The Value of Green Buildings
New Evidence from the United Kingdom

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Abstract

International growth in the built environment's sustainability and energy efficiency initiatives command that the UK's "green" commercial real estate sector be placed in an international context. We investigate the financial performance of London's BREEAM rated office buildings over the 2000-2009 period. Specifically, this study is the first to report the effects of rental contract features and "green" building competition on certified premiums in the market. Results from this analysis have three implications. First, there is a positive impact of a building's green characteristics on rental and sales transaction prices per net square meter in the order of 21 and 26 percent, respectively. However, these premiums could be moderated further with third party controls for building quality, a hedonic variable not widely disseminated in the UK. Secondly, rental contract features, i.e. lease term and rent free period, and market signals, i.e., days on market, have a moderating effect on returns to BREEAM certified rental prices, decreasing rental premiums by about five percentage points. Lastly, the expanding supply of BREEAM certified buildings, within a given micro-location, has a positive impact on rents and prices in general, but moderates the BREEAM premium further. Consequently, competition in "green" building markets decreases premiums in the rental and transaction markets by, three and one percentage points, respectively. Our analysis implies that future studies should incorporate third party building quality measures, rental contract features and competition measures in the empirical analysis of "green" commercial real estate.

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1. Introduction

In the current debate on climate change, buildings represent more than just places of operation or part of an investment portfolio. Rather, they are considered by policy makers, corporations and institutional investors to be vehicles for achieving energy efficiency, carbon abatement and corporate social responsibility. This shift in the perception and use value of buildings has led to changes in investment and regulations towards the built environment over the last decade, moving commercial property markets towards increased levels of energy efficiency and sustainability.

Some anecdotal evidence on these developments is provided by London's 2015 skyline, which is set to be a showcase of environmental buildings, displaying some of the most advanced and innovative applications of alternative energy technology in buildings. For example, The Shard, towering 72 stories and 306 meters into the London skyline, is being constructed to consume 30 percent less energy as compared to an otherwise similar building; Bishopsgate Tower, covered by 2,000 square meters of photovoltaic cells, will generate 200 kilowatts of its own electricity; and Broadgate Tower, through its extensive heat recovery system and efficient cooling plant, aims to reduce carbon emissions by 40 percent.

Part of the focus on energy efficiency is driven by the UK's robust regulatory framework regarding the carbon abatement and energy efficiency potential of the built environment. This framework is embedded in EU legislation, where buildings are a strategic cornerstone of the recently recast Energy Performance and Buildings Directive (EPBD). To comply with the EPBD, the UK has enforced building energy efficiency regulations through two initiatives. First, it has implemented the mandatory display of Energy Performance Certificates (EPCs), Declaration of Energy Certificates (DECs) and zero carbon building initiatives. Second, the UK has instituted a carbon market, solely aimed at building energy consumption, with the Carbon Reduction

Commitment Order (CRC) of 2010. The CRC is the first regulation of its kind that not only prices the negative externalities from buildings, but also ranks companies by means of carbon performance league tables. Allowance purchases commence in 2012 and are expected to yield £1bn in revenues for the UK Treasury.

Besides regulation, private sector involvement in energy efficiency is growing. In 1990, the UK commercial real estate market was the first to introduce a private third-party assessment tool to measure a building's environmental impact – the BRE Environmental Assessment Method (BREEAM). In fact, the BREEAM labeling scheme is a predecessor of the U.S. Green Building Council's LEED labeling scheme. Moreover, London's largest commercial landlords, including British Land, Grosvenor, Hammerson, Hermes and Land Securities, are taking action through the formation of the Better Buildings Partnership, with the aim to cut carbon emissions from commercial property and to improve the "sustainability" of London's commercial buildings.

Despite these initiatives, the financial implications of the transition to a "greener" building stock are not yet clear. This information becomes more important as the supply of commercial buildings certified to be "green" increases, demand for such buildings is affected by more private sector attention to "green" buildings, and regulations surrounding the energy efficiency and carbon abatement potential of buildings are tightened. For investors, it is important to understand the value and risk implications. For policy makers, it is important to evaluate the effectiveness of increased transparency through building performance disclosure. Thus, are more efficient new construction and retrofits of the existing stock just "doing good", or does it reflect better risk management and opportunities for profit maximization in a changing (investment) climate?

Prior published literature on the financial implications of "green" certification mostly focuses on the U.S., and results generally indicate a positive relationship between environmental certification and financial outcomes in the marketplace.

Eichholtz, Kok and Quigley (2010a) document large and positive effects on market rents and selling prices following environmentally certification of office buildings. Relative to a control sample of conventional office buildings, LEED or Energy Star labeled office buildings' rents per square foot are about two percent higher, effective rents are about six percent higher, and premiums to selling prices per square foot are as high as 16 percent. Other studies (Fuerst and McAllister 2011; Miller, Spivey and Florance 2008) confirm these findings. Moreover, these results appear robust over the course of the financial crisis, as Eichholtz, Kok and Quigley (2011) document for a recent dataset of 3,000 green buildings that both energy efficiency and "greenness" of buildings are capitalized into rents and sales prices. Moreover, this effect is not dented by the recent downturn in property markets.

To date, there are no academic studies investigating the market performance of "green" certified commercial real estate within the UK.[1] This paper investigates the financial performance of London's environmentally certified commercial building stock, measured by sales transactions and achieved rents over the 2000 to 2009 period. In an international context, London is one of the largest commercial real estate markets outside of the US, and monitoring and reporting on "green" financial performance is critical to appropriately direct new capital and to evaluate new market opportunities in international real estate investment.

For "green" real estate, there is a notable degree of uncertainty and skepticism surrounding profitability, environmental performance, operational efficiency, and transaction and

[1] There is one market-based initiative on this topic: the Investment Property Databank (IPD) and Hermes publish quarterly their IPD/ IPF Sustainable Property Index for UK sustainable properties. The "sustainable" commercial properties are retrieved from the IPD database, using a questionnaire covering: building quality, energy efficiency, waste management, building accessibility, water efficiency and flood risk.

development costs. This uncertainty may potentially lead to a lag in investment (Henry 1974; Holland, Ott and Riddiough 2000), which may impact the diffusion of market information, distort market efficiency, competition and pricing (Dolde and Tirtiroglu 1997). To assess the importance of these types of uncertainty, this paper makes two additional contributions to the nascent literature on building energy efficiency. First, we evaluate the moderating effects of contract features (*i.e.*, lease term structure and rent-free period) and market signals (*i.e.*, days on market) on market rents. London lease lengths and rent-free periods are lengthy relative to the U.S. market, which may translate to different expectations for capital valuation in the London market. Second, we investigate market dynamics by assessing the impact that competition for environmentally certified real estate has on "certified" and "non-certified" real estate prices.

To identify London's stock of certified buildings, we utilize BRE's database on green building certification – BREEAM. We match BREEAM-labeled buildings to the CoStar FOCUS database, over the 2005 to 2010 period. To address the lack in transparency of the real estate sector (leading to a lack of reliable data), we construct a hand-collected database using information from four different sources. This results in a final sample of 1,171 rental transactions, of which 67 rental transactions are in commercial properties certified by BREEAM. In addition, we match the address files on green buildings to sales transactions over the period 2000 to 2009. Following the same tedious data-collection procedure, we obtain a sample of 2,023 observations, including 70 BREEAM-certified transactions.

Using hedonic regression techniques, and taking particular care to control for differences between the sample of certified buildings and the sample of control buildings, the results of this study show that BRE-certified office buildings in London achieve substantial rent and transaction premiums relative to a control sample of buildings. The average rent per net square meter for the rental sample is £400 and the premium for a certified building is approximately £94

per net square meter per year. For the average unity (that measures some 1,268 net square meters), this translates, ceteris paribus, into extra annual rents worth £1.4 mn as a result of certification. The certified buildings' transaction prices are on average 26 percent higher per net square meter as compared to the control sample of non-certified real estate. Translated to pounds the premium paid for a BREEAM-certified building relative to a comparable building is some £8.9 mn.

Although the positive certification premia documented in this paper are in line with results for energy efficient and sustainable buildings in the U.S., U.K. premia appear at first to be much more substantial. However, after exploiting a subset of data as used in Eichholtz et al. (2010a), we find that the substantial magnitude of our results appears to be driven by the lack of appropriate quality controls in our U.K. analysis. There is no systematic indicator for building quality in the UK, and the "green" premium documented in this paper is therefore a reflection of building quality, energy efficiency and any other valuable elements of "sustainability." Further research is needed to disentangle the findings documented here further.

The remainder of this paper is outlined as follows. Section 2 introduces and discusses the UK market for "green" real estate. In Section 3, we discuss BREEAM and financial data obtained for commercial buildings in London. In Section 4, we outline the methodology for our analysis. In Section 5, we present the results of the formal analysis. Section 6 provides a discussion and some conclusions.

2. The UK Market for "Green" Office Space

2.1. Building Environmental Certification

Building certification processes in general, and "green" building certification specifically, are intermediation processes between building developers, investors and tenants in the context of what constitutes an "efficient" or "green" building. Intermediation may reduce investment in

"lemons" (Akerlof 1970). In the "green" real estate sector, labeling agencies may reduce adverse selection by being accredited and recognized assessors of environmental information. Thus, building performance disclosure may lead to reduced investment in poorly performing environmental buildings.

Within the UK, there are two private intermediaries of environmental information, BREEAM and LEED. In 1990, the UK's Building Research Establishment (BRE) began the independent certification of the environmental performance of buildings in the UK. The first commercial office space was certified in 1999. In Version 1998, a building could earn 27 credits, whereas this has been increased to 105 credits in Version 2008 (through seven upgrades over time). Under the 2008 scheme, a commercial office can receive BREEAM certification if it meets the minimum standards set by BRE in eight core dimensions: building management, health and well being, energy efficiency, transportation efficiency, water efficiency, material usage, pollution and land use ecology. The process of BREEAM and a comprehensive breakdown of weightings, minimum standards and points are outlined in Appendix A.

In 2010, BRE began assessing and certifying existing office stock with BREEAM In-Use. The objective of BREEAM In-Use is to create a program that identifies areas for improvement and enhancement for the existing building stock and introduce a sustained monitoring of performance in the built environment.[2]

Competition in the UK market is mainly with LEED, the Leadership in Energy and Environmental Design green building rating system designed by the U.S. Green Building Council. The method and organizational structure of LEED is different from BREEAM, but the end goal is quite similar: increasing the energy efficiency and sustainability of the built

[2] BREEAM. 2011. BREEAM In-Use. http://www.breeam.org/page.jsp?id=122. (accessed February 3, 2011)

environment through the certification of exemplary buildings.[3] The first LEED certified commercial office building in the UK was developed in 2007, but the scheme is not widely diffused yet: as of 2011, there are 10 buildings certified by LEED in the UK, with 39 more projects currently registered for certification (a majority of these projects being initiated by Intercontinental Hotels Group).

2.2. Supply of Green Office Space

Table 1 displays the percentage of BREEAM buildings certified every year relative to new construction or buildings in England, Wales and London as reported by the UK Office of National Statistics and BRE. Table 1 indicates that over the 2000 – 2008 period, supply of commercial office space has expanded by about 20 percent, adding 58,804 new commercial offices (about 19.4 million square meters) to England and Wales. London accounted for 20 percent of this growth, adding 12,165 buildings (about 4.4 million square meters). For England and Wales, the ratio of BREEAM certified buildings has increased from one percent of the new building stock per year to just under six percent in 2008. In addition, London went from under one percent to just under nine percent. Although BREEAM had a rapid building expansion, these buildings only culminated in about 2 percent of the stock for England, Wales and London. As of June 2011, BREEAM-certified space encompasses 5.8 million square meters of UK office space, translating to approximately 30 percent of new floor space.

- Insert Table 1 here -

Figure 1 geographically displays the UK office buildings labeled by BREEAM by their level of certification. The map displays the dispersion of green office buildings across the UK, with a significant cluster of buildings located in London (368 buildings, or 23 percent of the BREEAM

[3] LEED operates on a point system with the main focus being on the following elements: sustainable sites, water efficiency, energy and atmosphere, materials and resources and indoor environmental quality.

office population) with Bristol, Manchester, Newcastle-Upon-Tyne and Glasgow as the other cities with large concentrations of "green" buildings (171 buildings or 10 percent of the BREEAM office population). BRE also assigns a score that corresponds to a label, ranging from "Pass" to "Outstanding." The map displays that there is a significant clustering of highly rated buildings in London, with the number of Excellent and Very Good rated buildings far surpassing other markets (181 buildings).

- Insert Figure 1 here -

2.3. Demand for Green Office Space

Generally, the most important factor determining demand for office space is employment in the legal and financial service sectors (Wheaton, Torto and Evans 1997). Between 2000 and 2009, the UK experienced a business cycle recovery, leading to a steep expansion of the business services industry. Demand for commercial office space exploded, with London at the forefront of employment growth. U.S. evidence indicates that the financial service sector (i.e., legal services, national commercial banks, executive legislative and general office) began occupying LEED and Energy Star certified space over the 2004-2009 period (Eichholtz, Kok and Quigley 2010b). Data from London is indicating a similar trend, where financial services firms, advertising and insurance sectors are dominant users of "green" space.

Anecdotal evidence suggests that the move of tenants towards "green" real estate is due to enhanced reputation benefits, corporate social responsibility mandates and employee productivity.[4] Such a shift in tenant preferences suggests that tenants are using the buildings that they occupy to communicate their corporate vision to shareholders and employees. The literature on corporate social responsibility (CSR) has investigated this link between corporate social

[4] Nelson, A, and AJ Rakau 2010. Green Buildings: A Niche Becomes Mainstream. Deutsche Bank Research.

performance, reputation benefits and employer attractiveness (Margolis and Walsh 2003; Turban and Greening 1997) and thus far claims are more case-study oriented.

Another oft-invoked rationale for occupying green office space is tenant productivity. Miller et al. (2009) document in a survey that over half of occupants of environmentally certified buildings found their employees to be more productive. However, interpretation of these results is problematic, as these responses cannot be controlled for with management style and individual employee characteristics. However, surveys reporting on tenants in London indicate that there is indeed a shift in corporate preferences. A 2008 research report documents that 58 percent of tenants find energy efficiency "essential" and 50 percent find green attributes "essential."[5]

Improving the bottom line through building energy efficiency is often reported as one of the direct economic benefits for real estate investment companies when considering energy efficiency and sustainability in their portfolios. Jones Lang LaSalle (2010) reports that of 115 office properties in their portfolio for which the energy efficiency was improved in 2006, the average realized savings for 2007 and 2008 were £1,400,000 and £1,900,000 respectively. British Land (2010) reports that across their portfolio, there is a reported 12 percent decrease in energy use, amounting to £700,000 in annual savings in energy, and a decrease of 11.1 million kWh of energy used in 2009. Hermes (2010) has realized similar increases in managing the energy efficiency of their portfolio amounting to £330,000 in 2010.

Another stimulus for demand is government regulation. At the EU level, the European Commission's Energy Performance Buildings Directive (EPBD), passed in 2002, includes a mandate for zero-energy and low carbon buildings to be devised by each member state and implemented for new buildings by 2020 and new public buildings by 2018 (Directive 2010/31/EU, 2010)[1]. At the UK national level, regulators have implemented new regulatory

[5] CBRE 2010. Locational Preferences of Central London Occupiers. CBRE Research.

standards to meet the 2010 EPBD directive. In addition, the UK has robust requirements for government space. By law all government space is to have a BREEAM rating for all new buildings, and as of 2006, Energy Performance Certificate and Declaration of Energy Certificate.

Recently and unprecedented in any other country, the UK implemented a domestic carbon trading scheme for buildings as mandated by The Carbon Reduction Commitment Order 2010 (CRC). According to the Draft for Consultation (2010), it is required that every eligible undertaking in the UK reduces its emissions or pay at a rate of £12 per ton of carbon dioxide. Organizations that use 6,000MWh of electricity are required to participate by annually canceling allowances equaling the quantity of their emissions from their energy consumption. Enterprises can cancel allowances in three ways: by reducing emissions by July of each year, purchasing and applying domestic carbon credits or incurring a civil penalty. The CRC is the first regulation to enforce a pecuniary penalty upon the design, procurement and operational efficiency of buildings. Furthermore, CRC implementation will include comparative performance monitoring. Enterprises will be ranked on their ability to cancel allowances, with a performance league table. Consequently, building investors and tenants will be required to collaboratively enhance their building's energy efficiency.

3. UK Property Market Data

The UK's primary commercial real estate market is the London metropolitan market. As of June 2011, London was the most active commercial real estate market in the world, reaching £11.8 bn. in transaction volume.[6] By design, any UK study will be biased towards London, leading to the following concerns: first, in hedonic models at the national level, the "London-effect" creates inconsistent estimates in pricing common building characteristics, such as age,

[6] Real Capital Analytics Active Markets Tool, http://www.rcanalytics.com/methodologysources.aspx

story, renovations and amenities, as these features are specific to London and its history. Second, a sample that combines London, Manchester, Bristol or Leed's commercial markets is geographically not normally distributed, a concern when location is a principal factor in modeling rental and transaction prices. Third, UK databases overwhelmingly report rental and transaction observations in London, as transaction and building characteristic knowledge is more abundant for the London metro area than for any other region in the country.

To investigate the most significant and abundant commercial market in the UK, we isolate our sample and focus on the London metro area. To investigate the financial implications of "green" commercial real estate in London, we match BREEAM address files to a combined dataset of rents and property transactions[7] maintained by Estates Gazette International[8] (EGi) and CoStar FOCUS[9] over the periods 2005 to 2009 and 1999 to 2009, respectively. Over these periods, CoStar covered a sample of some 5,028 commercial leasing transactions and EGi and CoStar covered 4,500 sales transactions across London. However, an important impediment of the data is the lack of basic building characteristics, such as age, stories, amenities, third-party assessment of building quality, etc. To collect these missing hedonic features, we consulted Emporis, a global building and architectural design database, and hand-collected building features from building prospectus and advertisements. In addition, we went on physical site visits in London. This extensive data collection effort, coupled with removal of erroneous data,[10]

[7] Initially, Real Capital Analytics database was included. However, detailed investigations uncovered that the building size category did not adequately account for net or gross square meters. Thus, to remove measurement errors from regression analyses this dataset was removed for the control sample and in depth investigations were provided for BREEAM certified buildings. Since there are very few BREEAM transactions, it was incumbent to realize every transaction that occurred in the sample period. Consequently, certified transactions from EGi, CoStar and RCA account for 1,702, 306, and 15 number of transactions in the sample, respectively.

[8] EGi is a comprehensive commercial property database covering news, building reports, deals, auction, availability and occupier data and rateable values analysis. For this analysis we utilized the Building Reports database to collect detailed building information.

[9] CoStar FOCUS is a commercial property information platform covering deals, building reports, town reports, and rateable values. For this analysis we used the CoStar Focus Deals Database.

[10] In the CoStar rental dataset 2 observations were deleted due to impossible rental values. In the EGI and CoStar Dataset sales dataset 98 observations were removed from the sample due to impossible size values.

resulted in a complete rental sample of 1,171 lease transactions, including 67 BREEAM-certified leases, and a sales transaction sample of 2.023 observations, including 70 BREEAM-certified transactions.

Our dataset contains information on a building's environmental characteristics (i.e., BREEAM rating), quality characteristics, longitude and latitude, distance to local transportation networks, time of transaction, investor types and contract features. *Ex ante*, we have the following expectations concerning quality characteristics, contract features, market competition, investor types and location:

Quality Characteristics: We anticipate that rental unit size will play a significant and positive role in price and will have a moderating effect on the pricing of certification. In addition, standard hedonic features like age, stories, amenities and renovation should have a significant and positive impact, where younger, taller, and renovated buildings with amenities will have higher rental prices.

Contract Features: We can expect that longer lease lengths signal longer durations in cash flows, which means less fluctuation in tenants and more rental stability, given the tenants credit quality. This suggests a positive impact on price. However, longer rent-free periods can signal larger discounts in rental cash flows. Hence, mitigating prices. Furthermore, prices may also be discounted by longer days on the market. Consequently, we anticipate that certified lease lengths will moderate rental prices, rent-free periods and days on market.

Market Competition: Market competition may substantially influence certified rental prices. The Green Building Environment variable is a numerical measure of BREEAM certified buildings within a 500-meter radius and at the time of renting. *Ex ante*, it is suspected that as the

number of certified buildings in a micro-location increases, there will be increased moderating effects on the prices of certified buildings.

Investor Types: Investors in institutional real estate vary in their financial motives. Institutional investors seek stable returns on a longer-term horizon for of their stakeholders, whereas private developers and private investors may have more short-term oriented incentives. On the other hand, municipal or government agencies may own or invest to enhance value in urban areas, again leading to different incentives and price expectations. We anticipate that the type of investor has an impact on prices, where institutional investors pay less and municipal investors pay more due to the differences in return seeking for the shareholder, pension holder or tax payer.

Location: We employ multiple methods to control for the impact of location on price. First, using a traditional methodology, we control for building location using postcodes and transportation networks in London. London is broken down into "London Postcodes" the 1-3 letter prefix that corresponds to its compass location, followed by a 1-2 digit number. Transportation stations (i.e., UK's National Rail System, London Tube Stations and Docklands Light Rail) are geo-coded using latitude and longitude and station distances (within one kilometer) to buildings are calculated.

Table 2 depicts the dependent and independent variables of our analysis and compares the average characteristics of the "green" buildings in our sample with the buildings in our control sample. Columns (1) and (2) show that certified buildings have higher achieved rents, on average, than control buildings, but the variability for rents is higher in green buildings. The size of leases in green buildings is larger, on average, than rental transactions in the control sample, by about 50 square meters. In addition, green buildings are younger (Further analysis shows that

half the sample is less than 10 years old and a majority of control buildings is more than 20 years old.) More than half the certified sample is renovated, about double the control sample. Amenities are available in 64 percent of certified rentals and 84 percent of control rentals. The distance to the nearest train stations within 500 meters from certified rentals is greater by 50 meters.

The average lease length is longer by almost three years and with comparable variability to the control sample. Rent-free periods are longer by about three months, with greater variation than control rentals. The average number of days certified buildings are on the market is longer, albeit with high variation. On average, certified properties are competing with six other certified buildings at the time of rental, where as control rentals are in competition with on average four green buildings. In our sample, 65 percent of certified buildings are owned by a real estate or institutional investor, as compared to 44 percent of control buildings. Moreover, the municipal and government sector only owns five percent of the buildings in the sample, which is in contrast to government and municipal regulations that require a BREEAM label in government buildings.

Non-parametric comparisons between the sample of certified transactions and the sample of non-certified transactions yield similar results. The variable approximating competition in the sales transaction market is noteworthy. For certified buildings there are on average five "green" buildings in a given 500 square meter radius at the time of transaction, whereas in the control sample there are on average two green buildings at the time of sale. Indicating that certified buildings may be transacting in "hot spots".

- Insert Table 2 here -

4. Methods

We investigate the financial implications of environmental certification for London commercial office buildings through an *ex post* transaction-based hedonic model (Rosen 1974). We use the sample of BREEAM-rated office buildings and a control sample of conventional office buildings to estimate a semi-log equation relating office rents per net square meter (or selling prices per net square meter) to the hedonic characteristics of building's location:

$$= + + + \quad (1)$$

where the dependent variable is the logarithm of the rental price (selling price) per net square meter in commercial office building *i*. is a vector of hedonic characteristics (e.g., age, stories, size, public transportation accessibility etc.), rental contract features (e.g. lease length and rent free period), market signals (days on market), investor types, and macro-economic conditions (e.g., quarterly time dummies) of building *I*, and is a dummy variable with a value of 1 if building *i* is rated by BRE and zero otherwise. , , and are estimated coefficients and is an error term.

As a robustness check, we employ a propensity score weighting technique. In our application, propensity score matching aims to minimize the selection bias between certified and non-certified buildings by matching on the basis of their individual characteristics. Conditioning upon observable characteristics, we eliminate differences between "treated" green buildings and "non-treated" control buildings by estimating the propensity of receiving a BRE rating for all buildings in the sales and rental samples, using a logit model. The propensity score specification includes all hedonic characteristics available for each sample, and the resulting propensity score is subsequently applied as a weight in the regression of equation (1) (Black and Smith 2004).

In the second part of our analysis, our aim is to find out to what extent the supply of BREEAM rated buildings has on price. We therefore investigate to what extent local certified

building competition acts as a moderator to rental and transaction prices, in general, and how this may moderate BREEAM certified rented and transacted properties, in particular. Following Brambor, Clark and Gold (2006), we examine the interaction effects between certification and the market competition for certified buildings:

$$= + + + + + \quad (2)$$

where equation (2) introduces , the green building supply variable, into equation (1) to allow the logarithm of prices to be moderated by the level of "green" competition in the market. In addition, we interact certification status, , with the green building supply, , to isolate the moderating effects of certified buildings that geographically cluster.

Furthermore, we are interested in the marginal effect of "green" building competition. To assess the impact of a larger existing supply of "green" buildings on the effect of certified prices, we calculate:

$$\frac{}{} = + \quad (3)$$

where equation (3) is the marginal effect of certified rents or prices conditional on the existing green building supply. To support the robustness of the conditional marginal effect analysis, we introduce confidence interval bands for statistical significance and use kernel density estimators to show the density of the green building supply.

5. Results

5.1. Green Buildings and Rental Rates

Table 3 presents the regression results for the rental sample, relating the logarithm of rent per net square meter of commercial office space to a set of hedonic characteristics, neighborhood

controls and contract features. Results are presented for an ordinary least squares regression corrected for heteroskedasticity (White 1980). These specifications explain over half the variation in the logarithm of rents per square meter with an adjusted R-squared ranging from 49 to 61 percent.

Column (1) reports the basic results for the hedonic specification relating office rents to the hedonic characteristics, i.e., rental size, amenities, renovation dummy, time dummies and postcode dummies. The regression explains some 48 percent of the variation in the log of rental prices per net square meter. Rental size is positive and significant: larger spaces command higher rental rates per net square meter. The amenities dummy is positive and significant, with amenities leading to rental increases of some five percent. Buildings less than ten years old have rents that are 27 percent higher relative buildings more than forty years old. As expected, the importance of the age factor decreases as age increases. CoStar's building status dummy indicates that there is a nine percent premium for new or refurbished buildings over "second-hand" buildings. Contrary to expectations, transportation networks (train stations) have no significant influence on rental prices.

Most important, we document that the certification dummy is positive and significant. BREEAM-certified properties command a 28 percent premium over non-certified properties.

In column (2), we add control variables for rental contract features to the hedonic specification. The term structure of leases has the anticipated impact on rent levels: the rent per net square meter increases at a rate of 4.6 percent per additional year of lease, but the term structure is non-linear, implying that the maximum achieved rent is realized at a lease duration of about 12 years. Thus, the marginal increase in rent becomes zero once lease lengths surpass 11.5 years. (However, only some five percent of rental contracts pass this threshold.) The number of days that a space is on the market has no significant impact on achieved rents, whereas rent-free

periods have a significant and positive impact on rents. Importantly, rental contract features have a moderating effect on the certification coefficient, decreasing the "green" premium by five percentage points.

In columns (3) and (4), the propensity score specification is reported, excluding and including contract features and market signals, respectively. Results indicate that the propensity score weights decrease the importance of size, story and age coefficients. Moreover, building amenities, renovation status and building status lose significance. Column (3) indicates that the certified premium remains economically and statistically significant, but is compressed slightly by the propensity score weights. When contract features are added, the certified premium is moderated by five percentage points again.

In column (5), a propensity score specification is reported with further controls for the local supply of certified buildings. Green building supply does not have a moderating impact on rental contract features or on hedonic characteristics. However, as the number of observed certified buildings within the transacted building's micro-location increases, achieved rents per net square meter increase by 1.6 percent, indicating that there may be some evidence of green building "emanating" effects. Possibly, the variable is capturing neighborhood gentrification. In addition, the clustering of "green" buildings leads to lower achieved rents per net square meter for certified buildings, with each additional green building decreasing the premium by 1.4 percent, *ceteris paribus*. Consequently, there is also a moderating effect from the interaction variable. For the certified transactions as the number of certified buildings increases the premium decreases. Thus, at the average number of certified buildings (6.61), the premium is 21.1 percent, *ceteris paribus.*[11]

[11] Following equation (3), the premium is calculated as follows: 0.296 (coefficient on breeam certification) – 0.014 (coefficient on green building supply interacted with breeam certification)*6.61 (average certified building supply).

Figure 2A shows the results of the conditional marginal effects analysis. There are three axis: the left vertical access depicts the beta coefficient of the conditional marginal effect; the horizontal access is the certified building supply (the number of BREEAM certified buildings within 500 meters at the time of renting); and the right vertical access represents the green building supply's univariate kernel density estimate. The kernel density estimate is a non-parametric estimation of the probability density function.

In the figure, the thick dashed line depicts the kernel density of the certified building supply. From left to right, about 15 percent of observations have at least two certified buildings within 500 meters and less than five percent of the sample has more than six certified buildings surrounding them. The solid line shows the marginal effect of rents per net square meter, given that the unit is certified, with the certified building supply. The line displays that as certified buildings in a cluster increase, the "green" premium decreases by on average 1.4 percent. Confidence interval bounds indicate that this result is statistically significant until approximately 9 buildings, where the premium is still positive, but moderated substantially.

- Insert Figure 2A here –

5.2. Green Buildings and Transaction Prices

Table 5 presents the results for the sales sample hedonic specification, relating the logarithm of sales price per net square meter of office buildings to a set of hedonic characteristics, investor types and neighborhood controls. Results are presented for ordinary least squares regression model corrected for heteroskedasticity with clustered standard errors (White 1980, Froot 1989). At best, these specifications explain 28 percent of the variation in the sales price per net square meter.

Column (1) reports a basic hedonic specification relating sales prices to hedonic qualities, i.e., size, age, number of stories, and a dummy variables representing amenities and renovation, postcode dummies, transportation network controls and quarterly time dummies. The regression explains 21 percent of the variation in the log of prices per net square meter. The explanatory power of the model is low, but this is mostly due to standardization of the transaction price.

Building size has a negative and significant impact on transaction price, with transaction prices decreasing by 0.6 percent as building size increases by 1,000 square meters. Age and story are positive and insignificant. The amenity and renovation dummies are both negative and significant.

Most important, the "certified" coefficient is positive and significant, suggesting that BREEAM-certified buildings transact at a 43 percent premium during the sample period, after controlling for differences in quality and location. The magnitude of the coefficient is substantial, and we further elaborate on this result through a robustness check in Section 5.3.

In column (2) investor types are added to the specification. Their addition has a moderating effect on the certified premium, decreasing it to 35 percent.

In columns (3) and (4), the results for the propensity score specifications are reported, with and without investor types. The fit for this specification is about 26 percent. The hedonic characteristics are similar to the first specification, but are slightly smaller in magnitude. However, the certified premium is moderated by the propensity weights, and when controlling for investor types the "green" premium decreases further to 27 percent. The variables reflecting building location relative to the transportation network is significant and positive, where the price of buildings is positively related to transportation connectivity. Overall, the propensity score weighting seems to be an efficient method to making certified and non-certified office buildings more comparable.

Column (5) the results for the controls for the green building supply are reported. Controlling for the clustering of green buildings has a positive and significant impact on prices, about a 4.4 percent increase in transaction price per net square meter. Again, the green building supply has a moderating effect on the green premium. At the average number of certified buildings (4.67), the premium is 25.9 percent, *ceteris paribus.*[12]

– Insert Table 4 here –

Figure 2B depicts the results of the conditional marginal effects analysis. In the figure, the marginal effect of the sales price per net square meter and the certified building supply are shown. The three axis are consistent with Figure 2A. In the figure, the thick dashed line depicts the kernel density of the certified building supply. From left to right, about 30 percent of observations have at least two certified buildings within 500 meters and less than five percent of the sample has more than six certified buildings surrounding them. The solid line shows the marginal effect of the sales price per net square meter, given that the building is certified, with the certified building supply. The line displays that as certified buildings in a cluster increase, the "green" premium decreases, by on average 3.3 percent. Confidence interval bounds indicate that this result is statistically significant until approximately 8 buildings, where the premium is still positive, but moderated substantially.

- Insert Figure 2B here -

5.3. Robustness Check

[12] Following equation (3), the premium is calculated as follows: 0.412 (coefficient on breeam certification) – 0.033 (coefficient on green building supply interacted with breeam certification)*4.67 (average certified building supply).

The results documented in the previous sections are in line with the literature investigating the economic outcomes of LEED and Energy Star certification in U.S. commercial markets. However, we note distinct differences between the specifications used in the existing literature and this paper. Eichholtz et al. (2010a) specifically and extensively control for building quality and document that it had a moderating effect on the "green" premium. In the Tokyo real estate sector, Yoshida and Sugiura (2011), also extensively control for building quality and find that building quality accounted for a majority of the "green" premium as there is evidence of some degree of multi-collinearity between "green" buildings and building structure, age and management resulting in bias and inconsistency in the event of exclusion.

Due to data limitations, building structure features and management are not present in our dataset.[13] Controls for building quality are critical to filter out quality differences in the specification, since it would not be surprising for a BREEAM "Excellent" or "Very Good" rated building to be classified as "investment grade" or "Class A" office space. Appendix Table A1 provides a comprehensive documentation of all BREEAM issues and points. Given the extensive attention to finishes, lighting, and sustainability measures and the amount points to achieve such measures, "Very Good" and "Excellent" measures may in fact be building quality controls.

To further analyze the effect of lacking quality characteristics on the magnitude of premiums documented in this paper, we test how analyses in the benchmark paper on this topic (Eichholtz, Kok and Quigley 2010a) would be impacted by the removal of building quality controls. We compare our results with those of New York City, using data from Eichholtz et al. (2010a).[14] Results of the propensity score weighted hedonic specification for LEED and Energy Star

[13] This is unfortunate given the extant literature considering the value impact of the Building Owners and Managers Association International (BOMA) definition of Class A space, "the most prestigious buildings competing for premier office users with rents above average for the area. Buildings have high quality standard finishes, state of the art systems, exceptional accessibility and a definite market presence".

[14] Peseran et al. (2011) document in a paper on the spatial diffusion of exogenous shocks of the UK housing markets, that there is high correlation between the housing markets in London and New York City. Since the financial service labor markets and housing are correlated, it is likely that commercial real estate is also.

buildings in New York City are reported in Appendix B. Summarizing, when building quality controls are added to the specification the certified premiums for LEED and Energy Star are moderated by 4.2 percentage points for rents and sales are insignificant. Thus, future studies that acquire a more complete set of building quality measures may find more moderated premiums for "green" offices in London.

6. Discussion and Conclusion

Green buildings are a new commercial real estate product, with complex building technology and idiosyncratic design features, materials and equipment. However, it is important to keep in mind that the certification process has been introduced to enhance building efficiencies in a broader context. The global construction sector is responsible for 40 percent of natural resource consumption (RICS 2005) and 30 percent of global carbon emissions come from the built environment (Stern, 2010). Furthermore, small energy efficiency measures, such as improved insulation and LED light bulbs, has been calculated to increase building efficiency and reduce carbon emissions at positive net present value for investors (Enkvist, Naucler and Rosander 2007). Consequently, to achieve building efficiency gains under the current institutional framework a new dynamic has been embraced in the UK property sector.

This paper presents the first systematic analysis on the financial implications of buildings certified as "green," using the UK office market as a laboratory. The outcomes of our hedonic specification suggest that BREEAM building certification is a component that is being priced in rents and sales in London's office market. After controlling for propensity score weighted building hedonic characteristics, location, contract features, macro economic conditions and green building supply, "green" buildings lease for some 21 percent more as compared to non-green buildings. The sales specifications also control for propensity score weighted building

characteristics, location, investor types, macro economic conditions and green buildings supply and the results show that “green” buildings transact for about 26 percent more per net square meter than their non-green counterparts.

Translated into pounds, the average rent per net square meter for the London rental sample is £400 and the premium for a certified building is approximately £84 per net square meter per year. Translated to an annual rental income for the average green rental building, the rent increment on a certified space at this average size is some £107,352, *ceteris paribus*. The average selling price for the London control buildings in the sample is £29 mn, which indicates an increment of about £7.5 mn.

Our analysis offers a glimpse at the conditional nature of the certified premium. Market dynamics such as supply, demand and market information play a significant role in the evolution of the environmentally certified real estate in the UK. The supply of green buildings has grown 1.8 percent over the 2000-2008 period, resulting in some 1,600 “green” office buildings by 2010. On the other hand, we can only proxy for “green” demand. Given the information we have on the institutional demands investors and tenants face from corporate social responsibility initiatives, government regulations and globally binding carbon reduction commitments, there is distinct evidence that the demand for “green” is growing. However, how this translates into market information may play a significant role in this premia.

Market information can be highly disaggregated in commercial real estate. Since commercial real estate is highly illiquid, markets can be slow in communicating valuable information through price (Garmaise and Moskowitz, 2004). Certified real estate is no exception. For example, within London, over 2000 to 2009 and out of a cross section of 12,000 transactions, only 70 certified transactions could be found. In addition, transaction momentum over this same period was slow with over half of London’s “certified” transactions occurring in the 2007-2009 period. Thus,

there is some evidence that market information through transaction prices for “green” may be lagged.

Consequently, lagged market price information may have an impact on market efficiency. Dolde and Tirtiroglu (1997) investigated temporal and spatial information diffusion in US residential real estate. They found that there were four phases for exogenous shocks to prices to absorb through local real estate conditions and that initial stages can lead to compounding asymmetric information. Moreover, they find that initial low transaction volume can keep prices high because market information from prices is illiquid and not transparent across all markets.

Within the UK “green” context, if asymmetric information surrounding green buildings resulted in market inefficiency, then the introduction of “green market” information would, ceteris paribus restore market efficiency (see Keogh and D’Arcy, 1994, Keogh and D’Arcy, 1996, Keogh and D’Arcy, 1999 for in the UK context). Thereby, the accumulation of transaction prices or property valuation information in the building’s immediate market would lead to increased market efficiency.

In the context of London’s “green” office market over the 2000 to 2009 period, two key pieces of information relied upon by markets were absent, appraisals and transaction prices. Still today, appraisals do not explicitly take into account sustainable, environmental or green features in a building at the time of valuation (Lützkendorf and Lorenz, 2005). Thus, the only source of “green” market information was historical “green” transactions for rents and prices. Indicating that markets with persistently low green building rental and transaction volume would, ceteris paribus, report high transaction prices and markets with very high transaction volume would experience a “potential” decrease in prices.

Our results indicate that this premium may begin to decrease as neighborhoods saturate with environmentally certified green buildings. In London, where buildings transact with an

increasing supply of green buildings surrounding them, certified transaction prices begin to decrease. Thus, the diffusion of environmentally certified real estate is a contributing factor for realized arbitrage opportunities in this market. However, Figure 2 depicts that most rental and transaction markets have not supplied enough environmentally performing real estate to drown out arbitrage opportunities in local markets.

Future research should focus on the moderating impacts of the institutional climate surrounding green buildings. Specifically, knowledge is vacant on cost. Cost of construction is variable, but by how much and are these costs moderating over time as substitute or complimentary "green" building products are brought to market? To date, there is limited evidence reporting the statistically significant incremental costs of environmental performing real estate construction in the UK[15] and there is one analysis on US real estate projects. Furthermore, cost of certification and consulting that leads to certification is also missing. Environmental certification is a relatively complex process that has been introduced into the design and procurement process of building development (See Appendix A), with little known about transaction, certification and direct development costs (Fisher and Bradshaw, 2010). Lastly, more robust analysis on what drives the certified premium. In the future, certification in and of itself will not be sufficient. Robust information on certification components, which ultimately drive the real operational efficiency of the built environment, will be the competing factors in the near future as the green building supply increases and becomes a market standard.

[15] In the UK, BRE Center for Sustainable Construction and Cyril Sweett (2005) estimated the incremental construction costs for Breeam Good, Very Good and Excellent rated buildings for a naturally ventilated and air conditioned office spaces. For the naturally ventilated space (493 m^2), a Good Rating cost a maximum of 0.4percent and an Excellent Rating cost about 3.4percent. For an air-conditioned space (10,098 m^2), maximum costs for a Good rating of 0.2percent more and an Excellent rating of 7.0percent dependent upon location specifications.

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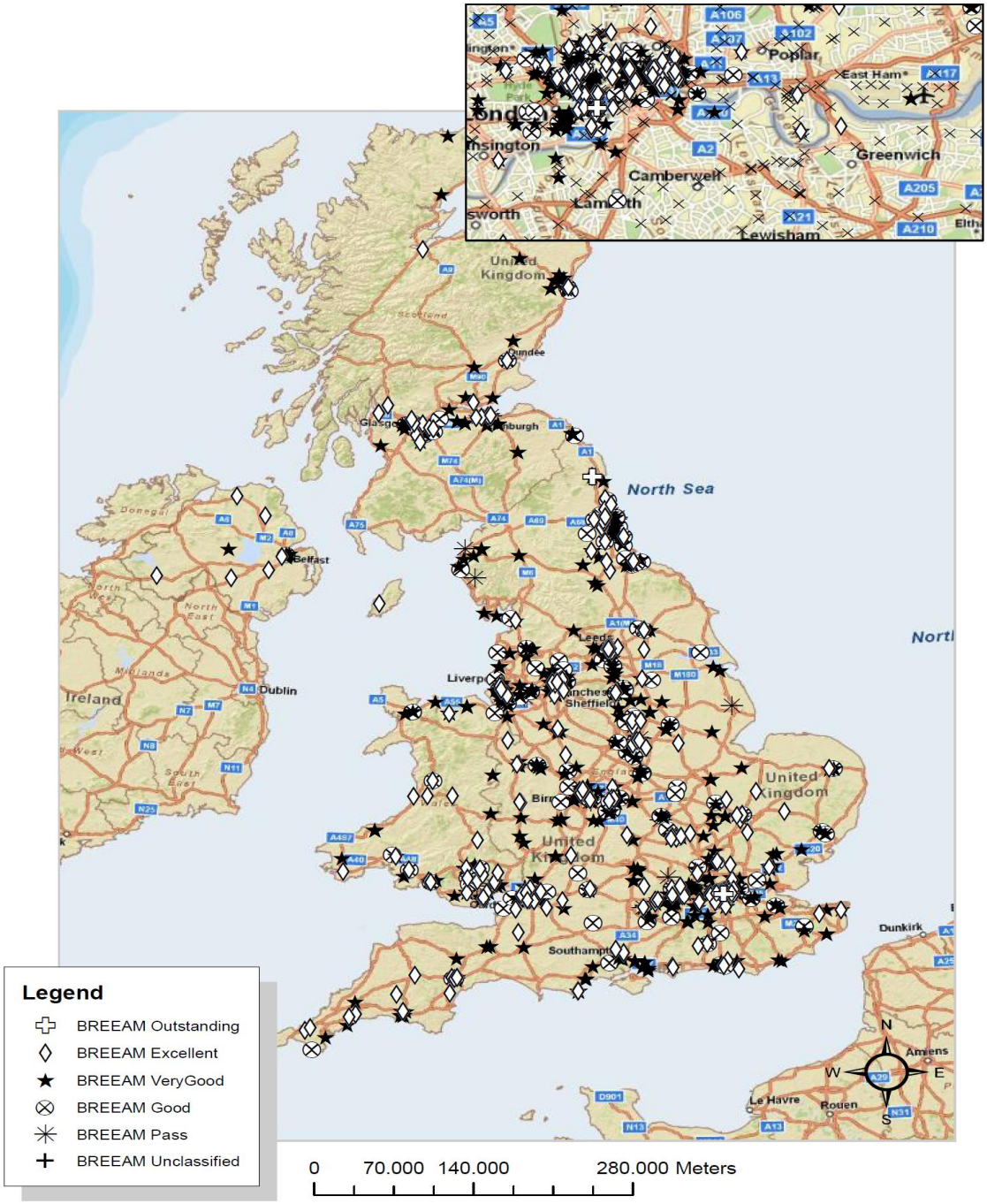
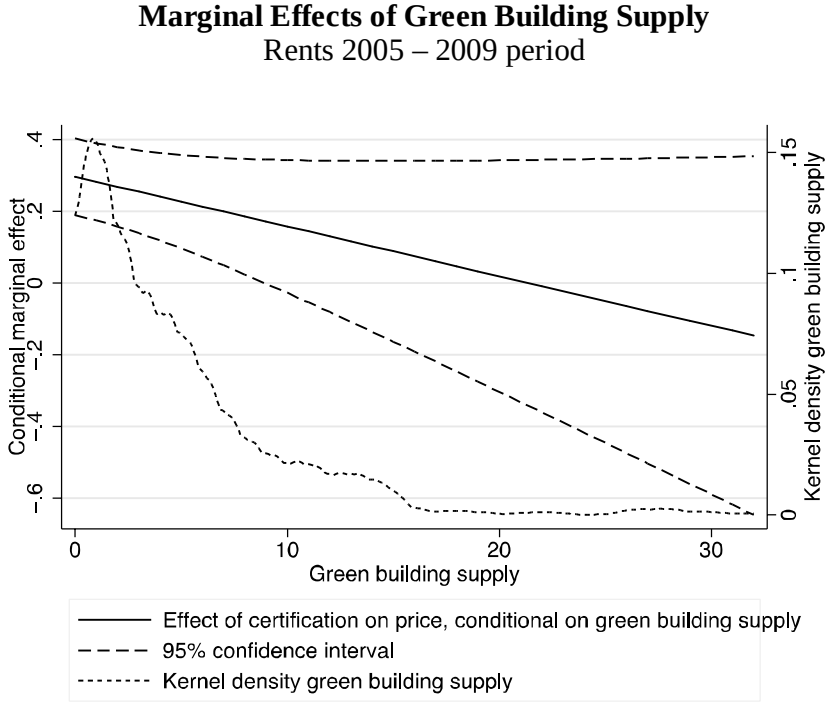
Figure 1
Geography of Green Buildings in the UK and London by BREEAM Rating



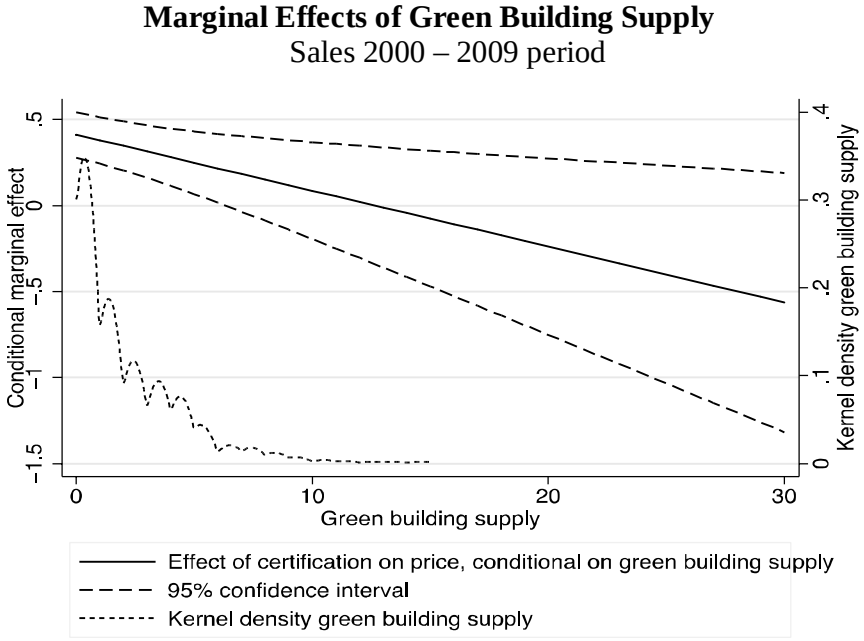
Notes: Figure 1 shows the geographic distribution of BREEAM certified buildings by ratings in the UK and London.

Figure 2
Marginal Effects of Green Building Supply
(Number of Green Buildings Within a 500-meter Radius)

A. Rental Sample



B. Transaction Sample



Notes: Figure 2 shows the conditional marginal effects of the green building supply on rental and transaction prices. The thick dashed line depicts the kernel density of the certified building supply. The solid line is the marginal effect of rents (sales) per net square meter, given that the unit (building) is certified, with the certified building supply. The two thick dashed lines denote confidence intervals.

Table 1
BREEAM Certified Buildings as a Proportion of Building Growth
Commercial Offices and BREEAM-Certified Space by Year

	(1)	(2)	(3)	(4)	(5)	(6)
Year	England & Wales - Commercial Offices	London - Commercial Offices	England & Wales BREEAM - Current Year	London BREEAM - Current Year	England & Wales - Current Year Percentage	London - Current Year Percentage
1998	241,464	72,035				
1999	243,343	71,983	21	11		
2000	248,931	74,976	50	15	0.89%	0.50%
2001	253,778	75,492	66	20	1.36%	3.88%
2002	260,115	76,728	97	31	1.53%	2.51%
2003	266,022	77,882	84	20	1.42%	1.73%
2004	271,653	79,934	95	32	1.69%	1.56%
2005	275,527	80,797	98	24	2.53%	2.78%
2006	285,738	83,114	127	26	1.24%	1.12%
2007	294,099	83,532	165	27	1.97%	6.46%
2008	300,268	84,200	364	59	5.90%	8.83%
			1,167	265		

Notes: Table 1 displays the year-over-year growth in commercial real estate and BREEAM-certified real estate, over the period 1998 to 2008.

The commercial offices group comprises mainly of purpose built office buildings and various types of non-domestic buildings converted to offices, offices over shops and computer centers. The commercial office category also includes central government offices but not local government offices.

Source: Adapted from Office for National Statistics, Commercial and Industrial Floorspace and Ratable Value Statistics, 1998-2008; BRE Certified Buildings Proprietary Database.

Table 2
Comparison of Certified Buildings and Control Sample
(standard deviations in parentheses)

	Rental Sample		Sales Sample	
Variables	Green Sample 67	Control Sample 1,104	Green Sample 70	Control Sample 1,953
Achieved Rent/ Sales Price	656	171	130,412	29,032
(GBP in thousands)	(1,200)	(546)	(154,581)	(73,088)
Achieved Rent/ Sales Price	523	400	8,521	6,858
(GBP per net sq.meter)	(191)	(192)	(6,540)	(7,035)
Building Characteristics				
Unit Size/ Building Size	1268	370	17,172	5,018
(net square meters)	(1948)	(998)	(14,376)	(10,189)
Stories	11.01	7.06	9.89	6.77
(number)	(9.42)	(4.54)	(0.43)	(0.20)
Age	28.55	45.72	24.01	40.55
(Years)	(32.14)	(31.98)	(31.62)	(33.25)
Amenities	0.63	0.78	0.66	0.67
(percent)	(0.49)	(0.42)	(0.48)	(0.47)
Renovated	0.58	0.27	0.50	0.27
(percent)	(0.50)	(0.45)	(0.50)	(0.44)
Distance to Nearest Train Stations*	458.03	409.47	385.93	409.57
(meters)	(186.45)	(222.29)	(202.13)	(210.99)
Green Building Supply**	6.16	4.14	4.67	1.97
(building count)	(4.58)	(4.73)	(4.72)	(2.99)
Investor Type*				
Real Estate			0.39	0.26
(percent)			(0.49)	(0.44)
Institutional			0.26	0.14
(percent)			(0.44)	(0.40)
Developer			0.14	0.02
(percent)			(0.35)	(0.14)
Municipal/ Government			0.03	0.03
(percent)			(0.17)	(0.18)
Private			0.10	0.34
(percent)			(0.30)	(0.47)
Unknown			0.09	0.16
(percent)			(0.28)	(0.36)
Contract Features				
Days on Market	764.10	386.50		
	(625.01)	(395.47)		
Lease term	9.46	5.99		
(years)	(3.47)	(3.53)		
Rent Free Period	7.25	3.50		
(months)	(9.28)	(4.88)		

Notes: Table 2 shows the descriptive statistics on the variables used in the analysis

* Straight-line distance calculation to the nearest train station within a 500-meter radius.

** The number of green buildings within a 500-meter radius surrounding a rental or sales transaction
*** Investor Type is broken into five major categories of buyers: Institutional Investors, Developers, Municipal/ Government Developers, Private Institutions and Unknown.

Table 3
The Premium for BREEAM Certified Buildings
(Dependent Variable: Logarithm of Rent per Net Square Meter)

	(Hedonic) (1)	(Hedonic) (2)	(PSM) (3)	(PSM) (4)	(PSM) (5)
BREEAM Certified	0.284***	0.233***	0.280***	0.241***	0.296***
	[0.036]	[0.038]	[0.040]	[0.042]	[0.054]
Certified Building Supply					
Certified Buildings					0.016***
					[0.004]
Certified Buildings*Certified					-0.014*
					[0.008]
Rent Contract Features					
Lease Term		0.046***		0.042***	0.042***
		[0.008]		[0.010]	[0.009]
Lease Term^2		-0.002***		-0.002***	-0.001***
		[0.000]		[0.000]	[0.000]
Days on Market		-0.000		-0.000	-0.000
		[0.000]		[0.000]	[0.000]
Rent Free Period		0.005***		0.004*	0.003
		[0.002]		[0.002]	[0.002]
Quality Characteristics					
Rental Unit Size	0.029***	0.023***	0.018***	0.013**	0.014**
(Net sq. meter in thousands)	[0.008]	[0.009]	[0.005]	[0.006]	[0.006]
Story Low	-0.409***	-0.401***	-0.351***	-0.330***	-0.322***
(1 = yes)	[0.060]	[0.056]	[0.060]	[0.058]	[0.056]
Story Medium	-0.203***	-0.208***	-0.125*	-0.113*	-0.100
(1 = yes)	[0.072]	[0.069]	[0.068]	[0.067]	[0.066]
Age 1 to 10 years	0.270***	0.238***	0.270***	0.236***	0.225***
(1 = yes)	[0.029]	[0.028]	[0.036]	[0.036]	[0.037]
Age 11 to 20 years	0.115***	0.107***	0.057	0.057	0.061
(1 = yes)	[0.031]	[0.031]	[0.047]	[0.046]	[0.045]
Age 21 to 30 years	0.109***	0.103***	0.121**	0.115**	0.112**
(1 = yes)	[0.039]	[0.039]	[0.049]	[0.049]	[0.050]
Age 31 to 40 years	0.112**	0.109**	0.084	0.082	0.079
(1 = yes)	[0.049]	[0.047]	[0.054]	[0.053]	[0.053]
Amenities	0.047*	0.023	-0.004	-0.018	-0.028
(1 = yes)	[0.024]	[0.024]	[0.028]	[0.028]	[0.028]
Renovated	0.003	0.006	0.017	0.018	0.024
(1 = yes)	[0.025]	[0.024]	[0.027]	[0.026]	[0.026]
Building Status:					
New or Renovated	0.092***	0.062***	0.076***	0.044	0.039
(1 = yes)	[0.020]	[0.021]	[0.027]	[0.027]	[0.027]
"Second Hand"	0.000	0.000	0.000	0.000	0.000
(1 = yes)	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Under Refurbishment	0.000	0.000	0.000	0.000	0.000
(1 = yes)	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Train Distance (Inverse)	-4.900	-4.837	-5.846	-6.421	-8.405
	[3.339]	[3.319]	[5.712]	[5.762]	[6.590]
Constant	4.808***	4.665***	5.149***	5.046***	5.094***
	[0.099]	[0.077]	[0.106]	[0.109]	[0.107]
Observations	1,150	1,150	1,150	1,150	1,150
R-squared	0.52	0.54	0.60	0.62	0.63
Adj R^2	0.49	0.51	0.58	0.60	0.61

Notes: All models include postcode dummies to control for location, and quarterly time dummies to control for time-variation in rental prices.
*, **, *** denotes significance at the ten, five and one percent level, respectively.

Table 4
The Premium for BREEAM Certified Buildings
(Dependent Variable: Logarithm of Sales Price per Net Square Meter)

	(Hedonic)	(Hedonic)	(PSM)	(PSM)	(PSM)
	(1)	(2)	(3)	(4)	(5)
BREEAM Certified	0.433***	0.353***	0.352***	0.271***	0.412***
	[0.042]	[0.058]	[0.041]	[0.048]	[0.068]
Green Building Supply					
Green Building Count					0.044***
					[0.004]
Certified Buildings*Certified					-0.033*
					[0.013]
Investor Types					
Real Estate Investor		0.305***		0.317***	0.292***
		[0.026]		[0.037]	[0.040]
Institutional Investor		0.273***		0.325***	0.307***
		[0.032]		[0.013]	[0.010]
Developer		0.380**		0.428***	0.382**
		[0.100]		[0.085]	[0.100]
Municipal Developer		0.060		0.367*	0.339*
		[0.116]		[0.148]	[0.152]
Quality Characteristics					
Building Size	-0.006**	-0.007**	-0.007**	-0.008**	-0.009***
	[0.002]	[0.002]	[0.003]	[0.002]	[0.002]
Story Medium	0.106	0.087	0.043	0.008	-0.003
	[0.068]	[0.069]	[0.040]	[0.040]	[0.043]
Story High	0.123	0.164	0.383**	0.346*	0.377*
	[0.068]	[0.078]	[0.123]	[0.140]	[0.160]
Age 1 to 10 years	0.078	0.059	0.180	0.151	0.143
	[0.107]	[0.106]	[0.141]	[0.136]	[0.133]
Age 10 to 20 years	0.198	0.178	0.240	0.211	0.222
	[0.129]	[0.128]	[0.141]	[0.138]	[0.133]
Age 20 to 30 years	0.048	0.035	0.098	0.080	0.080
	[0.139]	[0.140]	[0.181]	[0.179]	[0.177]
Age 30 to 40 years	0.099	0.074	0.217	0.179	0.178
	[0.161]	[0.160]	[0.184]	[0.186]	[0.186]
Amenities	0.057	0.006	0.005	-0.050	-0.051
(Yes=1)	[0.043]	[0.050]	[0.057]	[0.058]	[0.051]
Renovated	-0.094	-0.099	-0.136	-0.132	-0.131
(Yes=1)	[0.092]	[0.088]	[0.081]	[0.075]	[0.071]
Train Distance	8.118	6.841	14.295*	13.240*	13.153*
(Inverse)	[4.396]	[3.476]	[5.981]	[5.162]	[5.139]
Constant	7.895***	8.003***	8.638***	8.687***	8.761***
	[0.196]	[0.218]	[0.394]	[0.392]	[0.383]
Observations	2,023	2,023	2,023	2,023	2,023
R-squared	0.216	0.240	0.238	0.267	0.281
Adj R^2	0.18	0.21	0.21	0.24	0.25

Notes: All models include postcode dummies to control for location, and quarterly time dummies to control for time-variation in rental prices.

*, **, *** denotes significance at the ten, five and one percent level, respectively.

Appendix Table A1
The BREEAM Certification Process

1. Process of Certification

The process of BREEAM certification is lengthy and can take the duration of the design and construction process. The certification can begin with an assessment by a BREEAM certified assessor at the Design Stage followed by an additional assessment at the Post Construction Stage, but Post Construction Stage assessment can be done independently. Assessors are third party independent agents, i.e., they do not work for BREEAM nor do they consult with the BREEAM design team. Their role is to independently assess the core and shell of the building. In the design stage, the assessor determines building performance against the technical guidance. In the Post Construction Stage, the assessor can use the Design Stage assessment or conduct a full post construction assessment.

Assessments are carried out using BREEAM Environmental Weightings, Minimum Standards and Credits for Innovation. Buildings assessed by BREEAM are given a score, which corresponds to a BREEAM Rating. BREEAM ratings range from Unclassified with a score of less than 30 to Outstanding with a score greater than 85. BREEAM Scores are the achieved performance points received for fulfilling criteria within the eight core dimensions: Management, Health and Well Being, Energy, Transport, Water, Waste, Pollution, Land Use and Ecology, Materials and Innovation. Each of these sections are awarded points on a given BREEAM Issue.

Table 1 breaks down the BREEAM rating standards by weight, issue, title and indicates if the issue is considered for minimum standards for BREEAM ratings. Each BREEAM section is given a weight. Points for each section are then given their corresponding weight. There are points awarded on a range of issues corresponding to the environmental performance of the building, from Reduction of CO_2 emissions to Building Use Guides and Green Leases. Each issue is given a decision by the assessor and each decision is supported with evidence to support the issuance of points. For example, for the Management 4 – Building User Guide credit to be received. The aim of the issue must be satisfied and supported with evidence. Management 4's aim is, "to recognize and encourage the provision of guidance for the non-technical building user so they can understand and operate the building efficiently", worth 1 point and required for minimum standards to be received. Thus, a Building User Guide must be shown with proof of documentation for proof of the point. After each issues has been assessed, all claims and supporting documentation are compiled into a report.

At BREEAM headquarters, the reports are read and evaluated. First, all reports go through a basic check. In essence, this is a score or grade on the quality of the report, which includes assessment of items such as documentation, evidence and even language and style. Second, the reports themselves are given a score, i.e., graded. Reports with consistently failing scores result in a revocation of the BREEAM assessors license. Thirdly, BREEAM then confirms or denies the decision. This is based on the report conducted by the assessor or in some cases BREEAM repeats the assessment to have a robust confirmation of the report. Lastly,

BREEAM conveys the rating to the building. Should there have been problems or exceptions to be cleared from construction or renovation, then those must be cleared beforehand as the rating is denied until all requirements are satisfied.

2. Building Operational Performance

The building's operational performance is not reassessed by BREEAM once the building is fully operational. Thus, the certification does not convey any information about the empirical environmental performance of the building. However, there are two methods that BREEAM prescribes to attain the most optimal performance as established at the time of certification. One is a Green Building Guide, which is a detailed manual for tenants and building managers on "how to minimize the environmental impacts of the building" (BREEAM, 2009, pg. 25). Second is a Green Lease Agreement, which is a legally binding tenancy agreement that commits the tenant's occupation of the building to meet BREEAM criteria and that the building is managed and occupied in a sustainable way. Both the Green Building Guide and Green Lease Agreement if utilized in a building will justify awarding BREEAM credits in the Management Dimension. Below is a table that outlines the Minimum Standards to achieve the BREEAM rating by BREEAM issue and Rating (BREEAM, 2009).

BREEAM Scorecard

Weight	BREEAM Issue and Title	Minimum Standards	No. of Credits Available	Pass	Good	Very Good	Excellent	Outstanding
12	Management 1 – Commissioning	Yes	**2**	**1**	**1**	**1**	**1**	**2**
	Management 2 - Considerate Constructors	Yes	**2**				**1**	**2**
	Management 3 – Construction Site Impacts	No	**4**					
	Management 4 - Building User Guide	Yes	**1**				**1**	**1**
	Management 5 – Site Investigation	No	**0**					
	Management 6 – Consultation	No	**0**					
	Management 7 – Shared Facilities	No	**0**					
	Management 8 – Security	No	**1**					
	Management 9 - Publication Of Building Information	Yes	**1**					**1**
	Management 10 - Development As A Learning Resource	Yes	**1**					**1**
15	Health & Well Being 1 – Daylighting	No	**1**					
	Health & Well Being 2 – View Out	No	**1**					
	Health & Well Being 3 – Glare Control	No	**1**					
	Health & Well Being 4 - High Frequency Lighting	Yes	**1**	**1**	**1**	**1**	**1**	**1**

	Health & Well Being 5 – Daylighting	No	**1**					
	Health & Well Being 6 – Lighing Zones And Controls	No	**1**					
	Health & Well Being 8 – Indoor Air Quality	No	**1**					
	Health & Well Being 9 – Volatile Organic Compounds	No	**1**					
	Health & Well Being 10 – Thermal Comfort	No	**1**					
	Health & Well Being 11 – Thermal Zoning	No	**1**					
	Health & Well Being 12 - Microbial Contamination	Yes	**1**	**1**	**1**	**1**	**1**	**1**
	Health & Well Being 13 – Acoustic Performance	No	**1**					
19	Energy 1 - Reduction Of CO2 Emissions	Yes	**15**				**6**	**1** **0**
	Energy 2 - Sub-Metering Of Substantial Energy Uses	Yes	**1**			**1**	**1**	**1**
	Energy 3 – Sub-Metering Of High Energy Load	No	**1**					
	Energy 4 – External Lighting	No	**1**					
	Energy 5 - Low Or Zero Carbon Energy Uses	Yes	**3**				**1**	**1**
	Energy 6 – Building Fabric Performance And Avoidance Of Air Filtration	No	**0**					
	Energy 7 – Cold Storage	No	**0**					
	Energy 8 – Lifts	No	**2**					
	Energy 9 – Escalators And Travelling Walkways	No	**1**					
8	Transport 1 – Provision Of Public Transport	No	**3**					
	Transport 2 – Proximity To Amenities	No	**1**					
	Transport 3 – Cyclist Facilities	No	**2**					
	Transport 4 – Pedestrian And Cyclist Safety	No	**1**					
	Transport 5 – Travel Plan	No	**1**					
	Transport 6 – Maximum Car Parking Capacity	No	**2**					
6	Water 1 - Water Consumption	Yes	**3**		**1**	**1**	**1**	**2**
	Water 2 - Water Meter	Yes	**1**		**1**	**1**	**1**	**1**
	Water 3 – Major Leak Detection	No	**1**					
	Water 4 – Sanitary Supply Shut Off	No	**1**					
12.5	Materials 1 – Materials Specification	No	**4**					
	Materials 2 – Hard Landscaping And Boundary Protection	No	**1**					
	Materials 3 – Re-Use Of Façade	No	**1**					
	Materials 4 – Re-Use Of Structure	No	**1**					
	Materials 5 – Responsible Sourcing Of Materials	No	**3**					
	Materials 6 – Insulation	No	**2**					
	Materials 7 – Designing For Robustness	No	**1**					
7.5	Waste 1 – Construction Site Waste Management	No	**4**					
	Waste 2 – Recycled Aggregates	No	**1**					
	Waste 3 - Storage Of Recyclable Waste	Yes	**1**				**1**	**1**
	Waste 4 – Compactor	No	**1**					
	Waste 5 – Composting	No	**1**					
	Waste 6 – Floor Finishes	No	**1**					
10	Land Use & Ecology 1 – Reuse Of Land	No	**1**					
	Land Use & Ecology 2 – Contaminated Land	No	**1**					
	Land Use & Ecology 3 – Ecological Value Of Site And Protection Of Ecological Features	No	**1**					
	Land Use & Ecology 4 - Mitigating Ecological Impact	Yes	**2**			**1**	**1**	**1**
	Land Use & Ecology 5 – Enhancing Site Ecology	No	**3**					
	Long Term Impact On Biodiversity	No	**2**					
10	Pollution 1 – Refrigerent Gwp – Building Services	No	**1**					

	Pollution 2 – Preventing Refrigerant Leaks	No	**2**
	Pollution 3 – Refrigerant Gwp – Cold Storage	No	**1**
	Pollution 4 – No Emissions From Heating Source	No	**3**
	Pollution 5 – Flood Risk	No	**3**
	Pollution 6 – Minimising Watercourse Pollution	No	**1**
	Pollution 7 – Reduction Of Night Time Light Pollution	No	**1**
	Pollution 8 – Noise Attenuation	No	**1**
10	Innovation 1- Innovation	No	**1**

Source: (BREEAM Offices 2008 Assessor Manual, BREEAM, 2009)

Appendix B
The Value of Green Certification in the U.S.
(Based on Eichholtz, et al. (2011))

	Rental Prices			Transaction Prices		
	Full Sample	New York	New York	Full Sample	New York	New York
"Green" Certification	0.026***	0.161***	0.203**	0.133***	0.198	0.245
	[0.007]	[0.045]	[0.088]	[0.0167]	[0.151]	[0.153]
Class A	0.156***	0.119*		0.213***	-1.045***	
(1 = yes)	[0.013]	[0.069]		[0.0409]	[0.337]	
Class B	0.095***	0.177***		-0.0377	-0.854***	
(1 = yes)	[0.013]	[0.065]		[0.0336]	[0.277]	
Building Size	0.034***	0.046***	0.008	-0.0487***	0.0846	0.0155
(log)	[0.003]	[0.013]	[0.017]	[0.00989]	[0.0685]	[0.0647]
Occupancy Rate	-0.000	0.004***	-0.001			
(percent)	[0.000]	[0.001]	[0.001]			
Age 0 to 5 years	0.153***	0.401***	0.755**	-0.0242	-1.640	-1.911
(1 = yes)	[0.008]	[0.099]	[0.312]	[0.0445]	[1.167]	[1.178]
Age 5 to 10 years	0.073***	0.000	0.000	0.353***	-0.267	-0.317
(1 = yes)	[0.007]	[0.000]	[0.000]	[0.0344]	[0.219]	[0.222]
Age 10 to 20 years	0.073***		0.052	0.115***	0.572***	0.555***
(1 = yes)	[0.006]		[0.077]	[0.0330]	[0.188]	[0.189]
Age 20 to 30 years	0.021***	0.008	-0.134**	0.0870***	0.382***	0.308**
(1 = yes)	[0.005]	[0.026]	[0.063]	[0.0262]	[0.131]	[0.129]
Age 30 to 40 years	0.004	-0.141***	-0.052	0.0449	0.213	0.162
(1 = yes)	[0.005]	[0.029]	[0.072]	[0.0290]	[0.161]	[0.162]
Renovated	-0.005	-0.078***	0.048	0.0154	0.423***	0.405***
(1 = yes)	[0.004]	[0.020]	[0.029]	[0.0191]	[0.122]	[0.123]
Story Medium	0.053***	-0.027	0.054	0.167***	-0.582**	-0.901***
(1 = yes)	[0.004]	[0.062]	[0.043]	[0.0232]	[0.234]	[0.215]
Story High	0.061***	0.016	0.112*	0.338***	-0.259	-0.611***
(1 = yes)	[0.006]	[0.065]	[0.058]	[0.0285]	[0.263]	[0.231]
Amenities	-0.005	0.081***	0.047	0.0324*	0.135	0.132
(1 = yes)	[0.003]	[0.018]	[0.031]	[0.0189]	[0.101]	[0.103]
Public Transport	0.023***	0.015	0.091*	-0.124***	-0.221*	-0.198
(1 = yes)	[0.006]	[0.027]	[0.050]	[0.0263]	[0.128]	[0.129]
Constant	0.803	2.806***	5.044***	5.078***	4.471***	6.251***
	[0.646]	[0.568]	[0.656]	[1.952]	[0.680]	[0.751]
Observations	20,801	793	795	5,993	363	363
R-squared	0.833	0.431	0.334	0.662	0.405	0.386
Adj R2	0.816	0.404	0.303	0.616	0.344	0.327

Notes: Specifications are based on propensity score weighted hedonic regressions. Full sample results correspond to those reported in Eichholtz, Kok and Quigely (2011). Sub-sample rental and sales results are presented for New York City, NY.

*, **, *** denotes significance at the ten, five and one percent level, respectively.