is callable or convertible. One can expect that the bond spread should increase by the total value of debt, as the bond becomes riskier when the total amount of debt increases. However, the amount of debt can also reflect the financial health of the issuer. Callable bonds are likely to command higher spreads, reflecting the option value of the call. Convertible bonds and bonds with higher ratings should be associated with lower spreads.

Regarding the time to maturity, the literature suggests two possible outcomes: according to the "trade-off" hypothesis, there is a positive relationship between spread and time to maturity, as a bond becomes riskier due to the longer lending period, in which unforeseen events can occur (Goss and Roberts, 2011). Conversely, the "credit quality" hypothesis predicts a negative relationship between time to maturity and the spread, because longer-term borrowers are likely to be less risky borrowers.

We also use lagged firm characteristics in our model. For these variables, we expect that firm size, measured by the logarithm of

[9] For further details, please visit http://www.treasury.gov/resource-center/data-chart-center/interest-rates/.

total assets, is associated with a lower spread, since larger firms are better able to withstand negative shocks to cash flows and may be less likely to default. As a further measure of financial risk, we exploit the debt ratio, measured as total debt divided by total assets.[10] As the debt-to-asset ratio increases, firms should face higher bond spreads. We also control for firm Q, measured by the ratio of the market value of assets to the book value of assets. A higher firm Q indicates better growth opportunities, implying that the bond spread should be lower.

In estimating the regression reported in Eq. (3), we use bond data both at issuance and while trading in the secondary market. The bond data analysis at issuance is cross-sectional, while the secondary market data offer a panel setting. In the secondary market analysis, we also control for liquidity. We use equity turnover as a proxy for bond liquidity (Gebhardt et al., 2005), since increased liquidity can indicate better pricing of the bonds through decreasing uncertainty or it may indicate increased noise trading and higher volatility, leading to worse loan pricing.

We acknowledge that endogeneity is a concern in non-experimental, cross-sectional studies. For example, environmentally certified buildings are not randomly assigned to portfolios and building owners do not randomly invest in the environmental performance of buildings. For the OLS estimates of Eq. (3) to yield consistent estimates, we must therefore assume that our measure of environmental performance is uncorrelated with other explanatory variables. We use alternative estimation strategies to overcome the endogeneity concerns.

First, we use a two-stage least squares estimation. We regress the logarithm of the share of environmentally certified assets of each REIT portfolio on its lagged share and the logarithm of a local variable measuring the fraction of environmentally certified buildings in the area where a REIT's assets are located, combined with the other explanatory variables that we employ in the bond spread regressions. In order to create the weighted local measure of environmentally certified buildings, we use the market share of environmentally certified commercial buildings in each of the 30 largest markets in the U.S. over time.[11] The weighted local measure of environmentally certified buildings is calculated by aggregating the sum of the "green" market shares multiplied by the ratio of the number of buildings in a REIT portfolio in that particular market. In the second stage, we regress the fitted measure of environmentally certified buildings on bond spreads. We perform the Hansen J (Hansen et al., 1996) and Kleibergen-Paap (Kleibergen and Paap, 2006) tests to check the validity and identification of the models.

As a second robustness check, we use the changes in the bond spread after bond issuance and changes in explanatory variables, in order to eliminate the effects of unobservables. Our aim is to remove any possible impact of unobservable and time-invariant firm and bond characteristics, which can potentially be correlated with the share of environmentally certified buildings. By using first differences, the impact of such time-invariant characteristics is removed, allowing us to directly observe the impact of a change in the share of environmentally certified buildings of a given REIT on the change in the bond spread.

$$\begin{aligned} &ln(Environmental\ Certification\ Share_t) \\ &\quad = f(ln(Environmental\ Certification\ Share_{t-1}), \\ &\qquad Local\ Greenness_{t-1},\quad Non-GreenDummy, \\ &\qquad Bond,\quad FirmCharacteristics) \end{aligned} \tag{4}$$

$$\begin{aligned} &Bond\ Spread = g(ln(Environmental\ \widehat{Certification}\ Share_{t-1}), \\ &Non-Green\ Dummy,\ Bond,\ FirmCharacteristics) \end{aligned} \tag{5}$$

$$\begin{aligned} \Delta Bond\ Spread = f(&\Delta ln(Environmental\ CertificationShare), \\ &\Delta Bond\ Characteristics, \\ &\Delta Firm\ Characteristics) \end{aligned} \tag{6}$$

5. Empirical findings

5.1. Commercial mortgage spreads and environmental certification

Table 2 provides the regression results of Eq. (1). We regress mortgage spreads on an indicator of energy efficiency and environmental certification, and a large set of control variables. The standard errors are heteroskedasticity-robust and clustered by REIT. The models explain 51 to 54 percent of the cross-sectional variation in mortgage spreads.

Coefficients for the control variables are in line with expectations and consistent across specifications. In all specifications, the LTV coefficients indicate that there is significant nonlinearity in the relationship. This suggests that less risky firms face lower spreads and that riskier firms are crowded out at higher LTV levels. Time-to-maturity has a negative impact on the spread, supporting the "credit quality" hypothesis. Fixed-rate mortgages have significantly higher spreads. Finally, when multiple assets collateralize the mortgage contract, the spread declines, although the coefficients are insignificant. This effect is most likely due to diversification. The low secured debt ratio dummy has a positive coefficient, indicating that firms employing less secured debt pay a premium in the mortgage market (in line with Giambona et al., 2017).

Importantly, we document that if a mortgage contract is collateralized by an environmentally certified asset, the borrower faces significantly lower spreads. Columns 2 to 6 show that the overall effect of environmental certification on mortgage spreads is statistically and economically significant, and that it is not materially affected by the inclusion of additional variables controlling for mortgage and firm characteristics. Our findings are robust to including firm-fixed effects, as shown in Column 6. The decrease in mortgage spread is 24 to 29 basis points in Columns 3 to 6. For an average commercial mortgage in our sample, this translates into an annual interest payment that is lower by about $147,000 to $206,000.

The decreasing impact of environmental certification on mortgage spread remains after controlling for tenant and building quality. The dummy indicating that there is at least one S&P 500 tenant in a building has a negative impact on the mortgage spread, and that also holds for the building quality controls obtained from CoStar, reported in Column 5, except for the transit stop dummy. Ex ante, we expected that the transit stop dummy would lower the spread, as more centrally located buildings are typically more liquid assets that are easier to market to prospective tenants and buyers. The insignificance of the dummy might be due to the fact that we control for a large number of spread determinants in the regressions, including building quality. The transit stop dummy might be correlated with other observables, such as building quality, which could affect its significance. The results indicate that mortgages collateralized with buildings of higher quality have lower spreads. The presence of more than five amenities in a building, for example, is associated with a reduction in mortgage spread of 22 basis points. Building renovation decreases mortgage spreads by about 9 basis points (though it is statistically insignificant). The impact of environmental certification on mortgage spreads is robust to inclusion of these measures.

[10] In unreported regressions, we also include the interest coverage ratio, documenting similar results.

[11] See Holtermans et al. (2015) for a full list of the markets that are included.

Table 2
Environmental Certification and Mortgage Spreads OLS Regressions (2006–2015).

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Environmental Certification (1=yes)		−0.358***	−0.243**	−0.246**	−0.285**	−0.269*
		[0.136]	[0.110]	[0.110]	[0.133]	[0.141]
S&P 500 Tenant (1=yes)		−0.218**	−0.110	−0.117*	−0.107	−0.078
		[0.094]	[0.070]	[0.065]	[0.097]	[0.068]
Renovated (1=yes)					−0.085	−0.024
					[0.083]	[0.077]
Amenities (1=yes)					−0.216**	−0.137
					[0.092]	[0.089]
Transit Stop (1=yes)					0.030	0.044
					[0.079]	[0.061]
log(Asset Book Value)	−0.190***		−0.177***	−0.177***	−0.215***	−0.070**
	[0.043]		[0.040]	[0.042]	[0.060]	[0.035]
Less Than 10 Years Old (1=yes)	−0.108*		−0.113**	−0.110**	−0.093	−0.104
	[0.056]		[0.055]	[0.056]	[0.061]	[0.075]
LTV (in percent)	2.050***		2.029***	2.046***	1.943***	-0.274
	[0.674]		[0.709]	[0.676]	[0.720]	[0.739]
LTV Squared	−2.072***		−2.038***	−2.053***	−1.982***	−0.032
	[0.702]		[0.734]	[0.705]	[0.744]	[0.773]
Time-to-Maturity (in years)	−0.131***		−0.131***	−0.131***	−0.128***	−0.144***
	[0.014]		[0.014]	[0.014]	[0.016]	[0.011]
Cross-Collateralization (1=yes)	−0.475***		−0.482***	−0.477***	−0.410***	−0.519***
	[0.141]		[0.145]	[0.141]	[0.152]	[0.148]
Fixed Rate (1=yes)	1.394***		1.378***	1.388***	1.483***	1.388***
	[0.180]		[0.187]	[0.179]	[0.189]	[0.164]
Low Secured Debt Ratio (1=yes)	0.471**		0.496**	0.485**	0.597**	−0.031
	[0.194]		[0.194]	[0.195]	[0.233]	[0.270]
log(Firm Size) (lagged, t-1)	0.004			0.007	0.058	0.364*
	[0.050]			[0.050]	[0.053]	[0.193]
Market-to-Book (lagged, t-1)	−0.017			−0.026	−0.037	0.198
	[0.182]			[0.182]	[0.207]	[0.441]
Debt Ratio (lagged, t-1)	0.105			0.145	0.034	0.367
	[0.391]			[0.392]	[0.392]	[0.671]
Constant	2.349***	1.097***	2.331***	2.181***	1.915**	-3.347
	[0.748]	[0.249]	[0.468]	[0.742]	[0.822]	[2.928]
Year-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Asset Type-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm-Fixed Effects	No	No	No	No	No	Yes
Observations	5596	5596	5596	5596	2889	2889
Adjusted R-squared	0.513	0.326	0.514	0.514	0.537	0.646

The table presents the results of the regressions of mortgage spread on the environmental certification indicator, mortgage, building, and firm characteristics. The environmental certification dummy indicates whether an asset collateralizing a mortgage is LEED or Energy Star certified. Mortgage and building characteristics include the LTV ratio calculated as the ratio of encumbrance to the total book value of assets collateralizing a mortgage, the logarithm of asset book value, year to maturity and variables indicating whether the mortgage is a fixed-rate mortgage and whether there is any other asset collateralizing the mortgage. The regressions in Column 5 and 6 also include building quality characteristics. All regressions include asset type dummies, year dummies and location dummies by state. Column 6 also includes firm-fixed effects. Heteroskedasticity-robust and REIT-clustered standard errors are in brackets. *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively.

These findings suggest that mortgage lenders take the environmental characteristics of buildings into account in mortgage pricing, leading to lower mortgage spreads for certified buildings. These findings are in line with the lower occupancy risk and higher income generated by environmentally certified buildings (Eichholtz et al., 2010, 2013; Fuerst and McAllister, 2011), as well as recent findings on lower default risk for environmentally certified assets in a broad pool of CMBS loans (An and Pivo, 2018).

5.2. Corporate bond spreads and environmental certification

As the next step, we analyze REIT corporate bond spreads by investigating the relationship between the share of environmentally certified space in REIT portfolios and bond spreads at the time of origination. In the REIT corporate bond sample, we observe 240 bond originations from 2006 to 2015. Table 3 presents the estimation results of Eq. (3).[12] Columns 1 and 2 show the results for the OLS regressions, while Columns 3 and 4 pertain to the 2-stage GMM regressions, using the "regional green share" as the instrument. Column 5 provides the results of the first-difference analysis.

When we analyze bond pricing, both at origination and in the secondary market, we generally find that the coefficients of our variable of interest and the control variables have the expected signs. Among the controls, as expected, credit rating negatively impacts bond spreads at issuance. The spread declines by some 30 basis points for a one-unit increase in the rating. If the bond is callable, the spread increases significantly in the secondary market, reflecting the option value of the call. For convertible bonds, the spread is significantly lower. The coefficient of the market-to-book ratio is negative, although insignificant.

Controlling for market liquidity and the degree to which firms issue unsecured debt in the secondary market analysis does not affect the key result regarding the relationship between the environmental performance of the collateral and loan pricing, while we find mixed results for the relationship between our liquidity proxy and loan spreads. In the first-difference analysis, the coefficient of the change in equity turnover is significantly negative. This indicates that as liquidity increases for a given firm over time, the spread diminishes in the secondary markets. However, across firms, higher liquidity is associated with higher spreads. Regarding the low secured debt ratio dummy, we find that firms with low levels of secured debt have a lower spread relative to their peers. However, this only holds when we use the fifth percentile

[12] First-stage results available upon request.

Table 3
Environmental Certification and Corporate Bond Spreads OLS, 2-Stage GMM, and Change by Year Regressions (2006–2015).

VARIABLES	(1)	(2)	(3)	(4)	(5)
	OLS		2-Stage GMM		Δ by Year
Green Share (in logs)	−0.093*	−0.211***	−0.160	−0.738***	−1.201***
	[0.049]	[0.057]	[0.357]	[0.161]	[0.174]
Non-Green Dummy (1=yes)	0.463	0.942***	0.755	3.721***	
	[0.307]	[0.327]	[1.726]	[0.858]	
Low Secured Debt Ratio (1=yes)	−0.647	−0.838***	−0.541	−1.243***	
	[0.443]	[0.258]	[0.527]	[0.300]	
log(Firm Size) (lagged, t-1)	−0.149**	−0.281**	−0.193***	−0.243**	2.933***
	[0.072]	[0.111]	[0.070]	[0.110]	[0.673]
Market-to-Book (lagged, t-1)	−0.454**	−1.103***	−0.502**	−0.882***	−1.098**
	[0.184]	[0.203]	[0.228]	[0.222]	[0.489]
Debt Ratio (lagged, t-1)	0.887*	2.402***	1.124	3.287***	2.814
	[0.523]	[0.427]	[0.768]	[0.541]	[1.879]
Equity Turnover		0.302		2.165**	-6.785***
		[0.792]		[1.023]	[0.631]
Moody's Rating (8 to 17)	−0.218***	−0.084	−0.211**	−0.213**	
	[0.081]	[0.082]	[0.098]	[0.095]	
log(Bond Value Issued)	−0.272*	−0.132	−0.324**	−0.207*	
	[0.149]	[0.125]	[0.164]	[0.123]	
Time-to-Maturity (in years)	0.015	−0.014	0.022**	−0.012	
	[0.011]	[0.018]	[0.011]	[0.016]	
Callable (1=yes)	0.090	0.489***	0.101	0.488***	
	[0.117]	[0.121]	[0.115]	[0.114]	
Convertible (1=yes)	−3.426***	−4.556***	−3.578***	−4.642***	
	[0.531]	[0.470]	[0.501]	[0.473]	
Constant	9.685***	8.399***	9.538***	6.707***	
	[1.304]	[0.939]	[1.311]	[0.936]	
Year-Fixed Effects	Yes	Yes	Yes	Yes	No
Asset Type-Fixed Effects	Yes	Yes	Yes	Yes	No
Observations	240	1628	240	1628	1018
Adjusted R-squared	0.741	0.833	0.731	0.817	0.095
Hansen J (prob.)			0.034	0.518	
Kleibergen Paap (prob.)			0.287	0.000	

The table represents the OLS, 2-stage GMM, and change by year regressions of bond spread on Green share, bond characteristics and firm characteristics at bond origination and for the secondary market sample. Green share is the ratio of total square feet of LEED or Energy Star certified buildings to the total square feet of the portfolio in year t. Bond characteristics include the logarithm of debt value, year to maturity, Moody's rating and dummies indicating whether the bond is callable and convertible. Firm characteristics cover the logarithm of total assets, debt-to-asset ratio, firm Q calculated as the ratio of market value of assets to book value of assets, average monthly equity turnover, and a dummy for firms with low secured debt ratio. All financial controls are observed at year t-1. The regressions include asset type and year dummies. In the first stage of the last three regressions, we regress green share on the lagged green share, the logarithm of a local greenness measure and the explanatory variables from the second stage regressions. Hansen J and Kleibergen-Paap test probabilities for over-identification and under-identification are reported in the table. In Columns 1 and 3, we use the sample at origination. In Columns 2 and 4, we use the sample for the secondary market. Column 5, we take difference by year for all dependent and independent variables. Heteroskedasticity-robust standard errors are in brackets. Standard errors are clustered by bond in Models 2 and 5. *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively.

as the cutoff. At higher cutoff points or when using the secured debt ratio itself, we no longer find a significant relationship with loan pricing. The relationship between environmental asset quality and loan pricing is robust to the specification of the secured debt ratio.

We document that the overall portfolio share of environmentally certified buildings significantly lowers the bond spread. This result is particularly strong once bonds are traded in the secondary market, while weakly significant at the time of origination. This is potentially due to less degrees of freedom, but it may also signal that investors (can) only recognize the implications of environmentally certified buildings over time. For instance, doubling "environmental certification" share, that is, increasing the allocation to environmentally certified buildings for an average REIT from 3 to 6 percent, decreases the bond spread at origination by 21 basis points. On average, this corresponds to a decline in annual interest expense of $687,000 per bond. The results for the 2-stage GMM regressions, where we explicitly control for potential endogeneity, show a slightly higher impact of the allocation to environmentally certified buildings within a portfolio on bond spreads, corresponding to a 74 basis point decrease in bond spreads for doubling the share of environmentally certified buildings in a REIT portfolio.[13] The results of the first-difference analysis show that a one-standard deviation change in the logarithm of environmental certification share in a given year leads to a bond spread reduction of 62 basis points in that year. Additionally, REITs with zero environmentally certified properties face lower demand of bond investors in the secondary market. If a REIT has no certified assets in the portfolio, the spread increases by 0.9 to 3.7 percent in the secondary market. This effect seems large, but it is important to note that we observe bond spreads up to 20 percent in the secondary markets.

5.3. Decomposition of environmental certification

We separately evaluate the impact of LEED and Energy Star certification on the mortgage and bond spreads. Table 4 Panel A documents the mortgage results. The findings indicate that the

[13] In the two-stage least squares regressions, we reject the null hypothesis of the Kleibergen-Paap test that the model is under-identified and do not reject the null hypothesis of the Hansen J Test that the instruments are valid at the one percent significance level, indicating that our instruments are indeed valid and are performing in line with expectations.

Table 4
Decomposition of Environmental Certification and Debt Spreads (2006–2015).

Panel A – Commercial Mortgages

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
LEED (1=yes)	−0.406***	−0.389**				
	[0.142]	[0.169]				
Energy Star (1=yes)	−0.013	0.010				
	[0.122]	[0.165]				
High-Level LEED (1=yes)			−0.655***	−0.675***	−0.670**	
			[0.210]	[0.248]	[0.294]	
Low-Level LEED (1=yes)			−0.358*	−0.351	−0.166	
			[0.210]	[0.232]	[0.227]	
Constant	2.159***	1.886**	2.111***	1.953**	−3.326	
	[0.745]	[0.824]	[0.762]	[0.843]	[2.990]	
Mortgage Characteristics	Yes	Yes	Yes	Yes	Yes	
Firm Characteristics	Yes	Yes	Yes	Yes	Yes	
Year-Fixed Effects	Yes	Yes	Yes	Yes	Yes	
State-Fixed Effects	Yes	Yes	Yes	Yes	Yes	
Asset Type-Fixed Effects	Yes	Yes	Yes	Yes	Yes	
Firm-Fixed Effects	No	No	No	No	Yes	
Observations	5596	2889	5480	2838	2838	
Adjusted R-squared	0.515	0.537	0.516	0.538	0.647	

Panel B – Corporate Bonds

	OLS		2-Stage GMM		Δ by Year	
LEED Share (in logs)	−0.067**		−0.122		−0.387***	
	[0.031]		[0.097]		[0.054]	
Energy Star Share (in logs)		−0.127**		−0.451***		−1.416***
		[0.061]		[0.152]		[0.237]
Non-LEED Dummy (1=yes)	0.743***		1.070*			
	[0.216]		[0.581]			
Non-Energy Star Dummy (1=yes)		0.442*		1.999***		
		[0.266]		[0.686]		
Constant	7.963***	8.765***	7.280***	7.123***		
	[0.952]	[1.094]	[0.883]	[1.036]		
Bond Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Year-Fixed Effects	Yes	Yes	Yes	Yes	No	No
Asset Type-Fixed Effects	Yes	Yes	Yes	Yes	No	No
Observations	1628	1628	1628	1628	758	847
Adjusted R-squared	0.831	0.831	0.831	0.826	0.078	0.112
Hansen J (prob.)			0.864	0.696		
Kleibergen Paap (prob.)			0.000	0.000		

Panel A of the table presents the results of the regressions of mortgage spread on the decomposition of the environmental certification indicator. The LEED (Energy Star) dummy indicates whether an asset collateralizing a mortgage is LEED (Energy Star) certified. The table also shows the relationship between LEED certification levels and mortgage spread. The low-level LEED dummy includes Certified and Silver LEED labels. The high-level LEED dummy includes Gold and Platinum LEED labels. Heteroskedasticity-robust and firm-clustered standard errors are in brackets. *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively. Panel B of the table presents the OLS, 2-stage GMM, and change by year regressions of bond spread on the decomposition of environmental certification share for the secondary market sample. LEED (Energy Star) share is the ratio of total square feet of LEED (Energy Star) certified buildings to the total square feet of the portfolio in year t. Bond and firm characteristics are as in Table 3. The regressions include asset type and year dummies. In the first stage of the regressions in Column 3 and 4, we regress LEED (Energy Star) share on the lagged LEED (Energy Star) share, the logarithm of a local environmental certification measure and the explanatory variables from the second stage regressions. Hansen J and Kleibergen-Paap test probabilities for over-identification and under-identification are reported in the table. In Columns 5 and 6, we take difference by year for all dependent and independent variables. Heteroskedasticity-robust standard errors are in brackets. Standard errors are clustered by bond in Models 1, 2, 5, and 6. *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively.

documented effect is mostly determined by LEED certification. If the building collateralizing the mortgage is LEED certified, borrowers face 39 to 41 basis points lower mortgage spreads. On average, this implies lower annual mortgage interest payments by $200,000 to $345,000 for the mortgages in our sample. The results for Energy Star certification show that the certification coefficients are statistically insignificant. This result may be explained by the fact that LEED certification is better recognized by commercial real estate lenders than the Energy Star label due to more visibility in the capital market. Equally, the LEED certificate is broader in scope than the Energy Star label with a potentially stronger quality signal (see for example, Holtermans and Kok, 2017).

To further study possible heterogeneity in the documented effects, we also evaluate the impact of different environmental certification levels on mortgage spreads. We use the different quality levels in LEED certification, employing specifications that are otherwise similar to those employed previously. We first divide LEED certified buildings into two groups, by combining "Certified" and "Silver" certifications in the "low-level" dummy and "Gold" and "Platinum" certifications in the "high-level" dummy. The hypothesis is that, as the level of LEED certification increases, the mortgage spread is further reduced. Results are reported in the last three columns of Table 4 Panel A. We document a significantly negative relationship between LEED certification levels and mortgage spread. The interest rate spread on mortgages on buildings with lower-level certification is not significantly lower than the mortgage spread on non-certified buildings, once controlling for building quality. However, a higher-level environmental certification significantly reduces the corresponding mortgage spread by 66–68 basis points. We observe a 66-basis point decline in mortgage spreads for buildings with these labels (see Column 3). The results are also robust to building quality and firm-fixed effects as shown in Column 5.

Table 4 Panel B shows the decomposition of the environmental certification effect for the bond analysis. In Column 1 and 2 of Table 4 Panel B, we evaluate the spread impact associated with

Table 5
Decomposition of Environmental Certification and Mortgage Spreads Subsample Analysis OLS Regressions (2007–2015).

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
		2007–2009			2010–2015	
Environmental Certification (1=yes)	−0.101			−0.224**		
	[0.327]			[0.111]		
LEED (1=yes)		−0.514			−0.313**	
		[0.481]			[0.150]	
Energy Star (1=yes)		0.305			−0.027	
		[0.392]			[0.129]	
High-Level LEED (1=yes)			−1.080***			−0.578*
			[0.404]			[0.305]
Low-Level LEED (1=yes)			0.596			−0.522*
			[0.365]			[0.269]
Constant	4.671***	4.617***	4.899***	3.132***	3.123***	3.208***
	[1.203]	[1.198]	[1.693]	[0.887]	[0.892]	[1.006]
Building Characteristics	No	No	Yes	No	No	Yes
Mortgage Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Firm Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Year-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Asset Type-Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm-Fixed Effects	No	No	No	No	No	No
Observations	1313	1313	817	3596	3596	1609
Adjusted R-squared	0.493	0.494	0.544	0.512	0.512	0.492

The table presents the results of the regressions of mortgage spread on the environmental certification indicator, mortgage, building, and firm characteristics. The first three columns apply a subsample period form 2007 to 2009 and the last three columns apply a subsample period from 2010 to 2015. The environmental certification dummy indicates whether an asset collateralizing a mortgage is LEED or Energy Star certified, and the LEED (Energy Star) dummy indicates whether an asset collateralizing a mortgage is LEED (Energy Star) certified. The table also shows the relationship between LEED certification levels and mortgage spread. The low-level LEED dummy includes Certified and Silver LEED labels. The high-level LEED dummy includes Gold and Platinum LEED labels. Mortgage and building characteristics are as in Table 2 Heteroskedasticity-robust and REIT-clustered standard errors are in brackets. *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively.

the LEED and Energy Star shares applying OLS regressions. Doubling the LEED share reduces the bond spread by 7 basis points. Doubling the Energy Star share leads to a decline in the spread by 13 basis points. Columns 3 and 4 of Table 4 Panel B show the two-stage least square estimation results, with a LEED certification coefficient of 12 percent (though insignificant), and an Energy Star coefficient of 45 percent. The last two columns are for the change-by-year analyses. The coefficients for the LEED and Energy Star portfolio shares have the expected signs and are statistically significant.

Overall, our findings show heterogeneity in the impact of environmental certification by the certification type and the level of LEED certification similar to Eichholtz et al. (2013). We document that it is mostly LEED certification that has a significant impact on mortgage spreads. Additionally, the level of LEED certification matters: higher LEED certification levels are associated with larger reductions in the mortgage spread. For corporate bonds, Energy Star certification matters in most specifications.

5.4. The impact of the crisis: Mortgage analysis

We also evaluate whether the relationship between environmental certification and the cost of debt differs between the crisis and post-crisis period. Due to a lack of data, we can only perform this subsample analysis for the mortgage loans. Table 5 presents the results. The findings show that the impact of environmental certification is more evident during the post-crisis period. However, when differentiating between low- and high-level LEED certification we find that a high-level LEED label has a stronger impact on mortgage spreads within the crisis period than post-crisis, whereas post-crisis both a low- and high-level LEED label has a significant negative impact on mortgage spreads. We have three possible explanations for this observation. The first is that it may just be due to decreased degree of freedom during the crisis period, as the sample shrinks. However, we also have lower degrees of freedom in the post-crisis period, and the environmental certification remains significant there. The second possible explanation for this finding is that lenders have increasingly taken collateral quality into consideration, especially post-crisis. Third, it is important to note that the issue of energy efficiency, and the extent of environmental certification of buildings, is a fairly recent phenomenon, as documented by Holtermans and Kok (2017). Equally, the academic literature providing empirical evidence regarding the financial performance of environmentally certified real estate is of a rather recent vintage – none of the relevant articles were published before 2010. So, lenders may simply not have been aware of environmental certification programs, and would therefore not have included environmental considerations in their loan pricing. This could also explain the fact that in our secondary market analysis, we find stronger results when bonds are traded post issuance, as compared to when they were issued.

6. Conclusion and discussion

There is an ongoing debate about the financial outcomes of considerations related to corporate social responsibility (CSR), mostly focusing on operating measures of profitability. But beyond affecting operational performance, the CSR credentials of a firm may also influence its ability to raise capital, and the price of such capital (Chava, 2014). This topic has received only limited attention in the literature.

This paper is among the first to investigate the impact of direct measures of corporate social responsibility – buildings' environmental performance – on firms' cost of debt. In addition to analyzing cost of debt at the corporate level, we also address the financing cost of individual assets owned by firms. We focus on the real estate sector, which allows us to take this unique two-pronged perspective, given the explicit link between real assets and the mortgages collateralized by such assets.

This dual approach also addresses some of the concerns about endogeneity that are common in the literature regarding the financial effects of corporate social responsibility. By employing asset-level data within the same firm, and by controlling for a wide range of observable characteristics that may be correlated with (environmental) performance, we circumvent potential endogeneity issues at the firm level. Furthermore, at the corporate level, we apply a two-stage GMM method, instrumenting our unique measure of CSR performance with an exogenous indicator. In addition, we exploit the time variation in both corporate bond pricing and CSR performance, using secondary market data and our real estate-specific measure of portfolio environmental certification share.

Evaluating the mortgage spreads of environmentally certified buildings owned by REITs, we document that commercial mortgages on assets certified by Energy Star and LEED have significantly lower spreads as compared to non-certified assets. This effect is economically significant; if the collateral is environmentally certified, the mortgage spread declines by 24 to 29 basis points. At the point of means, the interest expense for a mortgage in our sample decreases with some $147,000 to $206,000. These findings are robust to controlling for tenant and building quality, for firms employing less secured debt, and to the inclusion of firm-fixed effects. Additionally, our findings demonstrate that the relationship is more evident during the post-crisis period.

Analyzing corporate bond spreads, we document that firms with a more environmentally efficient portfolio, measured by both Energy Star and LEED certification, have significantly lower bond spreads. Regarding the impact of certification on the cost of debt in the secondary market, we find that doubling the share of environmentally certified buildings, that is, increasing the share for an average REIT from 3 to 6 percent, decreases the bond spread by 21 to 74 basis points, depending on the specification. Importantly, REITs without any certified assets in their portfolios pay bond yield premiums of 1–4 percent in the secondary market. The results are robust to the inclusion of equity turnover as a proxy for bond liquidity, and controlling for firms employing less secured debt to signal their unobserved quality.

These findings provide an indication that the environmental performance of real estate assets reduces the cost of debt for REITs, possibly reflecting the lower risk and higher income associated with environmentally certified buildings. We also note that effects on corporate bond spreads are statistically significant in the secondary market analysis while just weakly so at issuance. While limited statistical power could play a role, it may also be the case that at the time of origination, lenders do not fully price risks and opportunities related to the environmental quality of the portfolio – such factors may materialize over time, allowing secondary market investors to more accurately price this information in.

The overall conclusion from our results is that the cost of debt capital, both in the form of mortgages and in the form of bonds, is significantly lower for REITs that own environmentally certified buildings than for their peers that do not, or do so to a lesser extent. These findings raise the question whether the overall cost of capital of REITs is affected in a similar fashion.

To answer that question, we need to look into the different components of the weighted average cost of capital (WACC). Besides the cost of debt, these are the cost of equity and the weights of debt and equity in the overall financing of the REIT. Table 1 shows that average debt ratios for REITs owning environmentally certified collateral are almost the same as the ratios for REITs that do not. This leaves the cost of equity capital. Although these aspects have not yet been investigated very widely, the literature does offer some relevant insights. Eichholtz et al. (2018) investigate the relationship between the environmental performance of REIT portfolios and the cost of equity. They document that a higher level of environmental performance in a REIT's portfolio is associated with a lower cost of equity capital: if a REIT would go from zero environmentally certified buildings to a portfolio consisting exclusively of certified buildings, the cost of equity would decrease by 29 to 74 basis points, depending on the specification and the certification used. This is not surprising, given that Eichholtz et al. (2012) find a lower beta for REITs with a higher portfolio allocation to environmentally certified buildings.

Combining these findings from the literature with our own results regarding the lower cost of debt, we conclude that REITs owning a higher fraction of environmentally certified buildings are likely to have a lower WACC as compared to, otherwise similar, peers. However, the exact reduction in the WACC is challenging to estimate, given that these inputs are estimated using different specifications, making it all but impossible to combine them into one overall estimate for the WACC. And of course, for investors in REITs, this lower cost of capital does not necessarily imply a "free lunch" – Eichholtz et al. (2012) do not document evidence of stock market outperformance for REITs that are more heavily invested in environmentally certified buildings.

The findings in this paper have some implications for real estate investors and policy makers. The commercial real estate sector is responsible for 46 percent of total U.S. energy consumption and emits 981 million metric tons of carbon dioxide per annum as reported by the Energy Information Administration (EIA). This environmental externality is currently addressed through regulatory responses that mostly focus on increasing market efficiency through enhanced transparency. More than ten major U.S. cities, including Boston, New York, Washington D.C., as well as the state of California, have enacted regulation mandating the disclosure of commercial building energy performance. In addition, voluntary environmental building certification schemes have diffused rapidly in the marketplace. If the capital market is efficient in pricing environmental performance, it will also be able to price environmental underperformance. Our results show that this has implications for the cost of capital of inefficient assets, providing an incentive for investors to develop investment strategies addressing the energy efficiency and environmental performance of buildings. This would provide a partial, market-based solution to an otherwise daunting policy challenge, potentially reducing the negative carbon externality the building stock imposes on society.

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