Environmental Performance and the Cost of Capital: Evidence from Commercial Mortgages and REIT Bonds[☆]

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Abstract

The increasing societal focus on environmental issues has led to differentiated corporate action as a response. This paper studies the impact of corporate environmental performance on cost of capital, using Real Estate Investment Trusts (REITs) as a laboratory. We document that loans on environmentally certified buildings command 25-31 basis point lower spreads. At the corporate level, REITs with a higher fraction of environmentally certified buildings issue bonds at lower spreads, an analysis of bond spreads in the secondary market corroborates this finding. The results provide evidence on the efficiency of the capital market in pricing risk-affecting environmental characteristics.

Keywords: Environmental performance, commercial mortgage valuation, corporate bonds, commercial real estate, real estate investment trusts (REITs).

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1. Introduction

As witnessed by the recent attention to the COP21 meetings in Paris, there is an increasing societal focus on environmental issues, most importantly the carbon externality from energy consumption, and its effects on climate change. This focus has led to global corporate action on environmental sustainability – a major aspect of the broader corporate social responsibility (CSR). While some firms, such as Unilever and Patagonia, have made CSR core to their business strategy, other firms invest in CSR just 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, Elfenbein, and Walsh (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. More recently, Servaes and Tamayo (2013) suggest a more nuanced conclusion, providing evidence that such positive relationship only holds for companies with high customer awareness. Eccles, Ioannou, and Serafeim (2014) document that companies voluntarily adopting sustainability policies subsequently perform better financially, both on the stock market as well as measured by accounting metrics.

Even though there seems to be some 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 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). Another mechanism is more direct, and relates to efficient use of resources, generating less pollution and waste, and an overall increase in organizational effectiveness (Sharfman and Fernando, 2008).

While CSR may directly affect the operations of a firm, another mechanism to influence its financial performance is through the cost of capital needed to finance operations. It has been argued that CSR-related investments may lead to a reduction in operational risk (An and Pivo, 2015; Albuquerque, Durnev, and Koskinen, 2014; Kytle and Hamilton, 2005), which could result in easier access to capital or a reduced cost of capital.

The literature investigating 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 higher spreads for better CSR performance. For example, D'Antonio, Johnsen, and Hutton (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 early findings: Bauer and Hann (2010) document 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 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. Chava (2014) analyzes the cost of equity and bank loans for companies with and without environmental concerns. The results show that firms without these concerns pay lower interest rates, and that investors in their stocks demand lower returns. Oikonomou, Brooks, and Pavelin (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 their findings, questions remain about the mechanism of the documented effects. There are also 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 company 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 real estate portfolios – Real Estate Investment Trusts (REITs) – and assets which are unequivocally related to the debt that underwrites those assets – 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 collateralizing them, implying that firm characteristics cannot explain the cross-sectional effects we may find, 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 REIT environmental performance on corporate bond spreads. The first-difference approach aims to isolate the impact of a change in the share of environ-

mentally certified buildings in a portfolio by a given firm on the change in bond spreads, eliminating any unobservable fixed effects.

In addition to the methodological advantages offered by analyzing commercial real estate, there is also the environmental relevance of the property sector. 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 US 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 and environmental performance of real estate is important for investors and policy makers.

As a proxy for the energy and environmental efficiency of buildings, we employ the LEED and Energy Star certification systems – both widely accepted measures of environmental building performance. Controlling for a broad set of mortgage and asset characteristics, we test how the capital market evaluates the environmental performance of collateral underlying financial products.

The results show that the spreads of mortgages on environmentally certified buildings are significantly lower than those on conventional buildings, with the difference varying between 25 and 31 basis points, depending on the specification. This translates into a reduction of $158,000 to $213,000 in the annual interest payment of an average commercial mortgage in the sample. The heterogeneity in a building's environmental performance is also reflected in mortgage spreads. A detailed analysis of buildings with different LEED labels shows that the decline in the interest expense is largest for Platinum labeled buildings, with an average reduction in interest payments of some $626,000. Additionally, the impact of environmental certification is mainly determined by the LEED certification. Similar heterogeneity across certification types and levels is found by Kahn and Kok (2014).

At the corporate level, we assess the fraction of a REIT portfolio that is environmentally certified – 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, even though the effect is economically quite small. A one-standard deviation increase in

[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`.

the share of environmentally certified buildings decreases the corporate bond spread at issuance by about 9 basis points. This translates into a difference in interest payment of $294,000 for the average corporate bond in our sample. Importantly, the first-difference analysis shows a 20-basis point decline in bond spread when a REIT increases its share of environmentally certified buildings by one percent.

The results in this paper add to the academic evidence on the economic implications of environmental performance in general, and for real estate in particular. There is strong evidence that environmentally certified buildings have a higher and more stable occupancy rate, and higher marginal rents and transaction prices (Eichholtz, Kok, and Quigley, 2010, 2013; Fuerst and McAllister, 2011), and that REITs with a higher share of environmentally certified buildings have stronger operational performance (Eichholtz, Kok, and Yönder, 2012). The reflection of environmental performance in the cost of capital to finance real estate assets and firms provides another market-based nudge for building owners and investors adopting more energy efficient investment practices in the commercial real estate market.

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 Performance and Real Estate Investments

It has been well documented that the commercial and residential real estate sector can play a pivotal role in the reduction of global energy consumption, given its significant footprint and the wide array of seemingly profitable energy efficiency measures and technologies at its disposal (Enkvist, Naucler, and Rosander, 2007; Kahn, Kok, and Quigley, 2014). The real estate industry has responded to the societal debate and regulatory response in different ways. One particularly important 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 consumer awareness, and thus 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, Kok, and Pogue, 2015). As of November 2016, the U.S. real estate market counted 20,673 commercial buildings with a LEED certificate and 26,938 commercial buildings with an Energy Star label.[3] Moreover, McGraw-Hill Construction estimates that 44 percent of new construction projects in 2012 were "green" and projections suggest that this share will increase to 55 percent by 2016.[4]

Comparable to investments in CSR for a general corporation, an important and lingering 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 environmental performance of buildings. Capitalizing on the widespread adoption of environmental certification, the literature consistently shows that certified commercial buildings generate significantly higher marginal rents and increased transaction prices as compared to conventional, but otherwise comparable buildings (Chegut, Eichholtz, and Kok, 2014; Eichholtz, Kok, and Quigley, 2010, 2013; Fuerst and McAllister, 2011). Importantly, these studies also find higher and more stable occupancy rates for environmentally certified buildings, which is the key yardstick for systematic risk at the asset level. For residential property, Brounen and Kok (2011) document not just higher values for more efficient homes, but also a significantly shorter time on the market when dwellings are on sale.

Analyzing the implications of investments in environmental performance at the corporate level, Eichholtz, Kok, and Yönder (2012) document that REITs owning a larger fraction of environmentally certified buildings display enhanced operating performance, as measured by return on assets (ROA), return on equity (ROE) and funds from operations (FFO). A four-factor model shows that REITs with larger fractions of environmentally certified space also exhibit significantly lower systematic risk (beta).

It is important to note that besides positive rent and value effects, the literature also consistently shows a negative relationship between environmental performance and risk: environmentally certified real estate assets tend to have higher and more stable

[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`.

[4]McGraw-Hill Construction Green Building Outlook 2013.

occupancy rates, are easier to sell, and have lower systematic risk. A recent paper by An and Pivo (2015) reiterates these results, documenting that commercial mortgages collateralized by environmentally certified buildings have a lower default risk. These findings are particularly important for the purpose of this paper, since lower default risk may translate into a lower required risk premium, and potentially also into a lower cost of debt.

3. Data

3.1. REITs and Green Buildings

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 US Green Building Council, and the US Treasury. This section describes how we use and combine the different datasets.

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.

Figure 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, Kok, and Pogue (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. The LEED and Energy Star shares show a comparable upward trend. In 2014, the cumulative Energy Star share slightly exceeded the cumulative LEED share and represented almost 4 percent of the total square footage of REIT assets.

– Insert Figure 1 here –

Figure 2 shows 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.[5] Moreover, not only the share of assets with an Energy Star or LEED certification increases over time, but the geographical coverage also increases 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.).

– Insert Figure 2 here –

3.2. REITs and Commercial Mortgages

The SNL database contains financial information on the assets owned by U.S. REITs, including encumbrance data for each building in every year, provided that there is a commercial mortgage collateralized by these assets in a REIT portfolio. SNL also provides information on the value of the encumbrance (the principal value of the debt), the interest rate, the maturity date, a dummy variable indicating whether it is a fixed rate contract, and a cross-collateralization dummy indicating whether the debt contract is cross-collateralized by other assets. Data on building characteristics, such as the address of the building, the asset type and the age of the building are partially provided by SNL, and enriched through the CoStar database.

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.[6] 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 terms by each year.[7] 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

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

[6]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 the 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.

[7]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.

includes 5,721 buildings owned by 148 REITs collateralizing 1,244 REIT mortgages, 195 of which are collateralized by Energy Star or LEED-certified buildings.[8] The average spread is 299 basis points for mortgages collateralized by environmentally certified buildings and 278 basis points for those 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: $168 million and $38 million, respectively. Environmentally certified assets have a somewhat larger LTV (50 percent) as compared to conventional assets (41 percent). Around 80 to 84 percent of the assets are financed with fixed rate mortgages. Cross-collateralization is more common among non-certified buildings: 39 percent, against 16 percent for environmentally certified buildings.

– Insert Table 1 here –

In general, high-quality buildings are more likely to be certified (Eichholtz, Kok, and Quigley, 2010). Therefore, the impact of environmental certification can also capture unobservable building characteristics. SNL provides information regarding 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 2,904 buildings from the SNL sample with the CoStar database, 102 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, 35 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.

3.3. 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 and

[8] 3 percent of the buildings in our mortgage sample are Energy Star or LEED certified. Specifically, 1.7 percent of the buildings have an Energy Star label and similarly, 1.7 percent are certified under the LEED program. These numbers are in line with the numbers reported in Figure 1.

credit rating. Following Anderson, Mansi, and Reeb (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. 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).

Merging the SNL data with the secondary market data from FactSet, we obtain a dataset of 422 bonds issued by 51 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. When we limit the data to the year of origination only, the average spread is 201 basis points. The average time to maturity is 7 years and at issuance the mean time to maturity is approximately 10 years. Some two percent and 34 percent of the bonds issued are callable and convertible, respectively. The value of total assets of an average REIT in the bond sample is $10 billion. The mean debt ratio is 52 percent, while the average firm Q is 1.48.

4. Methodology

4.1. REIT Commercial Mortgages

First, we use the asset-level data relating the presence of a label attesting to the energy efficiency or 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 energy efficiency and environmental performance of the collateral on the mortgage spread:

$$\textit{Mortgage Spread} = f(\textit{Environmental Certification, Building, Mortgage, Firm Characteristics}) \tag{1}$$

As building quality controls, we employ indicator variables for renovation, amenities and distance to public transport stops, as well as building size, a building vintage dummy

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

(less than 10 years old), and the logarithm of the book value of the building.[10] In all mortgage regressions, we control for year, state, and asset type-fixed effects.

We use the LTV ratio as one of the mortgage controls. Additionally, since lenders may keep the LTV lower for riskier firms or assets, we follow Titman, Tompaidis, and Tsyplakov (2005) and employ an indicator variable for LTVs larger than 0.7. This indicator variable should capture the higher LTV choice for less risky firms or assets. We also control for 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, debt ratio, and the market-to-book ratio.

4.2. REIT Corporate Bonds

In order to estimate the impact of energy efficiency and environmental performance on the bond spread of a REIT, we create a portfolio-level measure of environmental performance following Eichholtz, Kok, and Yönder (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:

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

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 estimate the following equation, explaining bond spreads by energy efficiency and environmental certification characteristics, as well as bond characteristics and a set of control variables:

$$Bond\ Spread = f(Environmental\ Certification\ Share,\ Bond,\ Firm\ Characteristics) \quad (3)$$

In Equation 3, we use the portfolio share of certified buildings in order to proxy for the environmental performance of each REIT. 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

[10] In unreported regressions, we also directly use the age of the assets but find insignificant results due to nonlinearity in the relationship. Results are available upon request.

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 use lagged firm characteristics in our model. For these variables, we expect that firm size, measured by the logarithm of 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.[11] 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 Equation 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. 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 Equation 3 to yield consistent estimates, we must therefore assume that our measure of environmental performance is uncorrelated with other explanatory variables. We use two different robustness checks to overcome the endogeneity concerns.

First, we use a two-stage least squares estimation. We regress the share of environmentally certified assets of reach REIT portfolio on its lagged share and a local variable measuring the fraction of environmentally certified buildings in the area where a REITs assets in the portfolio 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.[12] The weighted local measure of environmentally

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

[12] See Holtermans, Kok, and Pogue (2015) for a full list of the markets that are included.

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, Heaten, and Yaron, 1996) and Kleibergen-Paap (Kleibergen and Paap, 2006) tests to check the validity and identification of the models.

$$\begin{aligned} \textit{Environmental Certification Share}_t = f(&\textit{Environmental Certification Share}_{t-1}, \\ &\textit{Local Greenness}_{t-1}, \textit{Bond}, \textit{Firm Characteristics}) \end{aligned} \tag{4}$$

$$\textit{Bond Spread} = g(\textit{Environmental } \widehat{\textit{Certification}} \textit{ Share}_{t-1}, \textit{Bond, Firm Characteristics}) \tag{5}$$

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

As a second robustness check, we use the changes in the bond spread after bond issuance and 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.

5. Empirical Findings

5.1. Commercial Mortgage Spreads and Environmental Certification

Table 2 provides the regression results of Equation 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 53 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 coefficient is significantly positive; a higher level of borrowing at the individual building level increases the spread. The dummy indicating LTV ratios larger than 0.7 has a significantly negative coefficient, suggesting 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 building quality controls obtained from CoStar, reported in Column 5, have negative signs except the transit stop dummy. 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 10 basis points though it is insignficant. Proximity to public transport is not statistically and economically significant.

Importantly, we document that if a mortgage contract is collateralized by an environmentally certified asset, the borrower faces significantly lower spreads[13]. Columns 2 to 5 show that the overall effect of environmental certification on mortgage spreads is statistically and economically significant, and is not materially affected by the inclusion of additional variables controlling for building quality. The decrease in mortgage spread is 25 to 31 basis points. For an average commercial mortgage in our sample, this translates into an annual interest payment that is lower by about $158,000 to $213,000.

– Insert Table 2 here –

These findings suggest that mortgage lenders reflect the environmental characteristics of the certified buildings in mortgage pricing, leading to lower mortgage spreads for such buildings. Although we do not have information about the default rates of the underlying collateral, the findings are in line with the lower occupancy risk and higher income generated by environmentally certified buildings (Eichholtz, Kok, and Quigley, 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, 2015).

5.2. Corporate Bond Spreads and Environmental Certification

We then 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 313 bond originations from 2006 to 2015. Table 3 presents the estimation results of Equation 3. Columns 1 and 2 show the OLS regressions, while Columns 3 and 4 show the 2-stage GMM regressions, using the "regional green share" as the instrument. Columns 5 and 6 provide the results of the first-difference analysis. The results of the three different analyses are consistent with respect to the observed outcomes: the size of the coefficients,

[13]Our findings are robust to including firm fixed effects.

statistical significance levels and explanatory power of the models are only marginally affected by the estimation strategy.

The control variables show that the corporate bond rating and the convertibility option are the most important determinants of REIT bond spreads at origination, irrespective of the regression specification. For example, a one-notch increase in credit rating decreases the bond spread with 29 to 31 basis points.

The signs of the coefficients on the control variables of the bond and firm controls are as expected in the secondary market analysis. Time to maturity has a negative impact on bond spreads, supporting the "credit quality" hypothesis proposed by Goss and Roberts (2011). If the bond is callable, the spread increases significantly, reflecting the option value of the call. For convertible bonds, the spread is significantly lower. The coefficient of the rating is insignificant, although the sign of the coefficient is as expected. The coefficient of the market-to-book ratio is significantly negative. This indicates that higher future growth opportunities lower the bond spread. An 0.1 increase in the market-to-book ratio results up to a 12 basis-point increase in the bond spread.

We document that the overall portfolio share of environmentally certified buildings significantly lowers the bond spread. Importantly, this result holds only once bonds are traded in the secondary market, not at the time of origination. A one-standard deviation increase in overall "green" share decreases the bond spread by 9 basis points. On average, this corresponds to a decline in annual interest expense of $294,000 per bond. The results for the 2-stage GMM regressions, where we explicitly control for potential endogeneity, show a slightly higher impact of portfolio greenness on bond spreads, corresponding to a 13 basis point decrease in bond spreads for a one-standard deviation increase in the share of environmentally certified buildings in a REIT portfolio.[14] In terms of economic magnitude, this spread reduction would imply a decline in the interest expense by $366,000 for the average REIT bond in the sample. In the final column, we provide the results of the first-difference analysis. The findings show that a one-standard deviation change in the green share in a given year leads to a bond spread reduction of 20 basis points in that year.

– Insert Table 3 here –

Irrespective of the specification (OLS, 2SLS, first-difference), we document that the extent of environmental certification in the portfolios of REITs is significantly related to

[14]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 valid and are performing in line with expectations.

the spreads on corporate bonds, even though the effect is economically quite small. Despite the fact that the measure of environmental concerns is quite different, the discounts we document on the bond spreads are remarkably similar in magnitude as compared to Goss and Roberts (2011) and Chava (2014). Our results also provide evidence that environmental certification (or the effects thereof) are recognized more strongly in the secondary markets, as compared to the pricing effects at the time of origination. Although the coefficients of green share have the right sign, the impact of the green portfolio share on the bond spread at origination is insignificant. This is potentially due to lower degrees of freedom.

5.3. Decomposition of Environmental Certification

We separately evaluate the impact of LEED and Energy Star certifications on the mortgage and bond spreads. Table 4 documents the mortgage results. The findings indicate that the documented effect is mostly determined by LEED certification. If the building collateralizing the mortgage is LEED certified, borrowers face 38 to 39 basis points lower mortgage spreads. On average, this implies lower level of annual mortgage interest payments by $283,000 to $350,000 for the mortgages in our sample. The results for Energy Star certification show that the certification coefficients are negative, but 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.

– Insert Table 4 here –

To assess further possible heterogeneity in the documented effects, we evaluate the impact of different certification levels on mortgage spreads. We use increasing levels of 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 as the "low-level" dummy and "Gold" and "Platinum" certifications as the "high-level" dummy. We also evaluate separately "Gold" and "Platinum" labels. The hypothesis is that, as the level of LEED certification increases, the mortgage spread is further reduced. Results are reported in the last four columns of Table 4.

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. However, a higher-level building certification significantly reduces the corresponding mortgage spread by 68 basis points. The reduction is even somewhat larger for

"Platinum" labels: we observe a 75-basis point decline in mortgage spreads for buildings with these labels in the final column. Based on the average mortgage size in the sample, the interest expense on a mortgage collateralized by a LEED Platinum-certified building would be lower by approximately $626,000 per year relative to an otherwise comparable mortgage on a non-certified building.

Including the complete set of building quality controls, the certification coefficients increase relative to the findings in Columns 3 and 5, and continue to point to a decline in spreads as the level of buildings' environmental performance increases. The spread discount for high-level certifications remains statistically significant at 71 basis points when including the additional building characteristics. The discount for Platinum-certified collateral increases to 78 basis points and is significant at the one-percent level.

Table 5 shows the decomposition of environmental certification shares for the bond analysis. In Column 1 and 2 of Table 5, we evaluate the spread impact associated with the LEED and Energy Star shares applying OLS regressions. A one-standard deviation increase in the LEED share reduces the bond spread by 10 basis points. While the coefficient of the Energy Star share has the expected sign, the effect is statistically significant at one percent level as indicated in Column 2[15]. Columns 3 and 4 of Table 5 show the two-stage least square estimation results, with a similar outcome though the coefficient of the Energy Star share is statistically insignificant. 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 statistically significant.

– Insert Table 5 here –

Overall, our findings show heterogeneity in the impact of environmental certification by the certification type and the level of LEED certification similar to Eichholtz, Kok, and Quigley (2013). We document that it is mostly LEED certification that has a significant impact on mortgage and bond spreads. Additionally, the level of LEED certification matters: higher LEED certification levels are associated with larger reductions in the mortgage spread.

6. Conclusion and Discussion

There is an ongoing debate about the financial implications of CSR considerations, mostly focusing on operating measures of corporate profitability. But beyond affecting operational performance, the CSR credentials of a firm may also influence its ability to

[15]In unreported regressions, when we regress bond spread on the LEED and Energy Star shares at the same time, our results confirm that the green discount is originated from the LEED share.

raise capital, as well as the price of that capital (Chava, 2014). The topic of environmental performance and cost of capital has received scant attention in the literature, and this paper is among the first to investigate the impact of direct measures of corporate social responsibility – energy efficiency and environmental performance – on firms' cost of capital. In addition to analyzing cost of capital 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 that collateralize 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 from within the same firm, controlling for a large number 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 by 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 corporate environmental performance.

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 25 to 31 basis points. At the point of means, the interest expense for a mortgage in our sample decreases with some $158,000 to $213,000.

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 at bond issuance, we find that a one-standard deviation increase in the green portfolio share decreases the spread by about 9-20 basis points, which would translate into a $294,000-$630,000 reduction in the interest payment for an average REIT bond. These findings provide an indication that portfolio "greenness" reduces the cost of debt for REITs, possibly reflecting the lower risk and higher income associated with environmentally certified buildings.

Although the effects are statistically significant, the economic significance at the portfolio level is quite small, which is in line with findings for general corporates (Goss and Roberts, 2011) and in line with expectations, given the limited share of environmentally certified buildings in the portfolio of the average of U.S. REIT. We also note that effects on corporate bond spreads are statistically significant in the secondary market analysis only. While statistical power could be at play here, it may also be possible that at the time of origination, lenders do not fully price risks and opportunities related to the en-

vironmental quality of the portfolio – such factors may materialize over time, allowing secondary market investors to more accurately price this risk.

We decompose environmental certification and document that there is heterogeneity in the findings by certification type and quality. LEED certification has stronger impact than Energy Star certification, and we observe larger spread discounts as the LEED certification level increases. The difference in spread is 75 to 78 basis points for the most sustainable buildings, which are LEED Platinum-labeled.

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 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 "green" 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. This may have implications for the cost of capital of inefficient assets and for their market values, providing an incentive for investors to develop investment strategies addressing the energy efficiency and environmental performance of buildings. This effect would provide a partial, market-based solution to an otherwise daunting policy challenge, perhaps slowly reducing the negative environmental impact of the capital building stock.

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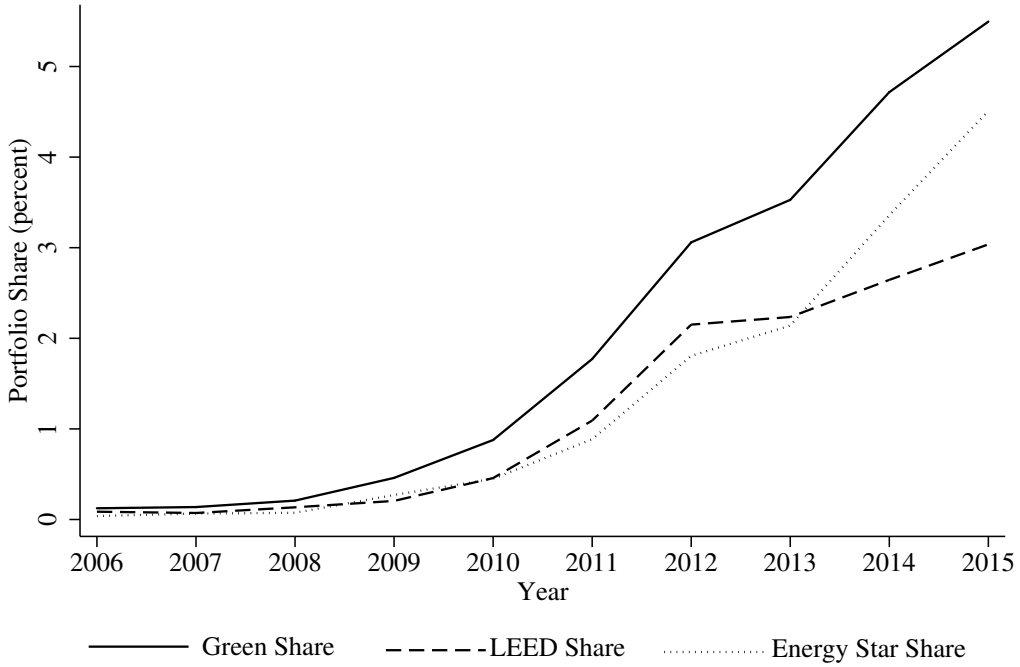
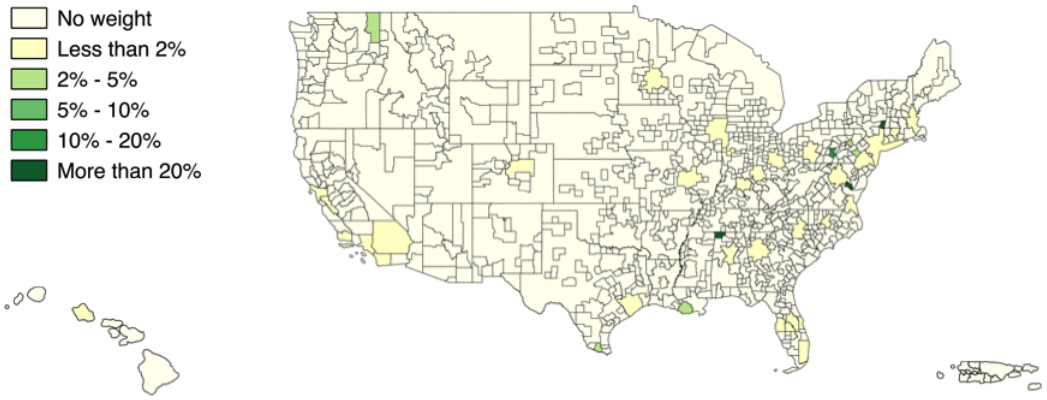
Figure 1: Portfolio Weights of Environmental Certification over Time (2006-2015)



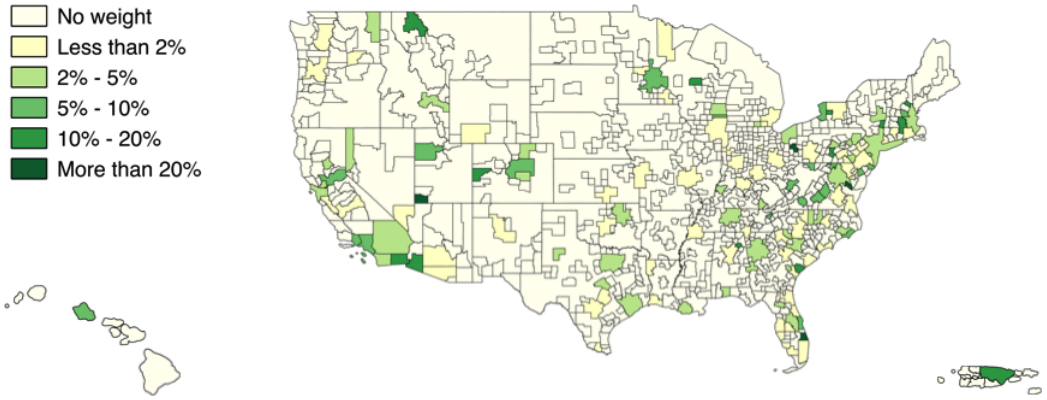
The figure displays the average share of environmentally certified buildings in REIT portfolios over time. The solid line depicts the share of buildings in REIT portfolios with an Energy Star label, LEED certification or both. The dashed and dotted lines represent the share of buildings in REIT portfolios that are certified under the LEED or Energy Star program, respectively.

Figure 2: Environmental Certification of REIT-Owned Assets by CBSA (2006, 2010, 2014)

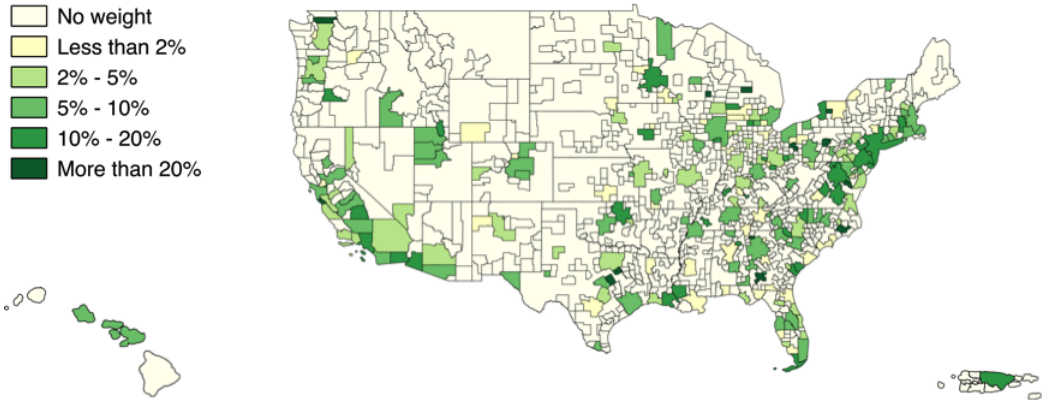
Panel A – Share of Environmentally Certified Buildings in 2006 (sq. ft.)



Panel B – Share of Environmentally Certified Buildings in 2010 (sq. ft.)



Panel C – Share of Environmentally Certified Buildings in 2014 (sq. ft.)



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.

Table 1: Descriptive Statistics
(2006-2015)

Panel A – Commercial Mortgages and Collateral Assets

VARIABLES	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.
	Non-Certified Collateral			Env. Certified Collateral		
Building Characteristics						
Renovated (1=yes)	0.16	0.36	2,802	0.35	0.48	102
Amenities (1=yes)	0.33	0.47	2,802	0.42	0.50	102
Transit Stop (1=yes)	0.22	0.41	2,802	0.49	0.50	102
Asset Book Value (in $ million)	37.73	92.17	5,526	167.55	297.55	195
Less Than 10 Years Old (1=yes)	0.26	0.44	5,526	0.23	0.42	195
Mortgage Characteristics						
Mortgage Spread (in bps)	277.63	162.56	5,526	299.07	144.95	195
Encumbrance (in $ million)	83.61	108.01	5,526	119.02	185.47	195
LTV (fraction)	0.41	0.27	5,526	0.50	0.29	195
Time-to-Maturity (in years)	6.94	4.85	5,526	6.25	3.87	195
Cross-Collateralization (1=yes)	0.39	0.49	5,526	0.16	0.37	195
Fixed Rate (1=yes)	0.84	0.36	5,526	0.80	0.40	195
Firm Characteristics						
Total Assets (in $ billion)	3.92	5.86	5,526	8.43	9.51	195
Firm Q	1.27	0.27	5,526	1.28	0.28	195
Debt Ratio	0.53	0.14	5,526	0.55	0.11	195

Panel B – Corporate Bonds

	All Bonds		
Firm Characteristics			
Green Share	0.03	0.06	2,019
Total Assets (in $ billion)	10.10	8.09	2,019
Firm Q	1.48	0.36	2,019
Debt Ratio	0.52	0.10	2,019
Bond Characteristics			
Bond Spread (in bps)	281.66	367.75	2,019
Moody's Rating	14.28	1.14	2,019
Debt Value (in $ million)	328.16	210.03	2,019
Time-to-Maturity (in years)	6.99	4.95	2,019
Callable (1=yes)	0.34	0.47	2,019
Convertible (1=yes)	0.02	0.12	2,019

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 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 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.

Table 2: Environmental Certification and Mortgage Spreads
OLS Regressions
(2006-2015)

VARIABLES	(1)	(2)	(3)	(4)	(5)
Environmental Certification (1=yes)		-0.402***	-0.251**	-0.259**	-0.307**
		[0.142]	[0.106]	[0.108]	[0.134]
Renovated (1=yes)					-0.098
					[0.090]
Amenities (1=yes)					-0.222**
					[0.096]
Transit Stop (1=yes)					0.020
					[0.079]
log(Asset Book Value)	-0.182***		-0.175***	-0.176***	-0.188***
	[0.042]		[0.039]	[0.042]	[0.064]
Less Than 10 Years Old (1=yes)	-0.098*		-0.107*	-0.099*	-0.123*
	[0.057]		[0.057]	[0.057]	[0.067]
LTV (in percent)	0.584***		0.566**	0.590***	0.657***
	[0.223]		[0.238]	[0.222]	[0.249]
LTV Dummy (LTV≥0.7)	-0.443**		-0.415**	-0.439**	-0.516***
	[0.183]		[0.192]	[0.183]	[0.197]
Time-to-Maturity (in years)	-0.139***		-0.139***	-0.139***	-0.137***
	[0.015]		[0.015]	[0.015]	[0.018]
Cross-Collateralization (1=yes)	-0.415***		-0.429***	-0.415***	-0.331**
	[0.145]		[0.149]	[0.145]	[0.155]
Fixed Rate (1=yes)	1.482***		1.457***	1.484***	1.610***
	[0.189]		[0.202]	[0.189]	[0.212]
log(Firm Size) (lagged, t-1)	0.007			0.009	0.024
	[0.049]			[0.049]	[0.054]
Market-to-Book (lagged, t-1)	-0.022			-0.027	-0.017
	[0.176]			[0.176]	[0.204]
Debt Ratio (lagged, t-1)	0.390			0.395	0.404
	[0.429]			[0.428]	[0.427]
Constant	2.219***	1.057***	2.442***	2.127***	2.045**
	[0.740]	[0.259]	[0.466]	[0.745]	[0.818]
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
Observations	5,721	5,721	5,721	5,721	2,904
Adj. R-squared	0.506	0.314	0.506	0.506	0.531

The table presents the results of the regressions of mortgage spread on the environmental certification indicator, mortgage and building 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 regression in Column 4 also includes building quality characteristics. All regressions include asset type dummies, year dummies and location dummies by state. Heteroskedasticity-robust and REIT-clustered standard errors are in brackets. *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively.

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	-0.696	-1.571**	-0.620	-1.816***	-9.754***
(in percent)	[0.434]	[0.645]	[0.453]	[0.638]	[1.623]
log(Firm Size)	0.013	-0.123	-0.032	0.263	4.676***
(lagged, t-1)	[0.086]	[0.113]	[0.117]	[0.238]	[0.578]
Market-to-Book	-0.305**	-1.203***	-0.284	-0.557*	0.582
(lagged, t-1)	[0.148]	[0.255]	[0.202]	[0.329]	[0.478]
Debt Ratio	0.249	2.110***	-0.058	-1.772***	11.139***
(lagged, t-1)	[0.514]	[0.528]	[0.610]	[0.672]	[2.171]
Moodys Rating	-0.294***	-0.158*	-0.308***	-0.494***	
(8 to 17)	[0.049]	[0.083]	[0.089]	[0.164]	
log(Bond Value Issued)	-0.193	-0.033	-0.118	-0.130*	
(in $ million)	[0.120]	[0.095]	[0.144]	[0.076]	
Time-to-Maturity	0.004	-0.032	0.012	-0.036	
(in years)	[0.014]	[0.021]	[0.013]	[0.028]	
Callable	0.148	0.573***	0.120	0.386***	
(1=yes)	[0.105]	[0.119]	[0.109]	[0.095]	
Convertible	-2.622***	-3.854***	-3.210***	-3.154***	
(1=yes)	[0.443]	[0.516]	[0.671]	[0.938]	
Constant	6.338***	6.213***	7.854***	7.293***	
	[1.244]	[1.015]	[1.470]	[1.964]	
Year-Fixed Effects	Yes	Yes	Yes	Yes	No
Asset Type-Fixed Effects	Yes	Yes	Yes	Yes	No
Observations	313	2,019	246	882	1,600
Adj. R-squared	0.757	0.727	0.743	0.796	0.034
Hansen J (prob.)			0.779	0.308	
Kleibergen–Paap (prob.)			0.000	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 and firm Q calculated as the ratio of market value of assets to book value of assets. 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, 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 CoIumns 1 and 3, we use the sample at origination. In Columns 2 and 4, we use the sample for the secondary market. Column 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 2 and 5. *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively.

Table 4: Decomposition of Environmental Certification and Mortgage Spreads
OLS Regressions
(2006-2015)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
LEED (1=yes)	-0.392***	-0.379**				
	[0.142]	[0.174]				
Energy Star (1=yes)	-0.051	-0.064				
	[0.130]	[0.167]				
High-Level LEED (1=yes)			-0.678***	-0.714***		
			[0.207]	[0.241]		
Platinum (1=yes)					-0.745***	-0.775***
					[0.256]	[0.286]
Gold (1=yes)					-0.669***	-0.699**
					[0.232]	[0.283]
Low-Level LEED (1=yes)			-0.316	-0.285	-0.316	-0.285
			[0.213]	[0.235]	[0.214]	[0.235]
Renovated (1=yes)		-0.099		-0.084		-0.084
		[0.091]		[0.093]		[0.094]
Amenities (1=yes)		-0.222**		-0.207**		-0.208**
		[0.096]		[0.097]		[0.097]
Transit Stop (1=yes)		0.024		0.023		0.023
		[0.079]		[0.083]		[0.083]
log(Asset Book Value)	-0.174***	-0.187***	-0.171***	-0.186***	-0.171***	-0.186***
	[0.042]	[0.064]	[0.042]	[0.065]	[0.042]	[0.065]
Less Than 10 Years Old (1=yes)	-0.098*	-0.123*	-0.110*	-0.131*	-0.110*	-0.131*
	[0.057]	[0.067]	[0.056]	[0.067]	[0.056]	[0.067]
LTV (in percent)	0.593***	0.665***	0.626***	0.697***	0.626***	0.697***
	[0.223]	[0.249]	[0.222]	[0.249]	[0.222]	[0.250]
LTV Dummy (LTV≥0.7)	-0.441**	-0.518***	-0.448**	-0.528***	-0.449**	-0.529***
	[0.183]	[0.196]	[0.185]	[0.198]	[0.185]	[0.198]
Time-to-Maturity (in years)	-0.138***	-0.136***	-0.137***	-0.136***	-0.137***	-0.136***
	[0.015]	[0.018]	[0.015]	[0.018]	[0.015]	[0.018]
Cross-Collateralization (1=yes)	-0.414***	-0.331**	-0.437***	-0.354**	-0.437***	-0.354**
	[0.145]	[0.155]	[0.146]	[0.155]	[0.146]	[0.155]
Fixed Rate (1=yes)	1.486***	1.611***	1.461***	1.586***	1.461***	1.586***
	[0.189]	[0.213]	[0.190]	[0.215]	[0.190]	[0.215]
Constant	2.110***	2.017**	2.058***	2.099**	2.059***	2.101**
	[0.748]	[0.818]	[0.765]	[0.837]	[0.765]	[0.837]
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
Observations	5,721	2,904	5,602	2,853	5,602	2,853
Adj. R-squared	0.507	0.531	0.507	0.532	0.507	0.532

The table presents the results of the regressions of mortgage spread on the decomposition of the environmental certification indicator, mortgage and building characteristics. 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. Gold and Platinum dummies indicate Gold and Platinum LEED labels, respectively. Heteroskedasticity-robust and firm-clustered standard errors are in brackets. *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively.

Table 5: Decomposition of Environmental Certification and Corporate Bond Spreads
OLS, 2-Stage GMM, and Change by Year Regressions
(2006-2015)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	OLS		2-Stage GMM		Δ by Year	
LEED Share	-2.322***		-3.123***		-6.656**	
(in percent)	[0.851]		[0.974]		[3.083]	
Energy Star Share		-0.998*		-0.734		-6.247***
(in percent)		[0.543]		[0.695]		[1.288]
log(Firm Size)	-0.123	-0.127	0.186	0.232	4.587***	4.601***
(lagged, t-1)	[0.113]	[0.114]	[0.210]	[0.253]	[0.576]	[0.570]
Market-to-Book	-1.188***	-1.192***	-0.607**	-0.651*	0.515	0.558
(lagged, t-1)	[0.256]	[0.255]	[0.308]	[0.335]	[0.477]	[0.478]
Debt Ratio	2.088***	2.054***	-1.690**	-1.666**	11.133***	11.078***
(lagged, t-1)	[0.527]	[0.528]	[0.668]	[0.673]	[2.169]	[2.177]
Moodys Rating	-0.161*	-0.147*	-0.477***	-0.399**		
(8 to 17)	[0.083]	[0.083]	[0.156]	[0.157]		
log(Bond Value Issued)	-0.027	-0.034	-0.107	-0.148*		
(in $ million)	[0.095]	[0.095]	[0.077]	[0.076]		
Time-to-Maturity	-0.032	-0.032	-0.018	-0.040		
(in years)	[0.021]	[0.022]	[0.024]	[0.030]		
Callable	0.575***	0.558***	0.352***	0.395***		
(1=yes)	[0.118]	[0.118]	[0.093]	[0.097]		
Convertible	-3.854***	-3.832***	-3.359***	-3.018***		
(1=yes)	[0.516]	[0.521]	[0.931]	[0.950]		
Constant	6.205***	6.144***	8.081***	6.553***		
	[1.014]	[1.012]	[1.713]	[2.187]		
Year-Fixed Effects	Yes	Yes	Yes	Yes	No	No
Asset Type-Fixed Effects	Yes	Yes	Yes	Yes	No	No
Observations	2,019	2,019	878	882	1,600	1,600
Adj. R-squared	0.728	0.727	0.797	0.796	0.032	0.033
Hansen J (prob.)			0.898	0.037		
Kleibergen–Paap (prob.)			0.000	0.000		

The table represents the OLS, 2-stage GMM, and change by year regressions of bond spread on the decomposition of Green share, bond characteristics and firm characteristics 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 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 and firm Q calculated as the ratio of market value of assets to book value of assets. All financial controls are observed at year t-1. The regressions include asset type and year dummies. In the first stage of the regressions in Colum 3 and 4, we regress LEED (Energy Star) share on the lagged LEED (Energy Star) share, 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 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.