Corporate real estate and green building: prevalence, transparency and drivers

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Abstract

Purpose – Green building is a megatrend in corporate real estate management. This paper aims to document the prevalence of green building reporting in public firms, assess how well firms apply good practices of green building and show which firms, countries and industry sectors are particularly advanced in the application of green building technologies.

Design/methodology/approach – The study uses data on green building reporting, green building scores and firm characteristics of 1,281 publicly traded firms from different industries in Organisation for Economic Co-operation and Development countries over a 5-year period. Regression analysis is used to relate the adoption of green building reporting and excellence in green building to firm characteristics.

Findings – The results indicate that there is a huge variation in green building activities and reporting in corporate real estate management across countries and industries. The study finds that firms in the financial and health-care sectors are leading in green building reporting. Environmental, social and corporate governance-oriented, profitable and large firms receive the highest green building scores.

Research limitations/implications – The results in this paper rely on the reported but not inevitably monitored green building activities. There may also be companies that use green building technologies but do not report on them. The conclusions are largely based on correlations and do not allow for causal statements (endogenous variables).

Practical implications – The results in this paper are crucial for practitioners in corporate real estate to benchmark their green building activities and reporting. Additionally, the paper sheds light on how information on green building is propagated in the financial market.

Originality/value – The paper looks at the drivers and barriers of green building for 25 countries and across all industry sectors (1,281 firms). In contrast to that most of the existing literature focuses on single countries and limits the analysis to companies in the real estate and construction industry. Additionally, the paper has a joint focus on publicly available green building reporting and green building scores.

Keywords Sustainability, Green building, Financing constraints, Corporate real estate management, Sustainable practices, Substainability reporting

Paper type Research paper

1. Introduction

Green building is of crucial importance for a sustainable economy. In line with the definition of the US Environmental Protection Agency, we refer to "Green or sustainable, building as the practice of creating and using healthier and more resource-efficient models of construction, renovation, operation, maintenance and demolition" [1]. It is estimated that the real estate and construction sector in developed countries is responsible for 30% of the energy consumption and 40% of the greenhouse gas emissions (Berardi, 2013). Moreover,

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Alawneh *et al.* (2019) report that these sectors are also responsible for 40% of the waste and 12% of water consumption worldwide.

Technological advances such as thermal insulation (Al-Homoud, 2005), energy-efficient windows (Buratti, 2017), improved ventilation, heating and air-conditioning systems (Chenari *et al.*, 2016), water management (Alawneh *et al.*, 2019), smart lightning systems (Xu *et al.*, 2019), as well as self-energy production (Chwieduk, 2003), can substantially reduce a buildings energy consumption. A recent study for the US residential real estate sector estimates that buildings that meet green building standards have a 43% lower energy usage (Zhao *et al.*, 2016).

Given the technological opportunities and the high carbon footprint of currently operating buildings, this raises the question of what drives or prevents corporations to adopt green building standards for their real estate. There is substantial regulatory and political pressure on the corporate real estate sector to develop and implement sustainable strategies to run its buildings and infrastructures (Hojem *et al.*, 2014). Governments worldwide have signed binding treaties such as the Paris agreement to reduce greenhouse gas emissions (Savaresi, 2016). Therefore, they enforce higher energy efficiency standards for the operation and construction of buildings (e.g. energy performance of the EU buildings Directive).

Apart from external pressure, there are numerous benefits of green building and its reporting for companies themselves, most notably cost-saving potential (Kats, 2003), investor relations and marketing benefits (Matisoff *et al.*, 2014; Tiwari *et al.*, 2011; Khanna *et al.*, 2013; and Eichholtz *et al.*, 2013). However, there are also significant barriers such as high initial costs compared to ordinary built real estate (Anh *et al.*, 2013).

The contribution of this paper is threefold. First, the paper looks at the drivers and barriers of green building for 25 countries and across all industry sectors (1,281 firms). In contrast to that most of the existing literature focuses on single countries and limits the analysis to companies in the real estate and construction industry. Second, the paper has a joint focus on publicly available green building reporting (Do companies report on green building? – intensive margin) and green building scores (How well are companies doing in terms of green building? – extensive margin). Especially the investigation of the drivers and barriers of green building reporting is novel. Third, the paper uses a quantitative approach using a novel and comparably large panel data set that is usually used for investors' decision-making (observations of firms over a five-year period).

The results in this paper are useful for corporate executive committees to propel green buildings and practitioners in corporate real estate because they allow them to benchmark their green building reporting and activities [2] *vis-à-vis* other companies in their country and industry. Moreover, the paper showcases the use of data generated for investment decisions for decision-making in the corporate real estate area. Additionally, the paper provides insights on how green building information is propagated into the financial market. To get investor attention for green building efforts it is important that green building activities are reported and that the excellence is visible e.g. by landmark buildings, positive effects on the environment, in sustainability reports or through certifications such as e.g. leadership in energy and environmental design (LEED).

2. Literature review

There is growing literature on the drivers of green building. Darko *et al.* (2017) review the literature regarding the drivers of green building. They consider 42 papers published in peer-reviewed journals and identify 64 drivers of green building. The most important drivers are government regulations and policies (Darko *et al.*, 2017; Falkenbach *et al.*, 2010; Qi *et al.*, 2010). In addition to that cost savings potential such as energy conservation (Low *et al.*, 2014; Murtagh *et al.*, 2016), reduced construction costs (Zhai *et al.*, 2014) and reduced

liability and risks (Chan *et al.*, 2009) appear to be important. Apart from costs savings green buildings may also be revenue-enhancing because they have positive marketing and investor relation benefits (Love *et al.*, 2012).

Factors that play an important role for companies in the real estate sector such as the reduction of vacancy rates (Gou *et al.*, 2013), improved demand for the buildings (Andelin *et al.*, 2015) and the rent premium for green building (Eichholtz *et al.*, 2013) do not play a major role in the corporate real estate sector, as the buildings are mainly self-occupied. Nevertheless, practitioners in corporate real estate observed that the occupancy rate and the internal demand for green buildings are higher. The existing literature is heavily focusing on the real estate sector. The considerations above indicate that a separate analysis of the drivers and barriers for the corporate real estate sector is merited. This paper intends to fill this gap.

Apart from pure cost-benefit considerations, it has also been found that green building is driven by altruism regarding environmental protection, waste reduction and corporate social responsibility (Mulligan *et al.*, 2014). Apart from this green building may also be adapted to improve the corporate image, culture and vision (Windapo and Goulding, 2015). Significant barriers for the green building named in the literature are higher initial costs and longer amortization periods in comparison to non-green buildings, tendency to maintain the status quo, as well as limited knowledge and skills of contractors (Anh *et al.*, 2013). Similarly, Masalskyte *et al.* (2014) report that there are huge differences in the adoption of green building policies (corporation-specific good practices and principles when it comes to green building) across industries.

The data used in the studies reviewed by Darko *et al.* (2017) are exclusively collected from surveys, interviews and case studies (or a mix of those). While insightful these methods have the drawback of selection bias (endogenous responses) and they only allow researchers to analyze small samples. Moreover, they are only looking at a cross-section of companies at a particular point in time. In contrast to this, this paper contributes to the literature by studying actual outcomes based on public company data and third-party green building ratings.

3. Data and descriptive statistics

We use data from the financial data provider Refinitiv on green building reporting, green building scores and firm characteristics. We start by selecting only companies which are headquartered in Organisation for Economic Co-operation and Development (OECD) countries with a market capitalization of more than six billion. We select OECD countries to have companies from different geographic locations and different cultural areas with developed capital markets. We limit our sample to comparably large companies to have good data coverage and a certain degree of comparability. We retrieve annual data for the years between 2015 and 2019. Furthermore, we remove all the observations from our sample for which we do not have full data availability. This leaves us with a panel data set of 1,218 companies from 25 countries observed over a 5-year period (unbalanced panel). Overall, our analysis covers 5,979 firm years [3].

As we are interested to investigate which companies report about green building and which companies receive high third-party green building scores our main variables of interest from the Refintiv data set are the green building dummy (GBD) and the green building score (GBS). GBD is an indicator variable that takes the value of one of the company reports about green sites or offices such as major refurbishments or certifications like LEED or building research establishment environmental assessment methodology (BREEAM) and zero otherwise. Moreover, Refinitiv benchmarks the quality of the green building activities of companies compared to their peers and awards a green building score which takes a value between 0 (no

reported activities) and 100 (highest score) [4]. Table 1 contains the descriptive statistics and reveals that 39.0% of the companies in the sample report about their green building activities. The empirically observed building scores range from 0.00 to 96.67 averaging at 34.36. This means there is a lot of variation in both green building scores (GBS) and reporting (GBD) across the sample which we aim to explain with our analysis.

We use the building to total assets ratio (BTA) as a rough proxy for cost savings. To calculate this ratio the reported building assets are divided by the total assets of the company. The numbers for a given year are taken from the latest available financial statement. We winsorize observations above the 99% quantile to avoid the inclusion of outliers. The intention behind this proxy is that the more building assets a company has the more potential cost-savings in buildings can be leveraged using superior green building technologies (e.g. energy-saving). This view is consistent with Kats (2003), Low *et al.* (2014), Murtagh *et al.* (2016), Zhai *et al.* (2014) and Chan *et al.* (2009) who name cost saving as a benefit of green building. Moreover, companies that have a high share of building assets are more likely to gather knowledge on green building and overcome fixed costs [barriers of the green building according to Anh *et al.* (2013)]. We, thus, expect companies with a higher BTA to have a higher likelihood of adopting reporting about green building and higher green building scores. To the best of our knowledge, this is the first study that uses this measure in connection with green building research.

We also retrieve data on proxies for a company's environmental, social and governance performance (ESG) and controversies (CON) to gauge how important general corporate responsibility and marketing benefits are. The scores are calculated by Refinitiv (financial data provider) and range between 0 and 100. Like mentioned before, in the relation to the green building score the ESG or CON score is the better the higher the number [5]. The idea is that a company that cares, in general, more about ESG topics is more likely to adopt green building and report about it. This is motivated by the previous literature that finds that green building is adopted to improve corporate social responsibility (Darko *et al.*, 2017). Moreover, companies with ongoing ESG controversies may seek to deploy green building to improve corporate image and marketing benefits. According to Eichholtz *et al.* (2013), green building may be used as a marketing device.

Moreover, we collect information on a company's return on equity (ROE) to measure a company's profitability. This ratio can take extreme values (e.g. if a company has high losses and an eroded capital base). To avoid that extreme values may bias our estimation we

Variable	*N*	N_Firms	mean	median	sd	min	max
GBS	5,979	1,218	34.36	0.00	43.10	0.00	96.67
GBD	5,979	1,218	0.39	0.00	0.49	0.00	1.00
BTA	5,979	1,218	0.13	0.08	0.14	0.00	0.77
ESG	5,979	1,218	53.37	54.51	18.84	1.98	93.50
CON	5,979	1,218	88.48	100.00	25.11	0.45	100.00
ROE	5,979	1,218	18.34	15.67	13.12	−3.60	51.13
LEV	5,979	1,218	18.74	15.88	15.48	0.00	65.88
MCP	5,979	1,218	23.35	23.19	1.10	19.14	31.12

Notes: The table contains a selection of descriptive statistics such as the number of observations (N), number of firms (N_Firms), mean, median, standard deviation (sd), minimum (min) and maximum (max) for the variables used in this paper. This includes green building score (GBS), green building dummy (GBD), building to total assets ratio (BTA), return on equity (ROE), leverage ratio (LEV), environmental, social and corporate governance performance (ESG), controversies (CON) and market capitalization in USD (MCP)

Table 1.
Descriptive statistics

winsorize the ROE variable at the 5.0% and 95.0% percent quantiles. As pointed out by Anh *et al.* (2013) higher (investment) costs for green buildings compared to regular buildings are a major barrier for corporate investments into green buildings. As a result of this, companies that are not very profitable may not be able or willing to invest in green building technologies.

A similar reason why some companies may not adopt green building reporting or underperform compared to their peers in terms of green building activities is that companies with little capital available for investments or little borrowing capacity are less likely to employ capital for green building projects. We use the leverage ratio (LEV) as a proxy for capital constraint companies. We calculate it as total debt divided by enterprise value. Total debt includes both long-term and short-term debt for the most recent fiscal period. Enterprise value is calculated as the sum of market capitalization, total debt, minority interests net of cash and short-term investments. We winsorize the variable at the 95.0% level (outlier treatment). To the best of our knowledge, we are the first study that uses this proxy in connection with green buildings.

In addition to that, we want to investigate potential size effects. The hypothesis is that a notable amount of fixed costs arises when green building activities are adopted. Companies need, for example, in-house knowledge and experts that understand and can drive green building projects. However, once acquired, the knowledge can be easily transferred to several buildings or productions sites. Thus, a larger company may engage in green building with a higher likelihood. In addition to that, they have more incentives and a better structure to report about it. We measure the company size with the market capitalization (MCP). To compare the market capitalization across different countries we measure it in US$. We use the logarithm of the market capitalization to reflect the non-linearity that size matters more for small values (e.g. one billion additional market capitalization for a company worth 10 billion has a different effect than for a company worth 100 billion).

To identify the impact of the above-described variables we enrich the data set with the Global Industry Classification Standard (GICS) sector code and the country of the firm (country where the headquarter is located). As emphasized in the existing literature, there is a lot of variation in green building activities across industries. This becomes evident in Figure 1. The financial sector shows the highest density of companies with green building reporting (55.41%). Also, the health-care industry (46.73%) and not surprisingly the real estate sector itself (43.56%) are comparably advanced in the application of green building reporting. In contrast to this only slightly above 22.14% of the companies in the utility and 24.14% of the companies in the materials sectors report about green building. This confirms the qualitative results of Malskyte *et al.* (2014) that there is a different perspective on green building activities across industries.

Panel A of Figure 2 shows that the number of companies with green building reporting is increasing over time from 36.93% in 2015 to 45.10% in 2019. Panel B of Figure 2 shows the prevalence of green building varies substantially across regions, and therefore also countries. We analyze regions instead of single countries, as we have only very few observations for some of the countries in our sample [6]. The cross-region comparison shows that in Europe 43.74% of the companies report about green building. In the Asia Pacific region, only 27.79% of the companies engage in reporting activities with respect to green building. The Americas region (North and South America) ranks in the middle with roughly 39.61%. This suggests, as emphasized in the previous literature (Darko *et al.*, 2017; Falkenbach *et al.*, 2010; Qi *et al.*, 2010), that the regulation in the single countries has quite some effect on the outcomes of green building in the corporate real estate sector. Moreover,

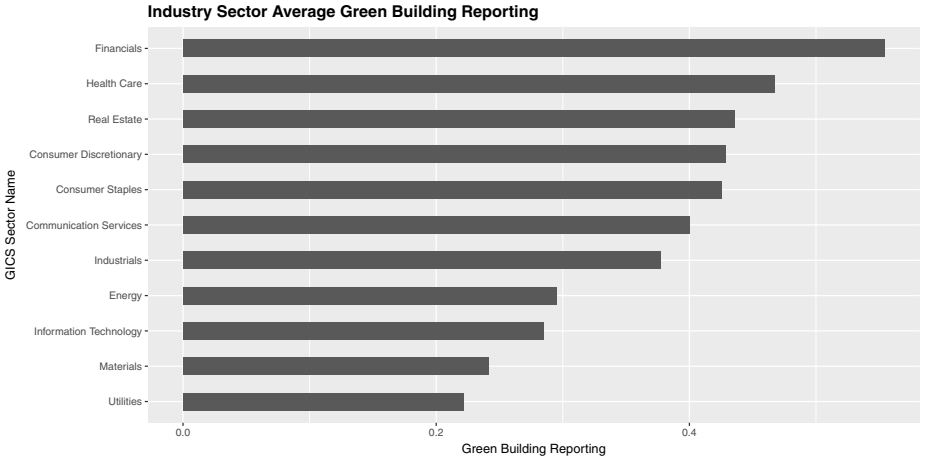

Figure 1.
Green building reporting across industry sectors

Note: Figure 1 displays the average number of companies per industry sector that report on green building activities. The Global Industry Classification Standard (GICS) sector code is used to group the companies into the industry sectors. The averages are pooled average across both the cross-section of firms and over time

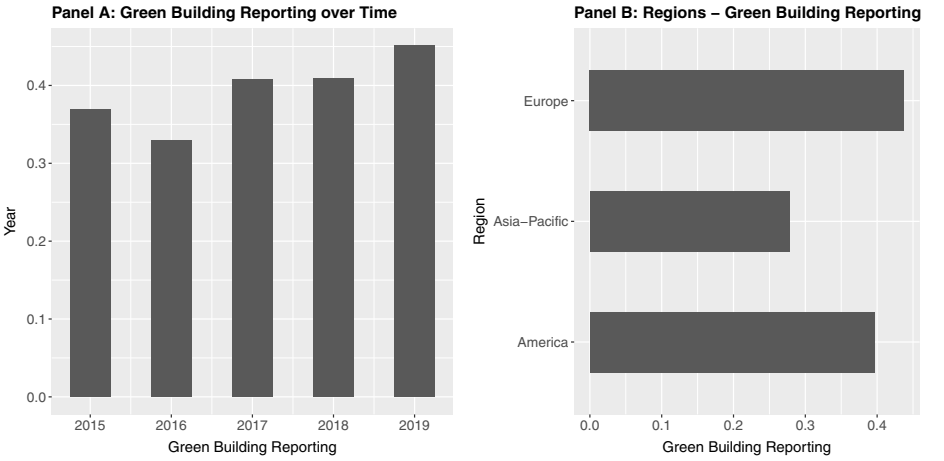

Figure 2.
Green building reporting over time and across the region

Note: Panel A of Figure 2 shows the number of companies that report about green building over the sample period between 2015 and 2019. Panel B shows the number of companies that report about green building across regions (Europe, Asia-Pacific, America). The headquarter of a company is used to determine the country and region a company is assigned to

this indicates (not surprisingly) that green building reporting is more widespread in developed countries.

4. Empirical analysis

4.1 Green building reporting

After we have obtained proxies for drivers of green building (barriers and benefits) based on observable company characteristics, we want to investigate the relation of these proxies to one of our variables of interest the GBD empirically. We use regression analysis to quantify the relationship between these variables. As mentioned above the GBD variable takes the value of one when a green building reporting has been adopted and zero otherwise. This means we are effectively modeling a probability (the probability that a company has adopted green building reporting or not). This variable indicates whether a company engages in green building activities at all and reports about it.

To consider, the binary nature of the variable we use a probit model to estimate the relations. This functional specification ensures that our model quantities remain between 0 and 1. To be exact, we model the GBD as a function of several country dummies α_c, time dummies α_t and industry dummies α_s as well as firm-level variables that vary across both time and firms X. The sensitivities to the explanatory variables are captured by β. We abstain from using firm fixed effects to avoid the incidental parameter problem (a non-linear model needs a high number of observations per fixed effect to estimate the fixed effects correctly). Thus, we estimate the following model:

$$\begin{aligned} Pr(GBD = 1 \mid X) &= \Phi\left(X^T \beta\right) \\ X^T &= [BTA,\ ESG,\ CON,\ ROE, LEV, MCP] \end{aligned} \tag{1}$$

where Φ is the cumulative distribution function of the standard normal distribution. Pr denotes the probability. Table 2 below contains the estimated coefficients and the associated standard errors (in parenthesis). Specification (1) is estimated without any fixed effects, specifications (2)–(4) include the fixed effects one by one and specification (5) is estimated with all the fixed effects. Intuitively, what we want to achieve with this estimate is to calculate the sensitivity of the GBD to drivers and barriers of green building. The fixed effects are a way to account for the influence of unobserved variables that vary across countries, time and industries and may influence the relation between the GBD and the drivers and barriers of green building reporting. In the following paragraphs, we will discuss the results. We are particularly interested in the statistical significance of the relationships, the economic magnitude of the estimated effects and the relative importance of the variables [7].

The coefficient of the BTA variable is positive and statistically significant in all five considered specifications. This means that a high share of building assets increases the likelihood that a firm adopts green building reporting. In terms of average marginal effects (AME) (based on specification 5) a one-unit increase in the variable would make the adoption of a green building reporting 20.94% more likely. One can also see that the effects are likely to be underestimated when industry, country and time effects are not sufficiently considered in the specification.

It makes intuitive sense that firms that have only a few buildings are less likely to report on green building activities. They have less cost-saving potential (see arguments in Section 3) from the adoption of the green building itself, and therefore also fewer incentives to report on

Variable	Dependent variable: Green building dummy (1)	(2)	(3)	(4)	(5)
Buildings to total assets (BTA)	0.329***	0.520***	0.489***	0.331***	0.707***
	(0.123)	(0.137)	(0.133)	(0.123)	(0.15)
Return on equity actual (ROE)	0.008***	0.009***	0.005***	0.008***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Total debt to enterprise value (LEV)	−0.002	0.001	−0.003***	−0.002	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Controversies score (CON)	−0.010***	−0.010***	−0.011***	−0.010***	−0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ESG score (ESG)	0.023***	0.026***	0.027***	0.023***	0.029***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Company market cap (MCP)	0.212***	0.199***	0.200***	0.209***	0.188***
	(0.02)	(0.021)	(0.021)	(0.02)	(0.022)
Constant	−5.817***	−5.579***	−5.696***	−5.763***	−5.438***
	(0.485)	(0.513)	(0.522)	(0.489)	(0.559)
Observations	5,979	5,979	5,979	5,979	5,979
Industry FE	No	Yes	No	No	No
Country FE	No	No	Yes	No	No
Time FE	No	No	No	Yes	No

Table 2.
Probability of green building reporting

Notes: The table below contains the estimation results of estimating equation (1) using a probit model and the data and variables as described in Section 3. The table contains point estimates of the regression coefficients and standard errors in parenthesis. *, **, *** denote significance at the 10%, 5% or 1% level, respectively

it. In the extreme scenario, it does not make sense for a company to report on green building activities if it does not even have building assets (BTA = 0). The positive relationship is also in line with previous results in the literature that show that cost savings are a major driver of green building (Darko *et al.*, 2017; Manoliadis *et al.*, 2006).

The ROE variable is also a statistically significant predictor of the likelihood that green building reporting is adopted. As hypothesized before and in line with the previous research profitable companies are more likely to adopt a green building, and thus report about it. The economic magnitude of the effect is also quite notable. One percent in increase in the ROE leads to a 0.20% increase in the probability that a company has a green building reporting (AME based on specification 5).

This result is consistent with the questionnaire survey evidence gathered, for example, in Ahn *et al.* (2013) for the US market. The evidence in their paper uncovers that the cost premium of green buildings is one of the major barriers to adoption. We use the ROI as a proxy for the profitability of a company. We argue that the obtained results in this study suggest that companies that produce losses are less likely to engage in green building (reporting). On the other hand, those that are profitable have fewer problems to overcome the barrier of high initial investment costs because they can use the profits to finance the investment in green building [8]. These results confirm the opinions raised by real estate professionals in the study of Ahn *et al.* (2013).

The total debt to enterprise value (LEV) is not significant in four out of five specifications suggesting that both statistical and economic significance of the capital base as a driver of green building in corporate real estate are negligible. With respect to the barrier for green building investments flow variables such as the ROE seem to be more important than stock variables such as borrowing capacity or the amount of equity financing. Nevertheless, the

coefficient has the expected sign suggesting that companies with a high degree of debt are less likely to report about green building.

As discussed before the literature agrees that green buildings are associated with cost premiums (Ahn *et al.*, 2013). Those costs can be either financed from ongoing profits (as proxied by the ROI and discussed above) or the capital stock (existing equity of the company) as proxied by the LEV variable. So, companies with a lot of equity can pay these initial cost premiums. Our results, however, suggest that they rather not use their reserves or borrowing capacity to invest in green building. To the best of our knowledge, this paper is the first that investigates the relationship between a proxy for financial leverage and green building.

As expected, the CON score is negatively related to the adoption of green building reporting. This points toward the hypothesis that companies that are exposed to negative headlines use green building reporting to improve their image and uncover marketing benefits from green building. A prominent example of such use of the green building is the "green" renovation of the Deutsche Bank Towers (Green Towers) in the aftermath of the financial crisis. Based on the AME (specification 5) a one-point increase in the CON score makes it 0.33% less likely that a company reports on green building activities.

These findings are in line with the results of the existing literature that finds that green buildings are used to improve the corporate image (Windapo and Goulding, 2015) and have marketing and investor relationship benefits (Matisoff *et al.* (2014) and Eichholtz *et al.*, 2013). The seminal paper the economics of green building written by Eichholtz *et al.* (2013) states "Sustainability may also be a marketing device that large corporations and small businesses alike can employ successfully." Our results support this claim.

The better the company is doing in general in terms of ESG performance, the better is also the companies green building performance. There is a statistically significant positive relationship between the ESG and the GBD variable. A one-point increase in ESG leads to a 0.87% increase in the likelihood that the GBD is equal to one (based on specification 5). This makes the companies general ESG performance one of the most important predictors of green building activities and highlights the importance of corporate social responsibility as a driver of green building. However, it should be noted that we cannot infer a causal relation in the direction from ESG to GBD because green building reporting or green building, in general, can also improve ESG scores (reverse causality). We can simply state that the two variables are related or significantly correlated.

The relation between corporate social responsibility and green building has already been uncovered in previous papers. A notable example is Mulligan *et al.* (2014). They surveyed building professionals from the USA (Michigan). The responses of the building professionals showed that corporate social responsibility is among the motivations for green building. Our results confirm that there is a high correlation between ESG scores (our measure to proxy for corporate social responsibility) and green building (reporting). We add to the literature by establishing this relation using data on actual firms' decisions rather than intentions or perceptions stated in a survey. Moreover, we show that the relationship is also important for markets outside the USA.

Finally, the results also show that the likelihood that a company has a green building reporting in place is increasing with the company's size. To the best of our knowledge, the consideration of size effects in green building research is novel. This relation has been investigated for ESG in general by Drempetic *et al.* (2019). They show that large companies have better ESG scores. They explain their result with the fact that larger companies have more resources and deliver more information and data that can be used for ESG scores. Our results show that the same applies to green building reporting. The findings can also be rationalized

with fixed cost components. The larger a company the more benefits arise from those fixed costs. It is also possible that regulation and public pressure are different for large companies.

Overall, it is reassuring that all the variables have the expected sign. This suggests that the model is well specified. However, the above analysis comes with certain limitations. Most notably due to the incidental parameters problem an inclusion of firm fixed effects is not feasible. As pointed out by Lancaster (2000) due to the non-linear nature of the model the marginal effects of the variables of interest depend on the value of the estimated fixed effects (unlike in a linear model). The firm fixed effects, however, cannot be reliably estimated in the non-linear setting with a maximum of five observations per fixed effect. As the model cannot be saturated with firm fixed effects an endogeneity problem arises, as the independent variables might be correlated with unobserved firm characteristics. As a result of this, no causal interpretation of the results is possible.

However, we believe that the calculated sensitivities alone are of interest. In addition to that, we try the alleviate the issue by using time, industry and country-fixed-effects when we estimate the models. Moreover, we explain scores in the next section where we also include firm-fixed effects in certain specifications.

The results of our analysis confirmed the results in the existing literature about green building which has become an impressive body of literature in recent years. We contribute to the literature by using a different methodological approach, international data and focus on corporate real estate instead of the real estate and construction industry.

4.2 Green building scores

After we have analyzed which companies use green building and report about it, we are now more interested in how good companies are doing compared to their peers (comparable companies) in terms of green building. As explained above we measure this with third-party green building scores from Refinitiv (financial data provider). As we are now modeling a score and not a probability, we use a linear panel data model for the analysis. The use of the linear model has the advantage that we can also include firm fixed effects. From an economic perspective, we are interested in the question of whether green building scores are driven by the same factors as the adoption of green building reporting. The question of whether companies report (intensive margin) or engage in green building activities at all is related but not identical to the question of how good companies are doing in terms of the green building once they have decided to adopt it (extensive margin).

The dependent variable in these regressions is the GBS. We model this variable as a function of the same explanatory variables as in equation (1). In addition to that, the model is saturated (depending on the specification) with time (α_t) and firm fixed effects (α_i). The β coefficients denote the sensitivity of the GBS to explanatory variables. The following model is estimated:

$$GBS_{i,t} = a_t + a_i + \beta_1 BTA_{i,t} + \beta_2 ROE_{i,t} + \beta_3 LEV_{i,t} + \beta_4 CON_{i,t} + \beta_5 ESG_{i,t} + \beta_6 MCA_{i,t} + \varepsilon_{i,t}. \quad (2)$$

Table 3 contains the results. Specification (1) is estimated with industry, country and year fixed effects. Specification (2) has time fixed effects only, specification (3) has firm fixed effects only and specification (4) combines firm and time fixed effects.

Variable	Dependent variable: Green building score (1)	(2)	(3)	(4)
Buildings to total assets (BTA)	16.499***	6.599*	−5.391	1.71
	(3.968)	(3.534)	(11.631)	(11.637)
Return on equity actual (ROE)	0.187***	0.224***	−0.035	−0.05
	(0.041)	(0.039)	(0.039)	(0.039)
Total debt to enterprise value (LEV)	−0.028	−0.053	−0.008	−0.038
	(0.035)	(0.034)	(0.035)	(0.035)
Controversies score (CON)	−0.310***	−0.298***	−0.167***	−0.128***
	(0.023)	(0.023)	(0.017)	(0.018)
ESG score (ESG)	0.772***	0.645***	0.542***	0.453***
	(0.032)	(0.029)	(0.037)	(0.04)
Company market cap	5.131***	6.023***	4.128***	1.443
	(0.583)	(0.56)	(0.944)	(1.082)
Industry FE	Yes	No	No	No
Country FE	Yes	No	No	No
Time FE	Yes	Yes	No	Yes
Firm FE	No	No	Yes	Yes
Observations	5,979	5,979	5,979	5,979
R^2	0.252	0.189	0.879	0.88
Adjusted R^2	0.247	0.187	0.848	0.85

Notes: The table below contains the estimation results of estimating equation (2) using a linear fixed effects panel regression model and the data and variables as described in Section 3. The table contains point estimates of the regression coefficients and standard errors in parenthesis. *, **, *** denote significance at the 10%, 5% or 1% level, respectively

Table 3. Drivers of green building scores

Intuitively, the model explains variation in the green building score with the drivers and barriers of green building. It should be noted that in this linear model the estimated coefficients can be interpreted directly as marginal effects of a one-unit increase in the associated variable.

In specifications (1) and (2) the results mirror the results regarding the green building reporting. There are both statistically and economically significant positive relations between BTA, ROE, ESG and MCP to the GBS.

The BTA variable proxies for potential cost savings, which have been also found to be an important driver of green building in the existing literature (Manoliadis *et al.*, 2006; Darko *et al.*, 2017). The ROE variable resembles the profitability of the company and we argue that the positive coefficient obtained in the regressions points toward the importance of the initial cost premium of green building as a barrier (Ahn *et al.*, 2013). The more profitable a company the higher the green building score. Similarly, the results for the ESG variable are in line with evidence in the previous literature that shows that corporate social responsibility is an important driver of green building (Mulligan *et al.*, 2014). The regression results show that companies that do well in terms of ESG (our proxy for corporate social responsibility of a company) also have a better green building score. We also find a positive and significant relation between size and green building scores. A relationship that has (to the best of our knowledge) so far only been studied for ESG in general but not a green building. Our analysis shows that the results obtained for ESG translate to green building.

Moreover, as before the LEV variable seems also not to play a significant role in explaining the variation of green building scores. We hypothesized that companies with a lot of debt cannot afford the cost premium for green buildings. This barrier is among others

mentioned in Ahn *et al.* (2013). We could not establish this relationship in our analysis. A joint interpretation of the results of the LEV and ROE variable suggests that losses or low profitability are a more important barrier for green building than low capital reserves. In addition to that, the CON variable is negatively associated with the GBS. In this context the CON variable proxies for potential marketing benefits. We argue that companies with ongoing controversies are more likely to adopt green building to enjoy marketing benefits and improve the corporate image. These two aspects have been identified as drivers of green building in Matisoff *et al.* (2014) and Eichholtz *et al.* (2013).

The regression specifications (1) and (2) also exploit cross-sectional variation across firms. The explanatory power of the considered variables is quite impressive. We measure the explanatory power of regression with the adjusted R^2. This measure reports the percentage of the total variation in the GBS that is explained by the explanatory variables. The adjusted R^2 value of specification: (1) shows that the variables jointly explain 24.70% of the variation in the green building dummy. Excluding industry and country effects in the specification, (2) significantly lowers the explanatory power of the model and the adjusted R^2 drops to 18.70%.

This points toward the importance of industry-specific and country-specific effects. Industry and country dummies explain a notable amount of the variation of the green building score. This confirms the results of Darko *et al.* (2017) regarding the impact of regulations, which differ across countries and the conclusions of industry differences as pointed out in Malskyte *et al.* (2014). Our paper contributes to the existing literature by studying those effects with a cross-country comparison.

If firm fixed effects are added, some of our explanatory variables lose their statistical significance. In specifications (3) and (4) the firm-fixed effects control for unobserved time-invariant firm effects. This means we are effectively exploiting variation within firms over time. In this specification, the coefficients associated with the BTA and the ROE variables are not significantly different from zero anymore. The only variables that still matter are the CON and the ESG variables, as well as the MCP. The explanatory power of this model is impressive. The R^2 of the model with firm fixed effects is increasing to 84.80%. In specification (4) with time-fixed effects, even the MCP loses statistical significance.

It should be noted that these results do not rule out a statistically significant effect of the variables that lost significance in the saturated equation. As explained above the results are only driven by within-firm variation. Cross-sectional variation across firms in the variable is absorbed by the firm fixed effects. It might, however, still be that those cross-sectional differences are driven by differences in the explanatory variables. We are just not able to distinguish it from other variables that vary in the cross-section of firms. However, the results still highlight that the ESG and CON are among the most important drivers of green building excellence. The results also indicate that the importance of the variables that drive green building reporting and green building excellence might be different.

5. Conclusion and outlook

This paper analyzes the existence of green building reporting and third-party green building scores for 1,281 companies in 25 OECD countries. The information is collected from the financial data provider Refinitiv. The data shows that green building reporting varies substantially across firms, industry sectors and countries. The results show that the likelihood that firms in the healthcare and financial sectors report on their green building

activities is approximately twice as high as for firms in the utility, materials and energy sectors.

In addition to that, there are notable cross-country differences. Countries in the Asia-Pacific region are lagging when it comes to green building. The country average of companies that report on green building is only 27.79%. In contrast to this in Europe, almost every second company reports on green building (43.74%). Moreover, using regression analysis the paper yields insights into both drivers and barriers for green building. We find evidence that companies with a high share of building assets, and therefore cost-saving potential are more likely to do well in terms of green building. Moreover, we find evidence for marketing benefits as proxied by ESG performance. The most important barriers seem to be general financial performance and debt capacity. This suggests that some firms may not be able to afford green buildings. Company size also matters.

This paper confirms results established in the previous literature via qualitative research methods. In addition to that, the paper shows that drivers that have been identified by the literature studying real estate and construction companies can be largely applied for corporate real estate in general in different sectors and countries.

The analyzed companies are clustered by headquarters, not by building locations. In the light of recent political developments, e.g. Germany shall become climate neutral by 2045 and already taken regulatory decisions, the question might arise whether companies are planning to shift and/or have already shifted industrial facilities to those regions which are less regulated and keep only offices and logistic buildings in the European region. In other words: Does the enforcement of Green Building result in the deindustrialization of Europe? This research question, among others, shall be analyzed and discussed in a follow-up of this paper.

Notes

1. This definition is common in the literature and among others also used by in the studies of Alawneh *et al.* (2019) and Ding *et al.* (2018). The definition can also be retrieved via the following weblink: US Environmental Protection Agency, in: https://archive.epa.gov/greenbuilding/web/html/.
2. Green building activities refer to green building as defined above, as well as associated activities such as reporting, marketing with green building or the use of it for corporate social responsibility and investor relation purposes.
3. We use aggregate firm level data. The data source does not offer building level data.
4. The green building scores are calculated as outlined in Refinitiv (2020) as all the Refinitiv ESG scores.
5. The ESG and Controversies scores are calculated as outlined in Refinitiv (2020).
6. For Colombia, Turkey, New Zealand and Israel we have less than 10 complete observation. It should be noted that for some OECD countries such as e.g. Greece there are no complete observations at all. A country level analysis could potentially be analyzed in a follow-up paper.
7. We abstain from executing unit root tests, as they require a large time dimension in the data to be valid. However, our panel data set has only a short time dimension ($T = 5$) and a large cross section ($N = 1{,}218$). Given that the time dimension is that short we believe that non-stationarity of our variables is not a problem. In addition to that the time fixed effects significantly alleviate a potential problem.
8. At this point it should be noted that the existing literature generally agrees that the high initial investment costs are outweighed by future benefits such as e.g. lower operating cost due to energy savings, rent premiums or marketing benefits.

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