The Value of Green Buildings
New Evidence from the United Kingdom

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Abstract

Attention to green building practices has substantially increased over the last decade, but evidence on financial performance of such investments is very limited outside of the United States. To fill this gap in the literature, this study investigates the financial implications of green building practices in the United Kingdom: one of the world's largest property markets and the first to introduce a formal green building rating scheme – BREEAM – in 1990. This rating scheme laid the foundation for the development of rating schemes such as LEED in the U.S. and Green Star in Australia.

We match proprietary information on BREEAM-rated office buildings to the characteristics of geographically nearby control buildings, their selling prices, and rental rates. This results in a sales transaction dataset of over 1,200 observations, and a rental transaction dataset of over 26,000 subject and control buildings. We then model the characteristics of green buildings that impact financial performance, controlling for differences in quality between subject and control buildings using a hand-collected set of hedonic characteristics. Results from this analysis suggest a positive impact of a building's green characteristics on sales and rental transaction prices in the order of 8 percent and 16 to 20 percent, respectively, depending on the model specification.

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1. Introduction

Governments all over the world are concerned with the environmental performance of the built environment. To improve building performance, policy makers are experimenting with different forms of market intervention. Regulation, (tax) incentives, information schemes, and "leading by example" are all being tried to various degrees and in different combinations.

For example, in 2002, the European Energy Performance Buildings Directive (EPBD) mandated that the energy performance of all new and renovated buildings measuring 1,000 m^2 and above be certified and displayed (Directive 2002/91/EC, 2002). In forthcoming legislation for 2010, the new EPBD directive is expected to expand these requirements to all existing buildings that undergo renovation. Moreover, new legislation includes a mandate for zero-energy and low carbon buildings to be devised by each member state (Memo 08/693, 2008). Cost-benefit calculations at the EU-level implicate that the European Commission is likely to support its legislation based on economic grounds: in a document an accompanying the recast proposal, the Commission claims that the costs of abolishing the 1,000 m^2 threshold would lead to €8 billion per year in capital costs, but would at the same time result in €25 billion per year in reduced energy costs by 2020 (Working Document, 2002/91/EC, 2008). It is almost certain that member states will need to comply with these new regulations in the next five to ten years, and therefore have to come up with financing for these capital outlays.

The U.K. is not immune to this upcoming legislation and is actively designing new regulatory standards to meet EU mandates. At the center of the debate is the environmental performance of commercial real estate. The U.K. government is planning for the expansion of its building regulations to include energy performance certificates on all buildings greater than 250 m^2 for public buildings, and for buildings that are frequented by the public, including prominent

commercial space. These regulations are aimed to "set the U.K. national economy to work on a more sustainable built environment" (Communities and Local Government, 2009).

However, it is unclear whether government involvement of this kind is required to improve the energy efficiency of the real estate sector. Some recent evidence (Enkvist, Naucler and Rosander, 2007) claims that many of the investments needed to make the built environment more energy efficient have positive net present value, even at current energy prices. This suggests that real estate market participants – developers and investors – should make energy efficiency investments, acting purely from a value-maximizing perspective. However, in order to convince market participants, robust evidence is needed that further investigates the financial performance of green buildings.

To date, there are very limited studies on the financial performance of environmentally certified buildings outside of the U.S. market. This makes investors, developers and the valuation industry in other markets hesitant in the development of a "green" commercial real estate market. The aim of this study is therefore to fill this gap in the literature, and to evaluate the financial performance of environmentally certified buildings in the U.K commercial real estate market.

In 1990, the U.K.'s Building Research Establishment (BRE), an independent non-profit trust that has been researching the sustainability of the U.K. built environment for the past 90 years, was the first third-party organization to independently certify the environmental performance of buildings (Reed et al., 2009). However, despite this head start, the knowledge regarding the economic performance of environmentally certified buildings in the U.K. is very limited. Early research on U.K. green commercial office space found only 26 low energy buildings and after cross referencing these observations in the U.K. Investment Property Database (IPD), only seven observations could be remained. Ultimately, such a small number of

observations is insufficient to make any sound inferences in the financial performance of energy efficient or sustainable office space. Indeed, some have pointed to the limited number of buildings that are certified within the U.K.'s institutionally owned property sector and the lack of basic quality information on commercial buildings in general. Together, these issues inhibit the amount of green building valuation data that can be cross-referenced in existing property valuation databases (Eichholtz, Kok and Quigley, 2010b).

This paper aims to investigate the financial implications of certified energy efficient and sustainable building practices on the sales and rental prices of U.K. office buildings. To identify these certified buildings, we utilize BRE's database on green building certification -- BREEAM. Using Geographic Information System (GIS) methods, we match these green buildings to a sample of 4,417 sales transactions from the Real Capital Analytics (RCA) database over the period 1999 to 2010. Of these sales transactions, the match yielded 78 BREEAM-certified transactions. The remaining transactions are used as the control sample.

In addition, we match BREEAM-labeled buildings to a sample of about 26,118 rental transactions in the CoStar FOCUS database, over the 2005 to 2010 period. This match yields 1,016 certified rental transactions. Similar to the sales analysis, the remaining transactions are used as the control sample.

For both samples, additional hedonic characteristics were provided by the Estates Gazette International London Offices property database. This database added hedonic characteristics for about 3,000 observations in the rental and sales sample. However, the depth and quality of hedonic regression modeling sales and rental prices is disappointing within the U.K. Thus, the interpretation of the results presented in this paper need to be interpreted with caution. Until more detailed data can be collected for the U.K., these estimates provide no more than a first step

towards assessing the financial implications of environmental certification in the commercial property sector.

Results of the study indicate that there is a positive effect following environmental certification of office buildings in the U.K. For a BREEAM-labeled office building, relative to a control sample, the sales transaction price is about 9 percent higher per square meter as compared to the control sample of non-certified real estate in the immediate geographic neighborhood. Translated to the bottom line, the premium for environmental certification is substantial: the average selling price for the 1,141 control buildings in the sample is £63.6 million, and holding all other factors equal, the premium paid for a BREEAM-certified building relative to a comparable building is £5.47 million.

Rental rates in certified space demonstrate a similar positive effect, the average rent per square meter for the rental sample is £232 and the premium for a certified building is approximately £35 per square meter per year. Translated into annual rental income for the average green rental building, the effects are also substantial. The average size of a BREEAM-certified rental transaction is about 723 square meters, and the annual rent increment on a certified space at this average size is some £193,000, *ceteris paribus*.

The remainder of this paper is outlined as follows. In Section 2, we briefly discuss the existing literature regarding the performance of environmentally certified buildings. Section 3 introduces and discusses the U.K. environmentally certified real estate market. In Section 4, we outline the BREEAM data and financial data obtained for commercial buildings in the U.K. In Section 5, we present the results of the formal analysis. Section 6 provides a discussion and some conclusions.

2. Existing Evidence on the Financial Implications of Green Building

There is a growing literature that purports a business case for the positive financial performance of environmentally certified (Energy Star and LEED) office buildings. In one of the first systematic research efforts, Eichholtz, Kok and Quigley (2010a) document that there are positive and large effects on market rents and selling prices following environmental certification. For a LEED or Energy Star labeled office building, the rental rate is about two percent higher per square foot, the effective rent is about six percent higher per square foot and the selling price is as high as 16 percent more per square foot, all relative to a control sample of conventional office buildings. Some other studies (e.g., Fuerst and McAllister 2011, Spivey and Florance, 2008) confirm these findings, suggesting that green buildings have higher rents and values than conventional buildings. These are the first convincing results to demonstrate green real estate premiums.

In a more recent study, Eichholtz, Kok and Quigley (2010c) document positive and robust premiums on environmentally certified buildings during the recent downturn in property markets, while the supply of green space has expanded from 4.6 percent in 2007 to 14.9 percent in 2009. For a data set covering more than 3,000 green buildings, they document significantly higher rents, effective rents and sales, as compared to conventional office space. Most important, these results hold whilst controlling for hedonic attributes and location using propensity score weights. The results also show that returns to green buildings during the 2007-2009 period are not significantly different from comparable high-quality office space.

3. Environmentally Certified Space in the U.K. Office Market

There is a growing awareness within the U.K. commercial real estate sector of the potential for a green real estate market and for sustainability in the built environment. Survey

results suggest that property professionals see environmental performance as increasingly important. In a 2008 research report, results of a survey of location preferences of Central London tenants show that 58 percent of tenants find energy efficiency "essential" and 50 percent find green attributes as "essential" (CB Richard Ellis, 2008). Sayce, Ellision and Parnell (2007) surveyed property investors and agents as to whether environmental (sustainability) factors affects yields, whether rents and yields will be affected by these factors in five years time, and how these factors will affect investment strategy. Results indicated that 30 percent of property advisors surveyed thought that yields were affected today and 60 percent thought yields would be impacted in the future. Of the property investment companies, 25 percent expected yield effects today and 80 percent expected effects in five years time. Banks and property developers did not find environmental factors very important. However, results from the survey are now five years old. A more recent illustration of industry interest in "green" and sustainability is the increasing popularity of the EcoBuild conference that was first held in 2005: the 2010 edition attracted an astounding 41,000 participants. The growing number of buildings certified under the BREEAM label is also an indicator of the industry's interest in this matter. The stock of certified buildings has expanded from under 500 buildings before 2000 to 1,618 in 2010.

3.1 Tenant Demand for Environmentally Certified Space

In the U.K., the second largest property market in the world, the green rental market has expanded in supply and demand over the past ten years. Yet, only a small portion of existing leasable office space is environmentally certified, amounting to approximately 5.8 million square meter of rentable green office space. Figure 1 geographically displays the U.K. office buildings labeled by BREEAM. As one can observe from this graph, the dispersion of green office buildings across the U.K. is quite wide, with relatively few buildings located in London. The

graph also shows the density of green office space for different regions in the U.K., and this information further underlines that the incidence of green buildings is lower in London than it is in the rest of the country.

---- Insert Figure 1 here ----

Most of the environmentally certified office space in the U.K. is new office space. BRE has only recently started an initiative to certify the existing office stock: BREEAM In-Use. Since the existing stock is large relative to the annual new supply of office space, focus in the existing stock is crucial for the reach of the environmental labeling effort in the U.K., and thus for the supply of green office space.

Tenant demand for green buildings is increasing as more tenants focus on decreasing operating expenses. Lower utility expenses are a key driver of tenant demand, with some studies indicating that environmentally certified buildings achieve energy savings as high as 30 percent (Katz, 2003) and operating expenses that are some 8-9 percent lower (McGraw Hill Construction, 2006). Commercial office managers are starting to produce statistics that offer a glimpse of the realized savings from environmental efficiency improvements. 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.[1]

[1] Another oft-invoked rationale for occupying green office space is tenant productivity. However, this is hard to measure as sample and control groups are very difficult to compare. In service sector jobs, performance is increasingly difficult to compare. However, there is some evidence claiming increased employee performance in green buildings. Miller, Pogue, Gough and Davis (2009) found in a survey that over half of occupants of environmentally certified buildings found their employees more productive. However, these results are difficult to interpret as these responses cannot be controlled for management style and individual characteristics of employees.

However, to engage in the investments needed for such savings, the owners of commercial office space first need basic awareness of their year-over-year energy consumption. Thus, building environmental management and implementation policies must be adopted. Within the U.K., environmental performance information is mostly proprietary, which leads to difficulties in measuring the real benefits and costs of sustainability. However, this can change by cultivating awareness of the potential for green buildings among property investors. Kok et al. (2010) created a global indicator of the environmental performance of listed property companies and private property funds. They rank companies by their environmental management practices and the actual implementation of these practices. A major finding of the study is that seven out of the ten highest ranked environmental performers in Europe are from the U.K. Yet, much of that score proved to be based on environmental management plans rather than on actual implementation.

3.2 Environmentally Certified Construction

In the "green" construction industry, more understanding is being shed on the life cycle cost of green buildings. Standard in real estate development is the evaluation of a project on the basis of construction costs, including the land value. Afterwards, consideration of the profitability of the project is compared to the relative costs. In the past, green building projects would often be rejected against non-green projects based on their higher construction costs and uncertain asset market values, occupancy rates and market rents. However, life cycle costing is a practice where all the capital costs of the project, i.e., acquisition costs, disposable costs, financing costs, and all relevant future costs, i.e., maintenance costs, occupation costs and

operating costs, are included (Kelly and Hunter, 2009). So far absent from these definitions is the cost of environmental externalities and intangibles.

In the past, large figures have been cited for the construction of green buildings, making development forecasts for green buildings a poor investment decision for today's future forecast. However, more recent figures have shown that average construction costs are some 2-3 percent higher for LEED-rated buildings in the U.S. (Katz, 2003). In a recent study on sustainable real estate projects in the U.S., Jackson (2009) shows that LEED-rated buildings cost on average 3.0 percent more, and Energy-Star-rated buildings cost on average 1.5 percent more. Yet, these figures do not amortize the costs of these environmentally improved operational efficiencies into the life cycle cost of the building.

4. Data

In the U.K., BRE is the primary third-party rating agency for energy efficient and sustainable buildings in the commercial property sector, awarding the BREEAM label. In the real estate market, BRE serves as an information broker for the underlying environmental credentials of the U.K. property market. The process of BREEAM certification and the minimum standards required are outlined in Appendix A.

Commercial offices can receive a BREEAM certification if these buildings meet the standards set by BRE in eight core areas. These core dimensions are building management, health and well being, energy efficiency, transportation efficiency, water efficiency, material usage, pollution and land use ecology. As of December 2009, 3,196 buildings in the U.K. had been awarded the BREEAM designation and 9,145 buildings had registered with BRE. Of those buildings awarded the designation, 1,618 were commercial office buildings.

The data on certification is broken down into two constructs. First, a transaction is flagged if it represents a building that has been certified by BREEAM. The binomial dummy variable results with a 1 if the transaction is certified and zero otherwise. Secondly, the certified buildings are given a score on the basis of fulfilling the standards of the eight core dimensions. These scores are equivalent to a BREEAM Rating, which is then prominently displayed within the building and advertised within the real estate community. The BREEAM Ratings are classified in Table 1. The highest score a building can receive is Outstanding. As of today, only one building has received the "Outstanding" label.

---- Insert Table 1 here ----

4.1. Sales Sample

We match the BREEAM database to a dataset of property transactions and prices maintained by Real Capital Analytics (RCA). Within the RCA U.K. database, there are 4,471 commercial office transactions for the 2001 to 2009 period, of which 1,201 had sufficient information to be included in our study. Of those transactions, 162 are BREEAM-rated transactions, and current information on building characteristics and transaction prices were available for 78 of these BRE rated transactions. Based upon the longitude and latitude of each BREEAM-rated building, we use GIS techniques to identify the buildings surrounding the BREEAM-rated buildings for 500-meter radii, which results in a neighborhood cluster for each rated building. A geographical representation of the sales sample is presented in Figure 2.

---- Insert Figure 2 here ----

Panel A of Table 1 provides the average characteristics of the "green" sample with the buildings in the control sample. Green buildings have a higher sales price, on average, than non-

green buildings. However, the variability in prices for green buildings is higher. Green buildings are larger on average as compared to control buildings, and they are taller by about two stories. On average, they are 13 years younger with comparable variability in age as compared to non-certified buildings. Panel B of Table 2 compares the percentage of transactions per year. The transactions are not evenly distributed over the 2000 – 2009 sample period, with the most transactions clustered in 2006 and 2007, for both the certified and control sample.

---- Insert Table 2 here ----

Figure 3 illustrates the distribution of characteristics of both certified buildings and the control sample. Panel A illustrates the differences between the control and certified sample in the price per square meter. On average, prices are higher for certified buildings. In Panel B, the age distributions of the certified and non-certified buildings display that a much larger percentage of buildings are younger. Panel C displays the differences in size measured in square meters.

---- Insert Figure 3 here ----

4.2. Rental Sample

We also matched the BREEAM database with a dataset of rental transactions and prices maintained by CoStar UK (Focus). Within the Focus database, there are some 32,000 commercial office rental transactions over the 2005 – 2010 period, of which 26,118 observations have complete information. Of those transactions, 1,016 are BREEAM-rated transactions. We again use GIS techniques to identify the buildings surrounding the BREEAM-rated transactions for 500-meter radii, which results in a neighborhood cluster for each rated transaction. A geographical representation of the rental sample is presented in Figure 4.

---- Insert Figure 4 here ----

Table 3 compares the average characteristics of the green buildings with the buildings in the control sample. The certified spaces have higher achieved rents, on average, than non-green buildings. However, the variability in prices for green buildings is higher. The achieved rent per square meter is lower for certified buildings. The letting unit size is larger on average than the control buildings. Green buildings have a higher percentage of being new or refurbished. There are fewer airports near them, but the average distance to the airport is less (under one kilometer). The number of train stations within a kilometer from BREEAM-certified building is smaller as compared to non-green buildings, but the distance to the nearest train station is 100 meters less. The rental transactions are not evenly spread over the 2005 – 2010 period, with the most lettings in 2008 and 2009 for both the certified and control sample.

---- Insert Table 3 here ----

Figure 5 illustrates the distribution of characteristics of both the certified buildings and the control sample. Panel A illustrates the differences between the control and certified sample in the achieved rent per square meter. The graphs mostly differ in density, where a larger proportion of rents are achieved at about 5.5 percent. Panel B, displays the differences in size measured in square meters, where the percentage of larger rental units is higher.

---- Insert Figure 5 here ----

5. Method

To investigate how the environmental certification influences the financial performance of commercial office buildings in the U.K., we use the standard valuation framework for commercial real estate. The analysis consists of BREEAM-rated office buildings, combined with a control sample of conventional office buildings. We estimate a semi-log equation relating

office selling prices per square meter (or rents per square meter) to the hedonic characteristics of buildings (e.g., age, stories, size, etc.) and control for the location of each building in two distinct ways:

(1)

(2)

In equation (1), the dependent variable is the logarithm of sales price per square meter .[2] The dependent variable represents commercial office building *i*. is a vector of the hedonic characteristics of building *i*. is a vector of neighborhood and transportation network controls for building *i*. 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. In equation (2), is a dummy variable with a value of 1 if building *i* is located in cluster n and zero otherwise.

5.1. Estimating Neighborhood Effects

For the sample of sales and rental transactions in equations (1) and (2) there are spatial relationships which may affect the sales or rental prices achieved. The location of a commercial office space has a clear relationship to its location and surrounding amenities, i.e., neighborhood. If the location of the office is impacted by these neighborhood effects, then so too are other offices in the area. This ultimately results in two problems. First, if the underlying spatial factors are omitted, sales or rental prices may be biased. Second, the error in omitting these variables causes error and this error is then correlated across all building observations, i.e., spatial autocorrelation, which results in inefficient estimates (Dubin, 1998).

[2] In the rental results the dependent variable is the logarithm of the rent per square meter.

Our methodology utilizes two methods to resolve the problems of omitted variable bias and spatial autocorrelation. First, using a traditional methodology in equation (1), we control for buildings in the central business district (Tse, 2002), control for city effects, and transportation networks. Buildings that are located in the central business district are treated with a binomial dummy variable, where location in the central business district of a city is equal to one. City effects are treated with a 311 distinct dummy variables, one for each city present in our sample. Transportation networks such as train stations (U.K.'s National Rail System) and airports (domestic and international) have been geo-coded using their latitude and longitude. Then using GIS methods, we calculate the distance from each building to the nearest train station (within one kilometer) and the nearest airport (within 50 kilometers).

Secondly, expanding on the work by Eichholtz, Kok and Quigley's application to commercial real estate (2010a, 2010c), we use Geographic Information System (GIS) methods to create neighborhood boundaries around each of the green buildings. Accordingly, the spatial interaction is assumed and that the location of the green building interacts with the control buildings in its immediate neighborhood (Anselin, 1998). In the geographic information system literature, this technique is called adjacency-based neighborhoods (Mitchell, 2009). In equation (2) the neighborhood is defined as a 500 meter radi circle around the green building and assigns a weight value to the green building and the non-green buildings within the radius of the green building. The weight matrix is then defined, where a weight of 0 indicates that the control building is not in the green buildings radius and a weight of 1 means the control building is within the radius.

As indicated by Dubin (1998) the error in measuring the factors to control for neighborhood effects in Equations (1) will ultimately decrease its omitted variable bias, but the

estimates error term will still be spatially correlated, resulting in inefficient estimates. In equation (2) using the neighborhood adjacency method the omitted variable bias and the spatial autocorrelation is treated directly. First, the setup controls for the value of the surrounding buildings and for the neighborhood amenities at the same time. Thus, access to neighborhood amenities e.g., train stations, restaurants, and the theater district, or, on the other hand, a location in or close by a derelict region is controlled for. Second, the spatial autocorrelation is treated by the weights matrix by defining the explicit dependency between the nearest buildings.

5.2. Propensity Score Matching

Propensity score matching aims to minimize the selection bias between certified and non-certified buildings by matching on the basis of their individual characteristics. In the case of real estate, the individual characteristics are the hedonic qualities of a building, i.e., age, size, amenities, etc. To control for the variation in the hedonic characteristics of certified buildings and control buildings, we estimate propensity scores 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 applied as a weight in the regression (Black and Smith, 2004).

6. Results

6.1. Sales Results

Table 4 presents the basic results for the sales sample, relating the logarithm of sales price per square meter of commercial office buildings to a set of hedonic characteristics. Results are presented for ordinary least squares corrected for heteroskedasticity (White, 1980). At best,

these specifications explain 60 percent of the variation in the sales price per square meter. The sample size is consistent for the conventional OLS specifications (Models 1 and 2) and propensity score specifications (Models 5 and 6), but is slightly smaller for the models with the clustered observations. There are less buildings in these models due to restrictions imposed on the data: each cluster needs to include one certified building with at least 1 non-green building.

Column (1) reports a basic model relating sales prices to hedonic qualities, i.e., size, age, number of stories, and a dummy variable representing renovation, traditional neighborhood controls, and transportation network controls. The regression explains 47 percent of the variation in the log of prices per square meter. The certification premium is positive and significant, and estimates a nine percent premium over non certified buildings. The first hedonic element, size, is negative and insignificant. Age and story are negative and significant: a one-year increase in age or a one-floor increase in the number of stories of a building will decrease the transaction price by 0.1 and 0.8 percent, respectively. The renovated dummy is positive and significant across all specifications. Renovated buildings achieve about a 15 to 16 percent premium over non-refurbished buildings. Neighborhood controls suggest that there is a large and positive premium for being located in London or the Central Business District of a city at approximately 20 percent, with the highest premium being calculated for buildings in London's CBD at just over a 50 percent premium. Transportation networks including airports and the National Rail System indicate that the number of airports within a fifty kilometer radius matter, resulting in a premium of about 2 percent. Most important, the coefficient on "Certified" is positive and significant, indicating that BREEAM-certified buildings transacted at a modest premium during the sample period, controlling for differences in quality and location.

In column (2) the BREEAM Rating is used as a proxy for certification, representing the level of certification achieved by a building. Ratings estimates are relative to non rated buildings. The BREEAM Ratings within our sample range from Good to Excellent. The fit of the model remains similar to column (1). The results show that the BREEAM rating for an Excellent rated building has a 22 percent premium. Very good and Good Ratings do not display a significant rating. This result most likely signifies that investors are willing to pay higher premiums for highly rated BREEAM buildings, representing a more vigorous environmental certficiation.

In columns (3) and (4), the specifications control for neighborhood effects using GIS techniques, and controls for the sales transactions within a 500-meter radius of a "green" transaction. The overall fit of this specification increases to over 60 percent of the variation in the price per square meter, indicating that controlling for micro-locational effects is more powerful as compared to conventional methods to control for "location location location". The coefficients on most of the control variables remain constant, except for the renovation dummy decreases and loses significance. The year-on-year price increases are highest in 2006, 2007, and 2008, relative to the base year of 2001. Most important, the certification premium decreases to 1.6 percent and is no longer significant. This may be due to the smaller number of BREEAM-certified in this setup, or to the stricter location control imposed on the data.

In columns (5) and (6) the results for the propensity score specifications are reported. The fit for this specification is about 45 percent. The certification premium increases, but remains insignificant. The hedonic characteristics behave similar to the first specification, but are slightly smaller in magnitude. The neighborhood controls also respond similarly, however, the number of train stations loses significance and decreases substantially in magnitude. Overall, the propensity

score model seems to be efficient in making certified and non-certified office buildings more comparable.

6.2. Rental Results

Table 5 presents the basic results for the rental sample, relating the logarithm of rent per square meter of commercial office space to a set of hedonic characteristics and neighborhood controls. Again, results are presented for ordinary least squares corrected for heteroskedasticity (White, 1980). These specifications explain over half the variation in the logarithm of rents per square meter with a range of 54 to 60 percent.

Column (1) reports a basic model relating office rents to the hedonic characteristics, i.e., letting size, amenities, a dummy variable for a new or refurbished property (relative to a second-hand letting), and neighborhood controls. The regression explains some 54 percent of the variation in the log of prices per square meter. The rental sample is relatively dispersed throughout the United Kingdom, and we account for this geographic variation by including 311 distinct city dummies (i.e., city-fixed effects). The city dummies are jointly significant at the one-percent level.

Building size is negative and significant: larger spaces command lower rental rates per square meter. The amenities dummy is positive and significant, with amenities leading to rental increases of some 12 percent. The building quality dummy indicates that there is an 18 percent premium for new or refurbished buildings over second-hand buildings. Contrary to expectations, transportation networks, including airports and the National Rail System, indicate that distances to airports and train stations increase rental premiums. However, these estimates are

economically very small. Most important, the certification dummy is positive and significant, and shows a 17 percent premium over non-certified buildings.

In column (2), we use the BREEAM ratings as a proxy for "greenness". The BREEAM Ratings for the rental sample range from Pass to Excellent. Each BREEAM Rated building shows a positive and significant premium with Excellent buildings showing the highest increase at a 22 percent premium.

In columns (3) and (4), the specifications control for neighborhood effects using GIS cluster techniques, and controls for the rental transactions within a 500-meter radius of a "green" transaction. The overall fit of this specification increases to over 60 percent. The certification premium decreases to 16 percent, and the BREEAM ratings for Excellent and Very Good increase to 26 and 19 percent, respectively.

In columns (5) and (6), the propensity score specification is reported. The fit for this specification is about 55 percent. The hedonic characteristics behave similar to the first specification, but are slightly less in magnitude. The neighborhood controls also respond similarly, however, their overall magnitude shrinks. The certification premium increases to 20 percent and the BREEAM Rating for an Excellent building increases to 27 percent.

7. Conclusion

This paper presents the first evidence on the financial implications of environmental certification in commercial real estate markets outside of the U.S. Our study relates sales and rental transactions of BREEAM-rated buildings and control buildings within the U.K., to building hedonic characteristics and neighborhood effects. To resolve the issues regarding differences in buildings quality and location quality between certified and non-certified buildings

(as pointed out in previous studies), we utilize two other sources to acquire substantially more hedonic characteristics. In addition, we control for neighborhood effects in two ways. First, by following the traditional real estate methodology, specifically controlling for those buildings within London, the Central Business District, and transportation networks. Secondly, we use GIS techniques to control for sales and rental transactions in the direct neighborhood of the "green" transaction. Last, we estimated the valuation effect of the certification premium by incorporating propensity score weights, based on the hedonic characteristics of certified and control buildings, putting more weight on those transactions with similar characteristics.

Results indicate that different neighborhood controls have impacts on the transaction and rental premium for BREEAM-certified office space. The traditional control for neighborhood effects suggests that the premium for certified buildings as compared to non-certified buildings is about 9 percent. When using GIS techniques, this premium decreases to 1.7 percent, without any significance. The decrease in the size of the "green" premium most likely represents the significant loss of observations and the absence of sufficient hedonic controls.

Neighborhood controls also have varying impacts on the certification premiums for rental transactions in the U.K. Incorporating traditional neighborhood controls indicates a substantial premium for certified lettings, at about 17 percent. Similar to the sales transaction sample, GIS techniques decrease the premium, to about 16 percent. The clusters seem to incorporate valuation effects of location amenities for which data is normally not available, such as restaurants, entertainment, and business support services. It is likely that incorporating each individual control for neighborhood amenities would not further impact the "green" premium, as the weight of these amenities is already at its highest by using the cluster-specification. Thus, the certified premium from the cluster specification is the most conservative. However, the rental analysis

lacks sufficient hedonic controls at this time and the documented premiums are more likely a guide to future expectations.

Results of the propensity score weighted specifications indicate that certified buildings do not have a statistically significant premium for sales transactions. Ultimately, this result may also be driven by the sample size, and statistical significance may be improved through more observations and increased hedonic information on the buildings. On the other hand, rents do display a "green" premium, even when accounted for the transaction's individual characteristics. Results show that propensity-score-weighted certified rental premiums are 20 percent as compared to non-certified buildings.

Lastly, different levels of BREEAM ratings have an economic impact on the premiums paid for Sales and Rents. Mostly, Excellent rated buildings are valued by investors and tenants. For sales transactions, an Excellent Rated building receives a 20 percent premium compared to non-rated buildings. Rents tell a similar story, an Excellent rated building rents at a 22 to 27 percent premium. Buildings that have achieved the Excellent Rating have superior environmental performance and this rating is very difficult to achieve. These buildings must reduce carbon emissions, introduce zero or low carbon technologies, have a building management guide or green leases and store or reuse recyclable waste.

Economically, these premiums translate into higher selling prices for BREEAM-certified real estate. The control sample indicates that prevailing transaction prices are on average £63.6 million over the 2001 – 2009 period. A certification premium of 8.6 percent indicates that, *ceteris paribus*, a BREEAM-certified building sells for £5.47 million more than a comparable non-certified building in its immediate neighborhood (within 500 meters). This result, although

meant as a guide, clearly indicates the current importance of environmental certification in the U.K. commercial property market.

Certified rents demonstrate a similar valuation effect, the average rent per square meter for the rental sample is £232 and the premium for a certified building is approximately £35 per square meter per year. Translated into annual rental income for the average green rental letting, the effects are also large. The average size of a green rental transaction in the U.K. is about 723 square meters, and the annual rent increment to a certified building at this average size is approximately £193,000 per annum, *ceteris paribus*.

In the future, the database we have created for this study will allow us to further investigate repeat sales for green certified office space in the U.K. Repeat sales analysis will increase the accuracy of estimates on the financial performance of green buildings over time, and decrease the reliance on scarcely available hedonic characteristics. With that said, future studies will also contribute to increased understanding of the hedonic characteristics of U.K. commercial real estate through hand collected hedonic features in the field. For now, the results in this paper provide a first indication on the positive financial implications of BREEAM certification for commercial office space in the U.K.

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Figure 1 – Geography of Green Buildings in the UK

Sample of BRE properties in the United Kingdom

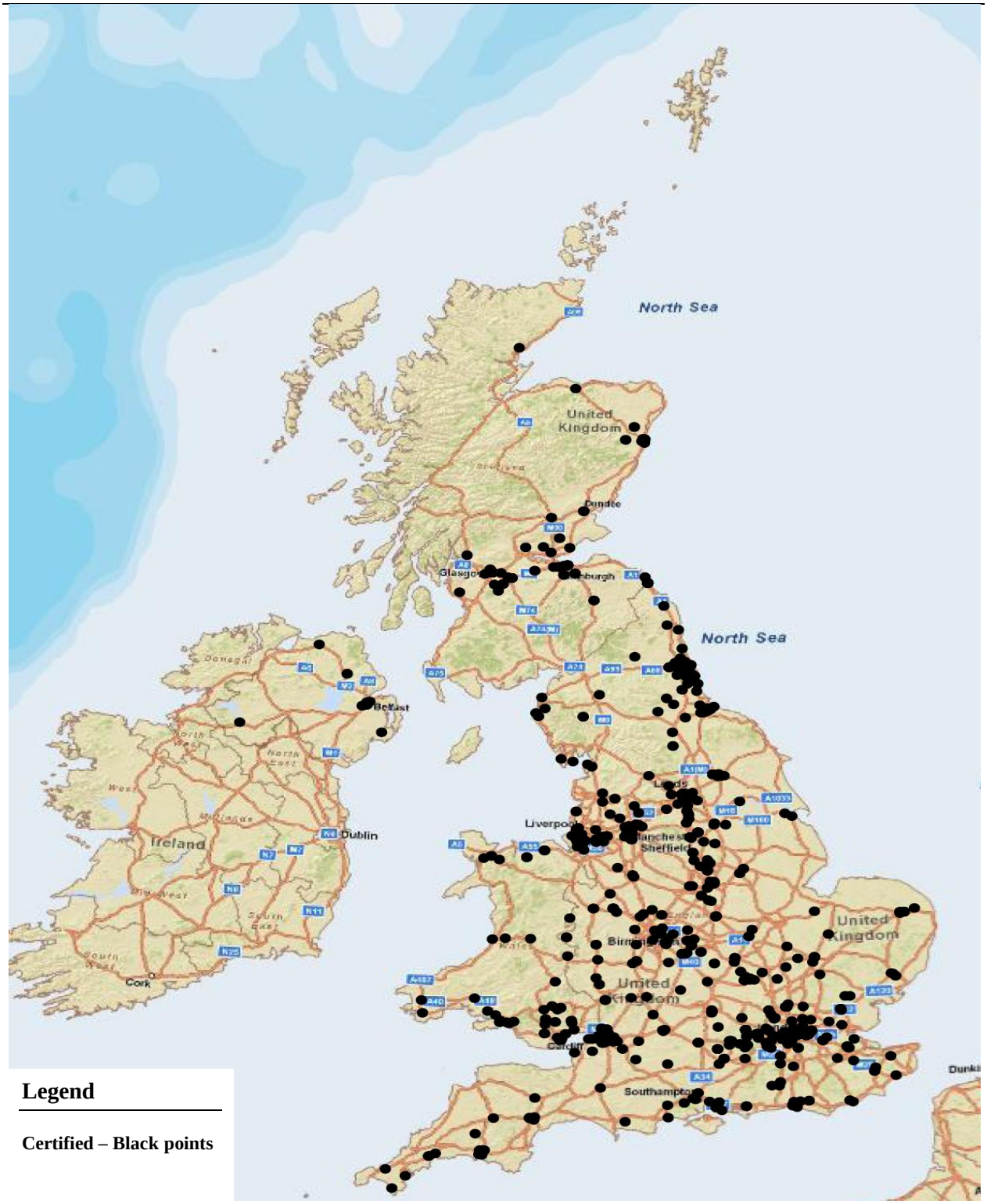


Figure 2 – Geography of the Sales Sample

Map of United Kingdom **Map of London**

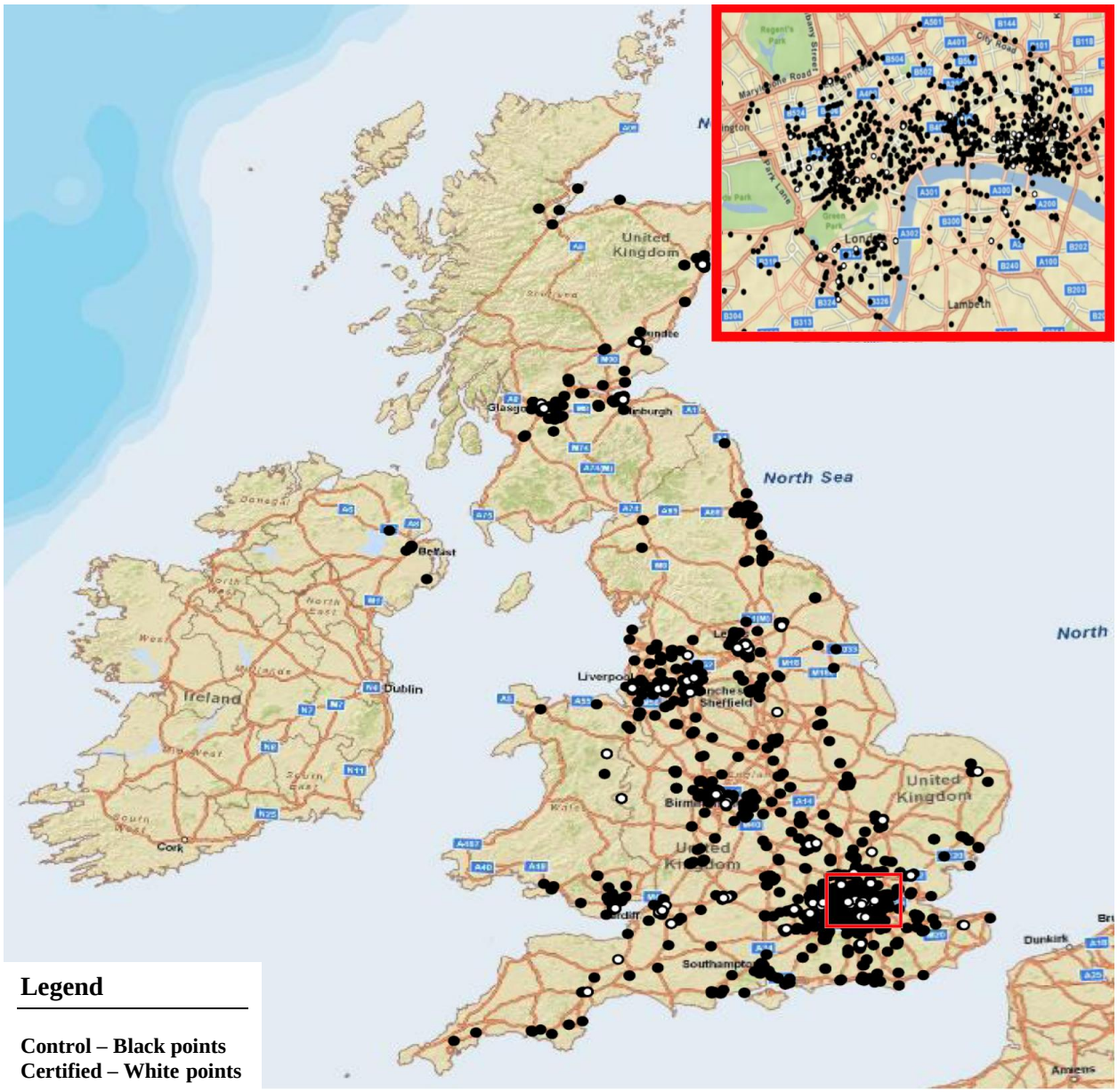
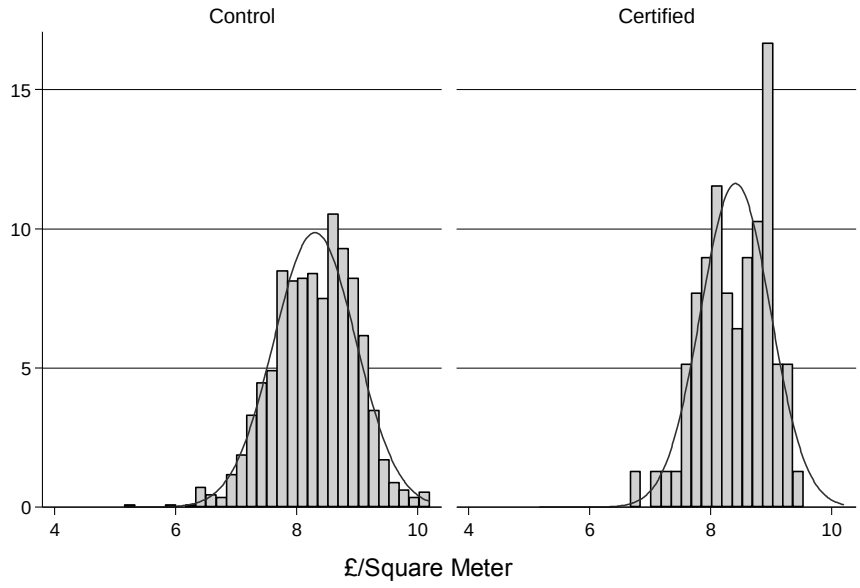


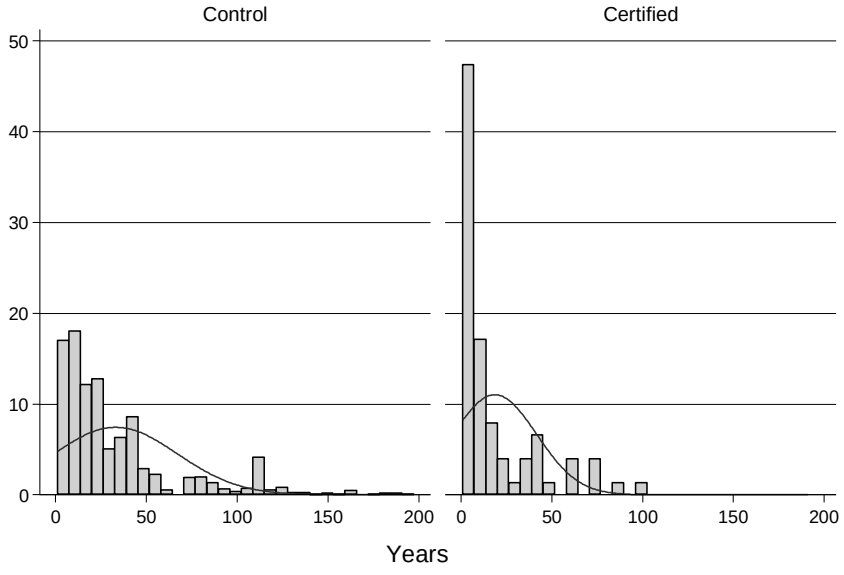
Figure 3 - Age, Sales Price and Size

Sales Sample: Certified Buildings and Control Sample

A. Sales Price Per Square Meter



B. Age



C. Size

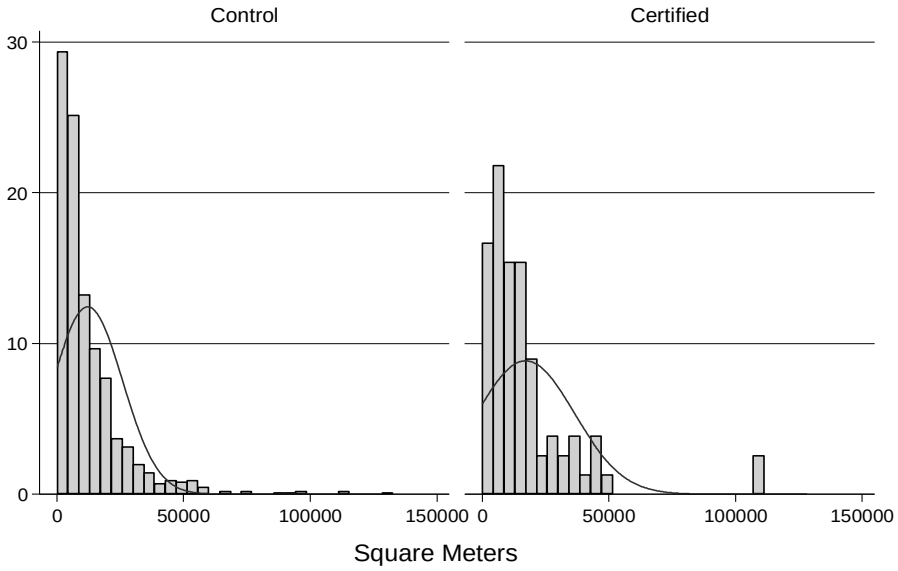

Control
Certified
30
20
10
0
0
50000
100000
150000
0
50000
100000
150000
Square Meters

Figure 4 – Geography of the Rental Sample

Map of United Kingdom

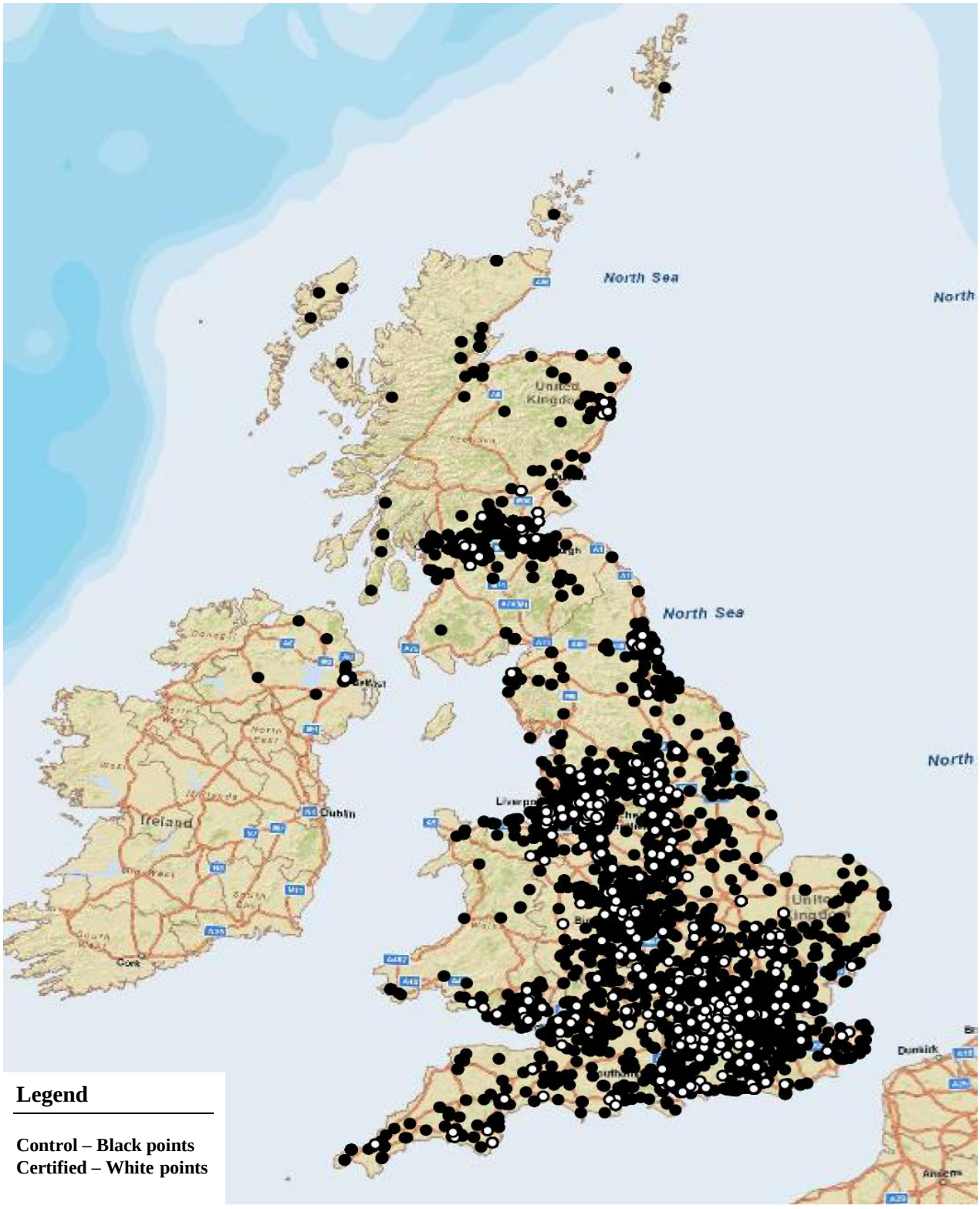
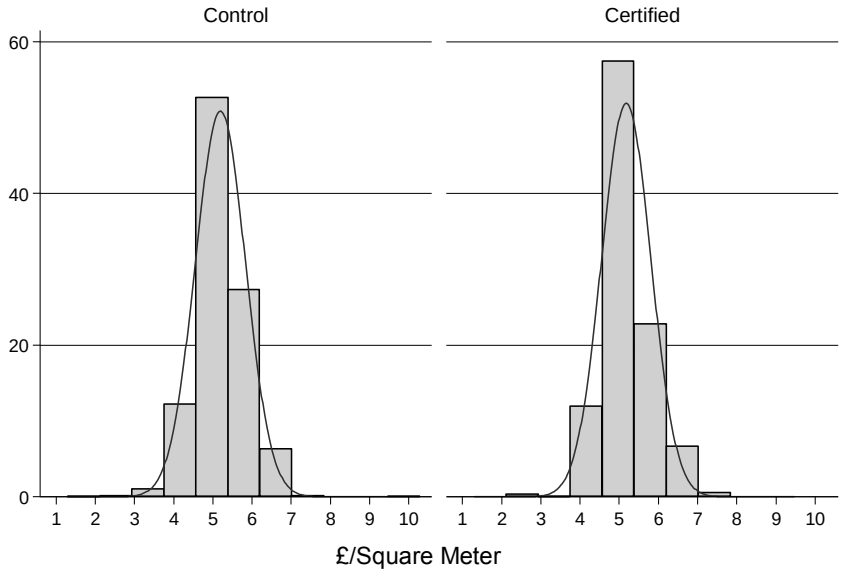


Figure 5 – Rents Per Square Meter and Size

Rental Sample: Certified Buildings and Control Sample

A. Rents Per Square Meter



B. Rental Unit Size

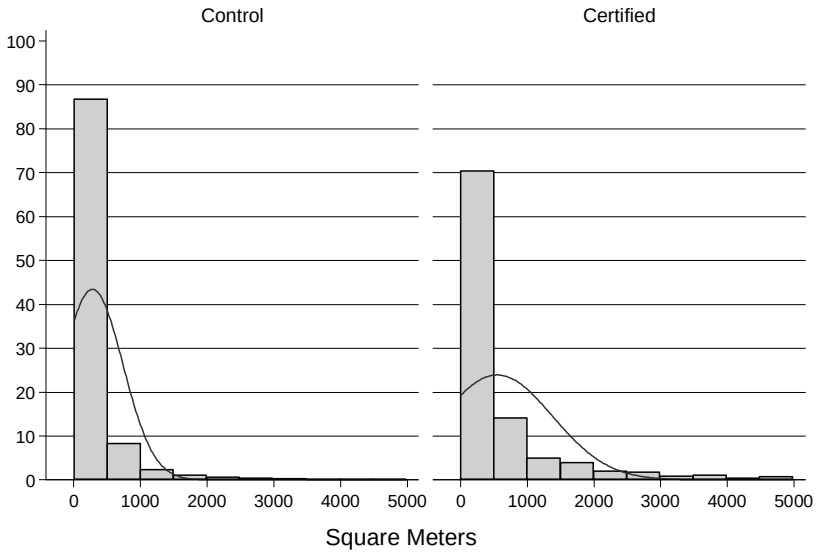


Table 1 – BREEAM 2008 Rating Benchmarks

BREEAM Ratings by Percentage Score

BREEAM Rating	% Score
Unclassified	<30
Pass	≥30
Good	≥45
Very Good	≥55
Excellent	≥70
Outstanding	≥85

(BREEAM 2008 Assessor Manual, 2009, pp. 29)

Table 2 – Panel A- Comparison of Certified Buildings and Control Sample

Sales Sample
(standard deviations in parentheses)

	Sales Data	
Sample Size	**Certified Sample**	**Control Sample**
	78	1,141
Sales Price	102,000,000	63,617,006
(GBP)	(163,000,000)	(94,116,742)
Sales Price	5,214	5,028
(GBP/sq. meter)	(2,690)	(3,493)
Building Size	17.16	12.53
(sq. meters)	(19.25)	(15.46)
Stories	10.32	8.11
(number)	(0.31)	(0.37)
Age	27.97	40.58
(Years)	(63.16)	(55.10)
Renovated Building	0.18	0.16
(1=Yes)	(0.39)	(0.36)
London	0.01	0.01
(1=Yes)	(0.11)	(0.10)
Central Business District	0.81	0.76
(1=Yes)	(0.40)	(0.43)
Number of Airports*	7.05	6.83
	(2.14)	(2.42)
Distance to Nearest Airport	11,700	11,800
(meters)	(4,993)	(5,361)
Number of Trains**	1.99	1.78
	(1.81)	(1.71)
Distance to Nearest Train	630	621
(meters)	(307)	(318)

** Number of airports within 50 kilometers of the building*
*** Number of train stations within 1 kilometer of the building*

Table 2 – Panel B - Comparison of Certified Buildings and Control Sample

Sales Sample
(standard deviations in parentheses)

	Sales Data	
Sample Size	**Certified Sample**	**Control Sample**
	78	1,141
Year of Sale		
2001	0.05	0.09
	(0.22)	(0.29)
2002	0.06	0.05
	(0.25)	(0.23)
2003	0.04	0.07
	(0.19)	(0.25)
2004	0.10	0.11
	(0.31)	(0.31)
2005	0.08	0.12
	(0.27)	(0.32)
2006	0.24	0.14
	(0.43)	(0.35)
2007	0.14	0.18
	(0.35)	(0.39)
2008	0.17	0.12
	(0.38)	(0.33)
2009	0.12	0.11
	(0.32)	(0.31)

Table 3 - Comparison of Certified Buildings and Control Sample

Rental Sample
(standard deviations in parentheses)

	Rental Data	
	Certified Sample	**Control Sample**
Sample Size	1,016	25,098
Achieved Rent	245,000	80,979
(GBP)	(944,000)	(280,256)
Achieved Rent	220	232
(GBP/sq. meter)	(173)	(927)
Letting Size	723	312
(Sq. meter)	(1,864)	(758)
New or Refurbished	0.42	0.36
(percent)	(0.49)	(0.48)
Second Hand	0.58	0.64
(percent)	(0.49)	(0.48)
Amenities	0.04	0.06
(percent)	(0.19)	(0.23)
Distance to Nearest Airport	14,100	14,896
(meters)	(10,400)	(9,298)
Number of Airports*	5	6
	(3)	(3)
Distance to Nearest Train Stations	613	769
(meters)	(305)	(280)
Number of Train Stations**	0.68	0.93
	(1.01)	(1.18)
Year Letting Contract Signed		
2005	0.15	0.15
	(0.36)	(0.36)
2006	0.16	0.20
	(0.37)	(0.40)
2007	0.14	0.17
	(0.35)	(0.38)
2008	0.32	0.28
	(0.47)	(0.45)
2009	0.22	0.19
	(0.41)	(0.39)
2010	0.01	0.01
	(0.10)	(0.10)

** Number of airports within 50 kilometers of the building*

*** Number of train stations within 1 kilometer of the building*

Table 4

Regression Results – Office Sales Prices and Certified Buildings 2000-2010
(dependent variable: logarithm of sales price per square meter)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Certified	0.087*		0.016		0.040	
	[0.046]		[0.054]		[0.061]	
BREEAM Rating:						
Excellent		0.20**		0.0054		0.21
		[0.095]		[0.14]		[0.14]
Very Good		0.063		0.020		-0.012
		[0.055]		[0.055]		[0.065]
Good		-0.039		-0.0083		-0.14
		[0.16]		[0.11]		[0.19]
Size	-0.019	-0.019	0.044	0.044	-0.032	-0.032
(Log)	[0.021]	[0.021]	[0.029]	[0.029]	[0.028]	[0.028]
Story	-0.0083***	-0.0085***	-0.0094**	-0.0094**	-0.0069*	-0.0075**
	[0.0031]	[0.0031]	[0.0043]	[0.0044]	[0.0038]	[0.0037]
Age	-0.0013***	-0.0012***	-0.0017***	-0.0017***	-0.0030***	-0.0030***
	[0.00030]	[0.00030]	[0.00036]	[0.00036]	[0.00048]	[0.00048]
Renovated	0.15***	0.16***	0.084	0.084	0.16***	0.17***
	[0.040]	[0.040]	[0.053]	[0.053]	[0.044]	[0.044]
London	0.21***	0.21***			0.20***	0.21***
	[0.066]	[0.067]			[0.072]	[0.072]
Central Business District	0.26***	0.26***			0.27***	0.27***
	[0.054]	[0.054]			[0.062]	[0.062]
London*CBD	0.56***	0.56***			0.56***	0.56***
	[0.071]	[0.071]			[0.078]	[0.078]
Year 2002	0.14**	0.15**	0.22**	0.22**	0.17**	0.17**
	[0.070]	[0.070]	[0.088]	[0.088]	[0.078]	[0.081]
Year 2003	-0.042	-0.041	0.15*	0.15*	-0.0010	0.00015
	[0.073]	[0.072]	[0.086]	[0.086]	[0.076]	[0.075]
Year 2004	0.12*	0.12**	0.11	0.11	0.17**	0.18***
	[0.061]	[0.061]	[0.083]	[0.083]	[0.067]	[0.067]
Year 2005	0.20***	0.20***	0.27***	0.27***	0.22***	0.22***
	[0.066]	[0.066]	[0.082]	[0.082]	[0.073]	[0.073]
Year 2006	0.38***	0.38***	0.40***	0.40***	0.40***	0.40***
	[0.061]	[0.061]	[0.072]	[0.072]	[0.066]	[0.066]
Year 2007	0.36***	0.36***	0.48***	0.48***	0.37***	0.37***
	[0.060]	[0.060]	[0.075]	[0.076]	[0.066]	[0.066]
Year 2008	0.18**	0.18**	0.40***	0.40***	0.23***	0.23***
	[0.070]	[0.070]	[0.081]	[0.081]	[0.071]	[0.070]
Year 2009	0.12*	0.12*	0.16**	0.16**	0.12*	0.12*
	[0.062]	[0.063]	[0.079]	[0.079]	[0.068]	[0.068]
Distance to Train	0.00012*	0.00012*			0.00010	0.00011

	[0.000064]	[0.000064]			[0.000067]	[0.000067]
Number of Trains	-0.011	-0.010			-0.0042	-0.0028
	[0.014]	[0.014]			[0.014]	[0.013]
Distance to Airport	2.25e-06	2.29e-06			2.77e-06	3.01e-06
	[3.22e-06]	[3.24e-06]			[3.51e-06]	[3.53e-06]
	0.015*	0.015*			0.018*	0.018*
Number of Airports	[0.0088]	[0.0088]			[0.010]	[0.010]
Constant	7.41***	7.41***	7.82***	6.89***	7.42***	7.41***
	[0.11]	[0.11]	[0.100]	[0.17]	[0.11]	[0.11]
Observations	1,198	1,198	656	656	1,198	1,198
R-squared	0.449	0.449	0.602	0.602	0.452	0.454
Adj R2	0.44	0.44	0.54	0.53	0.44	0.44

*Notes: Regressions 3 and 4 include 77 dummy variables, one for each location cluster. The dummy variables are jointly significant at the 0.01 level. Standard errors are in brackets. Significance at the 0.10, 0.05 and 0.01 levels is indicated by *, ** and ***, respectively.*

Table 5

Regression Results – Office Rental Prices and Certified Buildings 2000-2010 (dependent variable: logarithm of rent per square meter)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Certified	0.17***		0.16***		0.20***	
	[0.019]		[0.027]		[0.021]	
BREEAM Rating:						
Excellent		0.22***		0.26***		0.27***
		[0.035]		[0.060]		[0.036]
Very Good		0.18***		0.19***		0.19***
		[0.024]		[0.034]		[0.027]
Good		0.079**		-0.069		0.11***
		[0.038]		[0.065]		[0.039]
Pass		0.17**		0.072		0.18***
		[0.079]		[0.052]		[0.056]
Letting Size	-0.052***	-0.052***	0.064***	0.064***	-0.032***	-0.032***
(log)	[0.0049]	[0.0049]	[0.0060]	[0.0060]	[0.0065]	[0.0065]
Amenities	0.12***	0.12***	-0.012	-0.010	0.10***	0.10***
	[0.015]	[0.015]	[0.015]	[0.015]	[0.015]	[0.016]
New or Refurbished	0.18***	0.18***	0.14***	0.14***	0.19***	0.19***
	[0.0085]	[0.0085]	[0.011]	[0.011]	[0.010]	[0.010]
Year 2005	0.0014	0.00083	-0.048***	-0.048***	0.020	0.020
	[0.012]	[0.012]	[0.017]	[0.017]	[0.013]	[0.013]
Year 2006	0.048***	0.047***	0.022	0.022	0.060***	0.059***
	[0.011]	[0.011]	[0.015]	[0.015]	[0.012]	[0.012]
Year 2007	0.12***	0.12***	0.17***	0.17***	0.12***	0.12***
	[0.016]	[0.016]	[0.021]	[0.021]	[0.020]	[0.020]
Year 2008	0.12***	0.12***	0.23***	0.23***	0.13***	0.13***
	[0.011]	[0.011]	[0.016]	[0.016]	[0.012]	[0.012]
Distance to Nearest Airport	9.63e-06***	9.60e-06***			7.52e-06***	7.53e-06***
	[1.11e-06]	[1.11e-06]			[9.57e-07]	[9.50e-07]
Number of Airports	-0.027***	-0.027***			-0.024***	-0.024***
	[0.0049]	[0.0049]			[0.0045]	[0.0045]
Distance to Nearest Train Station	0.00014***	0.00014***			0.00013***	0.00014***
	[0.000028]	[0.000028]			[0.000039]	[0.000039]
Number of Train Stations	-0.0052	-0.0044			-0.0012	-0.00014
	[0.0057]	[0.0057]			[0.0070]	[0.0070]
Constant	4.11***	2.59***	4.56***	3.33***	3.77***	3.76***
	[0.078]	[0.079]	[0.042]	[0.070]	[0.050]	[0.050]

Observations	17,314	17,314	5,511	5,511	17,314	17,314
R-squared	0.544	0.545	0.604	0.605	0.558	0.558
Adj R2	0.51	0.51	0.59	0.59	0.53	0.53

*Notes:Regressions 1, 2, 5, and 6 contain 311 city dummies, which are jointly significant at the 0.01 level. Regressions 3 and 4 includes 161 dummy variables, one for each location cluster. The dummy variables are jointly significant at the 0.01 level. Standard errors are in brackets. Significance at the 0.10, 0.05 and 0.01 levels is indicated by *, ** and ***, respectively.*

Appendix A

BREEAM Process

1. Process of Certification

The general process of BREEAM certification is lengthy and can take on average XX months. The certification begins with an assessment by a BREEAM certified assessor. 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 on the eight BREEAM dimensions, i.e., 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 below breaks down the minimum standard for BREEAM ratings by BREEAM issue. It shows that 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 documentation and evidence to support their claim. For example, for the Management 4 credit to be received either a Building User Guide must be shown with proof of documentation. After each issues has been assessed, all claims and supporting documentation are compiled into a report.

At BREEAM headquarters, the reports are read and go through an evaluation process. 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).

Table 1 – BREEAM Rating Standards

Minimum BREEAM Standards

	BREEAM Rating/ Minimum Number of Credits				
BREEAM Issue	**Pass**	**Good**	**Very Good**	**Excellent**	**Outstanding**
Man 1 - Commissioning	1	1	1	1	2
Man 2 - Considerate Constructors				1	2
Man 4 - Building User Guide				1	1
Man 9 - Publication of building information					1
Man 10 - Development as a learning resource					1
Hea 4 - High Frequency lighting	1	1	1	1	1
Hea 12- Microbial contamination	1	1	1	1	1
Ene 1 - Reduction of CO2 emissions				6	10
Ene 2 - Sub-metering of substantial energy uses			1	1	1
Ene 5 - Low or zero carbon energy uses				1	1
Wat 1 - Water Consumption		1	1	1	2
Wat 2 - Water meter		1	1	1	1
Wat 3 - Storage of Recyclable Waste				1	1
LE 4- Mitigating ecological impact			1	1	1

Source: (BREEAM, 2009, pp. 31)