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Supply, Demand and the Value of Green Buildings

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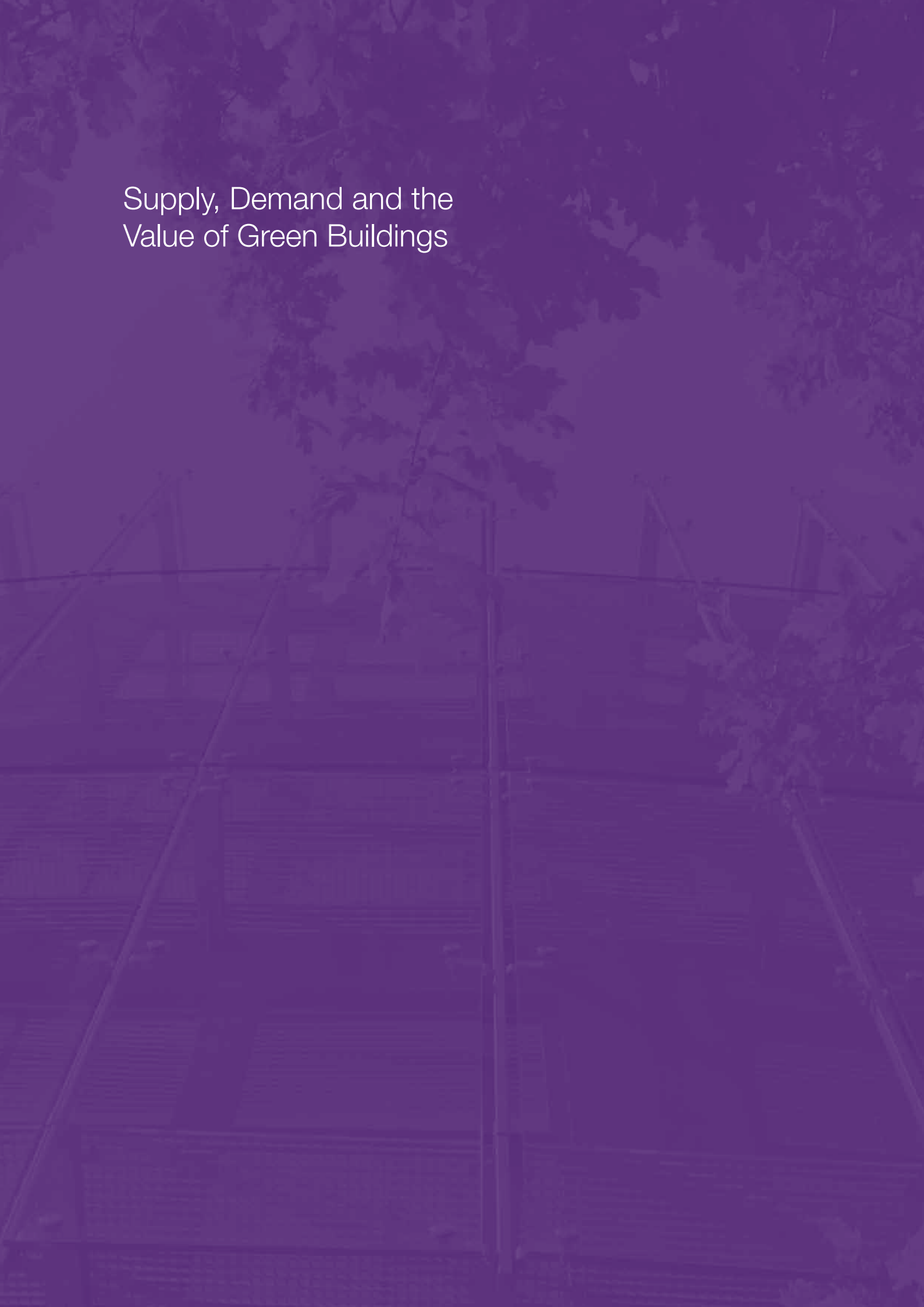

Supply, Demand and the Value of Green Buildings

Report for Royal Institution of Chartered Surveyors

A report for Royal Institution of Chartered Surveyors

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Summary

Attention to “sustainability” and energy efficiency rating schemes in the commercial property market has increased rapidly during the past decade. In the UK, commercial properties have been certified under the BREEAM rating scheme since 1999, offering fertile ground to investigate the economic dynamics of “green” certification on the commercial real estate sector. In this paper, we document that over the 2000-2009 period, the expanding supply of “green” buildings within a given London neighborhood had a positive impact on rents and prices in general, but reduced rents and prices for environmentally-certified real estate. The results suggest that there is a gentrification effect from “green” buildings. However, each additional “green” building decreases premiums for a certified building in the rental and transaction markets by one percent and four percent, respectively. In addition, controls for lease contract features like contract length and rent-free period have a modifying impact a certified rental premiums and should be taken into consideration in further research.

1.0 Introduction

In the current debate on global climate change, buildings are increasingly considered by policy makers, corporations and institutional investors to represent 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, gradually moving commercial property markets towards increased levels of energy efficiency and sustainability.

Anecdotally, London's 2015 skyline provides testimony to this development. London is set to be a showcase of environmentally sustainable 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 sky, is being constructed to consume 30 percent less energy than an otherwise similar building; Bishopsgate Tower (The Pinnacle), generates electricity through 2,000 square meters of photovoltaic cells; and Broadgate Tower, through its extensive heat recovery system and efficient cooling plant, aims to reduce carbon emissions by 40 percent. In general, for most of the new or renovated "institutional" real estate coming to market in London, energy efficiency and sustainability features are primary building components.

Part of the focus on energy efficiency is driven by the UK's 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 of Buildings Directive (EPBD)[1] and the Energy Efficiency Plan of 2011. 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 (by 2018). 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 among the first to price the negative externalities from energy consumption in buildings, and rank companies through carbon performance league tables[2]. Allowance purchases commence in 2012 and are expected to yield £1bn in revenues for the UK Treasury.

Besides regulation, private sector involvement in the energy efficiency of buildings 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 US 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. Importantly, there is a notable degree of uncertainty and skepticism surrounding the economic development of green buildings in the UK.

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 (2010) document large and positive effects on market rents and selling prices following environmental certification of office buildings. Relative to a control sample of conventional office buildings, LEED or Energy Star labeled office buildings achieve rents that are about two percent higher, effective rents that are about six percent higher, and premiums to selling prices as high as 16 percent. Other studies confirm these findings (Fuerst and McAllister, 2011a, Miller et al., 2008) and importantly, these results appear robust over the course of the financial crisis. Eichholtz, Kok and Quigley (in press) document in a recent study that energy efficiency and "greenness" of buildings is capitalized into rents and sales prices. This effect is not dented by the recent downturn in property markets.

1 At the EU level, the European Commission's Energy Performance of Buildings Directive (EPBD) 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 NUMBER 2002/91/EC 2002. Energy Performance of Buildings Directive. *L 1/65.* European Union: Official Journal of the European Communities, DIRECTIVE NUMBER 2010/31/EU 2010. Energy Performance of Buildings Directive Recast. *L 153/13.* European Union: Official Journal of the European Communities. The UK government has implemented new regulatory standards to meet the 2010 EPBD directive, including energy performance certificates and requirements for government space – by law all government space should have a BREEAM rating for new buildings as well as an Energy Performance Certificate and Declaration of Energy Certificate 2 According to the Draft for Consultation 2010. Draft Statutory Instrument: The Carbon Reduction Commitment Order 2010. *09D/506.* United Kingdom., 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 to avoid regulatory action.

For investors, it is important to understand the value and risk implications of the increased focus on "green" building in the commercial real estate sector. In the UK, "green" buildings have expanded over the past decade, accounting for just under ten percent of the current stock. However, market performance analysis of "green" certified commercial real estate is scarce within the UK[3]. This is surprising as London represents one of the largest commercial real estate markets in the world, leading transaction turnover volume globally[4]. Indeed, London, in line with New York City, is a dominant player in the global financial system, hosting a myriad of international financial and service sector firms (Clark, 2002). Also, London is capitalizing on the nascent "green" economy where there is a demand for "complementary" legal and financial instruments to support new markets, e.g. carbon markets and energy efficiency policy reforms (Knox-Hayes, 2009). Given London's significance, monitoring and reporting on the financial performance of "green" buildings is critical to appropriately direct new capital and to evaluate new market opportunities in international real estate investment.

This paper investigates the dynamics behind the financial performance of London's environmentally certified commercial building stock within the context of a changing supply and demand framework, measured by realized sales transactions and achieved rents over the 2000 to 2009 period. Addressing the economic fundamentals driving the value of "green" (i.e. supply and demand), this paper makes two contributions to the nascent literature on commercial building energy efficiency. Mainly, we investigate the role of the green building supply on market dynamics by assessing the impact of growing competition of environmentally certified real estate 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 of transparency in the real estate sector, we then construct a hand-collected database using information from four different sources. This results in a final sample of 1,149 rental transactions, of which 64 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 data-collection procedure, we obtain a sample of 2,019 observations, including 69 BREEAM-certified transactions.

We document that growth and concentration in the green building supply has had a negative price effect on the prices paid for "green" buildings, but a positive impact on neighborhoods in general. The diffusion of certified real estate over the last decade has contributed to the gentrification of London's commercial districts on the one hand. However, the growth in these buildings has made them a building standard and not an exception, which has ultimately impacted their prices.

The remainder of this paper is organized 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.

3 Fuerst and McAllister (2011) document for 24 BREEAM-rated properties in their UK sample that there is no significant impact on appraised capital values and rental values, using IPD's valuation data. Estimated equivalent yields have a very small and negative coefficient. In addition, 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. 4 Using the Real Capital Analytics Transaction tool, the ranking for the UK's transaction turnover remains consistently in the top five cities from around the globe.

2.0 The UK Market for "Green" Office Space

2.1 Building Environmental Certification

Building certification facilitates the intermediation process between building developers, investors and tenants in the context of what constitutes "quality" or "efficiency" in a building. This intermediation process may reduce investment in "lemons" (Akerlof, 1970). In the "green" real estate sector, rating agencies may reduce adverse selection by being accredited and recognized assessors of environmental information. Thus, building performance disclosure may lead to reduced investment in environmentally poorly performing 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 and at that time, a building could earn 27 credits. Today, the number of credits has increased to 105 credits in Version 2008 (through seven upgrades). 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 the existing office stock with BREEAM In-Use. The BREEAM In-Use program identifies areas for improvement and enhancement for the existing building stock and to introduce a sustained monitoring of performance in the built environment[5].

Competition for third-party environmental certification in the UK market is mainly with LEED, the Leadership in Energy and Environmental Design green building rating system designed by the US 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 environment through the certification of exemplary buildings[6]. 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 were ten 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

Green buildings are considered different from conventional buildings, because they command a different set of technological and human capital requirements compared to the common building stock. The green building supply is most likely driven by construction costs, the price signals of other certified buildings, the availability of raw materials and human capital to construct "green" and their prices, advances in green technology and even government policies mandating energy efficiency (See Kok et al., 2011b). Evaluating supply factors empirically is a separate exercise, but growth in the green building supply may have a dynamic impact on equilibrium prices over the 2000 to 2009 period.

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. 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 nearly nine percent. Although BREEAM certification expanded rapidly, these buildings constituted just two 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.

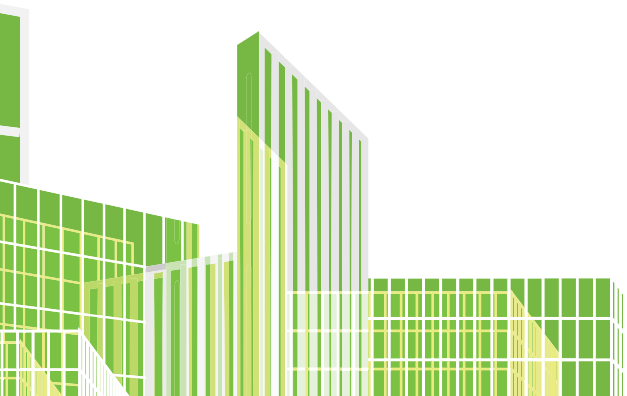
Table 1 **BREEAM Certified Buildings as a Proportion of Building Growth Commercial Offices and BREEAM-Certified Space by Year**

Year	Commercial Offices		BREEAM – Current Year		Current Year Percentage	
	England & Wales	London	England & Wales	London	England & Wales	London
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%
			1167	**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.

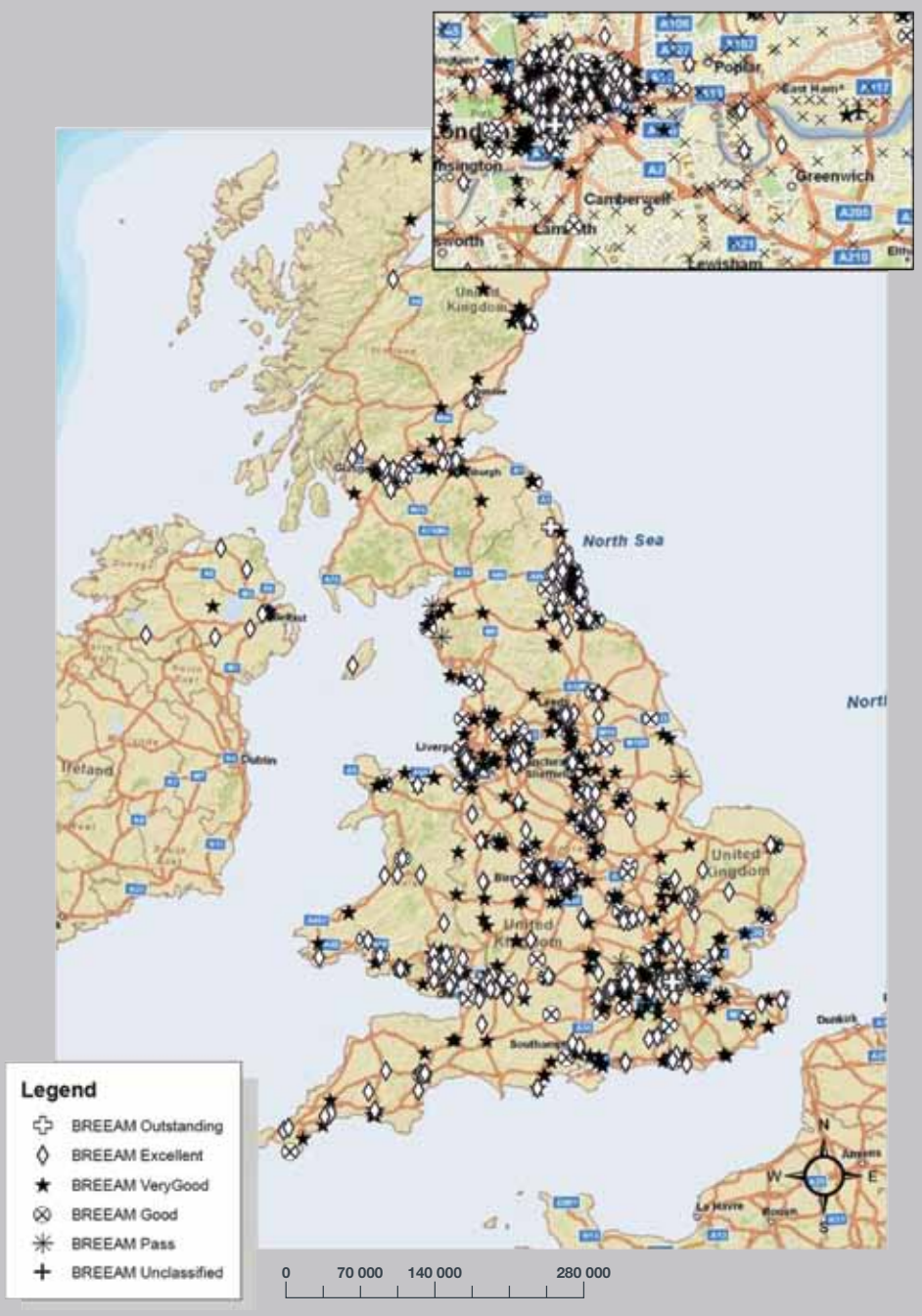
Source: Adapted from Office for National Statistics, Commercial and Industrial Floorspace and Ratable Value Statistics, 1998-2008; BRE Certified Buildings Proprietary Database.



5 For more information on BREEAM In-Use, see http://www.breeam.org/page.jsp?id=122.
6 LEED also operates using 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.

Figure 1 geographically displays the UK office buildings labeled by BREEAM by the 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 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 corresponding to a label, ranging from "Pass" to "Outstanding." Lastly, 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).

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



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

2.3 Demand for Green Office Space

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. For example, Jones Lang LaSalle (2009) reports for the 115 office properties in their portfolio for which the energy efficiency was improved in 2006, the average realized savings for 2007 and 2008 were £1.4 mn and £1.9 mn, respectively. British Land reported a 12 percent decrease in energy use in 2009 (some 11.1 mn kWh of electricity), amounting to £700,000 in annual energy savings[7]. Hermes has realized similar decreases through improved energy efficiency of their portfolio, amounting to £330,000 in 2010[8].

Institutional investors have different investment criteria than private sector investors, which includes incorporating corporate social responsibility initiatives. Their strategy incorporates Environmental, Social and Governance (ESG) screening criteria into their real estate investments. A recent report, commissioned by some of the largest institutional investors in Europe, documents the engagement of institutional investors in the green building sector. The property sector, whilst being mindful of management and implementation of energy efficiency and sustainability within their own portfolios, reduced 1.8 percent in carbon emissions and $1 bn in energy savings over the 2010-2011 period (Kok et al., 2011a).

Of course, the most important factor determining demand for rental space is employment in the legal and financial service sectors (Wheaton et al., 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. In the US, 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 et al., 2011). Data from London is indicating a similar trend, where financial services firms, advertising and insurance sectors are dominant users of “green” space. CBRE reports that 58 percent of tenants find energy efficiency “essential” and 50 percent find green attributes “essential” (CBRE, 2010).

Anecdotally, the move of tenants towards “green” real estate is due to enhanced reputation benefits, corporate social responsibility mandates and employee productivity (Nelson and Rakau, 2010). Shifting tenant preferences suggests tenants are using the buildings 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 performance, reputation benefits and employer attractiveness (Turban and Greening, 1997; Margolis and Walsh, 2003) although claims are mostly 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, in London there is a shift in corporate preferences.

7 British Land. Achieving More Together: Corporate Responsibility Summary Report 2010. 8 Hermes. RPI Summary Report 2010.

3.0 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[9]. 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, story, renovations and amenities, as these features are specific to London and its history. Second, a combined sample of London, Manchester, Bristol and Leeds commercial markets is geographically clustered in London, 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. Therefore, we isolate our sample by focusing on the London metro area.

To analyze the economic implications of "green" commercial real estate in London, we match BREEAM address files to a combined dataset of rents and property transactions maintained by CoStar FOCUS[10] and Estates Gazette Interactive (EGi)[11] 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[12]. However, an important impediment of the data is the lack of basic building characteristics, such as age, storey, 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 prospectuses and advertisements. In addition, we went on physical site visits in London. This extensive data collection effort, coupled with removal of erroneous data and portfolio sales, resulted in a rental sample of 1,149 lease transactions, including 64 BREEAM-certified leases, and a sales transaction sample of 2,019 observations, including 69 BREEAM-certified transactions.

Our dataset contains information on a building's environmental characteristics (i.e. BREEAM rating), quality characteristics, address, distance to local transportation networks, transaction date, 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: 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, storey, amenities and renovation should have a significant and positive impact, where younger, taller and renovated buildings with amenities will have higher rental prices. Moreover, differences between the "green" and control sample may manifest from differences in building quality variables. In the UK, building quality is rated on a per floor basis. Thus, a building is a collection of different building qualities, with the exception of "new" office buildings. We expect that building quality will have a positive impact on prices.

Contract Features: 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, reducing prices. Furthermore, prices may also be discounted by a longer period on the market. Moreover, contract features potentially have a moderating effect on certification.

Market Competition and Gentrification: Market competition may substantially influence certified rental prices. We create a "Green Building Supply" variable, which is a numerical measure of BREEAM-certified buildings within a 500-meter radius at the time of renting or sale for all buildings. Ex ante, as the number of certified buildings in a micro-location increases, there will be moderating effects on the prices of certified buildings. However, we suspect that increasingly renovated or new certified buildings will add to the value of a neighborhood.

9 Real Capital Analytics. See http://www.rcanalytics.com/methodologysources.aspx 10 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. 11 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. 12 Three databases were consulted for BREEAM transactions, Real Capital Analytics, Estates Gazette Interactive and CoStar FOCUS.

Investor Types: Theoretically, there should be no anticipated price differences for different investor types. However, principals and agents of financial capital may have different investment criteria and mandates. Principals, like private developers and investors manage their own financial capital, whereas, agents, such as real estate investors (i.e., REITs), institutional investors, and municipal government investors manage financial capital on behalf of shareholders, trustees and communities. Thus, the type of investor may have an impact on prices, following differences in investment horizon, and risk and return targets.

Location: Following standard methodology, we control for building location using ZIP codes and transportation networks in London. London is broken down into "London sub postcodes" the 1-3 letter prefix, which corresponds to its compass location. 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 then calculated.

Table 2 shows the propensity score weighted dependent and independent variables used in our analysis and compares the average characteristics of the "green" buildings in our sample with buildings in our control sample. 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 1,100 square meters. In addition, green buildings are younger (half the sample is less than 10 years old and a majority of control buildings are more than 20 years old), but when propensity score weighted this difference substantially decreases and the average age is 25 years old for propensity weighted buildings. More than half the certified sample is renovated, about double compared to the control sample. Amenities are available in 48 percent of certified rentals and 65 percent of control rentals[13]. Building quality variables suggest that above 75 percent of the certified sample is new or renovated and just over 20 percent is second hand on the market, which is comparable to the control sample. The distance to the nearest train stations within 500 meters from certified rentals is greater by 50 meters.

The average lease length in "green" properties is longer by almost three years and with comparable variability to the control sample, but the rent-free period is 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. The "green building supply" variable shows that, on average, certified properties have six other certified buildings in their immediate area at the time of rental, whereas control rentals have on average four green buildings in their immediate neighborhood.

In our sample, 60 percent of certified buildings are owned by a real estate or institutional investor, as compared to 50 percent of control buildings. Moreover, the municipal and government sector owns just five percent of the buildings in the sample.

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. Thus, certified buildings may be transacting in "hot spots".

13 One or more of the following amenities are in the transacted building or rented space: 24 hour access, 24 hour security, air conditioning, atrium, bicycle facilities, building reception, central heating, commissionaire, concierge, dockside, double glazing, electric heating, entry phone, gas central heating, gym, information point, lift(s), loading bay(s), marble ceilings, metal ceilings, natural light, parking spaces, raised floors, roof terrace, separate entrance, suspended ceilings.

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

	Rental Sample		Sales Sample	
	Green Sample	Control Sample	Green Sample	Control Sample
Variables	**64**	**1,085**	**69**	**1,950**
Achieved Rent/ Sales Price (GBP)	1,260,000 (2,460,000)	589,000 (1,640,000)	157,257,979 (120,586,319)	89,744,378 (189,537,292)
Achieved Rent/ Sales Price (GBP/net sq.meter)	521 (137)	429 (177)	6,985 (5,655)	6,340 (6,020)
Building Characteristics				
Unit Size/ Building Size (net square meters)	2,220 (3,811)	1,151 (3,057)	27,857 (19,182)	16,065 (27,169)
Storey (number)	11.28 (9.55)	7.29 (5.06)	11.71 (6.84)	9.70 (8.99)
Amenity (percent)	0.51 (0.50)	0.68 (0.47)	0.61 (0.49)	0.66 (0.48)
Building Renovated (percent)	0.69 (0.47)	0.56 (0.50)	0.35 (0.48)	0.33 (0.47)
Distance to Nearest Train* Stations (meters)	423.50 (168.87)	457.45 (218.81)	391.40 (187.68)	387.95 (204.80)
Unit/Floor Quality				
New or renovated	0.76 (0.43)	0.69 (0.46)	0.16 (0.35)	0.22 (0.36)
Second hand	0.24 (0.43)	0.29 (0.45)	0.07 (0.24)	0.55 (0.46)
Under construction	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Under refurbishment	0.01 (0.07)	0.02 (0.13)	0.00 (0.00)	0.00 (0.00)
Unknown	0.00 (0.00)	0.00 (0.00)	0.76 (0.42)	0.23 (0.40)
Green Building Supply** (building count)	7.20 (4.21)	4.21 (4.78)	4.28 (4.77)	2.40 (3.89)
Investor Type (percent)* **				
Real Estate			0.42 (0.50)	0.27 (0.44)
Institutional			0.17 (0.38)	0.24 (0.43)
Developer			0.13 (0.34)	0.02 (0.13)
Muncipal/ Government			0.04 (0.19)	0.03 (0.17)
Private			0.16 (0.37)	0.30 (0.46)
Unknown			0.07 (0.26)	0.14 (0.34)
Contract Features				
Days on Market	868.32 (644.39)	438.31 (403.10)		
Lease term (years)	9.62 (3.66)	7.01 (4.29)		
Rent Free Period (months)	6.14 (10.24)	4.76 (7.74)		

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.

4.0 Method

We investigate the economic 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:

(1) $$\log P_i = \alpha + \beta X_i + \delta g_i + \varepsilon_i$$

where the dependent variable is the logarithm of the rental price (selling price) per net square meter P_i in commercial office building i. X_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 g_i is a dummy variable with a value of 1 if building i is rated by BREEAM and zero otherwise. α, β, and δ are estimated coefficients and ε_i is an error term.

We estimate equation **(1)** using OLS corrected for heteroskedasticity with clustered standard errors (White, 1980), but employ propensity score weighting techniques to minimize bias between the BREEAM certified and control buildings. In our application, propensity score weighting aims to minimize the selection bias between certified and non-certified buildings by differentiating based on individual building characteristics. Conditional upon observable characteristics, we eliminate differences between "treated" green buildings and "non-treated" control buildings by estimating the propensity of receiving a BREEAM rating for all buildings in the sales and rental samples, using a logit model (Black and Smith, 2004). 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)** (See also Eichholtz, et al., in press.)

In the second part of our analysis, we document the impact the supply of BREEAM rated buildings has on transactions prices. We investigate how 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:

(2) $$\log P_i = \alpha + \beta X_i + \delta g_i + \theta C_i + \sigma g_i C_i + \varepsilon_i$$

where equation **(2)** introduces C_i, 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, g_i, with the green building supply, C_i, to isolate the moderating effect of geographic clustering of certified buildings.

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:

3) $$\frac{\partial \log P_i}{\partial g_i} = \delta + \sigma C_i$$

where equation (3) is the marginal effect of certified rents or prices conditional upon 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.

5.0 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. These specifications explain over half the variation in the logarithm of rents per net square meter with an adjusted R-squared ranging from 57 to 61 percent.

Column (1) reports the propensity-weighted results for the hedonic specification relating office rents to the hedonic characteristics, i.e. rental size, amenities, renovation dummy, time dummies and post-code dummies. The coefficient on rental size is positive and significant: larger spaces command higher rental rates per net square meter. Buildings less than 10 stories or even 20 stories transact for 35 to 12 percent less, respectively. For buildings less than ten years old, rents are 27 percent higher relative to buildings of more than forty years old. As expected, the importance of the age factor decreases as age increases. The amenities dummy is negative and insignificant. Regarding building quality, there is a seven and a half percent premium for new or refurbished buildings over buildings' under refurbishment or construction. Contrary to expectations, transportation networks (train stations) have no significant influence on rental prices.

Most important, the "green" certification dummy is positive and significant. BREEAM-certified properties command a 28 percent premium over non-certified properties, controlling for basic building characteristics.

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 4.3 percent per additional year of lease, but the term structure is non-linear. Thus, the maximum achieved rent is realized at a lease duration of about 12 years and the marginal increase in rent becomes zero once lease lengths surpass 11.5 years. (However, only some five percent of rental contracts surpass this threshold.) The number of days that a unit is on the market has no significant impact on achieved rents, whereas rent-free periods have a significant and positive impact on rents, i.e. longer rent-free periods are capitalized into the initial rents. Importantly, rental contract features have a moderating effect on the certification coefficient, decreasing the "green" rental premium by five percentage points.

In column (3), the specification is reported with further controls for the local supply of certified buildings. Green building supply does not have an impact on the value of rental contract features or 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. Thus, for buildings in general there is 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 some 1.5 percent, ceteris paribus. At the average number of certified buildings (6.07), the "green" premium is 21.8 per cent, ceteris paribus[14].

14 Following equation DIRECTIVE NUMBER 2010/31/EU 2010. Energy Performance of Buildings Directive Recast. *L 153/13.* European Union: Official Journal of the European Communities , the premium is calculated as follows: 0.315 (coefficient on breeam certification) – 0.015 (coefficient on green building supply interacted with breeam certification)*6.07 (average certified building supply).

Table 3 Office Rents for BREEAM Certified Buildings (2005-2009 period) (Dependent Variable: Logarithim of Rental Price per net square meter)

	(PSW) (1)	(PSW) (2)	(PSW) (3)
BREEAM Certified	0.280*** [0.039]	0.242*** [0.041]	0.305*** [0.053]
Certified Building Supply			
Certified Buildings			0.016*** [0.004]
Certified Buildings*Certified			-0.015** [0.008]
Rent Contract Features			
Lease Term		0.043*** [0.009]	0.043*** [0.009]
Lease Term^2		-0.002*** [0.000]	-0.001*** [0.000]
Days on Market		-0.000 [0.000]	-0.000 [0.000]
Rent Free Period		0.004* [0.002]	0.003*** [0.002]
Quality Characteristics			
Rental Unit Size (Net sq. meter in thousands)	0.017*** [0.005]	0.012** [0.006]	0.013** [0.006]
Story Low (1 = yes)	-0.354*** [0.061]	-0.333*** [0.058]	-0.325*** [0.056]
Story Medium (1 = yes)	-0.126* [0.069]	-0.114* [0.068]	-0.103 [0.067]
Age 1 to 10 years (1 = yes)	0.263*** [0.035]	0.230*** [0.035]	0.219*** [0.036]
Age 11 to 20 years (1 = yes)	0.053 [0.046]	0.053 [0.045]	0.058 [0.044]
Age 21 to 30 years (1 = yes)	0.111** [0.049]	0.105** [0.048]	0.102** [0.050]
Age 31 to 40 years (1 = yes)	0.075 [0.055]	0.075 [0.053]	0.075 [0.053]
Amenities (1 = yes)	-0.002 [0.028]	-0.017 [0.028]	-0.027 [0.028]
Renovated (1 = yes)	0.016 [0.026]	0.018 [0.026]	0.024 [0.026]
New or Renovated (1 = yes)	0.075*** [0.027]	0.044 [0.027]	0.038 [0.026]
"Second Hand" (1 = yes)	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]
Under Refurbishment (1 = yes)	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]
Train Distance (Inverse)	-5.318 [5.366]	-5.874 [5.405]	-7.711 [6.184]
Constant	5.443*** [0.105]	5.233*** [0.109]	5.280*** [0.104]
Observations	1,149	1,149	1,149
R-squared	0.592	0.613	0.627
Adj R^2	0.57	0.59	0.61

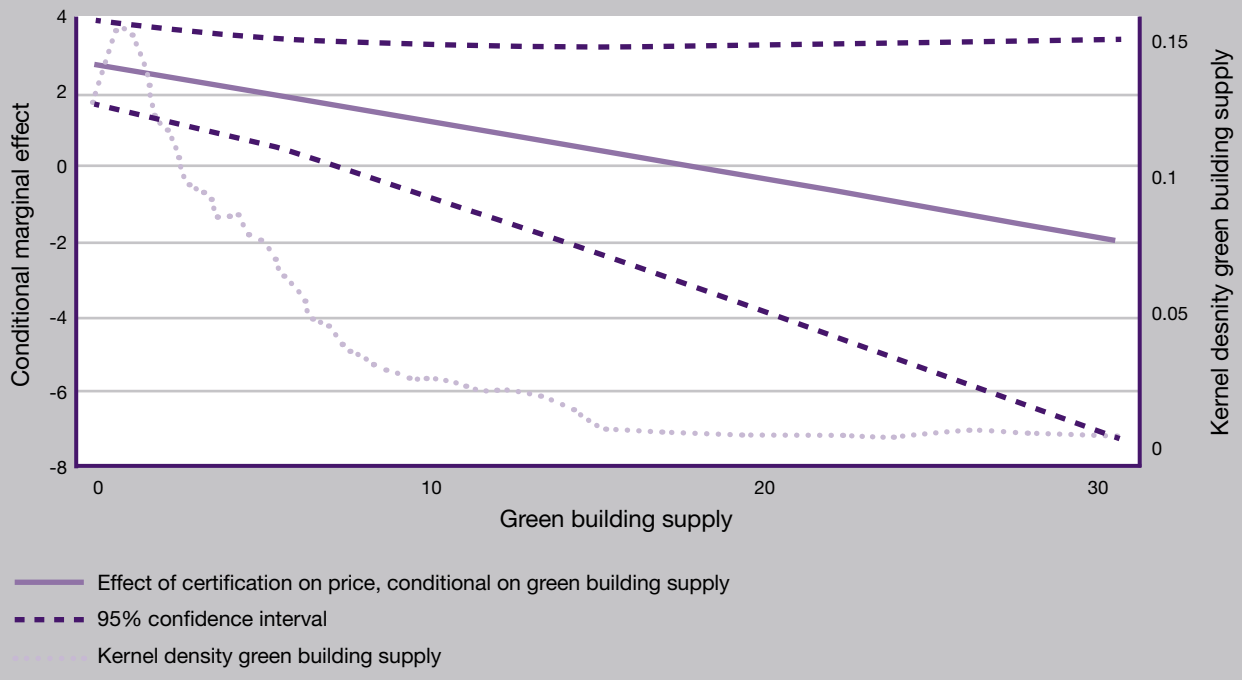
Notes: All models include Post code dummies to control for location, and yearly time dummies to control for time-variation in rental prices.

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

Figure 2A shows the results of the conditional marginal effects analysis. There are three axes: the left vertical axis depicts the beta coefficient of the conditional marginal effect; the horizontal axis is the certified building supply (the number of BREEAM certified buildings within 500 meters at the time of renting); and the right vertical axis 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 bold dashed line depicts the kernel density of the certified building supply. From left to right, about 15 percent of units 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 change in rents per net square meter for certified units when the certified building supply increases. Thus, when the number of certified buildings in a cluster increases, the "green" premium decreases by 1.5 percent, on average[15]. From confidence interval bounds, the certified supply interaction term is statistically significant until approximately 9 buildings, where the premium is still positive, but substantially lower.

Figure 2a **Marginal Effects of Green Building Supply – Rental Sample (Rents 2005–2009)**
Number of Green Buildings within a 500-meter radius



Notes: Figure 2 shows the conditional marginal effects of the green building supply on rental, transaction and transaction prices with respect to investor type. 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 is certified, with the certified building supply. The two thick dashed lines denote confidence intervals.

15 Green building supply and competition have a linear relationship with price, the estimations of non-linear parameters are very small and insignificant.

5.2 Green Buildings and Transaction Prices

Table 4 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. At best, these specifications explain some 25 percent of the variation in the sales price per net square meter.

Column (1) reports the propensity weighted hedonic specification relating sales prices to hedonic qualities, i.e., size, age, number of stories, and a dummy variable representing amenities and renovation, post-code dummies, transportation network controls and yearly time dummies. The regression explains 20 percent of the variation in the log of prices per net square meter.

Building size has a negative and significant impact on transaction price, with transaction prices decreasing by 0.007 percent as building size increases by 1,000 square meters. Age indicators are positive, but insignificant. Stories that are greater than 20 floors relative to those less than 10 increase in price by 23 percent. The amenity and renovation dummies are both insignificant as well. New and renovated buildings as a percentage of floor space is negative significant, suggesting that as new and renovated

Table 4 **Office Sales for BREEAM Certified Buildings (2000-2009 period) (Dependent Variable: Logarithm of Sales Price per Net Square Meter)**

	(PSW) (1)	(PSW) (2)	(PSW) (3)
BREEAM Certified	0.262** [0.067]	0.175* [0.075]	0.380*** [0.072]
Green Building Supply			
Green Building Count			0.046*** [0.006]
Certified Supply*Certified			-0.043** [0.013]
Investor Type			
Real Estate Investor		0.314*** [0.036]	0.285*** [0.047]
Institutional Investor		0.357*** [0.020]	0.346*** [0.019]
Developer		0.459*** [0.068]	0.409*** [0.079]
Municipal Developer		0.278 [0.137]	0.215 [0.122]
Quality Characteristics			
Building Size	-0.007** [0.003]	-0.007** [0.002]	-0.009** [0.002]
Story Medium	0.007 [0.027]	-0.038 [0.027]	-0.052 [0.031]
Story High	0.227* [0.084]	0.209* [0.088]	0.262* [0.097]
Age 1 to 10 years	0.283 [0.140]	0.258 [0.128]	0.249 [0.133]
Age 11 to 20 years	0.258 [0.132]	0.224 [0.128]	0.242 [0.126]
Age 21 to 30 years	0.122 [0.172]	0.101 [0.164]	0.103 [0.167]
Age 31 to 40 years	0.260 [0.212]	0.222 [0.207]	0.225 [0.209]
Amenities (1 = yes)	0.011 [0.057]	-0.051 [0.054]	-0.055 [0.048]
Renovated (1 = yes)	-0.126 [0.071]	-0.120 [0.066]	-0.118 [0.062]
New or Renovated (percentage of building)	-0.792* [0.321]	-0.870** [0.294]	-0.916** [0.217]
New or Renovated 2	0.720 [0.341]	0.795* [0.296]	0.858** [0.195]
Train Distance (Inverse)	14.551* [5.929]	13.267* [5.136]	12.973* [5.190]
Constant	7.941*** [0.140]	8.010*** [0.153]	8.120*** [0.132]
Observations	2,019	2,019	2,019
R-squared	0.221	0.252	0.271
Adj R^2	0.20	0.23	0.25

Notes: All models include ZIP code dummies to control for location, and yearly time dummies to control for time-variation in rental prices.

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

floor space increases there is a negative relationship with price, but later specifications indicate that this is for buildings with mostly second-hand space. Lastly, transportation networks have a positive impact on prices the closer the building is to a station.

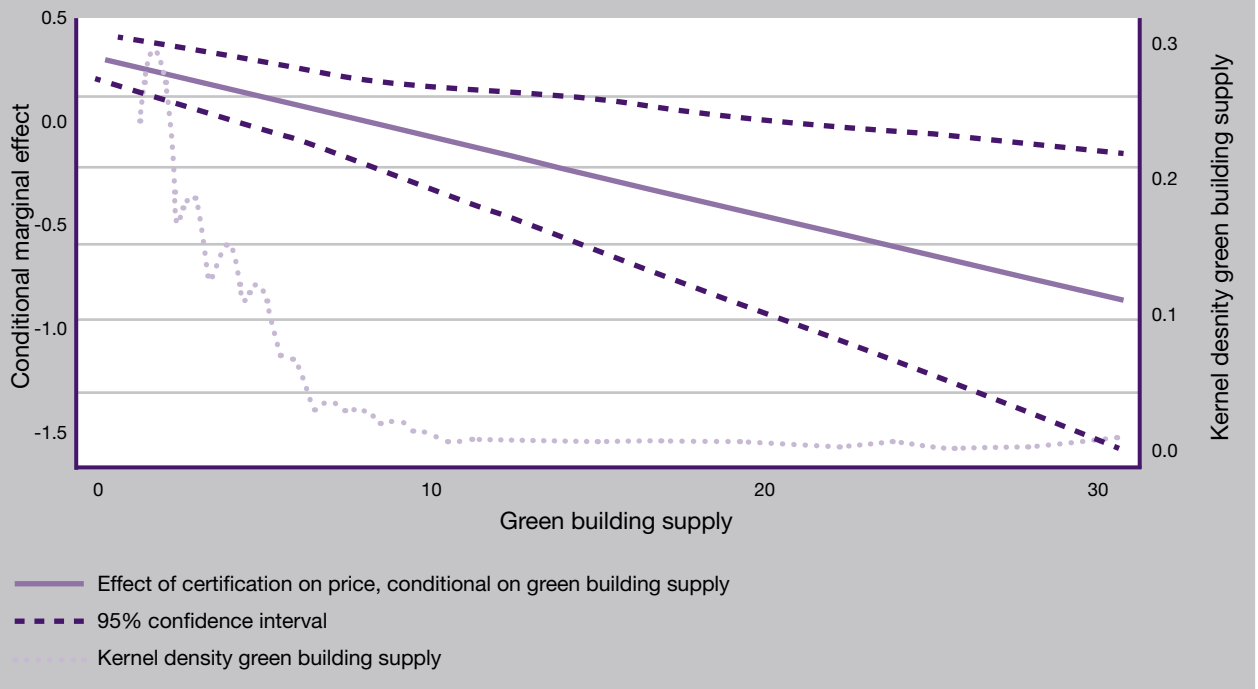
Most importantly, the "certified" coefficient is significantly positive, suggesting that BREEAM-certified buildings transacted at a remarkable 26 percent premium during the sample period, after controlling for basic differences in building quality and location. The magnitude of this coefficient is substantial, and we further elaborate upon this result through robustness checks in Section 5.3.

In column (2) investor types are added to the specification. Contrary to expectations, the identity of a buyer matters. Relative to private investors, real estate investors, institutional investors, and developers pay more for commercial real estate during the sample period. However, given the moderating effect investor types have on the certification and building quality variable, investor type may also be a proxy for building quality. Lastly, when a building has a larger proportion of new or renovated relative to second hand units, there is a large increase in price.

In column (3), the results including the variables for green building supply are reported. At first sight, the specification suggests that the premium for certification is 38 percent, but this coefficient reports the premium for green when there are no other green buildings present in the market and this event occurs for less than ten percent of the sample. Controlling for the clustering of green buildings has a positive and significant impact on prices, about a 4.6 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 (4.59), the premium is 18.2 percent, ceteris paribus[16].

Figure 2B presents 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 axes are consistent with Figure 2A. In the figure, the bold 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. As certified buildings in a cluster increase, the "green" premium decreases, by 4.3 percent, on average. The certified green building supply result is statistically significant until approximately 8 buildings, where the premium is still positive, but reduced substantially.

Figure 2b **Marginal Effects of Green Building Supply – Transaction Sample (Sales 2000–2009)**
Number of Green Buildings within a 500-meter radius



Notes: Figure 2 shows the conditional marginal effects of the green building supply on rental, transaction and transaction prices with respect to investor type. 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 is certified, with the certified building supply. The two thick dashed lines denote confidence intervals.

16 Following equation 3, the premium is calculated as follows: 0.380 (coefficient on breeam certification) – 0.043 (coefficient on green building supply interacted with breeam certification)*4.59 (average certified building supply).

5.3 Robustness Checks

The "premiums" documented for certified real estate are generally in line with the literature investigating the economic outcomes of LEED and Energy Star certification in US commercial markets, but the economic significance is much higher. However, we note distinct differences between the specifications used in the existing literature and this paper. Eichholtz et al. (2010) specifically control for building quality using the Building Owners and Managers Association (BOMA) building class definitions and document a moderating effect of these quality indicators on the "green" premium. In the Tokyo residential real estate sector, Yoshida and Sugiura (2011), control for residential building quality, and this building quality variable accounts for a large part of the "green" premium – as there is some evidence of multi-collinearity between "green" buildings and building structure, age and management. Their results find bias and inconsistency in the event of exclusion of such quality indicators.

In the UK datasets at hand, building quality measures, such as independent building structural features and management are measured by different building quality proxies then the US's commercial BOMA definitions. BOMA is a third party definition of building quality, which is consistently used across the US. In Europe and in the UK, the existing quality measures are not a third party measure and are not found consistently across all databases and buildings.

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 buildings to be classified as "Institutional 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 of points to achieve such measures, "Very Good" and "Excellent" measures may in fact be building quality controls or qualities synonymous with "institutional" grade real estate.

To further analyze the effect of lacking quality characteristics on the magnitude of premiums documented in this paper, we test how analyses on the first paper in this topic (Eichholtz et al., 2010) would be impacted by the removal of building quality controls. We compare our results with those of New York City, Chicago and Washington DC, using data from Eichholtz et al. (Eichholtz et al., in press)[17]. Results of the propensity score weighted hedonic specification for LEED and Energy Star buildings are reported in Appendix B. Summarizing, when building quality controls are not added to the specification, the certified premiums for LEED and Energy Star are moderated. The results for these three main US cities indicate that when we do not control for building quality results are comparable to the London specifications. Thus, future studies that acquire a more standardized documentation of building quality measures may find substantially lower premiums for "green" offices in London.

17 Holly, Peseran and Yamagata (2011) document the spatial diffusion of exogenous shocks of the UK housing markets and find 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.

6.0 Conclusion and Discussion

This paper investigates the evolving financial performance of London's environmentally certified commercial building stock within the context of a dynamic supply and demand framework, measured by realized sales transactions and achieved rents over the 2000 to 2009 period. We document that BREEAM certification has value in the London office market, but that value is conditional upon the economic conditions at the time of rent (sale).

Of course, "green" premiums may reflect increased construction or renovation costs, i.e. supply-side responses to increases in demand. To date, there is limited systematic evidence (mainly case studies) reporting the marginal costs of environmentally certified real estate construction in the UK and US commercial real estate sector. Furthermore, the transaction costs associated with certification, consulting, design fees, contingencies and development are also unavailable (Fisher and Bradshaw). We investigated the data available from the Building Cost Information Service database of the Royal Institution for Chartered Surveyors (RICS), and documented that data on just 14 BREEAM rated commercial buildings in the UK is available for elemental construction cost analysis. Unfortunately, this data is insufficient for meaningful statistical inference. Thus, future research incorporating construction and redevelopment cost may provide a better understanding of the ROI related to investments in "green" building.

Also, the supply of "green" buildings is expanding, which may influence the "green" premium documented here. This paper shows that growth in green building supply had an economically significant impact on London's commercial real estate prices in general and on certified real estate in particular. Green buildings' contemporaneous supply is a significant factor for the economic outcomes of energy efficient real estate. From 2000 to 2009, stand-alone green building rents and transaction prices are higher relative to "green" buildings with neighborhood competition. However, subsequent buildings that increasingly feature "green" credentials do not realize these same rental and price levels. Over the sample period, the supply of "green" buildings expanded by 1.8 percent, resulting in some 1,600 "green" office buildings in 2010. Within the UK, London had the highest growth in certified real estate where the supply expanded to 368 buildings as of 2010 and an average of 6 certified buildings, for a given neighborhood, at the time of certified rent or sale.

Within the context of London, where buildings transact with an increasing supply of "green" buildings surrounding them, it is thus important to take into consideration the diffusion of environmentally certified real estate. However, real estate supply in the UK is highly regulated, with British regulatory policies that limit development create considerable supply side restrictions in the commercial real estate market (Cheshire and Hilber, 2008). The geographical spread of green buildings in the UK confirms the theory of slow diffusion, and in the absence of a market equilibrium, there may still be profitable investment opportunities to "green" buildings in local UK markets.

Moreover, it is important to consider the volume of transaction evidence that is available for "green" buildings in London. After scouring 3 transaction databases and reviewing other studies, we conclude that green buildings are not transacting, which indicates one of two scenarios. First, that "green" buildings are owner occupied and are really not on the market or that "green" buildings are maintained as a buy and hold investment for investors.

With that being said, for capital cities around the world, increasing amounts of investment capital, regulation and urban policy are directed towards third-wave gentrification and at the corner stone of this typology is the sustainability and environmental agenda (Davidson and Lees, 2005; Bunce, 2009; Wyly and Hammel, 2008). There are studies that indicate positive performance in residential neighborhoods that undergo environmental gentrification (see Sieg et al., 2004; Campbell et al., 2010; Gamper-Rabindran and Timmins, 2011). However, there is some debate in the literature whether new buildings or renovation constitutes gentrification (Davidson and Lees, 2010), but our sample indicates that London City, Westminster, Kings Cross, etc., are incorporating both types of certified real estate into the urban landscape and as these figures grow, there has been a positive price impact on commercial real estate in general.

Last, intervention from governments and special interest groups in the UK has been substantial in the property sector. New construction or retrofits by the UK government are required to be BREEAM certified, and should have both EPC and DEC labels. New building codes incorporate stricter energy-efficiency mandates and by 2018, all new construction must adhere to zero-carbon standards. Ultimately, this will have a substantial impact on the supply of "certified" real estate and the competition within that market. The advent of the Carbon Reduction Commitment in 2012, in which capital market investors and tenants are responsible for buildings' CO2 emissions, represents another nudge towards increased demand for energy-efficient real estate, and can only increase the salience of sustainability for the commercial property sector.

18 For a specific case study focusing on BREEAM, BRE Center for Sustainable Construction and Cyril Sweett (2005) estimated the incremental construction costs for a single building in case it would have been rated by BREEAM as Good, Very Good and Excellent, distinguishing between natural ventilation air conditioning. For the naturally ventilated space (493 m2), a Good Rating cost a maximum of 0.4 percent more and an Excellent Rating about 3.4 percent. For an air-conditioned space (10,098 m2), maximum additional costs for a Good rating were 0.2 percent and for an Excellent rating 7.0 percent.

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Appendix A – The BREEAM Certification Process

A1 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 CO2 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.

A2 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).

Table A1 BREEAM scorecard

Weight	BREEAM Issue and Title	Minimum Standards	No. of Credits Available	Pass	Good	Very Good	Excellent	Outstanding
12	**Management** – 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	10
	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					

Weight	BREEAM Issue and Title	Minimum Standards	No. of Credits Available	Pass	Good	Very Good	Excellent	Outstanding
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	1				
	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

Table B The Value of Green Certification in the U.S. (dependent variable: logarithm of sales price per square foot)

	(1) Full Sample	(2) Chicago	(3) Washington	(4) New York
"Green" Certification	0.133*** [0.0167]	0.324*** [0.0591]	0.334*** [0.0594]	0.245 [0.153]
Class A (1 = yes)	0.213*** [0.0409]			
Class B (1 = yes)	-0.0377 [0.0336]			
Building Size (log)	-0.0487*** [0.00989]	-0.123*** [0.0415]	-0.170*** [0.0215]	0.0155 [0.0647]
Age 0 to 5 years (1 = yes)	-0.0242 [0.0445]	0.110 [0.122]	0.0403 [0.0768]	-1.911 [1.178]
Age 5 to 10 years (1 = yes)	0.353*** [0.0344]	0.427*** [0.0945]	0.655*** [0.0827]	-0.317 [0.222]
Age 11 to 20 years (1 = yes)	0.115*** [0.0330]	0.0630 [0.110]	0.230*** [0.0770]	0.555*** [0.189]
Age 21 to 30 years (1 = yes)	0.0870*** [0.0262]	-0.275*** [0.0866]	0.224*** [0.0609]	0.308** [0.129]
Age 31 to 40 years (1 = yes)	0.0449 [0.0290]	-0.124* [0.0728]	0.149** [0.0644]	0.162 [0.162]
Renovated (1 = yes)	0.0154 [0.0191]	0.0675 [0.0443]	0.0231 [0.0364]	0.405*** [0.123]
Story Medium (1 = yes)	0.167*** [0.0232]	0.474*** [0.109]	0.345*** [0.0441]	-0.901*** [0.215]
Story High (1 = yes)	0.338*** [0.0285]	1.170*** [0.124]	0 [0]	-0.611*** [0.231]
Amenities (1 = yes)	0.0324* [0.0189]	-0.337*** [0.0586]	-0.146*** [0.0389]	0.132 [0.103]
Public Transport (1 = yes)	-0.124*** [0.0263]	-0.471*** [0.0733]	-0.259*** [0.0680]	-0.198 [0.129]
Constant	5.078*** [1.952]	5.332*** [0.511]	7.221*** [0.282]	6.251*** [0.751]
Year-Fixed Effects	Yes	Yes	Yes	Yes
Observations	5,993	615	597	363
Green	686	34	22	16
R-squared	0.662	0.731	0.442	0.386
Adj R^2	0.616	0.705	0.404	0.327

Notes: Specifications are based on propensity score weighted hedonic regressions. Full sample results correspond to those reported in Eichholtz, Kok and Quigley (Directive number 2010/31/EU). Sub-sample rental and sales results are presented for New York City, NY.

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

Source: Based on Eichholtz, et al., in press

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