Sustainable Value Drivers

Research on the added value of environmental certification in the Dutch office market

By

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Preface

Before you lies the thesis "Sustainable Value Drivers: A Research on the Added Value of Environmental Certification in Commercial Real Estate Pricing". This dissertation ends the final part of my Master's degree Management in the Built Environment at the Faculty of Architecture, Urbanism and Building Sciences of the Delft University of Technology.

My motivation for this research evolved from my interest in financial and strategic issues. Additionally, economic mechanisms and theories sparked my interest from High School. In my opinion the Bachelor and Master of the Faculty of Architecture and Building Sciences slightly neglected quantitative research skills. My thesis gave me the opportunity to dive deep in such a quantitative question with a strategic character. The wish for quantitative research skills in combination with my drive for a future-proof built environment made me choose this topic. During the process I developed my data analysis skills which enables me to approach future assignments from multiple views. Also, I got more familiar with the fundamentals of real estate markets and gained more economic and commercial knowledge in the field of real estate.

I would like to express my gratitude to my supervisors. First, I would like to thank my main supervisor. Farley Ishaak for his week-to-week guidance and challenging feedback during the entire process. I would also like to thank Ellen Geurts for continuously sharing her knowledge and expertise. I would like to thank CBRE Nederland and especially Wybrand Gorter and Frank Verwoerd for providing me the opportunity to do this research. Without their contribution this thesis would not be possible. Finally, I want to thank my brother Dirk for his insights and being a helpful sparring partner during the year.

Enjoy the reading and in case you want more information feel free to contact me.

Sincerely,

Rens van Overbeek

Rotterdam
January, 2023

Executive summary

The construction and real estate sector accounts for 38% of the total Dutch CO2 emissions in 2020[1]. The increasing number of benchmarks[2] show the increasing awareness on climate change within the industry. The share of BREEAM-NL certified offices, the leading voluntary building certificate in the Netherlands, increased from 2.63% of the total take-up in 2015 to 32.25% in 2021[3]. Although real estate professionals perceive the added value of green buildings, the added value is neither precisely defined nor researched. Also valuation professionals have difficulties to quantify and appreciate green buildings accordingly[4]. This lacking economic evidence causes real estate developers and investors to be conservative in investing in sustainability and environmental measures. As a result, tenants, owners, and developers pass on the responsibility for the first step towards a sustainable built environment to one another, which is referred as the Vicious Circle of Blame[5].

This study tests the effects of environmental certification on the market value specifically in the Dutch office market. The empirical analysis tests the existence of tangible, economic benefits of certified office buildings in the Dutch real estate sector by examining the effects on rent levels and occupancy rates. Additionally, this study assesses the presence of the Vicious Circle of Blame in the Dutch real estate market.

To test the effect of environmental certification on market value a hedonic price modelling is used. This study will focus on the occupier market of the Dutch office sector and will examine more than 4,300 office lease transactions in the Netherlands provided by global real estate advisor and broker CBRE. Lease transactions are coupled with a set of important hedonic characteristics, controlling for property and locational characteristics. The scope of the analysis are lease transactions between 2015 and mid-2022 with a transaction rent of €30 - €550 per square meter and with a minimum leased floor area of 500 square meters. Semi-structured interviews were conducted to analyse the dynamics within the Dutch office market, and specifically the playing field between investors and occupiers.

A comparable analysis shows clearly that certified offices differ from non-certified offices and contain premium building characteristics. BREEAM-NL certified office buildings are larger, better occupied, newer, and more energy-efficient than non-certified office buildings. Additionally, BREEAM-NL certified office buildings are located at better accessible locations with higher levels of amenities. Regression modelling isolated the effect of BREEAM-NL certification and shows that environmental certification positively influences market value in the Dutch office market. After controlling for important location and building characteristics, the average premium for BREEAM-NL certified offices is 10.30%. As real estate markets are highly heterogeneous, the effect highly differ across cities and submarkets. When assessing the largest Dutch office markets, BREEAM-NL offices hold rental premiums of 12.64% in The Hague, 5.13% in Rotterdam and 6.50% in Utrecht. BREEAM-NL positively influences rent levels in Amsterdam. However, after controlling for office submarkets, this effect reduces and becomes not significantly different than zero. The results show that labour-intensive companies with a large workforce, such as Finance & Business Services, and environmentally harmful industries, such as Energy & Utilities, tend to pay an additional premium for certified office buildings which might be explained by their increased sensitivity to the intangible benefits of green and sustainable office buildings[6].

1; See Dutch Green Building Council (2021), chapter 1 "Het belang van CO2 reductie in de gebouwde omgeving".
2; BREEAM, GRESB, ESG
3; Own research
4; Interview Real Estate investor, October 22, 2022
5; See Royal Institution of Chartered Surveyors (2008), p. 3
6; Increased productivity and satisfaction rates, improved health and well-being, marketing, public image, and Corporate Social Responsibility

The results show that label scores positively influence property's market value. A simple bivariate correlation analysis shows that the rent per square meter is highly positively correlated with BREEAM-NL label score. Regression modelling shows that BREEAM-NL labels Good, Very Good and Excellent generate a rental premium of respectively 10.19%, 6.18% and 14.34%. This shows that better performing buildings generally command higher rent and suggests that tenants do value the tangible benefits of green buildings as environmentally friendly buildings can significantly reduce energy bills and service costs. Over the period of 2020H1 to 2022H2, the results do not show significant occupancy premiums for BREEAM-NL certified offices. However, building owners might foster a certain level of vacancy to hold space vacant to prepare it for future tenants or to wait for better market conditions which are not yet met (e.g., higher rents)[7]. Therefore, this so called frictional vacancy, does not necessarily lead to lower rents or market value. Despite the rental premiums, BREEAM-NL buildings do not yet result in a significant value premiums at the beginning of the project. The economic attractiveness and the investment feasibility of BREEAM-NL Excellent labelled office buildings highly depends on the location of the development.

The Vicious Circle of Blame is still partly present in the Dutch real estate market. Occupiers remain conservative in sustainability measures when it is accompanied with increases in expenditures. Investors are willing to invest in green buildings, however the occupier demand should be accompanied with the willingness to pay the incremental rent. This counterpart perfectly characterizes the current problem in the playing field of the Vicious Circle of Blame. Especially in peripheral areas, the potential rental premium is not able to cover the marginal costs. This lacking willingness to pay for green buildings hampers the economic feasibility of these sustainable investments and causes reluctance in investor's behaviour.

The study is exposed to certain limitations. The results are contingent upon the growth of certified stock, building regulations and other European regulatory developments and it should therefore be noted that the results are a snapshot of the current situation. Although the sample size was large enough to draw proper conclusions, due to the information asymmetry the dataset was far from exhaustive. Most important rent determinants are incorporated in the model, which is represented by the model's explanatory power. However, it is not possible to include all important rent determinants in the regression analysis which remains a limitation of regression modelling in general. The study is based on approximately 6.4 million square meter transacted floor area in the period of 2015 – 2022 and validates the generalisability of the results. However, the heterogeneity of real estate makes that the results should be interpret with caution.

The results provide insights in the behaviour of investors and tenants in the context of green buildings and shows a quantitative rental premium for environmentally certified offices. The results show owners and investors empirical evidence on the willingness to pay for green buildings and can contribute to the integration of sustainability measures in the valuation profession. The interviews suggest that owners and tenants are still mainly driven by European regulation and/or commercial interest. Intrinsic motivation plays only a minor role. These findings show regulators that sustainable regulations are an important and effective policy tool to break the Vicious Circle of Blame and reach climate goals by 2030.

7; See McDonald & McMillen (2011), chapter 12 "Real Estate Markets"

Abstract:

A considerable share of the global greenhouse gases is caused by the construction and real estate sector, but the increasing awareness on global climate change within the industry caused the emergence of multiple voluntary environmental certifications. The effects of environmental certification on office rents have received considerable attention in the last decade and there is now much evidence supporting the hypothesis that environmentally certified office buildings achieve higher rents over non-certified office buildings. Although much attention has been paid to the United States office market, less attention was spent on the European and specifically the Dutch real estate market. The aim of this thesis is to examine the relationship between environmental certification and market value within the Dutch office market and therefore answers the following question: How does environmental certification influence market value within the dynamics of the Dutch office market? Empirical evidence shows that BREEAM-NL certified office buildings hold an average rental premium of 10.30% over non-certified offices. Furthermore, the rental premium in the G5 varies between 5.13% and 12.64%. The results indicate that the rental premium is positively correlated with the label score and show rental premiums of 10.19%, 6.18% and 14.34% for respectively BREEAM-NL Good, Very Good and Excellent. The results do not show significant occupancy premiums for BREEAM-NL certified offices. This practical evidence on the willingness to pay from the Dutch occupier market intends to bring clarification in the public debate and helps owners and investors in their decision-making around environmentally certified investments in their building assets.

Keywords: green premium, rent premium, green buildings, real estate economics, BREEAM, hedonic price model, vicious circle of blame, office market rents, empirical analysis

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Abbreviations:

BAG:	Basisregistratie Adressen en Gebouwen (National Register of Addresses and Buildings)
BRE:	Building Research Establishment
BREEAM:	Building Research Establishment Environmental Assessment Method
CBD:	Central Business District
COP27:	Conference of the Parties to the United Nations Framework Convention on Climate change
CSR:	Corporate Social Responsibility
CSRD:	Corporate Sustainability Reporting Directive
DGBC:	Dutch Green Building Council
EPBD:	Energy Performance of Buildings Directive
EPC:	United Nations Climate Change Conference or Conference of the Parties of the UNFCCC
ESG:	Environmental, Social & Governance
GIS:	Geographic Information System
GRESB:	Global Real Estate Sustainability Benchmark
HPM:	Hedonic Price Model
IPCC:	Intergovernmental Panel on Climate Change
LEED:	Leadership in Energy and Environmental Design
MKB:	Midden- en Klein Bedrijf (Small- and Medium-Sized Enterprises)
NFRD:	Non-Financial Reporting Directive
NS:	Nationale Spoorwegen (Dutch Railways)
OCC:	Opportunity Cost of Capital
OLS:	Ordinary Least Squares
RICS:	Royal Institution of Chartered Surveyors
SDG:	Sustainable Development Goals
SPE:	Single Purpose Entity
USGBC:	United States Green Building Council
WorldGBC:	World Green Building Council
WTP:	Willingness To Pay

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1. Introduction

COP27, GRESB, BREEAM, SDG, ESG, CSRD, NFRD, SFDR, EPC. Only a glimpse of the many acronyms to report on sustainability aspects in the financial and real estate sector. The increasing number of benchmarks show that professionals, owners, investors, and occupiers, are increasingly aware of the rapid climate change happening right now. However, the wide range of acronyms and increasing number of benchmarks only partially led to more sustainable financing (United Nations Environmental Programme, 2022; Van Der Pol & Woutersen, 2022).

The Intergovernmental Panel on Climate Change presented a scenario in which earth's temperature is due to rise 1.5 degrees Celsius by 2050 (IPCC, 2021). This scenario meant that society only has a CO2 budget of 330 Gigaton left. Based on population, this would mean that there is only 946 Megaton CO2 left for the Netherlands. Right now, this budget corresponds to 5 times the current annual emissions of the Netherlands (DGBC, 2021). The built environment is responsible for 13% of the total CO2 emission in the Netherlands in 2020 and only includes the heating of the built environment by natural gas (CBS, n.d.). The Dutch Green Building Council states that the built environment, including the construction sector, accounts for 38% of the total Dutch CO2 emissions (DGBC, 2021). Therefore, the built environment plays a pivotal role in the transition to a sustainable future.

The rising gas prices and energy crises in 2022 led residents to be more aware of their energy consumption. The commercial real estate market also shifted from the traditional approach to a growing demand for green and healthy offices, driven by the emergence of multiple voluntary building certificates (CBRE, 2021b). These developments positively contributed to the public debate and fostered the political- and societal awareness of the rapid climate change.

1.1. Problem statement

Among professionals in the built environment, there is a common perception that sustainable buildings generate added value. However, the added value is neither precisely defined nor researched. Although investors and developers are experiencing an increasing urge to invest in sustainability, there is simultaneously the perception that sustainability is very difficult and costly to reach. Real estate developers and investors are conservative in investing in sustainability and environmental measures due to this lack of evidence in their economic feasibility (Eichholtz et al., 2010).

The phenomenon explaining the conservative behaviour towards a sustainable built environment, whereby every actor involved passes the responsibility for the first step onto someone else, is called "The Vicious Circle of Blame" (see figure 1) (Royal Institution of Chartered Surveyors, 2008).

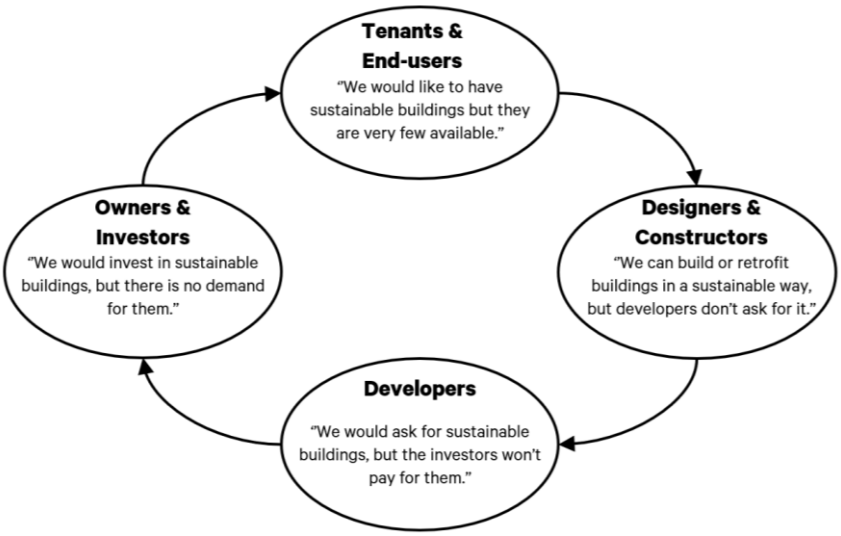

Figure 1: The Vicious Circle of Blame (adapted from RICS, 2008)

The Royal Institution of Chartered Surveyors (RICS) researched the drivers of this phenomenon during their conference in 2008. The inability to properly appraise and value the building's sustainability performance was seen as one of the main drivers of the Vicious Circle of Blame (Royal Institution of Chartered Surveyors, 2008). Although the literature on the economic benefits of green buildings increased enormously in the last decade, the formal integration of sustainability features into property valuations is still missing. According to a real estate investor, the benefits of green buildings are still difficult to quantify and even valuation professionals are not able to appreciate green buildings accordingly (Investor B, personal communication, October 22, 2022). Although valuation professions are more aware of the key role of environmental performance, the official appreciation of environmental performance in the valuation profession is rather limited to energy performance. (Valuation professional, personal communication, July 18, 2022).

To conclude, valuation professionals and organisations have a critical role to play in the transition towards an environmentally friendly built environment. Market actors will only respond positively to the transition, and change their perception in the Vicious Circle of Blame, when the valuation professionals recognise the (economic) benefits of sustainable- and green buildings and demonstrate this in their advice and valuations given to the market (RICS, 2008). The general conception that environmentally friendly buildings are very costly is not only false, but it also neglects the major benefits for occupiers, owners, and investors during the entire building life cycle.

1.2. Research aims and questions

Following this problem statement, the aim of this thesis was to examine the effects of environmental certification on the market value specifically in the Dutch office market. The empirical analysis will bring clarity in the existence of tangible, economic benefits of certified office buildings in the Dutch office market. BREEAM-NL will be considered as main environmental certification and the market value is assessed by examining the effects on rent levels and occupancy rates. The results show practical evidence of the willingness to pay for green buildings in the occupier market and thereby examines the economic feasibility of sustainable buildings. This evidence tries to turn the Vicious Circle of Blame into a positive feedback loop as depicted in figure 2. The research question that follows is:

How does environmental certification influence market value within the dynamics of the Dutch office market?

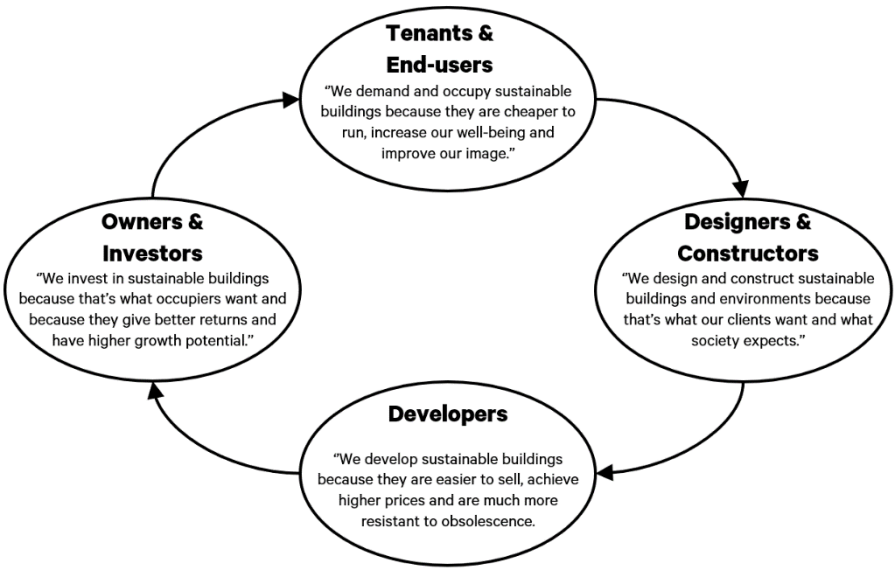

Figure 2: Positive feedback loop (adapted from RICS, 2008)

To examine the relationship between environmental certification and market value in the Dutch office market, the following sub-questions are formed:

1. What phenomena are driving real estate markets?
2. What are sustainable value drivers in the real estate market?
3. What building characteristics are determinants for real estate market value?
4. What drives the Vicious Circle of Blame in the Dutch real estate market?
5. How does BREEAM-NL certification influence market rent prices and occupancy rates in the Dutch office market?

Research question 1 analyses real estate market dynamics and lays the foundation for the theoretical framework. Research question 2 assesses different environmental certifications, including the benefits and drawbacks of the most common environmental certifications in the Netherlands. Research question 3 assesses the most important office rent determinants to include in the analysis later in this study. Research question 4 analyses the dynamics between the Dutch investors and tenants in relation to sustainable regulation, green buildings and environmental certification. Research question 5 tests the existence of green premiums in the Dutch real estate market and corresponds to the quantitative analysis itself.

1.3. Relevance

Societal relevance

National Governments are closely cooperating with the European Committee with the aim to reduce the greenhouse emissions and carbon footprint caused by the built environment (Rijksoverheid, n.d.). As a result, laws and regulations regarding the sustainability performance of buildings have been tightened over the last decades.

In 2018, the European Committee revised the Energy Performance of Building Directive (EPBD) to stimulate the building stock to be carbon neutral by 2050. The latest revision is focused on improvements in efficiency for the technical building systems (European Committee, n.d.-b.). In 2020, the Dutch government legislated the revised European Energy Performance of Building Directive (EPBD III) in the national Building Code (Rijksdienst voor Ondernemend Nederland, 2022b). The revised EPBD III also aims to provide a secure environment for individuals and businesses to make proper investment decisions (European Committee, n.d.-b.). In April 2021, the EU commission proposed to revise the Non-Financial Reporting Directive for a new Corporate Sustainability Reporting Directive (CSRD). The former laid down rules for large companies to publicly report information on environmental-, social – and diversity matters (European Committee, n.d.-a.). The new CSRD extends the scope of the Non-Financial Reporting Directive by obliging all large organisations in the EU to report detailed information on environmental- and social matters. The EU introduced sustainability reporting standards and obliged companies to audit their publications (European Committee, n.d.-a.). This revision aims to stimulate sustainable activities and investment across Europe (European Committee, n.d.-c.). Insights in the behaviour of tenants and investors in the Dutch office market can help to forge effective policy instruments. Additionally, their positioning towards environmental certification and recent regulations can help regulators to understand the complex dynamics within Dutch real estate markets.

From 2023, every office building in the Netherlands requires a minimum energy label C, which is a reinforcement of the former energy label directive from 2015 (Bouwbesluit 2012). Office buildings which do not comply with this standard are not allowed to operate anymore from the 1st of January 2023 (Rijksdienst voor Ondernemend Nederland, 2022a). This new regulation also forces investors and developers to set sustainability higher on the agenda. The Dutch coalition accord for 2022 presented the ambition to be the European frontrunner in combating climate change. The Dutch government aims to reduce their CO2 emissions by 60% in 2030, which is higher than the European goal of 55% in 2030 (VVD, D66, CDA & ChristenUnie, 2021). To put the national ambition in a broader context, the ambition is higher than Spain and

France, which aim to reduce respectively 23% and 49% of the total greenhouse gasses by 2030. However, the ambition is less than Germany and Sweden, which aim to reduce respectively 65% and 63% of the Greenhouse gasses by 2030 (CBRE, 2022). A study of Netherlands Environmental Assessment Agency (2020) showed that with the current policy the Netherlands will reach a reduction of only 34% in 2030. The study argued that the 2030 ambition is only realistic when most of the building owners invest in one or more cost-efficient sustainability measures (Netherlands Environmental Assessment Agency, 2020). Empirical evidence on the economic feasibility of sustainable investments and benchmarks can persuade these owners to invest.

BREEAM is an all-encompassing environmental assessment method, focused on sustainability performance throughout the entire life cycle (planning, design, construction, operation). BREEAM-certified buildings are generally more environmentally friendly, protect and preserve natural resources and increases the well-being of the users (BREEAM, n.d.). BREEAM-NL criteria, the official Dutch version of global BREEAM directive, are exceeding the statutory minimums, the decision of building owners to assess their assets on BREEAM-NL is therefore always voluntarily (DGBC, n.d.-a.). BREEAM provides a practical framework for sustainable developments, and, similarly to the revised EPBD III, help investors to make proper investment decisions. However, to reinforce these claims, investors first need to have practical evidence from the market, proving the increased returns and market value. Only then, owners and investors will pro-actively commit to a future proof and environmental-friendly built environment as depicted in figure 2.

Academic relevance

In the academic field, the body of knowledge on green building economics is rapidly growing. The effects of environmental certification in the United States office market have been extensively studied (Fuerst & McAllister, 2009; Eichholtz, Kok & Quigley, 2010; Fuerst & McAllister 2011a; Fuerst & McAllister, 2011b; Eichholtz, Kok & Quigley, 2013; Reichardt, 2014; Holtermans & Kok, 2017). However, less attention has been paid to European markets, including the Dutch office market. The U.S. office market was able to be researched more extensively due to the world's largest commercial real estate database CoStar. As a result, research conducted on price premiums related to green certifications mainly focused on LEED and Energy Star certifications as the leading building certificates in the United States. BREEAM-NL is currently the leading building certificate in the Dutch real estate markets for industrial, office, retail, educational and hotel properties. However, the relationship between BREEAM-NL and market rents is yet to be researched, creating a huge research gap in the literature on sustainable value drivers in Netherlands. Additionally, research has tended to focus on only a few control variables, mostly limited to size and location, it is not clear whether the published price premiums can be fully accounted to environmental certifications. Hence, additional studies on the effects of environmental certification are needed.

In the Netherlands, Kok & Jennen (2010) studied the influence of energy labels on market rents based on transactions in the period of 2005-2010. Previously published Dutch Master of Science theses also examined the relationship between energy-efficient office buildings and market rents in the Dutch office market (Baas, 2013; Leien, 2014; Van den Broek, 2010; Van Manen, 2019). Last year, CBRE published a Pan-European report on the value of environmental certification (CBRE, 2021a). Fifteen cities in twelve countries, with Amsterdam as one of them, were analysed on a comparison basis to identify possible rent and occupancy premiums. This research will contribute to this body of literature by providing results on rent and occupancy premia based on recent transaction data across the Netherlands. The findings advance the current literature body on green building economics in the Netherlands and zoom in on the largest office markets in the Netherlands. Another contribution is the analysis of the existence of the Vicious Circle of Blame in the Dutch estate sector. The findings give more insight in the behaviour and positions of important players towards green buildings.

1.4. Research scope

This research will focus on the occupier market of the Dutch office sector and will examine office lease transactions in the Netherlands between 2015 and mid-2022. The empirical analysis will assess the market adoption of certified buildings and tests the existence of rent and occupancy premia in the years after 2015. This thesis uses market rent, derived from the market conditions at moment of lease, which can also be defined as transaction rent and excludes any incentives to the landlord as is the case in contract rent. The dataset is constructed of lease transactions of real estate agent CBRE B.V. and complemented with data on BREEAM-NL certifications of the Dutch Green Building Council. Further information on the scope and exclusion criteria for the final sample are covered in the descriptive statistics in chapter 4.

1.5. Dissemination and audiences

The findings are relevant for all actors present in the Vicious Circle of Blame of RICS (2008) depicted in figure 6. The prime actors in the construction and real estate sector are (institutional) investors, developers, valuation professionals and sustainability experts, but the results are also relevant for asset- and portfolio managers and other actors concerned with sustainable investments. The results are relevant for valuation professionals and can contribute to future appraisals of offices, and specifically on sustainability aspects. Possible rent and occupancy premiums and increased market adoption of certified office buildings can affect the economic performance and yields of these assets and are therefore relevant for future valuations.

Additionally, the findings on investors and tenants' behaviour towards environmental certification is highly relevant for regulators, such as national and European governments. Regulation has proven to be an important pull-factor for investors and owners to invest in sustainability. Insights from the Dutch real estate market might contribute to regulatory developments aiming to break the Vicious Circle of Blame.

1.6. Reading guide

Chapter two provides the necessary theoretical underpinnings for this research and presents a theoretical framework of real estate markets, sustainable value drivers and important office rent determinants and therefore answers the first three research questions. Chapter three explains the methodology and is followed by chapter four with the empirical analysis answering research questions four and five. Chapter five covers the conclusion, including limitations and recommendations.

	Chapter	Scope
1	Introduction	Introduction of the topic, including problem statement, research aim and questions, societal and academic relevance.
2	Theoretical underpinnings	Literature study on real estate market fundamentals and drivers, environmental certificates, regulatory developments and rent determinants.
3	Research methodology	Explanation of the hedonic price model, variables and hedonic equations. Justification of methodology and interviewees.
4	Empirical analysis and discussion	Multiple regression analysis on rental and occupancy rate premiums in BREEAM-NL certified offices including explorative interviews with experts.
5	Conclusion	Conclusion and answers on the main research question, limitations and implications of the study and recommendations for future research.

Figure 3: Reading guide (source: author)

2. Theoretical underpinnings

First, real estate markets in general will be positioned in the larger capital market. Then, it will distinguish different types of real estate markets and go more into depth in the fundamentals of commercial real estate markets. The 4-quadrant model of DiPasquale & Wheaton (1992) provides a conceptual framework for the interrelationship of space markets, asset markets, and the construction market and visualises the effect of macro-economic factors on the property market. Secondly, environmental certification will be analysed and the most common systems, BREEAM-NL, LEED and WELL, will be shortly presented. To be able to interpret the results, the tangible and intangible benefits of these environmental certification systems will be analysed. Finally, all important rent determinants will be assessed. To be able to quantify the rental premium, one should control for all other important rent determinants in the space market. It ends with the conceptual framework which links the abovementioned concepts together and will be the basis of this study.

2.1. Real estate markets

Real estate markets are directly related to the (national) economy. The returns in the office market, as significant part of the real estate market, tend to be influenced by the national economy whereby periods of high economic growth increase the returns of investment (Van Gool et al., 2013). Ling & Archer (2017) show the relationship between real estate markets and capital markets, and argue that the value is derived from local user markets, capital markets and property markets as depicted in figure 4. In the capital market, real estate competes with many other investment opportunities for the required funding (Ling & Archer, 2017). The two markets come together in the property market, whereby the required investment returns and rental rates determine property value (Ling & Archer, 2017). Wheaton (1999) showed the interrelationship between the commercial real estate investment volume and the U.S. economy and found positive correlations between economic upcycles and investment volume in multifamily residential and industrial real estate. Van Gool et al. (2013) compared the yearly take-up in the office market with the Dutch economy and showed that a growing economy result in a net increase in yearly take-up. For every type of real estate, there are a few important economic factors which influences the demand for real estate, whereby employment growth is the most important one for the office market (Van Gool et al., 2013).

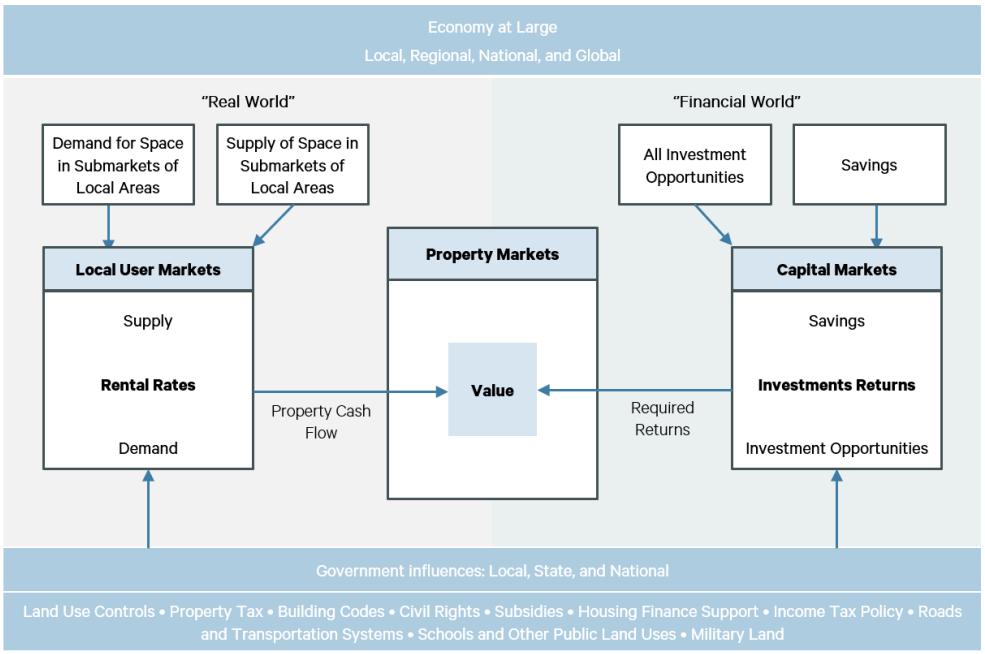

Figure 4: Interrelationship between Real Estate Markets and Capital Markets (adapted from Ling & Archer, 2017)

Real estate markets can be classified into different markets and the literature includes varying definitions. First, commercial real estate can be distinguished from non-commercial real estate. According to Van Gool et al. (2013), the latter include mainly residential real estate, used for housing, but also include public real estate, such as hospitals, schools, prisons, and religious structures. The former includes buildings which are used for commercial purposes, as a production factor. CoreNet (2015) defined commercial real estate as the supply side of real estate markets, with providing real estate as their main business. This differs from corporate real estate whereby real estate is used as a resource to be able to conduct their main business (CoreNet, 2015). Pirounakis (2012) defined commercial real estate as all real estate what intents to generate income, either by lease or sell transactions. Miller (2010, p. 4) used the definition of *"income-producing assets, generating rental or other income and having a potential for capital appreciation"*. This definition emphasizes the clear difference of corporate and commercial real estate, whereby commercial real estate uses brick and mortar as their primary business. This thesis follows the definition of Pirounakis (2012) and Miller (2010) and defines commercial real estate as income-producing assets by either lease or sell transactions.

If we take a closer look at commercial real estate, it can be classified into different functionalities. Miller (2010) categorized commercial real estate in multifamily residential property and nonfarm non-residential property. Van Gool et al. (2013) distinguished the office market, retail market, industrial & logistics market, and residential market. Geltner et al. (2007) also named smaller types of space markets such as the hotel market and healthcare.

Van Gool et al. (2013) defined the office as an independent production factor wherein commercial and administrative activities take place. Falk (2002) continued and argued that offices are primarily for the service industry and De Lange (1989) suggested that offices are mainly focused on deskwork. Rottke & Mutl (2015, p. 42) consolidated these definitions to: *"an office property is defined as the space where desk work prevails regardless of the business affiliation [...] the office must be self-contained and marketable."*. The location of the office is often considered as an important strategic resource for an organisation. As a large share of the population lives in cities, and many amenities are in these cities, most of the larger office clusters can be found in the city centres, which is often referred as the Central Business District (CBD) (Van Gool et al., 2013). The demand for offices, defined as the total number of square meters office in use at that specific moment, is largely dependent on (macro) economic factors such as employment growth, consumer confidence, political influence, inflation rate, and technological developments (Van Gool et al., 2013). This thesis follows the definition Rottke & Mutl (2015) and includes single-tenant, multi-tenant and mixed-use buildings in the analysis.

Fundamentals

DiPasquale and Wheaton (1992) were the first to provide a conceptual framework of the interrelation of markets for real estate assets and space. They divided the real estate market into two, interrelated, markets: space market and the asset market. The two markets are linked to each other based on the simple supply and demand theory. Where the demand for tenants is determined in the space market, the demand for owning real estate is determined in the asset market. To simplify, the space market controls the demand for space and the asset market determines a certain supply level of space.

The space market forms a rent level whereby the demand of space equals the supply of space. The demand for space comes the occupiers of space, either tenants or owners, either households or firms, using the space for production or consumption purposes (Geltner et al., 2007). Although both residential and commercial real estate follow the theory of DiPasquale & Wheaton (1992), this thesis will focus on commercial real estate alone. The demand for office space comes from owners, occupiers, or owner-occupiers. In corporate real estate, firms use real estate as production factor required to run their operations, such as retail stores, logistic halls, or simply offices to accommodate employees. In commercial real estate, the real estate is core of the operations, the investment vehicle, and is therefore only active on the supply side (CoreNet, 2015). The demand curve in the space market is based on the rent level, real estate cyclicity, and other exogenous macro-economic factors (DiPasquale & Wheaton, 1992). The rent level, determined by

the demand curve, effects the demand for real estate in the asset market. The model simplified the rent level to the net rent paid per square meter and excludes operating costs associated with occupying the office space. It is difficult to uncover the real rent, as it can include confidential incentives (McDonald & McMillen, 2011).

A third market, the construction market, is the second link between the space and asset market. When the value of the assets, determined in the capital market, equals the costs of construction, supply of real estate will grow. Although the asset value should balance the construction costs in the long run, these two can significantly vary in the short run caused by the delays and uncertainties in the construction industry. These interrelationships are depicted in the four-quadrant model in figure 5.

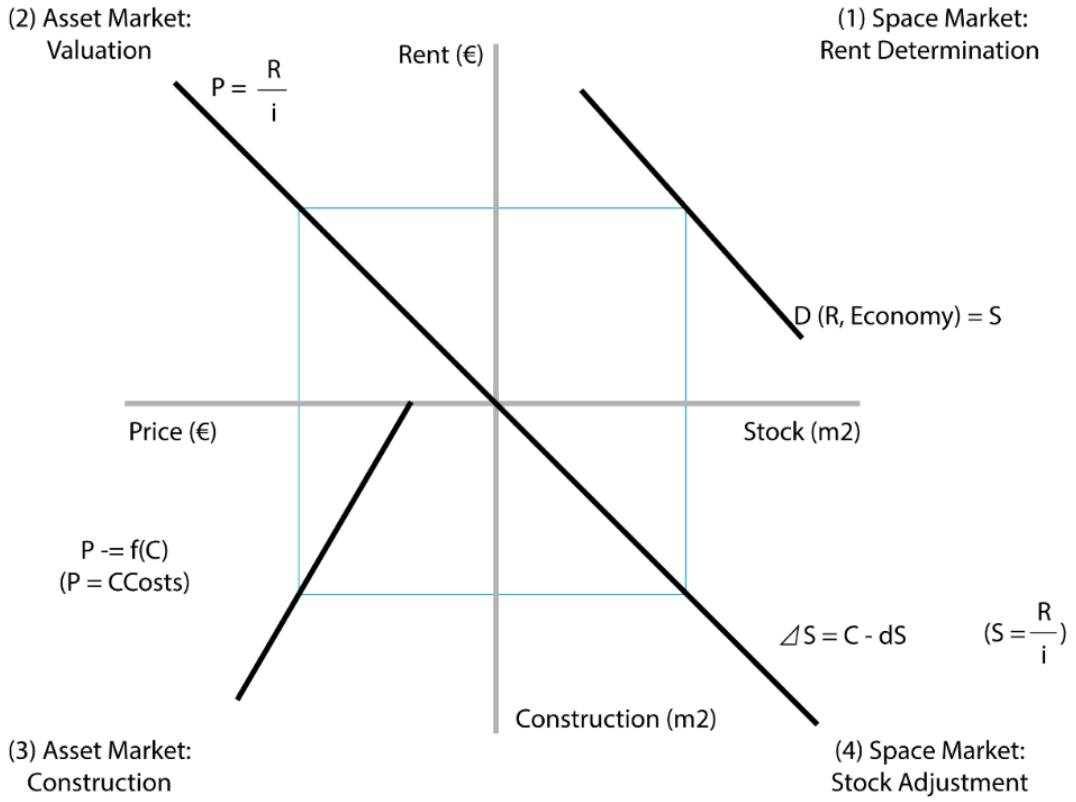

Figure 5: 4-quadrant model (DiPasquale & Wheaton, 1992)

The first quadrant represents the space market whereby the horizontal axis describes the current stock. The rent of a certain stock is formed by determining the demand of that level of stock and couple it with the corresponding rent level the vertical axis. The second quadrant represents the asset market. The slope of the curve illustrates the required capitalization rate of investors. The asset market determines the asset's value, *P*, by multiplyin the rent level, *R*, by the required capitalization rate, *i*. A higher required cap rate result in a steeper curve, while a reduced cap rate results in a gentler curve (DiPasquale & Wheaton, 1992). The capitalisation rate is composed of three components: Opportunity Cost of Capital (OCC), risk and growth forecast. First, there is a certain risk-free return for investments. This is based on the standard returns of other investment opportunities, such as state obligations or stocks. The second component is the risk factor, which is higher in more risky investments. The third, negative, component is the growth forecast, which is higher for investment which a high growth potential. Investors are willing to pay more for an asset today if the future cashflows are expected to grow in the future (Geltner et al., 2007; Van Gool et al., 2013). The third quadrant represents the construction market as part of the asset market. Construction only starts when the price (per square meter) equals the construction costs. The higher the prices per square meter in the asset market, the higher the construction volume in the construction market (Van Gool et al., 2013). The steep

curve is caused by the fundamental problems as the inelasticity of construction and scarcity of land (DiPasquale & Wheaton, 1992). The fourth quadrant represents the stock adjustment, ΔS, which is not a separate market. The net change of the stock equals the level of construction minus the depreciated stock, *dS*, determined by the depreciation rate, *d* (DiPasquale & Wheaton, 1992). A higher depreciation rate, whereby more buildings will be deprived of the stock, causes a more vertical stock adjustment curve (Van Gool et al., 2013).

The model of DiPasquale & Wheaton (1992) does not include vacancy. Vacancy can be defined as the unoccupied space in a building. McDonald & McMillen (2011) build on the 4-quadrant model and incorporates a vacancy rate in a long-term equilibrium. Although vacancy is often considered negative, the demand for vacancy can be fostered by landlords who are willing to hold space vacant to prepare it for future tenants or to wait for better conditions which are not yet met (e.g., higher rents). This is called frictional vacancy (McDonald & McMillen, 2011). The rent represents the opportunity costs for vacant space: the demand for vacant office space will therefore decrease when rent increase. Also, the more volatile the rent, the greater the value potential is to wait and hold some space vacant (McDonald & McMillen, 2011). Frictional vacancy is therefore not necessarily negative for owners and investors. Natural vacancy is the long-term vacancy rate when supply and demand are in equilibrium (McDonald & McMillen, 2011). Any divergence from the natural vacancy rate means excessive demand or supply of office space (Chou & Wong, 2015). Excessive supply will drive the rent downwards. Excessive demand, causing a vacancy rate below the natural vacancy level will force the rents up (Chou & Wong, 2015; McDonald & McMillen, 2011). Frictional vacancy provides the opportunity to respond to the elastic demand of real estate markets. Vacancy rate is considered in the analysis by incorporating the occupancy rate at moment of lease. Newly delivered buildings often incentive early tenants by discounts or rent-free months to occupy the building and make it more attractive for future tenants.

The concepts of value and rent have many definitions in the current scientific and business literature. First, it is important to note the difference between *price* and *value*. The value is determined by what is worth for (prospective) owners and the price is what is actually paid, which can be defined as the transaction price. The price is determined by a real exchange of property and the value is based on future cashflows of the property (Van Gool et al., 2013). The Royal Institute of Chartered Surveyors define market rent and value in their Red Book as *"the estimated amount for which an interest in real property should be leased/exchanged on the valuation date between a willing lessor and willing lessee on appropriate lease terms in an arm's length transaction, after proper marketing and where the parties had each acted knowledgeably, prudently and without compulsion"* (RICS, 2020, p. 8). The market value differs from the investment value, which is defined as the value of the asset for a prospective investor for individual investment purposes (RICS, 2020; Van Gool et al., 2013). This is a subjective value based on the investor's required yield (Van Gool et al., 2013) and not directly connected to the market value. This thesis uses the market rent, derived from the market conditions at moment of lease and the following negotiations, which can also be defined as transaction rent. This excludes any incentives to the landlord or any indexations as is the case in contract rent (Van Gool et al., 2013).

This thesis analyses solely the occupier market, which can be defined as the space market in the 4-quadrant model of DiPasquale & Wheaton. As said, the rent is formed by office demand and the results will show whether there is a higher demand for certified office buildings than for the non-certified office stock. According to the 4-quadrant model, an increased demand will cause a higher rent level for certified buildings over non-certified buildings and eventually higher asset values. An important prerequisite for the economic feasibility of certified buildings is that the rent premium exceeds the marginal costs of certified buildings. Otherwise, no construction will take place in the third quadrant and the construction industry has no incentive to innovate. This characterizes the playing field of the Vicious Circle of Blame as discussed in the problem statement. The economic feasibility of certified buildings will be assessed in chapter 4.

Drivers

Real estate activity can be considered as highly cyclic, whereby different real estate market exhibit different time-series (Wheaton, 1999; Pirounakis, 2012). The 4-quadrant model of DiPasquale and Wheaton (1992) can be used to visualize the effect of one shock in the space market on the asset market, which provokes increasing (decreasing) activity in the construction market. This one-cycle ends when the space market reached a new certain equilibrium. This time-series behaviour is triggered by the supply inelasticity, caused by extensive construction periods and durability of real estate (Pirounakis, 2012). Geltner et al. (2007) continues with the market actor's behaviour, which also creates cyclicality. Market actors are not equally able to interpret information accurately and tend to make investment decisions based on historical data rather than future predictions (Rottke & Mutl, 2015).

Exogenous shocks, such as macro-economic developments or socio-economic events, also influence real estate market dynamics. For example, national economic growth is highly dependent on the short-term interest. In times of economic booms, the demand for products exceeds the supply, which eventually will increase inflation. As economic growth is an important determinant for office space, macro-economic developments are crucial for real estate performance. Going back to the 4-quadrant model, economic growth will increase the demand for space and therefore shift the demand curve to upwards. The shock can also take place in the asset market, wherein an increasing number of investors are interested in real estate. Investors are willing to pay more for a certain future cashflow, characterized by a lower capitalisation rate, shifting the demand curve counter clockwise. This thesis controls for this time-series behaviour by taking the transaction year into account as important control variable in the rent level analysis.

2.2. Sustainable value drivers

The increasing climate awareness and the regulatory developments boosted the emergence of multiple voluntary and mandatory building certifications measuring the building's environmental performance (Saunders, 2008). Figure 6 shows the regulatory developments on both European (top) and national level (below).

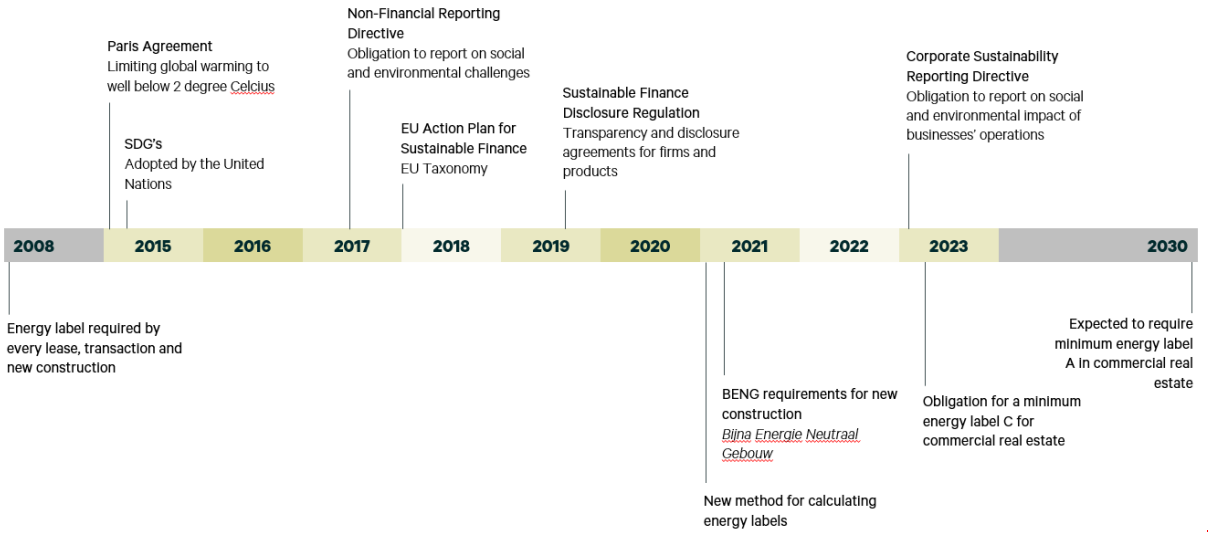

Figure 6: Regulatory developments on national and European level (source: author)

The regulatory context in the Netherlands shifted from voluntary initiatives towards formal agreements. The 2015 Paris Agreement started of many regulatory developments aiming to stimulate sustainable operations in the European Union. The Non-Financial Reporting Directive (NFRD) obliges large organisations to report on social-, environmental and diversity and integrity matters (European Committee, 2014). The following EU Action Plan for Sustainable Finance aims to integrate environmental, social and governance (ESG) matters in organisation's financing policy (European Committee, n.d.-d). This process is essential to deliver the European Green Deal and become Net Zero by 2050. Another aim of this action plan is to decouple economic growth from resource use. To make this happen, these European regulations all aim to boost market transparency and encourage market participants to invest in sustainable financing (European Committee, n.d.-d). The EU Taxonomy, part of the Action Plan for Sustainable Finance, establishes one formal classification system to determine whether activities and investments in the European Union are environmentally sustainable (European Committee, 2020). For the real estate sector, the EU Taxonomy stipulates contribution criteria and rules to not significantly harm climate adaption, water, circular economy, pollution prevention and biodiversity. Activities that are eligible for the EU Taxonomy are the construction, renovation and acquisition of new and existing buildings, and the installation, maintenance and repair of building installations (European Committee, 2020). The Sustainable Finance Disclosure Regulation (SFDR) in 2019 and the Corporate Sustainability Reporting Directive (CSRD) in 2023 build on previous directives. The latter formally amends the NFRD of 2017 and extends the scope by obliging more companies to report.

Over time, the European regulations take a more formal and compulsory role in the operation and financing of larger European countries. Interviews conducted in this study showed that these regulations, first mainly mandatory for listed companies, play a critical role in the decision-making process of large layers in the construction and real estate sector. Especially listed companies and organisations with a societal role (e.g., institutional investors and pension funds) are accountable to their constituency and shareholders for their environmental and financial performance. Among these organisations, the abovementioned regulations caused a real shift of focus towards certified assets only (Real Estate investor A, personal communication, October 134, 2022).

One can also see this transition on a more national level. The regulations take mainly place in the playing field of energy labels, whereby the requirements were strengthened from a mandatory energy label to a minimum energy label C in 2023 and most likely to energy label A in 2030. Without a doubt this will have a large effect on the appetite for less environmentally friendly buildings in the Dutch real estate sector.

Environmental certifications

Building certifications give occupiers and tenants reliable information on the building's environmental performance, reducing the information asymmetry in the commercial real estate market (Holtermans & Kok, 2017). This section first reviews the three different building certificates to eventually compare the methodology and applicability. Furthermore, it includes an international literature review on the intangible and tangible benefits of green buildings and environmental certifications.

Besides the mandatory energy label for buildings, there are a few voluntary building certificates present in the Dutch real estate market. Of all certificates, BREEAM, LEED and WELL are (inter)nationally most often used and are all certification systems which value the environmental performance of buildings.

BREEAM

The Dutch Green Building Council (DGBC) was established in 2008 as a member of the World Green Building Council (WorldGBC). The WorldGBC is the parent organisation of all national councils in the world (DGBC, n.d.-b.). The purpose of the DGBC is to support the transition to a future-proof built environment. It is established as a market initiative and has evolved to a broad movement consisting of more than 350 partners striving for a sustainable built environment (DGBC, n.d.-b.).

BREEAM (Building Research Establishment Environmental Assessment Method) is now the world's leading environmental assessment method for large infrastructure and building projects developed by Building Research Establishment (BRE). It values the asset's environmental, social, and economic sustainability performance across the entire lifecycle. It distinguishes the performance between new constructed assets, assets in-use and refurbished assets. The final rating ranges from Pass, Good, Very Good, Excellent to Outstanding. The final rating is visualized with a total score percentage and the number of stars on the official BREEAM certificate (Building Research Establishment Ltd, 2022). BREEAM is currently used in 86 different countries among which U.K., U.S.A, Norway, Germany, China, and the Netherlands. DGBC adapted BREEAM to the Dutch regulations and developed BREEAM-NL in 2009 (DGBC, n.d.a). The aim of BREEAM is among others to create market recognition for environmentally friendly buildings and to increase awareness among practitioners on the advantages of environmentally friendly buildings. In total, BREEAM-NL already certified 1.874 projects with a total area of almost 26 million square meters (DGBC, n.d.-a.). Over the years, the assessment methods were regularly updated to the new technical standards. As BREEAM-NL is a voluntary label and the criteria are all extra-legal, the assessment methods must follow amendments of the national regulations. The latest amendments of BREEAM-NL reward owners and investors to certify their new constructed buildings also with BREEAM-NL In-Use to encourage sustainable operation and maintenance after the building is delivered.

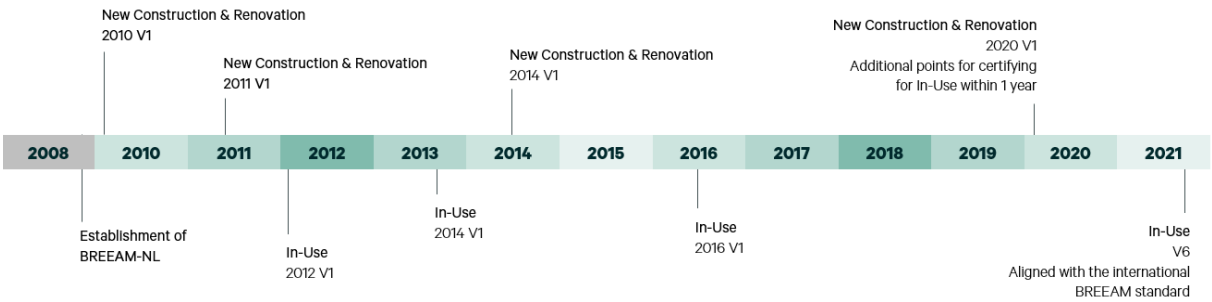

Figure 7: Development of BREEAM-NL over the years, BREEAM-NL New Construction (top) BREEAM-NL In-Use (down) (source: author)

BREEAM-NL assesses every asset objectively on nine separate categories: management, health and comfort, energy, transportation, water, materials, waste, land use and ecology and pollution. Every asset can score additional innovation points for innovations which increases the sustainability performance even more than the existing scoring categories. This stimulates designers, developers, and investors to increase the sustainability performance of their assets even more. For every assessment a BREEAM-NL expert and -assessor is required. The expert advises the project team in the process and ensures all relevant information will be documented throughout the process. The assessor is an independent third-party expert which officially assesses the project on the BREEAM-NL criteria (BREEAM-NL, 2020).

New Construction

The primary aim of BREAAM-NL New Construction 2020 is to reduce the environmental impact of new buildings during the entire lifecycle in a robust and cost-efficient manner (DGBC, 2020). To maximize the score, it is recommended to integrate the BREEAM-NL criteria early in the design process. However, the assessment after project delivery can only result in an official BREEAM-NL certificate as the asset's environmental performance after project delivery can significantly differ from the requirements set in the design phase. The design assessment is purely supportive in the process and can only result in a provisional BREEAM-NL design certificate. An asset can be assessed with BREEAM-NL New Construction maximum 12 months after it is delivered and (partly) occupied. After 12 months the asset will be considered as an existing building (DGBC, 2020).

Although BREEAM-NL New Construction evaluates the asset on the same nine categories as BREEAM-NL In-Use, as described in the previous section, the individual credits differ across the labels. The environmental assessment is based on a balanced scorecard, which incorporates the relative importance of each category (BRE, 2016). In their briefing paper "New Methodology for Generating BREEAM Category Weightings" they explain their new methodology to propose appropriate weightings for every life cycle stage in every building sector. The relative weightings for every category without the additional innovation points are depicted in figure 8.

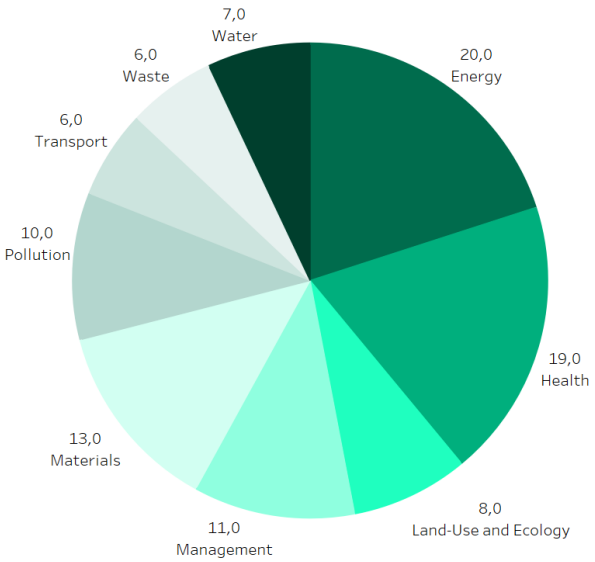

Figure 8: Relative weightings BREEAM-NL New Construction (adapted from DGBC, 2020)

To qualify for a certification, the asset is also required to comply with certain mandatory credits in areas such as energy, water, and waste. This guarantees that the asset, despite the balanced scorecard which enables to compensate scores between categories, complies with basic environmental requirements.

In-Use

The primary aim of BREEAM-NL In-Use is to reduce the negative environmental impact during the use phase of buildings (DGBC, 2021). BREEAM-NL In-Use distinguishes two categories:

1. Asset: Assessment criteria based on the location and architectural- and climate components.
2. Management: Assessment criteria based on how property management is organised and maintained.

Both categories can be assessed and certified separately. The BREEAM-NL In-Use score only reflects the categories included in the assessment. To qualify for the 'Asset' part, not more than 20% of the building's usable floor area can be hull. To qualify for the 'Management' category, the building should be occupied for more 12 months before the time of assessment and have an occupancy rate of more than 80%. In addition, the building should contain consumption data over minimum 12 months (DGBC, 2021). To maximize the environmental and economic impact, the assessment of separate stories or areas is exceptional for multi-tenant buildings. In case of a multi-tenant building, the assessment can be demarcated based on all shared facilities (all in ownership or maintenance of the asset manager) or in combination with lettable units (DGBC, 2021). The demarcation should be physically separated (e.g., walls and floors) from the rest of the building. The relative weightings for every category without additional innovations points are depicted in figure 9.

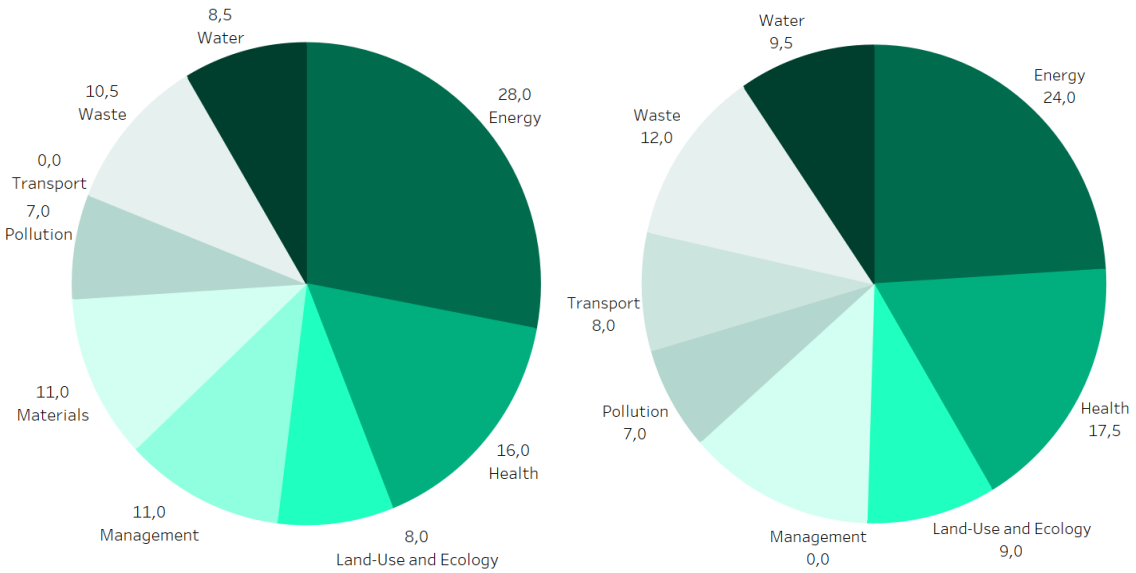

Figure 9: Relative weightings BREEAM-NL In-Use (a) Management (b) Asset (adapted from DGBC, 2021)

LEED

The LEED rating system, developed by the United States Green Building Council (USGBC), values green, healthy, efficient- and cost-saving buildings (USGBC, n.d.). LEED aims to preserve natural resources and biodiversity and give credits related to location and transport, sustainable sites, water efficiency, energy and atmosphere, material use, indoor environmental quality and hands out specific credits for innovation and local environmental priorities among assets (USGBC, n.d.). The rating system is suitable for every type of real estate and applies different systems for new construction, core and shell and fit outs. The scores range from certified (40-49), silver (50-59), gold (60-79) to platinum (80-100) (USGBC, n.d.).

WELL

WELL certification is emerged from the increasing demand for healthy workspaces (WELL, n.d.). It uses evidence-based research to value buildings and organisation on the categories air, thermal comfort, light, community, mind, movement, water, sound, materials, and nourishment. The main aim of WELL is to stimulate employee productivity to attract and retain talent for organisations. The focus on health and well-being enables organisations who are WELL certified to strengthen their ESG scores (WELL, n.d.).

Comparison

BREEAM and LEED are both voluntary certification systems which values energy performance, waste, health, transport, and material use and are to a certain extent comparable. WELL is an environmental certification system especially focused on user's health and well-being. Sanders (2008) compared the environmental certifications in the U.K. context. Where BREEAM applies specific weightings to certain credits, the LEED rating system uses equal weightings for every credit. The different categories do have specific weightings but differ across BREEAM and LEED (Sanders, 2008).

BREEAM and LEED are both compatible for every type of real estate. LEED specified their rating system for every type of real estate, applying different weightings for schools, retail, and offices. BREEAM uses one certification system for all non-residential real estate, and only makes exceptions for data centres. A comparison of the weighting system is depicted in table 1.

Table 1: LEED and BREEAM-NL New Construction comparison (adapted from Saunders, 2008)

Category	LEED	BREEAM-NL
Management	-	11%
Health	16%	19%
Energy	33%	20%
Transport	16%	6%
Water	11%	7%
Materials	13%	13%
Waste	-	6%
Land-use and ecology	10%	8%
Pollution	-	10%
Integrative process	1%	-
Total	**100%**	**100%**

Intangible benefits

Leasing and occupying *green* buildings are associated with a variety of benefits. A study of Zhang et al. (2018) argued that the improved indoor environmental quality of green buildings results in increased comfort and health among end-users. Green buildings generally have better thermal and visual comfort, and green building occupants enjoy higher productivity and satisfaction rates (Zhang et al., 2018). A study of Harvard (2017) tested the effect of indoor environmental quality on health and productivity rates. The study analysed 10 LEED Platinum buildings and concluded that occupants of green, environmentally certified, offices score 26% higher on cognitive tests and 30% less on symptoms of the sick building syndrome. Also, occupants of green buildings valued their sleep quality 6% higher than occupant in non-certified offices. Eichholtz et al. (2009) developed a framework for corporate social responsibility (CSR) in leasing strategies. The authors identified different motivations to actively pursue a green housing strategy. Governmental institutions are more willing to lease green buildings due to their public accountability and businesses with environmentally harmful operations actively pursue a green leasing strategy to protect their public reputation. Large businesses, such as banks and law firms, tend to lease a significant share of green space due to their dependency on their labour force and the increase in productivity accompanied by green buildings. However, the presence of these large businesses might be a result of their general demand for high-quality office space as green buildings tend to be of higher quality than traditional buildings. Within densified areas, organisations are less likely to prefer green offices over traditional offices. These areas are often close by the Central Business District and tend to base their housing strategy on the traditional saying "location, location, location" (Eichholtz et al., 2009). Eichholtz et al. (2010) also concluded that the fact that environmentally harmful businesses and labour-extensive firms are more present in green buildings suggest the importance of the intangible effects of environmental certifications. Qiu et al. (2017) researched the factors influencing commercial buildings to obtain green- and environmental certifications and concluded that more factors than solely reduced energy consumption play a role in the motives to obtain a green certification. Companies are more willing to obtain a green certification for their commercial building than individual owners. In addition, owner-occupiers are more reserved in obtaining green certifications than owners who rent out their building. This suggests that the present value of the incremental rent outweighs the present value of the reduced energy consumption, confirming the intangible effects such as marketing and corporate social responsibility (Qiu et al., 2017).

Tangible benefits

The effects of environmental certification on office rents have received considerable attention in the last decade. There is now much evidence supporting the hypothesis that environmentally certified office buildings receive higher yields over non-certified office buildings. The higher yield expresses itself in both higher rents and occupancy rates. The outcomes of the current literature body can be found in table 2.

The current literature has quite varying conclusions, but all indicate that there is a significant price premium for green buildings compared to conventional buildings. Kok & Jennen (2010) conducted the only research in the Dutch office market and indicated a rental discount of 6,5% for non-green office buildings over green buildings[1]. Eichholtz et al. (2010) examined the relationship between market value and Energy Star certification and concluded a significant rental premium of 3% and a sale premium of 16% for Energy Star certificated office buildings after controlling for quality variables such as building size, -class, -age and -height. Fuerst & McAllister (2011b) examined the effect of the different LEED levels on rent premium and showed a significant rent premium of up to 16% for LEED Platinum. Eichholtz et al. (2013) examined the relationship between energy-efficiency and market rents in Energy Star certified buildings. One dollar energy-savings is accompanied with a 3.5% incremental rent and 4.9% incremental market value. Eichholtz et al. (2010) raised the question if these incremental rents for certified buildings could only be allocated to the reduced energy consumption or if intangible effects (e.g., well-being, productivity, corporate social responsibility) of the certification are also part of the premium. The increased valuation associated with the reduced energy consumption did not declare the total premium associated with environmental certification which implies that the intangible effects of a certain environmental label seem to be important as well.

The results among previous studies indicate a negative relationship between the price premium and location premium. The price premium appears to be higher further away from the Central Business Districts, indicating a higher price premium in smaller submarkets and in the periphery (Eichholtz et al., 2010; Porumb et al., 2020). The research of Porumb et al. (2020) on the impact of building location on green certification price premiums showed a 10,5% additional premium for green offices outside the city centre. This emphasizes the importance to accurately control for location variables and to take future research broader than only the largest office markets.

Besides a positive relationship between certification and market rents, various research also indicates a positive relationship between certification and occupancy rates, suggesting an even higher price premium in effective rents (Reichardt et al., 2012; Eichholtz et al., 2010; Whiley et al., 2010). Reichardt et al. (2012) find an increase in occupancy of 4,5% in Energy Star certified office buildings. Eichholtz et al. (2010) examined the relationship between certification and effective rents and discovered an 11% higher occupancy rate for green buildings compared to non-green buildings. Using the hedonic pricing model, Whiley et al. (2010) found a 10-11% higher occupancy rate for Energy Star certified buildings and a 16.2-17.9% higher occupancy rate for LEED certified buildings. Fuerst & McAllister (2009) focused their research solely on the relationship between eco-labelling and office occupancy rates. They found a smaller, but still significant, increase in occupancy of 3% for Energy Star certified buildings and 8% for LEED certified buildings. The results of the research of Holtermans & Kok (2017) indicated an incremental premium of 1.5% for average rent and 4.1% for effective rent, indicating also higher occupancy rates for certified buildings over non-certified buildings.

1; green energy labels (A-C) vs. non-green energy labels (D-F)

Table 2: Outcome of current literature on green price premium (source: author)

Source	Market	Sustainable value driver	Price premium	Data range
Kok & Jennen, 2010	Dutch office market	Energy label	-6,5% rent discount[1]	2005 – 2010
Eichholtz, Kok & Quigley, 2010	U.S. office market	Energy Star certification	3% rent premium (7% effective rent) & 16% sale premium	2007 – 2009
Wiley, Benefield & Johnson, 2010	U.S. office market	Energy Star & LEED certification	7.3-8.9% and 15.2-17.3% rent premium	2008
Fuerst & McAllister, 2011a	U.S. office market	Energy Star & LEED certification	3-5% rent premium, 18% and 25% sale premium	2009, 1999 – 2009
Fuerst & McAllister, 2011b	U.S. office market	Energy Star & LEED certification	4% and 5% rent premium, 26% and 25% sale premium	2008, 1999 – 2008
Reichardt, Fuerst, Rottke & Zietz, 2012	U.S. office market	Energy Star & LEED certification	2.5% and 2.9% rent premium	2000 - 2010
Eichholtz, Kok & Quigley, 2013	U.S. office market	LEED certification	7.9% effective rent premium	2005 – 2009
Chegut, Eichholtz & Kok, 2014	U.K office market (London)	BREEAM certification	19,7% rent premium, 14,7% sale premium	2000 – 2009
Devine & Kok, 2015	U.S office market	Energy Star & LEED certification	2.7% and 3.7% rent premium	2008 – 2013
	Canadian office market	LEED certification	10.2% rent premium	2008 – 2013
Hui, Chan & Yu, 2015	Shanghai office market	LEED certification	12,8% rent premium	N.A.
Holtermans & Kok, 2017	U.S. office market	Energy Star & LEED certification	1.5% and 1.9% rent premium and 6.6% and 14.8% sale premium	2004 – 2013
Porumb, Maier & Anghel, 2020	Finland, France & German office market	Green certification (BREEAM, DGNB, LEED, HQE)	19% price premium	2010 – 2015
Li, Fang & Yang, 2021	Chinese office market	LEED certification	19,5% rent premium	N.A.
	Shanghai office market	LEED certification	25,5% rent premium	N.A.
	Beijing office market	LEED certification	20,8% rent premium	N.A.
Onishi, Deng & Shimizu, 2021	Tokyo office market	Variety of green labels**	6,5% rent premium 5,4% rent premium for medium-sized old buildings & 2,6% rent premium for large-sized new buildings	2009 – 2019

**an average discount of 6,5% for non-green buildings (label D-G)*

***CASBEE, CASBEE for Real Estate, DBJ Green Building Certificate*

Cost premiums

To put the green premium in a broader context, the marginal costs of green buildings should be analysed as well. Chegut, Eichholtz & Kok (2019) studied more than 2,900 construction projects in the United Kingdom on construction costs and duration and examined the marginal costs and duration for BREEAM labelled developments. After controlling for building, client, and location characteristics, they found 30 to 38 percent higher construction costs for buildings certified as BREEAM Outstanding. Buildings certified as Excellent or Very Good cost 5 to 19 percent to construct. The results do not show significant cost premiums for buildings certified as BREEAM Good or Pass. Additionally, Chegut et al. (2019) studied the project duration for these certified offices. Due to the limited number of observations, buildings were clustered in two groups: Pass/Good certified buildings and Very good/Excellent/Outstanding certified offices. Results show that the upper group take on average 13 percent longer to construct[2].

Chegut et al. (2019) then analysed the different construction cost elements separately. On average, BREEAM labelled buildings costs 32% more to design than non-certified buildings. Fittings and finishes are found to be respectively 32 and 28 percent more expensive and preliminaries[3] and contingencies cost together on average 12 percent more in BREEAM labelled construction projects. On average, design fees, fittings, finishes and preliminaries respectively account for 3.6, 2.1, 0.04 and 11.1 percent of the total construction costs (Chegut et al., 2019). BouwkostenKompas, a cost calculation tool from IGG Bouweconomie, provides key figures on building costs for many types of utility of residential construction projects. The cost premia for BREEAM-NL Excellent certified construction projects are similar to the research of Chegut et al. (2019) and provided evidence of cost premia on national level. It is important to note that the real estate markets, and therefore construction markets, are highly heterogeneous. In the Netherlands alone, the construction costs differ largely across regions. The costs of a straightforward office block of 8 to 12 layers can differ up to 20% in raw building costs between Drenthe and South-Holland and North-Holland (IGG Bouweconomie, 2022).

Table 3: Cost premiums for BREEAM-NL certified construction projects in South-Holland (source: IGG Bouweconomie)

Type of office	Building costs (€ / square meter gross floor area)	Additional costs for BREEAM-NL Excellent certification (€ / square meter office space)	Average cost premium
Office villa	€2.139	€290	14%
Small office (industrial area)	€1.508	€229	15%
Small office	€1.551	€215	14%
Office block (max. 6 layers)	€1.690	€194	11%
Office block (max. 8 layers)	€1.960	€197	10%
Office block (max. 12 layers)	€2.031	€165	8%
Special construction (low rise)	€2.138	€159	7%
High rise office tower (max. 16 layers)	€2.003	€163	8%
High rise office tower (max. 20 layers)	€2.083	€160	8%
High rise office tower (above 20 layers)	€2.419	€158	7%
Special construction (high rise)	€2.463	€164	7%

2; Contract length as dependent variable.
3; site-specific overhead costs of any construction project

2.3. Real estate rent determinants

Real estate can be characterized as a heterogeneous good (McDonald & McMillen, 2011). Real estate is location and type specific, immobile and cannot be easily moved from one location to another. In addition, buildings cannot be easily adapted to other functionalities (Geltner et al., 2007). Offices consist of a set of characteristics such as floor area, height, and geographical location. It can be considered as a bundle of product characteristics typical and unique for that particular property. It is possible that BREEAM-NL certified office buildings have other premium building characteristics. To isolate the rent effect of BREEAM-NL certification and not overestimate the effect of the certification alone, it is important to take all important real estate rent determinants into account.

This section will review important rent determinants for offices based upon previous studies to (hedonic) price models of offices on a macro-, meso-, and micro level. Van Gool et al. (2013) define the three levels as follows. Macro level factors are connected to macro-economic developments, the meso level corresponds to the direct environment of the property and the micro level is concerned with building characteristics of the property itself.

Macro level

As discussed in chapter 1.1, real estate markets are highly influenced by macro-economic factors such as economic- and employment growth and real estate cyclicity, as discussed in chapter 1.3.

Employment growth has proven to be a significant rent determinant for offices (Eichholtz, Kok & Quigley, 2010; Eichholtz, Kok & Quigley, 2013). This is in line with the theory of Van Gool (2013) who argued that employment growth is one of the most important determinants for office demand. Fuerst & McAllister (2011b) included the market conditions at the time of transaction which was proven to be of significance at the 1 percent level.

Meso level

Rent determinants on meso-level are associated with the characteristics of the direct surroundings of the office building. The location of an office is considered of great importance for organisations (Van Gool, 2013). Although zip codes are able to distinguish between two different locations, the zip code itself does not contain any data on the attractiveness of the business climate itself. Location theories show house prices decrease with the distance to the CBD: to maintain a certain utility level, households' willingness to pay for land decreases as commuting time increases (McDonald & McMillen, 2011). This so called bid-rent function depends also on the distance to amenities. Urban hierarchy theories are highly dependent on the total population and number of services (McDonald & McMillen, 2011). Firms have similar bid-rent functions, which depends on the distance to the market. Other local highlights, such as stations or parks, can cause a local peak in the bid-rent function (McDonald & McMillen, 2011). The total population, number of job opportunities, and average house prices might be able to cover the total attractiveness of the local business climate in the analysis later. Not every city fits within the monocentric city model. Amsterdam has multiple centres, such as South-Axis and Central Station Area, and is a city with a polycentric character. Such cities have multiple peaks in the bid-rent function, representing secondary business areas. Submarkets (e.g. Amsterdam South-Axis) are included to control for inner-city differences in business climate.

Rottke & Mutl (2015) argue that accessibility mainly explains the variety of rent levels across different locations and that this differs across real estate sectors. The concept of accessibility can be interpreted in many ways and can relate to the proximity of highway junctions, airports, and bus-, tram- and train stations (Rottke & Mutl, 2015). The level of amenities also corresponds to the meso-level. Van Gool (2013) argues that most prime office locations are in the city centres due to the presence of many facilities. However, individual firms across sectors will value these locations differently. For example, a characteristic office organisation tends to value face-to-face contact with their customers and partners, typical for Central Business Districts, more than others (Rottke & Mutl, 2015). In general, the current literature all uses submarkets or clusters to control for geographical differences in rent level (Fuerst & McAllister, 2011b;

Holtermans & Kok, 2017; Robinson & Sanderford, 2016; Chegut, Eichholtz & Kok; 2014). The concept of accessibility is supported by the study of Eichholtz, Kok & Quigley (2013) which found the proximity to public transport, within 250 meters, to be a significant rent determinant. Kok & Jennen (2010) found the distance to the closest NS (Dutch Railways) station and the Google Walk Score, a determinant for the proximity of daily amenities, of significance at the 1 percent level. The problem with Google Walk scores is that it is based on the current situation, being unable to calculate the Walk score of historical points in time. Other types of transport accessibility which are proven to be statistically significant are the distance to the closest entrance to the highway and the average commuting time (Dunse & Jones, 1998). Porumb, Maier & Anghel (2020) found a significant negative relationship between the distance to the city centre and the enjoyed green premium. This can suggest that within A-locations, close to the city centre, the location premium outweighs the enjoyed green premium, emphasizing the importance of accessibility in office locations. Dunse & Jones (1998) confirmed this with a literature review which found the distance to the Central Business District to be statistically significant. Additionally, they found the number of square meter office space within a two-block radius statistically significant, proving the importance of being part of a certain business district.

This thesis will control for various location factors. To control for local business climate, the number of residents, total employment and average house prices will be included in the analysis. Submarket dummies will control for differences within cities. The number of sport facilities, supermarkets and restaurants will cover the level of amenities in the proximity. The density of amenities is preferred to the distance to amenities: despite the similar distance, an office building close by a rural shop is valued less than the office building above a supermarket in the Central Business District. Walk time to subway- and train stations measure the accessibility by public transport and the distance to the closest highway junction measure the accessibility by car.

Micro level

Micro-level rent determinants are associated with the object itself, which can be divided into the building and the lease contract. Where the building factors focus more on the physical attributes of the building, the lease factors tend to be more commercial variables.

Building variables

The quality of the building is of critical importance for its value. However, the concept of quality is quite broad and can include many variables. The current real estate research tends to use building age as a determinant for the overall building quality as this represents the technical and aesthetical depreciation (Rottke & Mutl, 2015). However, they also suggest that taking age as a quality indicator is arguable as older buildings can obtain monumental status or go through major renovations. It is therefore recommended to take (large) refurbishments into account when calculating price indices. Rottke & Mutl (2015) advocate building size and height as determinants for the building's representativeness. Larger buildings are generally more present in the environment, attracting more potential visitors or customers. The vertical premium is supported by various other real estate studies in the office market (Koster, 2013). As the building size is highly dependent on the number of storeys, including both variables in the regression might cause multicollinearity (Rottke & Mutl, 2015). Several studies tried to examine the effect of architectural qualities on real estate value. Hough & Kratz (1983) already studied the effect of architecture on office rents and found a significant premium for office buildings which contained architectural excellence. Turan et al. (2020) tested the effect of the amount of daylight on office rents and concluded a 5-6% rent premium for offices with high amount of daylight. Although daylight brings more advantages than only architectural quality, it indicates the importance of the lay-out of the façade. Fuerst, McAllister & Murray (2009) found a rental premium in office buildings designed signature architects. This premium could either be the result of the architect's name but could also be an indication of the architectural quality.

Facilities on-site, amenities, also affect the quality of the building. Fuerst & McAllister (2011a) only found significant results for fitness- and banking facilities. However, these studies are based on historical data and the recent new ways of working might have accelerated the importance of on-site amenities as

fitness facilities, food courts and conference rooms. Technical characteristics such as energy performance and environmental certification gain increasing importance in real estate valuation. The study of Kok & Jennen (2010) on the added value of green energy labels in the Dutch office market showed a 6,5% discount for office buildings with a red energy label with a higher energy demand. Besides the ecological responsiveness (Eichholtz, Kok & Quigley, 2016), green office buildings enjoy generally lower operating costs, increased well-being and productivity, higher market value and positively contribute to the environment (Zhang, Wu & Liu, 2018).

The current literature body shows significant effects of building size (Eichholtz et al., 2010; Fuerst & McAllister, 2011; Eichholtz, Kok & Quigley., 2013; Holtermans & Kok, 2017; Robinson & Sanderford, 2016; Chegut, Eichholtz & Kok, 2014; Dunse & Jones, 1998), building age (Fuerst & McAllister, 2011a; Fuerst & McAllister 2011b; Robinson & Sanderford, 2016; Chegut, Eichholtz & Kok, 2014; Dunse & Jones, 1998) and number of stories (Fuerst & McAllister, 2011a; Fuerst & McAllister, 2011b; Eichholtz, Kok & Quigley, 2013; Robinson & Sanderford, 2016; Chegut, Eichholtz & Kok, 2014; Dunse & Jones, 1998). Considering the age of the building, Fuerst & McAllister (2011a) also found significant effect on recent renovation on the rent level. These renovations presumably improve the general quality of the building and extend the (functional) lifespan. In the American literature, various studies found significant effects of the building classes (A, B or C) on the rental price per square meter (Eichholtz, Kok & Quigley, 2010; Fuerst & McAllister, 2011a; Fuerst & McAllister, 2011b); Holtermans & Kok, 2017). In this thesis, building size, and building age will be considered as primary building characteristics. Major renovations and the building's energy label will measure the technical and environmental performance of the property.

Commercial variables

Although the lease factors do not influence the value of the building as a whole, these factors can have a significant effect on the lease agreement of single rent transactions. Rottke & Mutl (2015) point out lease length, options, and incentives as the three critical lease factors for office rent indices. Given the hypothesis that owners prefer long-term leases, they argue that short-term leases are accompanied by higher rents. This is partly because more movements result in higher transaction costs and higher vacancy levels. Long-term leases also reduce the flexibility for tenants, which result in a higher willingness-to-pay for short-term leases (Rottke & Multi, 2015). The study of Chegut, Eichholtz & Kok (2014) examined the green premium of BREEAM certified office buildings in London and show a significant effect of lease term at a 5 per cent level.

Incentives are an important aspect in lease negotiations and can also influence the flexibility of the tenant. Incentives are used to attract the potential tenant into a lease transaction and is more common by excessive office supply (Rottke & Mutl, 2015). Incentives can include, but are not limited to, options to cancel or renew the contract, options to downsize or expand the rentable area and subletting options (Rottke & Mutl, 2015). Rent-free periods are commonly used as an incentive in the Netherlands and influences the real rent as well. Chegut, Eichholtz & Kok (2014) showed a significant effect of rent-free period on the rental price per square meter at a 10 per cent level. Additionally, for potential tenants, it is more attractive to enter a fully occupied and operating building. As vacant buildings are more difficult to market, real estate agents might offer first entrants discounts and other incentives to occupy the building. Fuerst & Mcallister (2011) and Reichardt et al. (2012) found a significant effect of vacancy level on rent levels. Rottke & Mutl (2015) show in their international literature review a significant rent premium for options to downsize the rental area. However, the exact role of incentives in commercial property price indices is difficult to quantify as they tend to be confidential. Type of contract plays a critical role in the willingness-to-pay for green certification. Especially the energy pricing mechanism in the lease contract influences the tenant's behaviour and incentive towards saving energy. The full-service gross contract includes all utility costs, passing on the responsibility for the energy bill entirely to the owner. In contrast, the triple net contract excludes all utility costs from the monthly rent, making the tenant themselves responsible for the energy consumption (Zhang, Wu & Liu, 2018). Robinson & Sanderford (2016) differentiated between triple-net and full-service gross leases and show a significant effect for both at the 1 percent level. This is complementary to the study of Reichardt (2015) which showed a significant effect of a triple-net lease at the 1 percent level.

Conclusion

The literature review provides a list with office rent determinants with are proven to be of importance in historical real estate research. The outcomes of the literature review are summarized in table 4 and shows all variables which will be considered in the regression analysis. It is important to note that only variables who have a significant effect in this study will be reported.

Table 4: Important office rent determinants (source: author)

Macro level	Meso level	Micro level *Building variables*	Commercial variables
(Inter)national economy	Submarket	Building size	Occupancy rate
Number of residents	Number of restaurants	Building age	Lease length
Number of job opportunities	Number of sport facilities	Renovation history	Lease size
House prices	Walk time to train station	Energy performance	
Transaction year			

2.4. Conceptual framework

Based on the international literature review in the previous sections, a conceptual model can be developed. The conceptual model in this research is based on the main relationship to be examined.

It is suggested that environmental certification has a certain effect on the market value in the Dutch office market. The environmental certification acts as *independent variable* influencing market value as *dependent variable*. However, the market value is composed of the implicit value of all underlying building characteristics which can be categorized in location- building- and commercial variables. To isolate the effect of environmental certification on market value, this research should take these *control variables* into account. As discussed in chapter 2, real estate market drivers, including economic growth, supply & demand, influences the time-series behaviour of real estate markets. Therefore, the research should take these drivers as *moderating variable* into account. The conceptual model is depicted in figure 10.

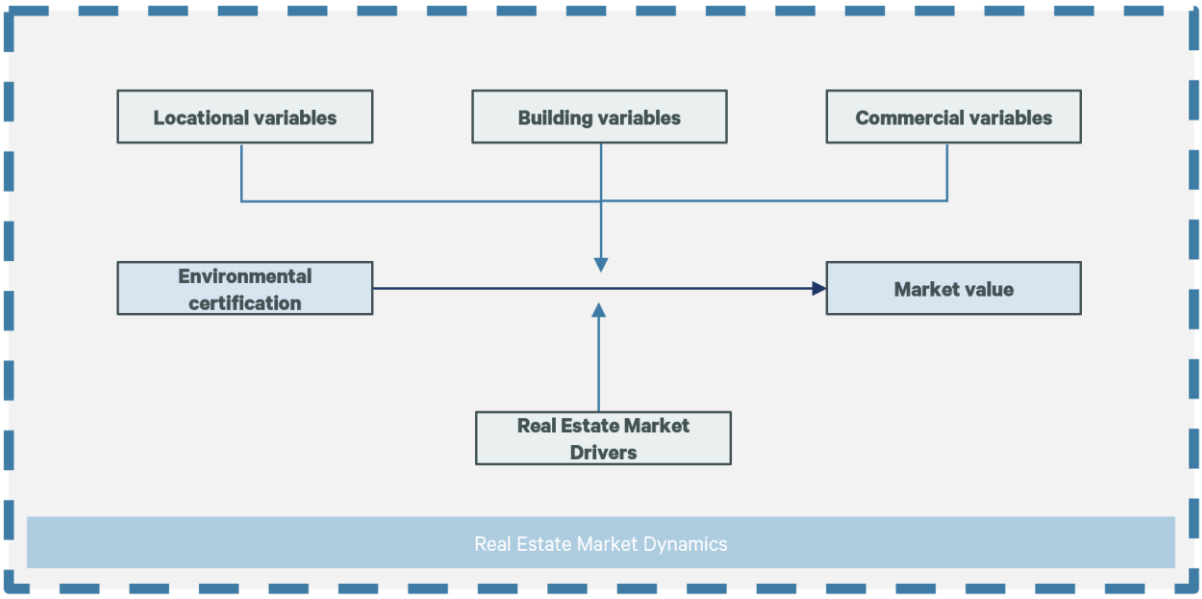

Figure 10: Conceptual model (source: author)

3. Research methodology

3.1. Research design

In order to examine the relationship between environmental certification and market value, an mixed method is used. This mixed-method research takes both a qualitative and quantitative approach and uses explorative data triangulation to test the international literature to the Dutch context. Explanatory and explorative semi-structured interviews will complement the multiple regression analysis and together will be used to interpret the results. A visualization of the research design is depicted in figure 11.

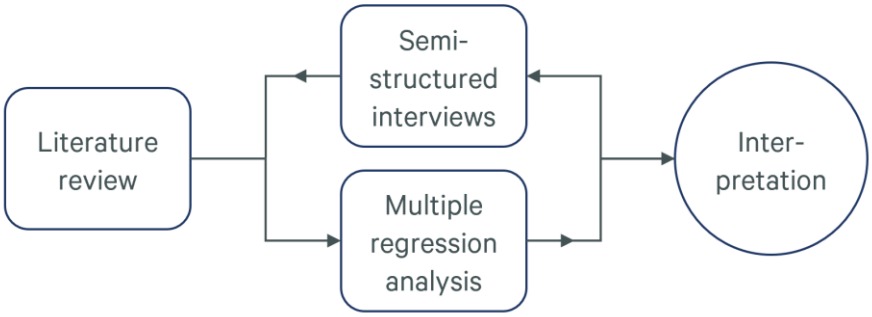

Figure 11: Research design, short (source: author)

3.2. Methodology

Hedonic price modelling

This quantitative research follows the current literature (Kok & Jennen, 2010; Eichholtz et al., 2010; Eichholtz et al. 2013; Porumb et al., 2020) and uses the hedonic price model to test the hypotheses on the relationship between environmental certification and market rents in the Dutch office sector. The hedonic price model is a commonly used technique to analyse the marginal impact of rent determinants in real estate research.

As discussed in chapter 2, real estate can be considered as a bundle of product characteristics typical and unique for that particular property. In other words, very few properties are so closely comparable that they are interchangeable as exact substitutes (J. Rouwendal, personal communication, February 18, 2021. Additionally, real estate is a durable good and is rarely considered obsolete within 30-50 years. This demonstrates the inelasticity of the supply of space as demand cannot be reduced quickly if demand slows (Geltner et al., 2007). This heterogeneity and immobility eventually lead to localized and segmented markets, making it difficult to properly value a set of properties.

Rosen's general theory on product differentiation (1974) also assumed that goods are sold as a bundle of utility-bearing characteristics but that the willingness to pay for those characteristics may change with income. The underlying theory of the hedonic price model is that goods are specified by their unique characteristics and therefore the value of that particular good can be defined as the sum of implicit prices of the underlying characteristics (Herath & Maier, 2010). In market equilibrium, the implicit prices attributed to the office characteristics equals the willingness to pay for those characteristics. Meaning that the sum of the implicit prices equals the building's market value (Freeman, 1979). The hedonic price theory takes the form of a regression analysis and will be used to determine the relative importance of each building characteristic in the overall market value.

Based on the theory that a real estate object is a heterogeneous good, defined by the underlying bundle of unique building characteristics, Dunse & Jones (1998) argues that building Z consists of N unique building characteristics (I).

I. $Z_1, Z_2, \dots \dots, Z_n$

The rent of building Z is defined by the number and quality of all N characteristics from equation I. The rent (R) of building Z can be described as:

II. $R_z = f(Z_1, Z_2, \dots \dots, Z_n)$

Equation III is the general hedonic equation following from this theory.

III. $R(Z_k) = \beta_0 + \sum_{i=1}^{n} \beta_i Z_{ik} + \varepsilon_i$

$R(Z_k) =$ dependent variable, implicit value of characteristics Z of the product bundle K

$\beta_0 =$ intercept, value

$\beta_i =$ the coefficient strength (value) of independent (control) variable i

$Z_{ik} =$ independent (control) variable of product K

$\varepsilon_i =$ observed statistical error

The current literature criticizes the applicability of hedonic price modelling in real estate research. Chin & Chau (2003) set forth the main criticisms regarding the applicability in the housing market, which are mostly also applicable to the office market. Considering the implicit prices as indication for the willingness to pay assumes the real estate market is in equilibrium. This requires perfect competition and perfect information. Additionally, the market equilibrium suggests there is no interdependence between the implicit prices of underlying characteristics. First, due to market imperfection equilibrium is not possible in real estate markets. This may emerge among others from the fact that real estate markets are unable to quickly respond to changing market conditions (Freeman, 1979). Second, Chin & Chau (2003) suggest that if there are no interdependencies between the underlying implicit prices, these implicit prices are identical in all areas for all types of real estate. Another assumption is that real estate markets are operating under perfect competition. Although a real estate transaction involves high transaction costs, many buyers (tenants and owner-occupiers) and sellers (developers and investors) are active, and no single actor can significantly influence market conditions. The assumption that all market actors have perfect information regarding the price and properties is arguable. Rottke & Mutl (2015) argue that real estate market inefficiencies are difficult to quantify and therefore all hedonic price indices include certain noise.

The segmented character of real estate is also widely considered as an empirical issue of hedonic price modelling (Freeman, 1979; Chin & Chau, 2003). Real estate markets cannot be considered as one single market, even in distinct cities. It is important to accurately separate submarkets. Misspecification of submarkets would result in biased results (Chin & Chau, 2003). Misspecification of variables is also considered as an unavoidable issue in hedonic price modelling. This can be either over-specification, in the case an irrelevant characteristic is included in the regression, or under-specification, whereby relevant characteristics are ignored (Chin & Chau, 2003). Both empirical problems lead to biased, incorrect statistical analysis (Pirounakis, 2012).

Despite the limitations of the hedonic price model, the model is widely justified as methodology in real estate research. Other well-known methods for real estate price indices such as repeat-sales methods and sales comparison approaches (Herath & Maier, 2010; Pirounakis, 2012) only account for heuristic evidence, whereby the hedonic price model can prove the correlations and significance of the value of individual rent determinants (Herath & Maier, 2010). The abovementioned methods are suitable for constructing real estate price indices, but not able to determine the marginal impact of the underlying property characteristics. Multiple regression analyses are best able to control for quality and do not need multiple transactions for every case (Pirounakis, 2012) and is therefore the justified methodology in this thesis.

Variables

This section presents the operationalisation of the conceptual framework presented in chapter 2. To isolate the effect of environmental certification on market rents, the hedonic regression should control for all significant rent determinants. The control variables can be grouped in location-, building-, and commercial variables. To prevent misspecification of variables, this research builds on previous literature, using variables which have proven to be of significant effect on market value as discussed in chapter 2. In every situation, the number of cases should exceed the number of control variables in the hedonic regression (Pirounakis, 2012). The operationalisation of the conceptual model, including all variables, is depicted in figure 12. A detailed explanation of every variable can be found in the appendices.

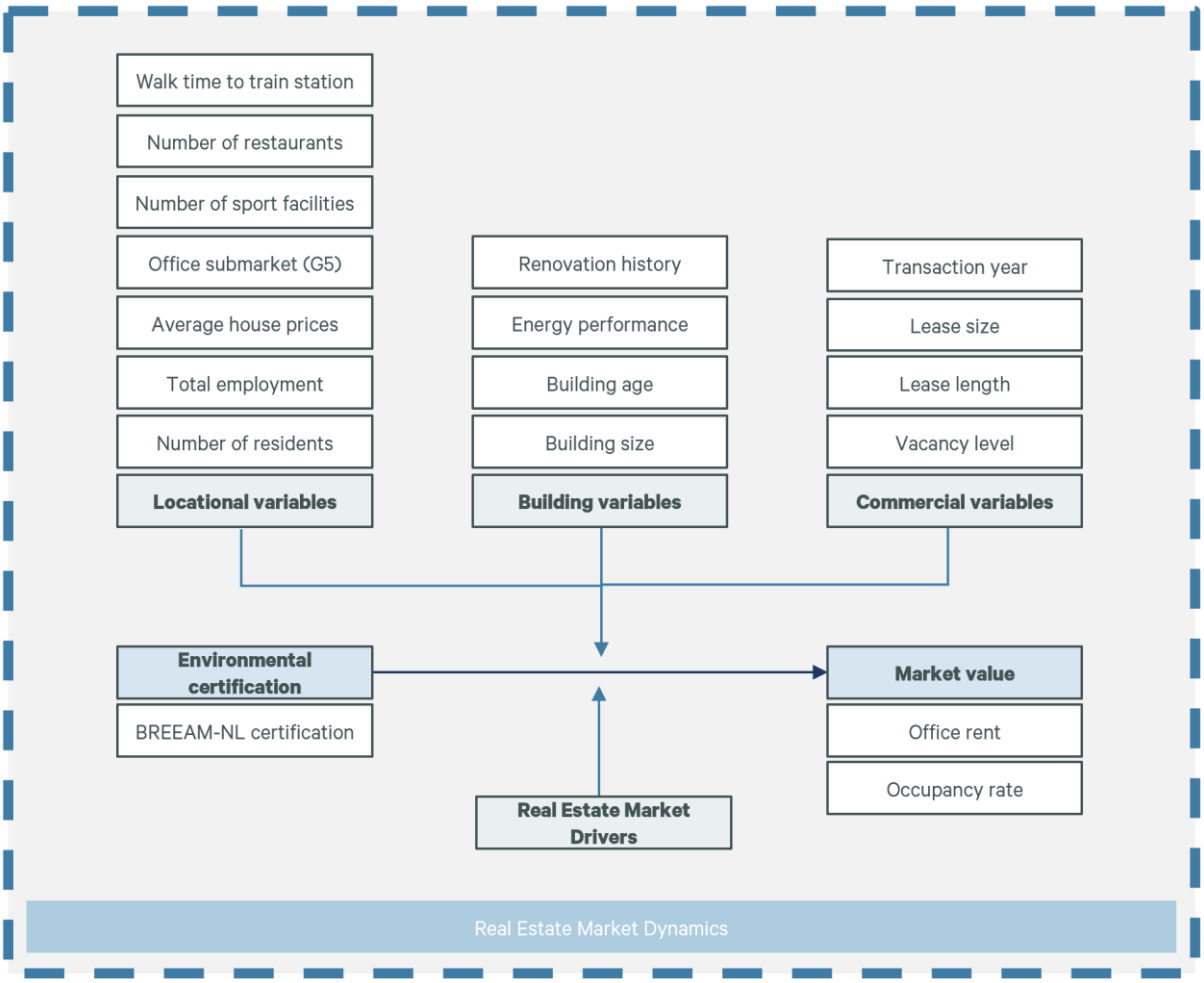

Figure 12: Operationalisation (source: author)

Following this operationalisation, the general hedonic equation for rent per square meter for this thesis can be formed (IV). The rent of building K is hereby the sum of the implicit value of all rent determinants Z grouped in locational, building and commercial variables.

IV:

$$R(Z_k) = \beta_0 + \beta_t T + \sum \beta_l L + \sum \beta_b B + \sum \beta_c C + \beta_e E + \varepsilon_i$$

β_0 = intercept, value

β_i = the coefficient strength (value) of independent (control) variable *i*

T = time dummy

L = locational control variables

B = building control variables

C = commercial control variables

E = environmental certification

ε_i = observed statistical error

Equation IV can be extended by substituting the group variables with every single control variable in the regression analysis. The entire hedonic equation for this thesis will be as followed (V). To control for macro-economic factors, the time dummies will represent one transaction year each.

V:

$$\begin{aligned} R(Z_k) = {} & \beta_0 + \beta_1 T + \beta_2 LOC + \beta_3 NUMRES + \beta_4 SUBM + \beta_5 AMEN + \beta_6 ACCESS \\ & + \beta_7 HPRICE + \beta_8 EMPLOY + \beta_9 SIZE + \beta_{10} GRADE + \beta_{11} LABEL \\ & + \beta_{12} REN + \beta_{13} V + \beta_{14} BREEAM + \varepsilon_i \end{aligned}$$

β_0 = intercept, value

β_i = the coefficient strength (value) of independent (control) variable *i*

T = time dummy

L = location

$NUMRES$ = number of residents in the area

$SUBM$ = (office) submarket

$AMEN$ = amenities (restaurants and sportfacilities)

$ACCESS$ = accessibility (by car and train)

$HPRICE$ = average house price in the area

$EMPLOY$ = total employment in the area

$SIZE$ = building size (log)

$GRADE$ = building grade by age

$LABEL$ = energy label of the property

REN = renovation dummy (1 = renovated)

V = vacancy level at moment of lease

$BREEAM$ = BREEAM-NL certification dummy (1 = certified)

ε_i = observed statistical error

The next hedonic equation (VI) changes the dependent variable in equation V to the occupancy rate (0 – 100%). The hedonic equation is similar to equation V, however occupancy rate at moment of lease is removed and the market rent, defined as euro per square meter office space, is added to the equation as important control variable. As these hedonic equations form two entirely separate regression models, this does not cause disturbance in the results.

VI:

$$\begin{aligned} O(Z_k) = {} & \beta_0 + \beta_1 T + \beta_2 LOC + \beta_3 NUMRES + \beta_4 SUBM + \beta_5 AMEN + \beta_6 ACCESS \\ & + \beta_7 HPRICE + \beta_8 EMPLOY + \beta_9 SIZE + \beta_{10} GRADE + \beta_{11} LABEL \\ & + \beta_{12} REN + \beta_{13} BREEAM + \beta_{14} RENT + \varepsilon_i \end{aligned}$$

β_0 = intercept, value

β_i = the coefficient strength (value) of independent (control) variable *i*

$RENT$ = building's market rent per square meter office space

ε_i = observed statistical error

Hypotheses

The main aim of this research is to examine the relationship between environmental certification and market rents. The main question in this research is *How does environmental certification influence market value within the dynamics of the Dutch office market?* In sub question 5, *how does BREEAM-NL certification influence market rent prices and occupancy rates in the Dutch office market,* the main concept of this thesis is operationalized in the Dutch context. Based on the current literature on green price premiums, the following hypotheses are formulated which will be analysed and tested using the multiple hedonic regression:

> *H0: BREEAM-NL certified office buildings do not receive higher rents over non-certified office buildings*

The null hypothesis is that BREEAM certification does not positively influence the market rent of Dutch office buildings.

> *H1: BREEAM-NL certified office buildings receive higher rents over non-certified office buildings.*

Despite the varying results in the current literature, almost every study reports a positive green premium for certified office buildings over non-certified office buildings. The results of these previous studies are depicted in table 7.

> *H2: Price premiums associated with environmental certification are positively correlated with the label score*

Eichholtz, Kok & Quigley (2013) showed a positive relationship between the LEED score and rent level. Their study focused on almost 21,000 rent transactions and 6,000 sale transactions in the United States. Holtermans & Kok (2017) also researched the green premiums associated with environmental certification. They focused on more than 5,000 certified office buildings and almost 92,000 control buildings in the U.S. commercial real estate market. Although they did not find a positive relationship in rental values, they did find a positive significant effect of the LEED score and sale price.

H3: Price premiums associated with environmental certification is likely to be higher in environmental-harmful and labour-intensive sectors

Eichholtz, Kok & Quigley (2016), in their study on housing decision of more than 11,000 tenants in the United States, show that tenants in more environmental-harmful sectors (such as oil, mining- and construction industry) lease large shares of green office space. They argue that leasing green office space can counteract the negative attention associated with their operations. Additionally, the results show that organisations in the legal- and financial services are major tenants in green office buildings, which supports the economic, intangible, advantages of green office space. Eichholtz, Kok & Quigley (2009) also showed significant shares of green leasing in the Mining and Construction industry. Second, in their sample of 3,179 tenants in 1,180 green office buildings, the Public Administration also tend to be more likely to lease environmentally labelled office buildings. Lastly, the results supported the hypothesis that labour-intensive sectors are more likely to rent green office buildings.

H4: BREEAM-NL certified office buildings enjoy higher occupancy rates over non-certified office buildings.

Fuerst & McAllister (2009) investigated the effect of LEED and Energy Star labels on the occupancy levels of offices in the United States. Their study of 2,147 environmentally certified office buildings with each at least 10 comparable non-certified office buildings showed an 8% occupancy premium for LEED certified offices and 3% occupancy premium for Energy Star certified office buildings.

3.3. Data collection

Mixed-method research requires different data collection methods. This section describes the process of data collection and structuring methods.

Quantitative data

To examine the economic effects of environmental certification in the Dutch office market, a combination of three datasets is used. This study uses existing secondary data collected by the Dutch Green Building Council and real estate advisor and broker CBRE B.V. (NL). CBRE Group, Inc. is a worldwide real estate consultant with more than 105,000 employees in over 100 countries (CBRE, n.d.-a.). They offer strategic advice in every phase of the real estate cycle: advisory & transaction services, taxations, development services and property management (CBRE, n.d.-b.).

Transaction data

This study uses transaction data from CBRE B.V. (NL). In August 2022, this dataset contained more than 16,000 sale- and lease transactions in the Netherlands from 2004 onwards with a minimum size of 500 square meter office space. The list, used as base set, provides information on the lease characteristics, such as type of lease, length, and size and hedonic characteristics, such as address, amenities, and submarkets. This list is composed by real estate agents in their regional offices with close contact with all local brokers (Amsterdam, The Hague, Rotterdam, Utrecht, Eindhoven, Zwolle) and supplemented with real estate transaction data of Dutch real estate magazines such as Vastgoedmarkt and Property NL.

Stock data

A second dataset of CBRE B.V. (NL) is used which includes stock data of more than 20,000 offices in the Netherlands. This dataset comprises information from Kadaster and BAG supplemented by information on occupancy rates and proximity to important amenities. The occupancy level is expressed as the absolute vacancy at the end of every quarter. The occupancy level is calculated by dividing the absolute vacancy by the total building size. For the rent analysis, hypothesis 1-3, this list is matched with the transaction data. For the occupancy rate analysis, hypothesis 4, this list is used is base set.

The Dutch Green Building Council, owner of BREEAM-NL, provides updated lists of all BREEAM-NL certified properties in the Netherlands. This list includes the label scores, relative scores, and certification date. Using Kadaster, the properties were complemented with their unique BAG ID to be able to link them with the corresponding lease transaction(s). Later the geographical coordinates were added to analyse the geographical spread across the country. Data on other environmental certifications, such as WELL and LEED, were collected through the online public project directory of the responsible organisations. Additional GIS analysis were conducted to complement the already comprehensive dataset with value-adding hedonic characteristics such as highway and railway proximity.

Interviews

In addition to the quantitative statistical approach, explorative and explanatory semi-structured interviews are used. This qualitative research method aims to test the applicability of the international literature review to the Dutch context. As the hedonic price model is a purely quantitative method, the explorative semi-structured interviews help to get an overarching view of the role of environmental certification in the Dutch office market. Additionally, the interviews help to interpret the results from the multiple regression analysis.

According to Blaikie & Priest (2019) this explorative qualitative approach can be used to develop hypothesis or to identify important variables for the following quantitative analysis. Semi-structured interviews are chosen based on the small number of planned interviewees and the varying conditions and drivers across markets and sectors. The interviewees are active in the real estate sector with an expertise in sustainability or valuation and play an active role in the Vicious Circle of Blame as presented in the problem statement. In total, two transaction managers are interviewed active in respectively the Greater Region Amsterdam (A) and Greater Region Eindhoven (B) and two nationally operating real estate investors (A/B) are interviewed who both have high sustainability ambitions. A BREEAM-NL In-Use Expert is interviewed to answer technical questions. Additionally, he could provide interesting insights in the main drivers for building owners to certify their buildings on BREEAM-NL. The protocol for each interview can be found in the appendices. The outline can differ across interviews based on their individual role and expertise.

3.4. Data analysis

This section will discuss how the data will be analysed, and the quality of the available data and potential limitations regarding the available data. As discussed in section 3.3., this research will make use of secondary data provided by real estate broker and consultant CBRE B.V. and the Dutch Green Building Council. Outlier variables were detected and handled accurately to come to a clean dataset. It should be noted that the researcher should be consistent and transparent when dealing with outliers. Chapter 4 will analyse the lease transactions on its representativeness for the entire Dutch real estate market.

Data tools

This study used several software programs for the analyses. First, IBM SPSS Statistics 28 software is used to structure the dataset and to develop the regression models. Graphs on market adoption, rent differences and maps on the geographical spread are created via the analytical software Tableau. Additionally, Microsoft Excel is used to analyse the differences in occupancy rate as depicted in figure 22. Microsoft Excel was preferred for this analysis due to the accessible programming language. Independent t-tests analysed the differences in group means. The t-test is used as this thesis only distinguishes two different populations: BREEAM-NL certified office buildings and non-certified office buildings.

The explanatory and explorative interviews were fully recorded and verbatim transcribed afterwards. Interviews were highlighted and analysed on key-words. Transcripts were approved by all interviewees and are available on request.

Transparency

Freeman (1979) argued the general accuracy of the data available in real estate research as real estate prices are often based on estimated valuations which may not equal the actual market value. Herath & Maier (2010) agreed that rent values may not be characteristic for the actual value of the property. Additionally, it may include incentives to future tenants such as free rent periods. This thesis partly solved this problem by using actual transaction rent rather than asking rent or book value.

The dataset does not comprise every real estate transaction in the Netherlands. As is the case with every real estate research publication, the results are heavily influenced by the sample used. It is almost impossible, especially in commercial real estate, to include very real estate transaction deal as there are varying ways to transfer real estate besides asset deals (Ishaak, Van Schie & De Haan, 2021) and the exact details are often concealed (Van Gool et al., 2013; McDonalds & McMillen, 2011) Additionally, commercial real estate price indices are often published by or in cooperation with large real estate consultancies, and are therefore often exposed to biased results (Rottke & Mutl, 2015). Although real estate research on commercial property price indices will always include some statistical error or nuisance (Rottke & Mutl, 2015), it does not mean that empirical research is not useful at all. It is therefore important to be transparent on the representativeness of the sample and data used.

Reliability

Reliability shows the consistency of the method and results. The sample and timeframe used highly influenced the results. The research uses data of CBRE B.V. (NL) and is influenced by their corporate structure and strategy. First, their database excludes real estate transactions smaller than 500 square meters. This possibly excludes companies in the Dutch SME industry (Dutch: Midden- en Klein Bedrijf). Second, CBRE B.V. (NL) operates from six regional offices in the Netherlands: Amsterdam, Rotterdam, The Hague, Utrecht, and Zwolle. Every office has its own focus and region they operate in. CBRE B.V. (NL) mainly focuses on larger office markets in the Netherlands, which automatically means that the six regional offices are geographically not equally spread throughout the country. This corporate strategy also, implicitly, biases their real estate transaction list and should therefore be presented transparently to the reader. Nevertheless, the dataset is of such size that the results will be based on a representative sample of the entire Dutch real estate sector.

Secondly, the spirit of the age influenced the results. Sustainability is an increasingly important topic on political and commercial agendas and political actions and company strategies are influenced by the public debate. In the last decade, the built environment has become more energy-efficient as the result of new national and European regulations (Netherlands Environmental Assessment Agency, 2022). Therefore it can be expected that the current green premium will slightly differ from the green premium in one to two years. Referring back to the 4-quadrant model, increasing demand for green buildings in a fixed stock will move the rent levels upwards. More green building construction, on the other hand, can again stabilise this rent level. The changing dynamics between real estate demand and supply causes that the results are a snapshot of the current situation and do not provide certainty for future transactions and valuations. Still, the sample size used is able to provide compelling evidence on the existence of quantitative rental premiums and the results should be interpret as a guidelines rather than the exact truth.

Validity

Internal validity is concerned with the extent to which the operationalisation is representative for answering the main research question. The market value is assessed by examining the effects on rent levels and occupancy rates. Using the 4-quadrant model, one could argue that rental income is an appropriate measure for defining market value. Both occupancy and rent is needed to generate rental income, in the absence of either no rental income will be generated and market value will decrease significantly.

External validity concerns the extent to which the results of this study can be generalized to the entire population, the entire Dutch office market. The total Dutch office stock accounts for 47,500,000 square meter (NVM, 2021). CBRE B.V. provides detailed property data for more than 33,000,000 square meter office space, approximately 70% of the total stock. Between 2016 and 2020, more than 6.3 million square meter office space is transacted in the Dutch office market (NVM, 2021). CBRE provide data on approximately 4.8 million square meter leased floor area, resulting in an average saturation of 84% over the period 2016 – 2020. This study focuses on the Dutch office market and given the average saturation rate validates the generalizability to the entire population. However, as already noted, the results should be interpret as a guidelines rather than the exact truth. The generalization to other commercial real estate markets is rather limited. Other real estate markets, such as industrial and logistics and retail do value other rent determinants, such as accessibility, way different (Rottke & Mutl, 2015) . These other types of commercial real estate are designed for other purposes and do accommodate other activities. Nevertheless, results can certainly indicate that BREEAM-NL certification does add value in commercial real estate pricing, but the exact numbers do not relate to other types of commercial real estate. The results can be generalized to other European office markets with caution. Although these markets act under the same European regulations and are the result of the same classical location theories (McMillen & McDonalds, 2011), real estate markets are highly heterogeneous.

4. Empirical findings and discussion

This chapter will first describe the Dutch office market in general and then zoom in on the occupier market and specifically the market adoption of certified offices. Secondly, it will present the descriptive statistics to eventually assess rental and occupancy premia of BREEAM-NL certified offices. Finally, the effect of label scores on the rental premium will be assessed and the results will be compared intersectoral to discover any differences across industries.

4.1. Univariate analysis

Market analysis

In 2022, the total stock accounted for 47,500,000 square meter (NVM, 2021). Regarding the total stock, the largest office markets in the Netherlands are Amsterdam, The Hague, Rotterdam, Utrecht and Eindhoven, also known as the G5 (Dutch: Grote Vijf). However, the total stock is slowly declining for years. Average rents in the Netherlands move around €135 per square meter while prime rents are around €455 per square meter (CBRE, 2022). From the G5, Amsterdam has the highest average rent of approximately €270 per square meter per year, followed by Utrecht and Rotterdam with €165 - €160. Before the global pandemic, the vacancy rates were historically low since the financial crisis in 2007. In Q3 2022, the vacancy rate in the Netherlands moves around 11,2%, resulting in approximately 5,300,000 square meter vacant office space. The average long-term vacancy rate (5 years) is 11,5% (CBRE, 2022). The Dutch office market leans more towards leasing rather than own-use. More than 65% of the total stock is leased out and in the last two years more than 80% of the transactions were lease transactions (NVM, 2021). The take-up recovered in the second half of 2021 with a total take-up of around 1,2 million square meters, an increase of 30% compared to 2020 (NVM, 2022). The recent economic development highly influenced the price levels in the investment market. For the first time in ten years, the gross initial years increased across all real estate classes. According to CBRE (2022), the prime offices see a change in price of around -15% between April and June this year. The effect on the total investment volume is expected to be nihil.

According to CBRE (2022), 58% of the total stock is certified with a minimum energy label C, 26% is not yet certified with an energy label, 9,7% of the stock does not meet the minimum energy label and 6% of the total stock is not eligible for the new regulations. From the non-certified stock, it is estimated that 49,3% will meet the energy label requirement and 50,7% does not meet the minimum requirements for label C. Rijksdienst voor Ondernemend Nederland (2022) estimated in similar research that at 1st of July of this year only 48% of the total stock was certified with an energy label C or higher. This was based on an estimation of 65,000 eligible office buildings. Although the results differ, the stock clearly lacks behind in their sustainability performance. Additionally, since 2020 the energy labels are measured with a new methodology. In the upcoming 5 years, the label of 10% of the stock expires. In a research of W/E advisors (2019) it is estimated that only 36% of the certified offices will meet the requirements for label C again. NVM (2022) emphasizes the increasing (value) gap between modern, energy-efficient offices and the older, less energy-efficient offices.

Although BREEAM-NL is a voluntary certificate, it is strongly growing over the last couple of years. According to annual reports of the Dutch Green Building Council, the number of certified assets has grown significantly to more than 2,400 certified assets in 2022. The growth over the years is depicted in figure 12 below. It should be noted that BREEAM-NL In-Use is only visible after 2019 due to the validity period of 3 years. Based on yearly reports of DGBC, BREEAM-NL In-Use grew from 101 issued certification in 2015 to 320 in 2020. In 2021, a record number of 672 certification were issued. Consequently, the total certified floor space increased from 7,500,000 square meter in 2017 to more than 28,000,000 in 2021 which result in a Compound Annual Growth Rate (CAGR) of 29,93%. Figure 14 shows the spatial distribution of BREEAM-NL certifications in The Netherlands and Amsterdam. To make sure the analysis includes most of the certified office space in the Netherlands, this visualization includes both solely offices and mixed-use buildings.

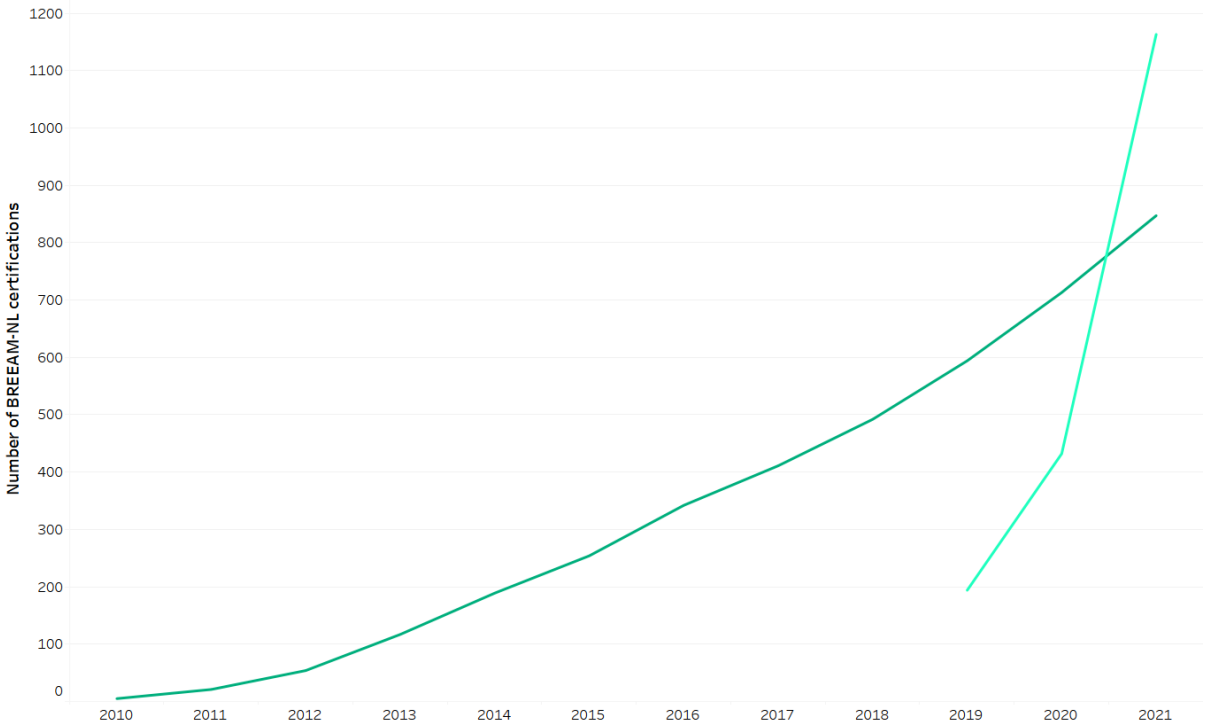

Figure 13: Growth of BREEAM-NL certifications over the years (source: author)

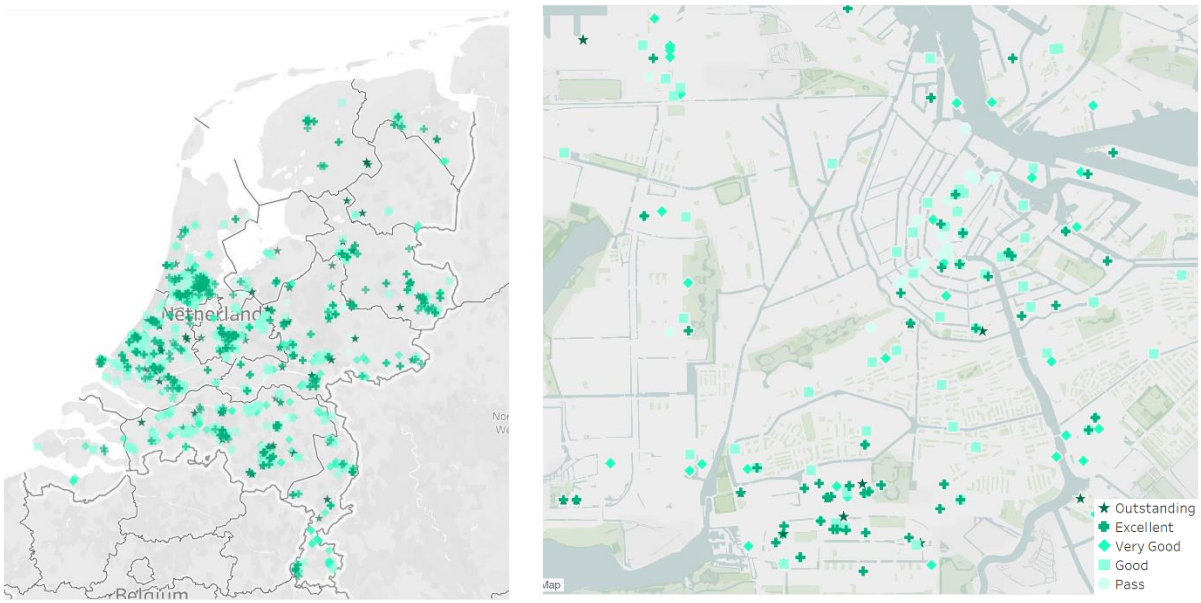

Figure 14: Spatial distribution of BREEAM-NL certifications in The Netherlands (a) and Amsterdam (b) (Source: author)

As discussed in the theoretical underpinnings, multiple other environmental certifications are arising in the Dutch real estate sector. Currently 29 projects with more than 500,000 square meters are certified with WELL Silver, Gold or Platinum and 6 other projects are Health-Safety rated, a certification to address health risks included but not limited to COVID-19. In total 40 buildings with approximately 390,000 square meters are LEED certified from which 8 buildings are Platinum and 22 buildings Gold certified.

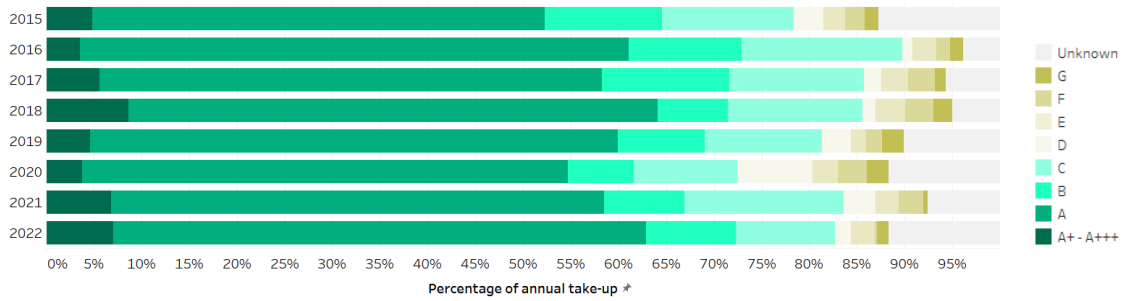

Figure 15: Percentage of yearly take-up by energy label (source: author)

Halfway 2022 more than 60% of the total yearly transacted leased floor area was certified with energy label A or higher. This number has been gradually increasing from almost 51% in 2015 to around 60% last year. Compared to the status of the total office stock, one can conclude that the transactions take place mostly in office buildings which are labelled with minimum label A. Surprisingly, still more than 4% of the total leased area in 2022 was labelled with an energy label D or lower despite the new regulations for 2023.

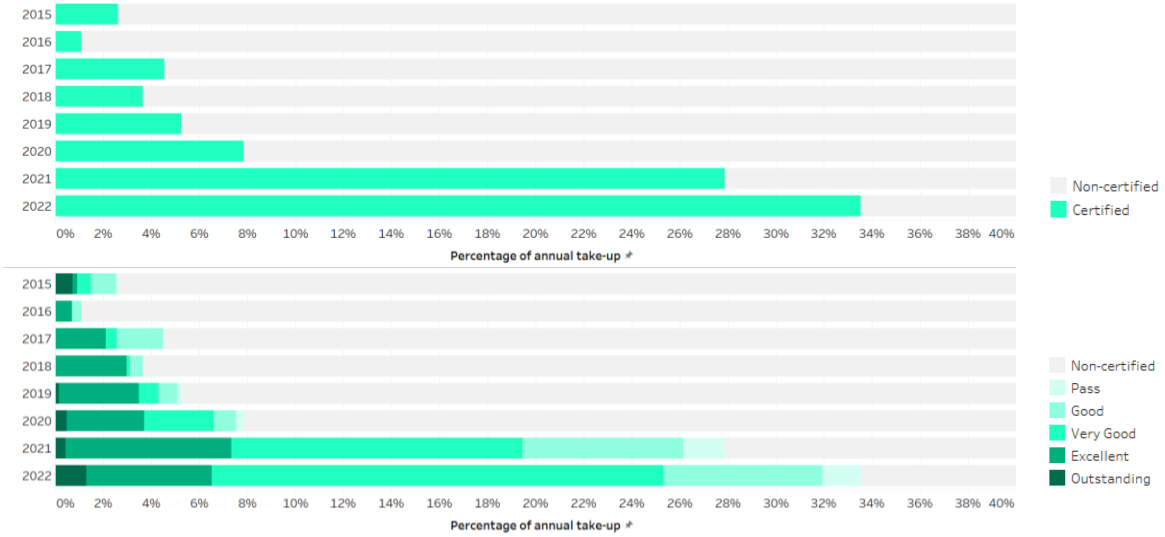

Figure 16: (a) Percentage of take-up per year by BREEAM-NL certification, (b) Percentage of take-up per year by BREEAM-NL label score (source: author)

In 2015, 2.63% of the total take-up was BREEAM-NL certified at moment of lease. This number gradually increased to 8.91% in 2020. The last two years, this number rapidly increased to 32.25% in 2021 and mid-way 2022 to 35.85%. This shows that occupiers are increasingly adopting sustainability measures in their housing strategy. The rapid increase runs parallel to the exponential growth of BREEAM-NL In-Use certified assets (see figure 13). It might also be explained by the global COVID-19 pandemic. According to the interview with transaction manager B, companies increasingly value healthy working environments in the last 2.5 years. He argued that managements are aware of the importance of proper air-handling systems and that this development is closely linked to green and healthy offices. Zooming in on the label scores in 2021, 1.62% was Pass, 7.46% Good, 13.55% Very Good, and respectively 7.29% and 0.51% certified with BREEAM-NL Excellent and Outstanding. It is important to note that the dataset is concentrated on the larger office markets in the Netherlands with generally more qualitative office stock than peripheral areas.

Descriptive statistics

The original dataset contained 11,761 lease transactions dating from 2004 and later. For the sake of relevance, only lease transactions from 2015 onwards were used for this research, resulting in a dataset of 6,190 transactions. Additionally, in consultation with real estate agents the rent cap was set on €550 per square meter, excluding outliers with unrealistic rent levels. In total, fourteen lease transactions were excluded with a rent level above €550 per square meter. Lease transactions without rent level were excluded from the dataset as well. After enriching the dataset with important hedonic characteristics such as building age, building size and location, the final dataset contained 4,244 lease transactions.

The lease transactions are geographically spread across the country with a clear emphasis on the Randstad. Most lease transactions took place in Amsterdam (N = 1244), followed by Utrecht (N = 422), The Hague (N = 397), Rotterdam (N = 392) and Eindhoven (N = 249). In total 1540 transactions are located outside the big five cities.

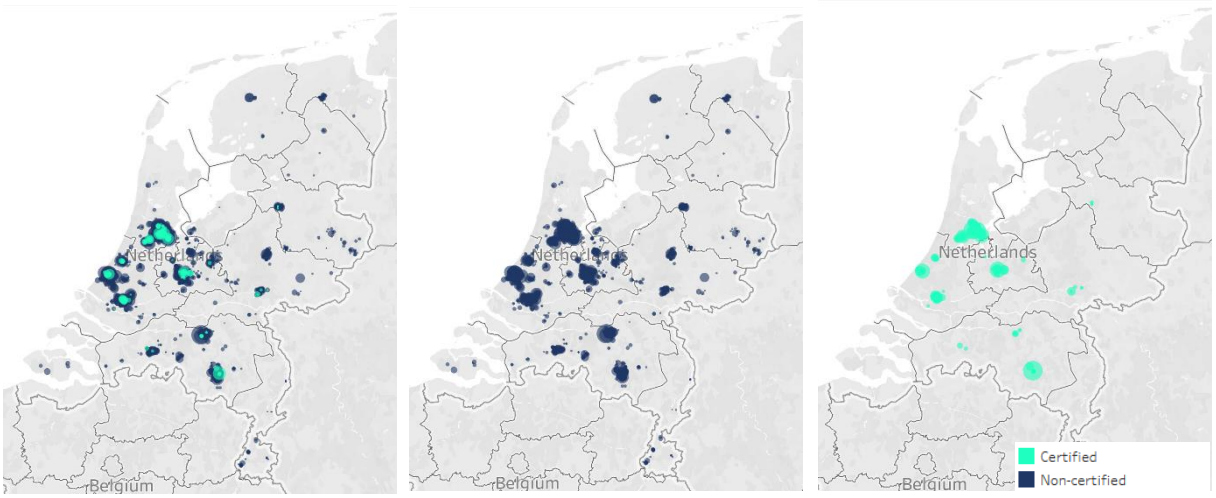

Figure 17: Geographical spread of lease transactions in The Netherlands (blue = non-certified, green = certified) (source: author)

Figures 18 and 19 visualize the relationship between lease rent and transaction year. The horizontal axis represents the transaction date and the vertical axis the rent level per square meter. BREEAM-NL certified and non-certified offices are presented in respectively green and blue. The size of the scatterplot in figure 19 represents the lease size in square meters. Both figures show on average higher rent levels for BREEAM-NL certified buildings over non-certified buildings. Both figures also shows more rapid growth in rent level for BREEAM-NL certified buildings. The numbers behind the graph can be found in the appendices and this table presents the average transaction rent over the years and presents both the arithmetic as the geometric mean rent. The latter is less sensitive to outliers and uses the square root of all observations. Lease transactions in BREEAM-NL certified buildings command higher rent levels than in non-certified buildings for every transaction year. In the last 5 years, rent levels in BREEAM-NL certified buildings have a Compound Annual Growth Rate of 5.80%. In this same period, rent levels in non-certified buildings have a Compound Annual Growth Rate of 3.35%. This 5-year average show that rent levels in certified office buildings tend to grow more rapidly than non-certified office rents.

Further analysis should make clear if this difference is due to BREEAM-NL certification or if BREEAM-NL certified buildings have other premium characteristics that contribute to a rent premium. To account for possible premium hedonic characteristics, a multiple regression analysis is used.

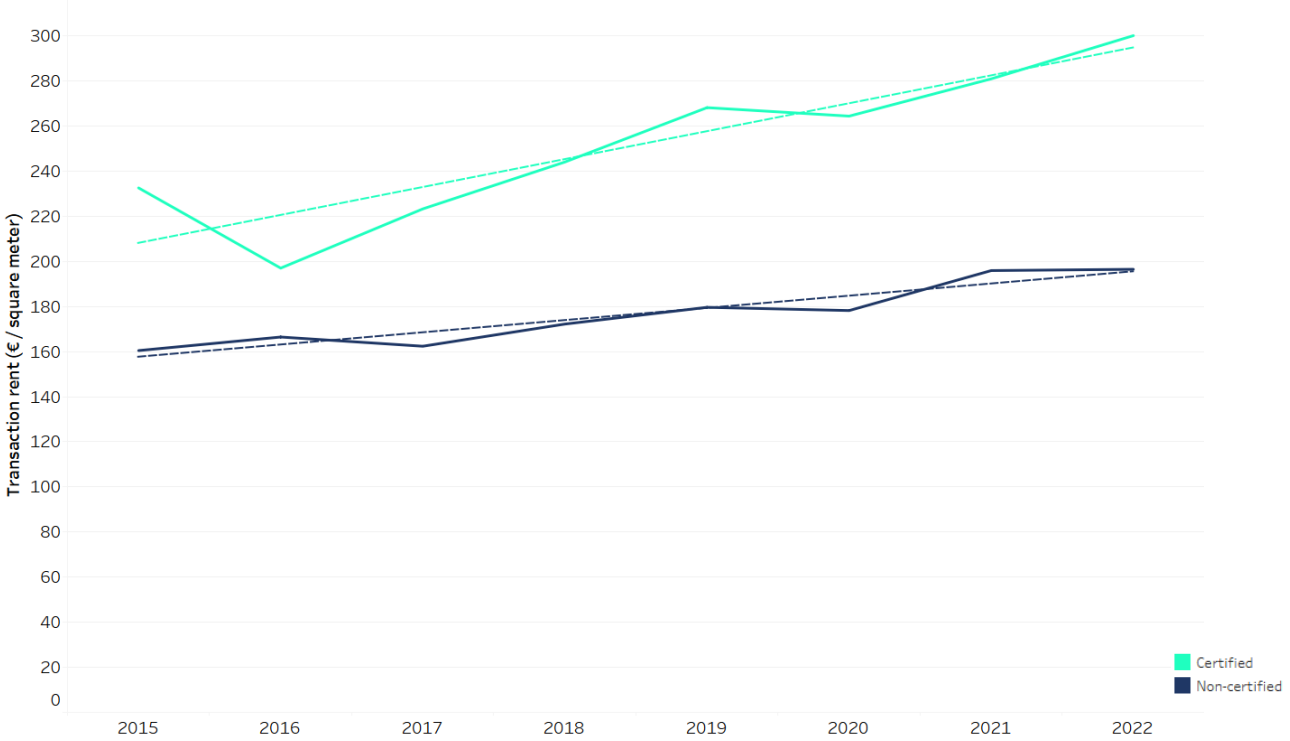

Figure 18: Average transaction rent by BREEAM-NL certification (source: author)

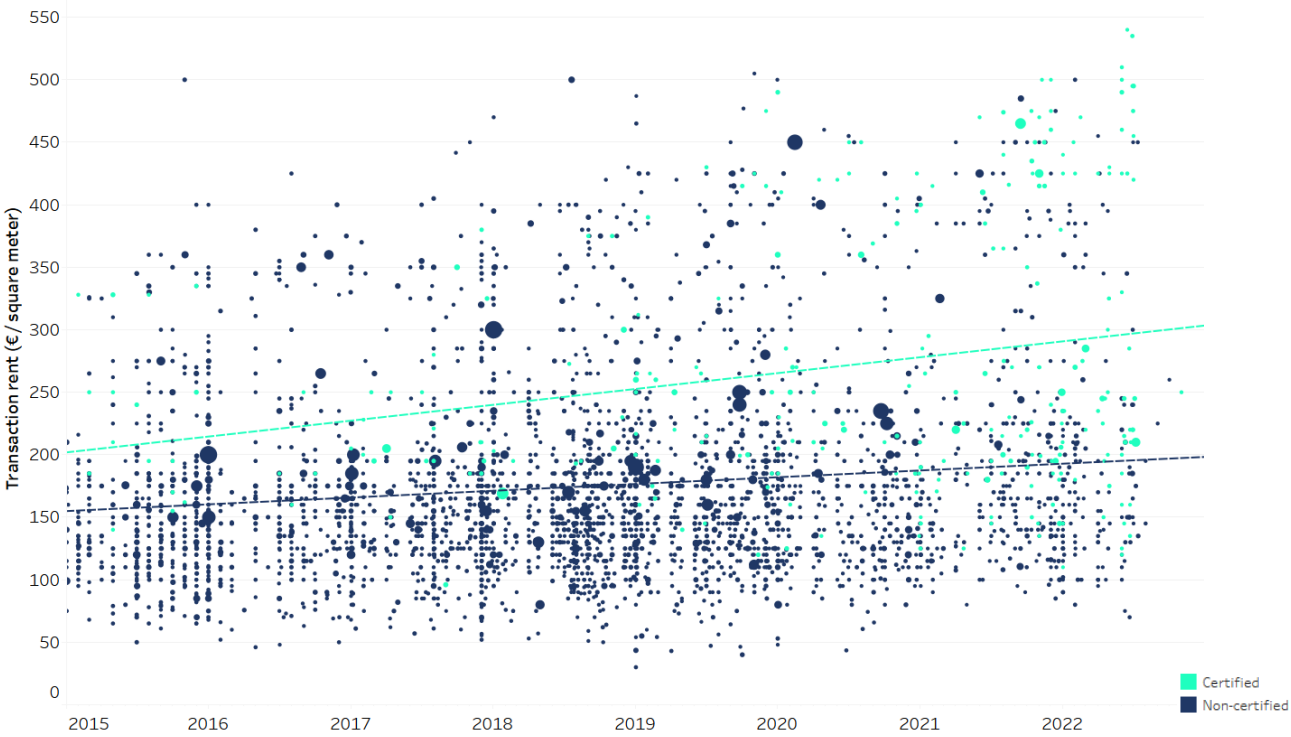

Figure 19: Scatterplot transaction rent by transaction date by BREEAM-NL certification (source: author)

Table 5 presents the descriptive statistics and highlights the differences including the corresponding t-tests for equality of means between transactions in non-certified buildings and BREEAM-NL certified buildings. The table presents the group means for certified and non-certified leases. The standard deviations are shown in brackets. Column 5 presents the results of the t-test and assesses if the differences across the group means are significantly different than zero. The significance of the t-tests is indicated by asterisks. A detailed explanation of the presented variables can be found in the appendices.

Table 5: Descriptive statistics (source: author)

	Total sample N = 4,355	**Non-certified lease** N = 4,024	**BREEAM-NL certified lease** N = 331	**t-test**
Lease Rent (€ / sqm)	180.98	173.41	271.35	-15.92***
	(84.07)	(76.97)	(109.16)	
Ln Lease Rent (€ / sqm)	5.11	5.08	5.53	-19.91***
	(0.41)	(0.39)	(0.39)	
Lease Floor Area (sqm)	1,708.99	1,711.40	1,680.35	0.20
	(2,715.90)	(2,741.39)	(2,394.68)	
Ln Lease Floor Area (sqm)	6.90	6.90	6.89	0.33
	(0.99)	(0.99)	(1.01)	
Occupancy rate at moment of lease (%)	84.22	83.89	88.13	-3.74***
	(26.36)	(26.88)	(18.77)	
Building Size (sqm)	11,596.77	10,640.18	23,017.56	-13.64***
	(13,740.48)	(13,092.80)	(15,989.47)	
Ln Building Size (sqm)	8.81	8.73	9.78	-22.50***
	(1.17)	(1.16)	(0.78)	
Building Age	44.35	45.80	27.05	10.128***
	(90.49)	(93.89)	(19.64)	
Major Renovation (%)	6.53	5.52	18.60	-5.99***
	(24.70)	(22.83)	(38.97)	
Energy Label	5.63	5.54	6.68	-15.01***
	(2.20)	(2.24)	(1.21)	
Number of Supermarkets	1.33	1.29	1.79	-4.25***
	(1.83)	(1.80)	(2.06)	
Number of Restaurants	45.04	43.48	63.61	-4.52***
	(77.71)	(77.79)	(74.24)	
Number of Sport facilities	1.56	1.48	2.45	-8.07***
	(1.85)	(1.81)	(2.10)	
Distance to train station	1.07	1.11	0.48	12.95***
	(1.75)	(1.80)	(0.72)	
Walk time to train station	13.82	14.43	6.59	13.24***
	(21.42)	(22.06)	(8.63)	
Walk time to subway	0.98	0.97	0.99	-2.03**
	(0.16)	(0.16)	(0.11)	

Note: Numbers represent group means and standard deviations are shown in brackets. Significance at the 0.10, 0.05 and 0.01 levels are indicated by *, ** and *** respectively.

First, the average rent paid for certified buildings is significantly more than the rent paid in non-certified offices with an average rent of €271 for certified offices and €173 for non-certified offices. Certified buildings tend to be bigger than non-certified buildings with an average total floor area of 23,018 square meters above 10,640 square meters. The difference in occupancy rate at moment of lease indicates that lease transactions in BREEAM-NL certified buildings generally take place in buildings with significantly less vacancy than leases transacted in non-certified buildings and one could therefore argue that certified offices are more attractive to occupy. Also, certified office buildings are significantly newer than non-certified buildings with an average age of 27 years over 46 years. More than 18% of the certified leases took place in buildings which are at least once completely refurbished. This is significantly higher than 5.52% of the non-certified leases. This major difference can be partly explained by the fact that building owners often certify their buildings in combination with a major renovation. BREEAM-NL certified leases score higher on energy performance than non-certified buildings[4]. However, both certified as non-certified leases took mostly place in buildings with energy label A.

When examining location proxies, it seems that BREEAM-NL certified buildings are located more in central areas than their non-certified counterparts. BREEAM-NL certified buildings have more supermarkets, restaurants and sport facilities in their direct proximity than non-certified buildings. The distance and walk time to respectively train and subway stations are the only variables which are negatively correlated with the overall attractiveness of the property. Lower scores indicate a smaller distance to the amenities which indicate an increase in accessibility. Certified buildings are better accessible by train than their non-certified counterparts. Contradicting, non-certified office buildings are significantly closer by subway stations than BREEAM-NL certified offices with a walk time of 0.97 over 0.99 respectively.

The results show clearly that certified offices differ from non-certified offices and contain premium building characteristics. BREEAM-NL certified office buildings are larger, more occupied, newer, and more energy-efficient than non-certified office buildings. Additionally, BREEAM-NL certified office buildings are located at better accessible locations with higher levels of amenities. The regression analysis should clarify if the rent premium paid for BREEAM-NL certified office space is the result of these premium building characteristics or that the rent premium is the result of the BREEAM-NL certificate itself.

4; energy performance is coded as 1 = G, 2 = F, 3 = E, 4 = D, 5 = C, 6 = B, 7 = A, 8 = A+ - A+++.

4.2. Green premium

Certification premium

The regression models include continuous-, categorial-, and dummy variables. The regression coefficient for continuous variables indicates the change of the dependent variable by a change of 1 unit of measurement of the independent variable (Field, 2013). For categorial variables, such as energy label (A+++ to F), the regression coefficient indicates the average change over all categorial variables. The regression coefficient for the binary dummy variables indicates the change (increase or decrease) of the dependent variable by the presence (1) or absence (0) of the independent binary variable. BREEAM-NL certification, including the underlying certification levels, is an important dummy variable, which can either be present or absent in an office building. The regression coefficient of BREEAM-NL certification therefore indicates the rent premium per square meter office space if the building was BREEAM-NL certified at moment of lease. Another important dummy variable is renovation history, which is present (1) if the building is majorly refurbished after its completion. As said, only leases with a transaction date after certification date are considered as a certified lease. Although at first this seems the fairest, investors and building owners do anticipate on a future BREEAM-NL certification in their marketing campaign. Therefore, new constructed buildings with a planned BREEAM-NL assessment will probably be marketed with this certificate and the corresponding rent premium.

First, the existence of a green premium will be tested. Table 6 reports the result of the Ordinary Least Squares regression models on the natural logarithm of rent per square meter. Various models are specified to test the hypotheses of chapter 3. Table 6 column (1) – (3) assesses the rent premium of BREEAM-NL certification. Table 6 column (4) and (5) tests the locational factor and examines the differences across core cities, including Amsterdam, and more peripheral areas and table 6 column (6) and (7) examine the robustness of the results by testing the effect of major renovations and technological developments on the green premium.

Table 6: OLS regression on rental premium (source: author)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Green certification	**Location proxies**	**Property characteristics**	**G5 interaction factor**	**G5 submarkets**	**Excluding major renovations**	**Building Code**
BREEAM-NL certified	0.450***	0.234***	0.163***	0.160***	0.098***	0.113***	0.096***
	(0.023)	(0.016)	(0.015)	(0.015)	(0.012	(0.014)	(0.012)
Amsterdam				-0.125*			
				(0.064)			
The Hague				-0.071***			
				(0.027)			
Rotterdam				-0.084**			
				(0.040)			
Utrecht				-0.013			
				(0.027)			
Eindhoven				0.048**			
				(0.020)			
Year of transaction		YES	YES	YES	YES	YES	YES
2015 dummy							
2016 dummy		0.011	0.015	0.014	0.006	-0.002	0.013
		(0.017)	(0.016)	(0.016)	(0.013)	(0.013)	(0.013)
2017 dummy		0.052***	0.045***	0.046***	0.053***	0.049***	0.055***
		(0.015)	(0.014)	(0.014)	(0.011)	(0.012)	(0.011)
2018 dummy		0.105***	0.100***	0.101***	0.086***	0.081***	0.086***
		(0.014)	(0.013)	(0.013)	(0.011)	(0.011)	(0.011)
2019 dummy		0.125***	0.109***	0.110***	0.102***	0.093***	0.105***
		(0.015)	(0.014)	(0.014)	(0.011)	(0.012)	(0.011)
2020 dummy		0.146***	0.137***	0.137***	0.129***	0.123***	0.126***
		(0.016)	(0.015)	(0.015)	(0.012)	(0.013)	(0.012)
2021 dummy		0.207***	0.191***	0.190***	0.189***	0.179***	0.194***
		(0.017)	(0.016)	(0.016)	(0.013)	(0.013)	(0.013)
2022 dummy		0.180***	0.170***	0.171***	0.164***	0.148***	0.161***
		(0.020)	(0.019)	(0.019)	(0.015)	(0.016)	(0.015)
Number of restaurants		0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of sportfacilities		0.033***	0.028***	0.030***	0.001	0.000	0.001
		(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
Walktime to train station		0.000**	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Average housing price		0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of job opportunities		0.001***	0.001***	0.001***	0.001***	0.001***	
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	
Submarkets		NO	NO	NO	YES	YES	YES

Occupancy rate of moment of lease			0.070***	0.071***	0.019	0.020*	0.016
			(0.015)	(0.015)	(0.012)	(0.012)	(0.012)
Building size (log)			0.044***	0.044***	0.045***	0.046***	0.043***
			(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Property Grade			0.053***	0.052***	0.034***	0.032***	0.043***
			(0.005)	(0.005)	(0.005)	(0.005)	(0.004)
Energy label			0.007***	0.006***	0.005***	0.006***	0.004***
			(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Renovation dummy			0.104***	0.100***	0.113***		0.131***
			(0.016)	(0.017	(0.014)		(0.014)
Constant	5.077***	4.146***	3.595***	3.608***	3.716***	3.721***	3.735***
	(0.006)	(0.025)	(0.041)	(0.048)	(0.041)	(0.050)	(0.041)
R-squared	0.086	0.612	0.656	0.657	0.784	0.770	0.782
Adjusted R-squared	0.085	0.611	0.654	0.655	0.780	0.766	0.779
Number of observations	4,234	4,211	4,062	4,062	4,062	3,787	4,062

Note: The dependent variable is the natural logarithm of the transaction rent per square meter office space. Standard errors are shown in brackets. Significance at the 0.10, 0.05 and 0.01 levels are indicated by *, ** and *** respectively.

H1: *BREEAM-NL certified office buildings receive higher rents over non-certified office buildings.*

Consistent with the current literature body, the coefficient of the environmental certification dummy is positive and highly significant in all regression models. Table 6 column (1) presents the relationship between BREEAM-NL certification and rent without controlling for any important building characteristics and shows a significant positive coefficient of 0.455. This regression model corresponds to differences in figure 18 earlier, whereby the graph shows the differences between certified and non-certified rent levels.

Table 6 column (2) controls for important location proxies such as city size, amenities and accessibility. The estimated coefficient for BREEAM-NL certification reduces to 0.234 but is still highly significant at the 1% level. There is a positive relationship between transaction year, coded as dummy, and rent level which can be explained by the yearly inflation rate. Rent level is positively correlated with the number of restaurants and sport facilities in the proximity, showing a premium for buildings in more central areas with higher levels of amenities. The results show a significantly negative coefficient for walk time to train stations, suggesting higher prices for better accessible offices. The average house prices and the number of job opportunities are positively correlated with the rent level, showing higher rents in larger metropolitan areas.

Table 6 column (3) also accounts for important building characteristics such as age, size, and environmental performance and shows that larger buildings generally command higher rents than smaller buildings. The correlation between transaction year and rent level is consistent across the different regression models. The rent level is positively correlated with the building's occupancy rate at moment of lease. This shows that building owners often offer incentives and lower rent levels to first entrants. Empty buildings are more difficult to market and could result in higher vacancy levels in the long-term. Property Grade[5], which takes the building's age as quality indicator, is significantly positively correlated with the average rent per square meter. This means that newer buildings generally have higher rent levels than older, comparable buildings. Renovation history is also positively correlated, showing that refurbished offices generally hold higher rent levels than their non-refurbished comparable buildings. Renovations generally extent the (functional) lifespan and the technical and environmental performance of the building. Additionally, energy labels are both positively correlated with the rents, specifically showing that higher environmental performance pays off in higher office rents. Real estate investor A confirmed this premium by arguing that higher rent levels are justified if it can be compensated by the savings on their service costs (Real Estate investor, personal communication, October 14, 2022). Table 6 column (3) shows, after controlling for all abovementioned rent determinants, a positive and significant regression for BREEAM-NL certification of 0.163, supporting hypothesis 1. This regression coefficient shows on average a rent premium of 17.70% for BREEAM-NL certified offices over non-certified comparable buildings[6].

Although table 6 column (3) controls for important location proxies such as city size and employment, it does not take the qualitative attractiveness of the business climate into account. As said, the G5 accounts for 21% of the total Dutch office stock. The spatial concentration of offices brings many advantages for firms to locate in these areas. There are two types of agglomeration economies, defined as the productivity advantages accompanied with clusters of economic activities, which makes cities distinctive over other peripheral areas (McDonald & McMillen, 2011). Urbanisation economies describe the advantages which originate from the size of the local economy, such as good infrastructure and a wide range of goods, services and amenities. These distinctive factors cause an increase productivity over peripheral areas. Localisation economies describe the advantages that emerge from the size of the sector economy in a particular area. Examples of productivity advantages are knowledge spill-overs and labour pooling (McDonald & McMillen, 2011).

5; coded as >20 years = 1, 10 to 20 years = 2, 0 to 10 years = 3

6; as the dependent variable is the natural logarithm of rent per square meter, the rent premium can be calculated by the e-return of the regression coëfficient: e^[0.163] = 17.70%

The heterogeneity of real estate markets and the distinctive attractiveness of the G5 makes it impossible to break down the effect of BREEAM-NL certification to one single rent premium. The average rent levels in Amsterdam (€270) compared to the other cities (€165) already show the differences across the cities, not to mention the rural areas. To control for the urbanisation economies, model 4 includes a dummy variable for the G5 cities. Model 5 also controls for localisation economies and geographical differences across cities by including all submarkets of the G5 as dummy variables. Surprisingly, model 4 shows negative coefficients for all G5 dummies while one would expect significant rental premiums for offices located within the G5. However, this confirms the distinctive character of the underlying submarkets. The effect of abovementioned distinctive factors is highlighted by the increase in explanatory power from 65.5% to 78.0%. After controlling for the property's geographical location, the rental premium for BREEAM-NL certified leases is 10.30%[7] and validates the first hypothesis.

Table 6 column (6) excludes buildings which are completely refurbished and results in a dataset of 3,787 observations. BREEAM-NL assessments are often accompanied with major renovations and to test if the green premium is caused by the renovation rather than the BREAAM-NL certificate all renovated buildings should be excluded from the analysis. The potential price premium caused by the technical upgrade is hereby excluded and the rent premium will better represent the green premium associated with environmental certification alone. The estimated regression coefficient of BREEAM-NL certification increased from 0.098 to 0.113. The effect is still highly significant and shows the robustness of the results.

Table 6 column (7) tests the effect of the Building Code on rent level. Over the years, the building sector underwent major technical developments. The technical and functional quality of the building largely depends on the regulations at time of construction. The first national Building Code in the Netherlands took effect in 1992. Since then, the Building Code was renewed twice in 2003 and 2012. The latter contains still the applicable building rules. Property Grade, indicating the overall quality of the building, is initially based on building age. However, the applicable Building Code could be a better measurement for the overall quality of the building. The change of R2 is nihil compared to the column (5), which measures the building's quality based on 10 – year groups. However, the estimated regression coefficient of BREEAM-NL certification slightly decreased to 0.096, which means that the Building Code periods better capture the technical and environmental performance than Building Age which would otherwise be designated to a BREEAM-NL certification.

Table 7 tests the differences across cities and splits the sample in the largest five office markets in the Netherlands. Table 7 column (1) – (5) depict the results for the separate model specifications and shows a significant rental premium for BREEAM-NL certification of 12.64%[8] in The Hague, 5.13%[9] in Rotterdam and 6.50%[10] in Utrecht. The differences among cities can be explained by local rent ceilings. Certain areas have a rent ceiling which sometimes hampers the possibility for rental premiums in the area (real estate investor B, personal communication, August 17, 2022). Rental premiums in Amsterdam and Eindhoven are not significantly different from zero. The estimated coefficients for transaction year show clearly the significant rent increases in Amsterdam compared to the rest of the G5. The insignificance in Eindhoven might be explained by the limited number of observations: 14 certified leases clustered in 6 certified buildings whereby one building is responsible for 7 certified leases (50%). The insignificance in Amsterdam might be explained by several factors. The municipality of Amsterdam hold already stricter rules regarding building performance, and therefore the market standard is generally more energy-efficient than in other cities (Gemeente Amsterdam, n.d.). Also, locating in the capital city might be the most important factor to locate in Amsterdam

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7; e^[0.098] = 10.30% average rental premium
8; e^[0.119] = 12.64% in The Hague
9; e^[0.050] = 5.13% in Rotterdam
10; e^[0.063] = 6.50% in Utrecht

Lastly, the *bias-variance trade*-off might affect the insignificance in the results. The *bias-variance trade-off* suggests that a model should balance between *underfitting* and *overfitting* the data. The bias term can be defined as the difference between the true mean and the estimated mean of the model and the variance term is the spread of the data (Hastie, et al., 2017). *Overfitting* is the phenomenon that a model fits the given dataset too closely, limiting the generalizability to other data, resulting in low bias and high variance. This is often the case if a model is equipped with too many parameters. *Underfitting* is the phenomenon that a model, often with very few parameters, fits the given dataset poorly and therefore not able to identify underlying patterns, resulting in high bias and low variance (Briscoe & Feldman, 2011). When table 7 column (1) would be simplified by excluding inner-city submarkets, BREEAM-NL certified buildings would receive a significant rental premium in Amsterdam. However, the inner-city submarkets are of such importance for predicting rent levels, indicated by the increase in explanatory power from in table 6 from 65.5% to 77.9%, that the effect of environmental certification would be overestimated when one would ignore this parameter.

To conclude, the results show that BREEAM-NL certified offices receive higher rents than non-certified office buildings and enjoy a rental premium of 10.30%. The results show that the green premium differs across cities and varies between 5.13% - 12.64% in the G5. The strength of the coefficient is similar to the rental premiums documented in the studies of Wiley, Benefield & Johnson (2010), Devine & Kok (2015) and Hui, Chan & Yu (2015).

Assumption testing

The final model, table 6 column (5), will be tested against the assumptions of a multiple regression. A multiple regression holds five assumptions: linearity, homoskedasticity, normality, independent errors, and no multicollinearity (Field, 2013). All graphs used for the assumption testing can be found in the appendices. The dependent variable, rent per square meter, should be normally distributed. The dependent variable is transformed to the natural logarithm of the rent per square meter for the purpose of normality. The skewness of the rent was found to be 0.385, showing a slightly right-skewed distribution. The kurtosis of the natural logarithm of the rent was found to be 0.2, showing a more heavy-tailed distribution.

The assumption of linearity assumes that the dependent variable has a linear relationship with the independent variables. Partial regression plots are created to assess the relationship between the rent level and each independent variable. To test homoskedasticity, the standardized residuals are plotted against the predicted residuals in a scatterplot. The scatterplot shows graphical evidence on homoskedasticity as the standardized residuals are clustered around 0 and equally distributed. The error does not increase by increasing values of predicted values and therefore does not show any sign of heteroskedasticity. Additionally, a multiple regression assumes independent errors with no correlation between residuals (Field, 2013). The assumption of independent errors can be tested by several means. The Durbin-Watson tests the correlation between errors and can vary between scores 0 and 4. A score of 2 means that there is no correlation between residuals and that the errors are independent. According to Field (2013), Durbin-Watson scores less than 1 and greater than 1 indicate violation of independent errors. The model specification indicate a Durbin-Watson score of 0.055 which would indicate potential correlation. However, the scatterplot show that the residuals do not show any sign of serial correlation. To detect potential multicollinearity, VIF scores of every independent variable are assessed. A VIF score below 5 is preferable and indicates no potential multi-collinearity. A VIF score between 5 – 10 indicate potential multicollinearity. VIF scores above 10 should be avoided. Tests for multicollinearity indicated that the dataset did not show any signs of multicollinearity. House prices did have a VIF score of 6, but after assessing the intercorrelation of the average housing price, no correlation is above 0.60 and the correlation has no logical explanation. The assumptions of normality of errors, or multivariate normality, can be tested by looking at the histogram and normal probability plot. This histogram shows that the standardised residuals showed are normally distributed and the normal probability plot shows the points are closely following the linear line without substantial deviation. As the data falls more or less on the linear line, it can be assumed that data is normally distributed.

Table 7: OLS regression on rental premium in G5 (source: author)

	(1)	(2)	(3)	(4)	(5)
	Amsterdam	**The Hague**	**Rotterdam**	**Utrecht**	**Eindhoven**
BREEAM-NL certified	0.009	0.119***	0.050*	0.063**	-0.073
	(0.018)	(0.046)	(0.026)	(0.030)	(0.065)
Year of transaction	YES	YES	YES	YES	YES
2016 dummy	0.031	0.009	0.032	0.044	0.034
	(0.020)	(0.042)	(0.036)	(0.027)	(0.053)
2017 dummy	0.074***	0.048	0.032	0.082***	0.038
	(0.018)	(0.038)	(0.032)	(0.026)	(0.046)
2018 dummy	0.132***	0.014	0.037	0.130***	0.034
	(0.018)	(0.037)	(0.030)	(0.036)	(0.045)
2019 dummy	0.204***	0.013	0.066**	0.128***	0.113**
	(0.018)	(0.037)	(0.032)	(0.025)	(0.047)
2020 dummy	0.217***	0.120***	0.114***	0.165***	0.108**
	(0.020)	(0.044)	(0.034)	(0.028)	(0.054)
2021 dummy	0.309***	0.052	0.117***	0.136***	0.241***
	(0.020)	(0.049)	(0.038)	(0.033)	(0.058)
2022 dummy	0.310***	0.053	0.087*	0.182***	0.147**
	(0.022)	(0.068)	(0.046)	(0.040)	(0.063)
Number of restaurants	0.001***	0.000	0.001***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of sportfacilities	0.017***	0.004	0.001	0.004	-0.020*
	(0.004)	(0.007)	(0.006)	(0.006)	(0.011)
Walktime to train station	-0.210***	-0.005***	0.000	-0.002**	-0.003**
	(0.042)	(0.001)	(0.001)	(0.001)	(0.001)
Submarkets	YES	YES	YES	YES	YES
Occupancy rate of moment of lease	0.035	0.022	0.063**	-0.048*	-0.027
	(0.024)	(0.035)	(0.028)	(0.028)	(0.048)
Building size (log)	0.041***	0.018*	0.027***	0.035***	0.016
	(0.006)	(0.011)	(0.009)	(0.009)	(0.016)
Property Grade by Bullding Code	0.009	0.036**	0.062***	0.066***	0.087***
	(0.006)	(0.016)	(0.011)	(0.009)	(0.016)
Energy label	0.010***	-0.005	0.005	-0.003	0.006
	(0.003)	(0.005)	(0.005)	(0.005)	(0.008)
Renovation dummy	0.123***	0.109	0.138***	0.126*	
	(0.017)	(0.070)	(0.027)	(0.076)	
Constant	4.927***	4.581***	4.509***	4.604***	4.471***
	(0.071)	(0.115)	(0.088)	(0.081)	(0.131)
R-squared	0.792	0.584	0.579	0.650	0.495
Adjusted R-squared	0.787	0.556	0.551	0.630	0.445
Number of observations	1,224	383	379	416	232

Note: The dependent variable is the natural logarithm of the transaction rent per square meter office space. Standard errors are shown in brackets. Significance at the 0.10, 0.05 and 0.01 levels are indicated by *, ** and *** respectively.

Label score

H2: Price premiums associated with environmental certification is positively correlated with the label score

Table 8 column (1) – (5) test hypothesis 2 and examines if the green premium paid for BREEAM-NL certified offices is positively correlated with label scores. A simple bivariate correlation analysis shows that rent level is highly correlated with the BREEAM score (0-100), r (4,243) = 0.313, p < 001. Each model specification compares one single BREEAM-NL label against the non-certified stock.

Table 8: OLS regression on rental premium by label score (source: author)

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	Green certification (Pass)	**Green certification (Good)**	**Green certification (Very Good)**	**Green certification (Excellent)**	**Green certification (Outstanding)**
BREEAM-NL certified					
BREEAM-NL Pass	0.048				
	(0.051)				
BREEAM-NL Good		0.097***			
		(0.021)			
BREEAM-NL Very Good			0.060***		
			(0.021)		
BREEAM-NL Excellent				0.134***	
				(0.021)	
BREEAM-NL Outstanding					0.021
					(0.054)
Year of transaction	YES	YES	YES	YES	YES
2016 dummy	0.003	0.000	0.003	0.016	0.003
	(0.015)	(0.013)	(0.013)	(0.005)	(0.013)
2017 dummy	0.050***	0.049***	0.051***	0.049***	0.050***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
2018 dummy	0.085***	0.083***	0.086***	0.085***	0.085***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
2019 dummy	0.100***	0.096***	0.102***	0.102***	0.101***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
2020 dummy	0.135***	0.126***	0.133***	0.134***	0.135***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
2021 dummy	0.1205***	0.195***	0.203***	0.203***	0.207***
	(0.014)	(0.014)	(0.013)	(0.014)	(0.014)
2022 dummy	0.168***	0.157***	0.176***	0.171***	0.167***
	(0.017)	(0.016)	(0.016)	(0.017)	(0.017)

Number of restaurants	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of sportfacilities	0.000	0.001	0.000	-0.001	-0.001
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
Walktime to train station	-0.001***	-0.001**	-0.001**	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Average housing price	0.002***	0.002***	0.002***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of job opportunities	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Submarkets	YES	YES	YES	YES	YES
Occupancy rate of moment of lease	0.023*	0.022*	0.024*	0.023**	0.024**
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Building size (log)	0.040***	0.044***	0.041***	0.041***	0.040***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Property Grade	0.035***	0.034***	0.033***	0.036***	0.035***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Energy label	0.006***	0.005***	0.006***	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Renovation dummy	0.133***	0.132***	0.121***	0.124***	0.137***
	(0.016)	(0.015)	(0.015)	(0.015)	(0.015)
Constant	3.775***	3.728***	3.767***	3.764***	3.776***
	(0.043)	(0.042)	(0.042)	(0.042)	(0.043)
R-squared	0.760	0.763	0.772	0.771	0.761
Adjusted R-squared	0.756	0.759	0.769	0.767	0.757
Number of observations	3,761	3,840	3,843	3,843	3,759

Note: The dependent variable is the natural logarithm of the transaction rent per square meter office space. Standard errors are shown in brackets. Significance at the 0.10, 0.05 and 0.01 levels are indicated by *, ** and *** respectively.

Table 8 column (1) show that buildings certified with a BREEAM-NL Pass label do not command higher rent levels than non-certified buildings. This can be explained by the fact that existing real estate overall are able to score Good when owners decide to certify their offices (BREEAM-NL In-Use Expert, personal communication, September 30, 2022) and already comply with the market standard.

Table 8 column (9) – (11) show that BREEAM-NL labels Good, Very Good, and Excellent generate a rental premium of respectively 10.19%, 6.18% and 14.34%. Surprisingly, Very Good labelled office buildings hold lower rent levels than Good labelled office buildings. Again, this might be explained by the *bias-variance trade-off*. When the model would exclude inner-city submarkets, the labels do show a consistent significantly positive relationship across all BREEAM-NL labels. Additionally, the dip in the results might be explained by the novelty of the label and therefore the relative small number of certified buildings in the entire set. Nevertheless, the result do show that upper labels, BREEAM-NL Excellent, do command an additional premium over lower labels.

Table 8 column (12) depicts the results for BREEAM-NL Outstanding certified buildings and do not show a significant rent premium. This might be the result of a low number of observations with an Outstanding label (N = 13) clustered in a few buildings (N = 5).

Due to the low number of observations, it was not possible to distinguish the rent premiums per city. The results therefore only indicate the general relationship between label score and rent level across the entire dataset. Figure 20 visualizes the relationship between the numeric BREEAM-NL score and the rent level. Based on the entire sample, there is a Pearson correlation of $r(4,243) = 0.3134$, $p < 0.001$. Most of the points in the upper half of the graph are located in Amsterdam. If we distinguish between Amsterdam and the rest of the Netherlands, we can identify a Pearson correlation between BREEAM-NL score and rent of $r(2,999) = 0.346$, $p < 0.001$ if we exclude Amsterdam, and, $r(1,244) = 0.370$, $p < 0.001$ in solely Amsterdam.

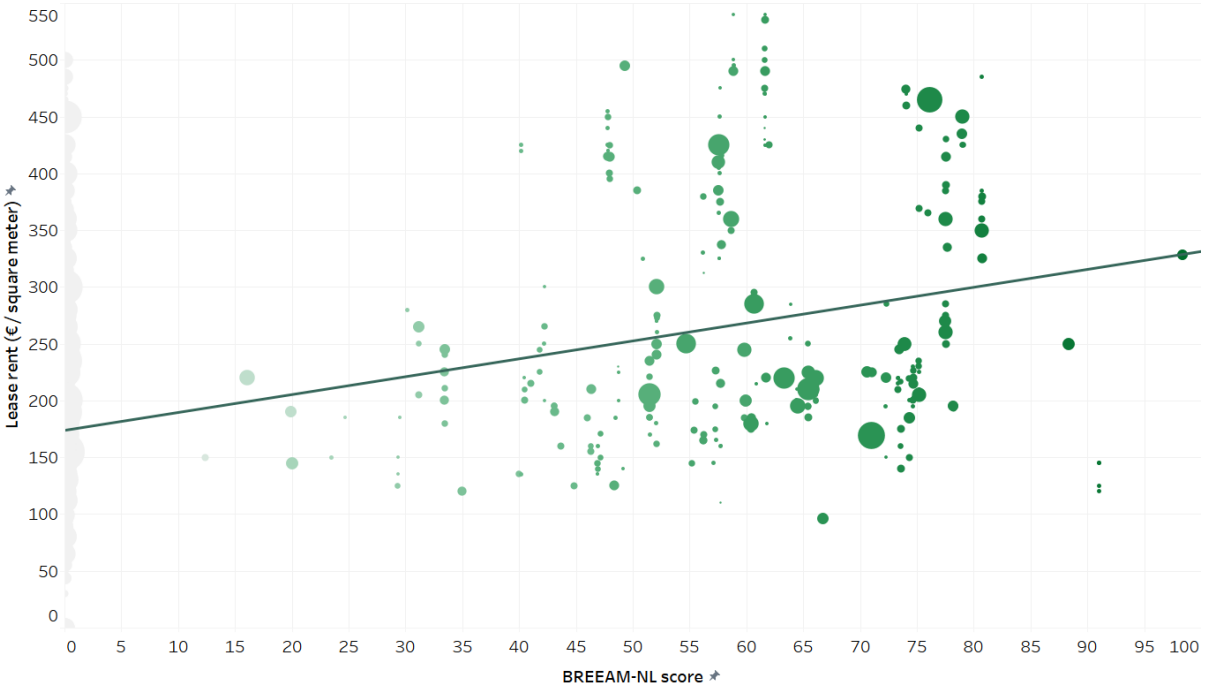


Figure 20: Relationship between label score and rent (source: author)

11; e^[0.097] = 10.19% for BREEAM-NL Good
12; e^[0.060] = 6.18% for BREEAM-NL Very Good
13; e^[0.134] = 14.34% for BREEAM-NL Excellent

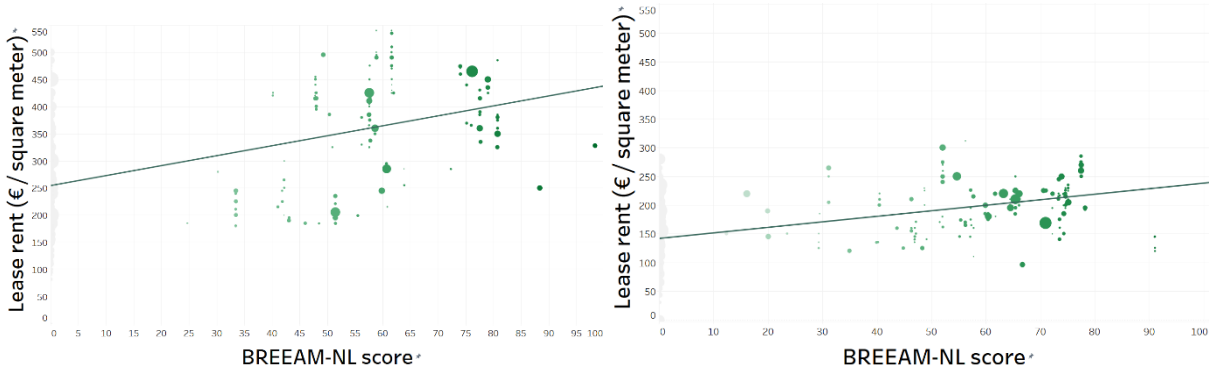


Figure 21: Relationship between label score and rent (a) Amsterdam only, (b) the Netherlands, excluding Amsterdam (source: author)

To conclude, the price premium associated with environmental certification is positively correlated with the label score: higher BREEAM-NL scores result generally in higher rent levels. BREEAM-NL labels Good, Very Good and Excellent command rent premia of respectively 10.19%, 6.18% and 14.34%. The positive trend in the rent premiums can have multiple drivers. It can be concluded that tenants value BREEAM-NL certified offices more than the brand alone. Tenants could value the intangible benefits of the improved indoor climate and enjoy higher productivity and satisfaction rates. As real estate investor A argued that some sectors (e.g., business services) can rationalize more easily that they need green buildings due to this increased productivity. Another explanation can be that the tenants value the energy savings accompanied with high-scoring BREEAM-NL assets. BREEAM-NL In-Use also values the actual energy consumption additional to the building's calculated energy performance. Energy-, electricity- and water consumption are examples of BREEAM-NL credits whereby a high score can lead to significant reductions in service costs. Tenants may also value the improved public image accompanied by green buildings: occupying the most sustainable building in the capital city can positively contribute to the war for talent (real estate investor A, personal communication, October 14, 2022).

Intersectoral differences

Lastly, hypothesis three tests if green premiums are likely to be higher in sectors which are more sensitive to the intangible benefits of green buildings[14]. Twelve different sectors are distinguished in this thesis: Business Services, Education, Energy & Utilities, Finance, Health & Social Care, Hospitality & Leisure, Life Sciences, Manufacturing, Public & Non-Profit, Retail & Distribution, Technology & Media, Transportation, Others. Table 9 shows the distribution of leased certified area per industry.

H3: Price premiums associated with environmental certification is likely to be higher in environmental-harmful and labour-intensive sectors

Table 9: Leased certified area by industry (source: author)

	(1)	(2)	(4)	(5)
Industry	**Certified office space**	**Share of total certified office space**	**Total leased floor area**	**Certified floor area as share of total leased floor area**
Business Services	154.698	28%	2.033.026	8%
Education	11.423	2%	239.406	5%
Energy & Utilities	37.354	7%	289.645	13%
Finance	54.240	10%	702.794	8%
Health & Social Care	19.554	4%	413.614	5%
Hospitality & Leisure	1.957	0%	92.136	2%
Life Sciences	19.826	4%	122.501	16%
Manufacturing	14.206	3%	426.612	3%
Public & Non-Profit	28.160	5%	906.411	3%
Retail & Distribution	59.977	11%	416.014	14%
Technology & Media	90.975	17%	1.334.858	7%
Transportation	25.921	5%	187.376	14%
Others	32.864	6%	146.346	22%
Total	**551.156**	**100%**	**7.310.738**	

A regression analysis should clarify if certain industries, e.g. public and environmentally harmful businesses, are willing to pay a premium for these intangible benefits. Table 9 column (1) builds on previous models and tests the effect of type of industry on the willingness to pay for green buildings. For this model specification, only certified leases (N = 323) are considered to solely isolate the WTP for green buildings. However, the model can be disturbed by certain industries who primarily focus on upper labels. Therefore, table 9 column (2) – (4) assesses respectively BREEAM-NL Good, Very Good and Excellent separately to isolate the WTP for a certain label. Due to low number of observations, only the abovementioned three labels will be assessed. Only green premium significant at the 0.05 level will be discussed.

14; increased productivity, well-being, corporate social responsibility and public image.

Table 10: OLS regression on willingness to pay by industry (source: author)

	(1)	(2)	(3)	(4)
	WTP for Green Certification	**WTP for BREEAM-NL Good**	**WTP for BREEAM-NL Very Good**	**WRP for BREEAM-NL Excellent**
Year of transaction	YES	YES	YES	YES
Submarkets	YES	YES	YES	YES
Location proxies	YES	YES	YES	YES
Property characteristics	YES	YES	YES	YES
Sector				
Business Services	0.098**	0.001	0.198**	-0.011
	(0.046)	(0.063)	(0.097)	(0.059)
Education	0.108	0.019	0.283*	-0.162
	(0.071)	(0.128)	(0.146)	(0.100)
Energy & Utilities	0.130***	0.109	0.297***	-0.037
	(0.050)	(0.100)	(0.112)	(0.064)
Finance	0.118**	0.001	0.239**	-0.019
	(0.043)	(0.065)	(0.109)	(0.061)
Health & Social Care	0.028	-0.092	0.291*	-0.021
	(0.059)	(0.082)	(0.156)	(0.094)
Hospitality & Leisure	-0.221**		-0.246	-0.219**
	(0.098)		(0.170)	(0.093)
Life Sciences	0.065	-0.190		-0.380***
	(0.065)	(0.120)		(0.094)
Manufacturing	0.164***	0.068	0.179	0.043
	(0.056)	(0.127)	(0.119)	(0.079)
Public & Non-Profit	-0.006	-0.175	0.101	-0.021
	(0.063)	0.136	(0.115)	(0.094)
Retail & Distribution	0.148***	0.084	0.322***	0.016
	(0.045)	(0.068)	(0.104)	(0.064)
Technology & Media	0.091**	0.022	0.223**	-0.051
	(0.042)	(0.063)	(0.104)	(0.059)
Transportation	0.139**	0.061	0.346*	0.000
	(0.054)	(0.076)	(0.192)	(0.073)
Constant	3.115***	4.810***	5.234***	5.644***
	(0.253)	(0.432)	(0.885)	(0.252)
R-squared	0.914	0.959	0.938	0.971
Adjusted R-squared	0.897	0.936	0.898	0.956
Number of observations	323	96	98	97

Note: The dependent variable is the natural logarithm of the transaction rent per square meter office space. Standard errors are shown in brackets. Significance at the 0.10, 0.05 and 0.01 levels are indicated by *, ** and *** respectively.

Table 9 column (2) tests the effect of type of industry on the WTP for green certification in general. The industries Finance and Business Services are characterized by labour-intensive companies which highly rely on their workforce. The results show that companies in these two industries are willing to pay an additional premium for BREEAM-NL certified offices of respectively 13% and 10%. Eichholtz et al. (2009) suggested that (space-intensive) firms in the tertiary sector can take significant advantages of the energy savings in green buildings. Due to the large workforce, the increased employee productivity and satisfaction can play a substantial role for these organisations as well and therefore explains the increased willingness to pay of these organisations. The results show that companies within the Energy & Utilities sector generally are willing to pay an additional green premium of 14% for BREEAM-NL certified buildings. Companies within the Energy & Utilities sectors are often more exposed to environmentally harmful operations and the improved public image of green buildings can be used for marketing purposes to disguise the negative character. The results show that the transportation and manufacturing sector generally values green buildings higher than other sectors and are willing to pay additional premia for BREEAM-NL certified buildings of respectively 18% and 15% on average. An analysis of the lease transactions showed that the transportation industry includes many of the world's biggest logistical companies and, similar to the Energy & Utilities sector, they might use green buildings to counteract the negative character of the industry. According to real estate investor A, housing costs are generally responsible for only a small portion of the total P&L of large organisations. Therefore, they can rationalize very easily why occupying green buildings can be very strategically. Surprisingly, the results do not show an increased willingness to pay for green buildings from the Public & Non-Profit sector. Despite the government's strategy to only lease sustainable office buildings (Ministry of the Interior and Kingdom Relations, n.d.), the results do not show an additional premium for environmentally certified offices. It can be the result of low number of observations (N = 9). An analysis of the lease transactions within this sector showed that more than 20% of the tenants are non-profit foundations[15]. Another explanation can be that foundations generally have little budget for housing costs and occupying environmentally certified buildings might cause unnecessary additional expenses. The results show an increased willingness to pay for BREEAM-NL certified buildings for the Retail & Distribution and Technology & Media sector. Although the additional premium cannot be explained by the nature of the organisations, it can be caused by the accountability to their investors and shareholders. Additionally, the dataset concerns office lease transactions. Tenants in abovementioned sectors need office space for their headquarters. In these cases, similar benefits as for the Business Services and Finance sector apply.

Table 9 column (2) – (4) controls for label scores and assesses the labels separately. Table 9 column (2) present the results for BREEAM-NL Good, and, after controlling for important location and building characteristics, the type of industry does not have a significant effect on the rental premium. Table 9 column (3) presents the results for BREEAM-NL Very Good. Business Services, Energy & Utilities, Finance, Retail & Distribution and Technology & Media show a significantly positive premium for a Very Good label. The former three can be explained by the abovementioned, intangible, benefits of green buildings. Table 9 column (4) present the results for BREEAM-NL Excellent, and, after controlling for important rent determinants, no industry show a significantly increased WTP for an Excellent label. Surprisingly, Hospitality & Leisure and Life Sciences show a significantly reduced WTP for a BREEAM-NL Excellent labelled office building. Hospitality & Leisure and Life Sciences have respectively only one and three observations in Excellent certified leases, and therefore the results do not provide compelling evidence.

To conclude, green premiums associated with environmental certification is suggested to be higher in sectors which are more sensitive to the intangible benefits of green buildings. The results show consistently premia for the Energy & Utilities sector who could use green buildings to disguise their environmentally harmful operations. Firms in the Finance and Business Services industry are willing to pay more for green buildings due to their dependency on their workforce. Both are in line with hypothesis three. Tenants within the Retail & Distribution and Technology & Media sector are shown to have an additional willingness to pay for green buildings as well. The results relate to large office transactions within these industries, whereby the same benefits apply as for labour-intensive industries.

15; Based on search for 'stichting' included in tenants' business name, exact number might be significantly higher.

4.3. Occupancy premium

In the green premium analysis, every case represented a single lease transaction. Here, one building could contain multiple lease transactions which were included in the multiple regression analysis. In the analysis of occupancy premiums, every case represents one single building. Vacancy levels and occupancy rates are measured on building level and it represents the share of the building that is occupied by a firm (occupier). The initial dataset contained absolute vacancy levels for more than 20,000 office buildings in the Netherlands. Using building size, the corresponding occupancy rate is computed. After consulting the database administrator, the scope of the analysis was limited to the G5, their direct surroundings, and other larger office markets such as Haarlemmermeer, Delft, Zwolle, Groningen, Tilburg and 's Hertogenbosch. This resulted in a dataset with 8,335 individual buildings.

The dataset of the Dutch Green Building Council with all valid BREEAM-NL certified buildings contains only certificates from 2019 onwards due to the validity period of 3 years for BREEAM-NL In-Use certificates. In the absence of the first certification date, the analysis of occupancy premiums is limited to the last 3 years.

H4: BREEAM-NL certified office buildings enjoy higher occupancy rates over non-certified office buildings.

Table 11 shows the average occupancy rates of non-certified and certified offices in the dataset and the results of the independent t-test for equality of means between non-certified and BREEAM-NL certified buildings. For the analysis, every six months is assessed separately. In 2020, BREEAM-NL certified offices were generally more occupied than non-certified offices. In 2021 and 2022, non-certified offices were more occupied than the certified stock. The t-test shows that the differences in occupancy rate were only significantly different from zero in 2020 H1, 2021 H2 and 2022 H1. The varying results of the independent t-test do not show compelling evidence that BREEAM-NL certified offices enjoy higher occupancy rates than non-certified offices.

Table 11: Independent t-test for equality of means – occupancy rate BREEAM-NL certification (source: author)

	Levene's Test			**Significance**				
	F	**sig**	**t**	**One-Sided p**	**Two-Sided P**	**Group**	**Group mean**	**Mean difference**
Mean occupancy rate 2020 H1	14.000	0.001	-2.384	0.009	0.018	Non-certified	0.9457	
						Certified	0.9607	0.01502
Mean occupancy rate 2020 H2	4.850	0.028	-0.440	0.330	0.660	Non-certified	0.9429	
						Certified	0.9463	0.00334
Mean occupancy rate 2021 H1	0.530	0.466	0.718	0.236	0.473	Non-certified	0.9421	
						Certified	0.9344	-0.00770
Mean occupancy rate 2021 H2	0.714	0.398	1.999	0.023	0.046	Non-certified	0.9468	
						Certified	0.9264	-0.02035
Mean occupancy rate 2022 H1	4.860	0.028	3.106	0.001	0.002	Non-certified	0.9525	
						Certified	0.9255	-0.02702

The difference in occupancy rates can be explained by several factors. First, a BREEAM-NL assessment is often accompanied with a major refurbishment. Practice shows that building owners always aim for one BREEAM-NL level higher than the initial quick-scans shows. This proves to be a feasible and cost-efficient step to score higher on BREEAM-NL (BREEAM-NL In-Use Expert). Often the building should be vacant to start a major refurbishment, especially when the façade is also part of the renovation. This required vacancy is also perceived as a major barrier towards sustainable building renovations (real estate investor A, personal communication, October 14, 2022). The renovation results in higher vacancy levels during and directly after the renovation (and certification). Secondly, in 2021 and 2022 almost 30 new BREEAM-NL certified offices were delivered. If we examine the take-up volume over the years, we can see a dip in the take-up volume of 2021 due to the COVID pandemic. In 2022, the take-up slightly increased but is still recovering. In combination with the historically low vacancy levels, many newly constructed, certified buildings came vacant on the market. Thirdly, as explained in chapter two, landlords might foster some level of vacancy to prepare it for future tenants (frictional vacancy) or to wait for better market conditions (such as higher rent levels). Frictional vacancy does not necessarily lead to lower rent levels. As the independent t-test also considers frictional vacancy, it could therefore cause some statistical error in the analysis.

The insignificance of the results might be the result of the dataset or the novelty of BREEAM-NL itself. As said, the dataset only contains data from 2019 onwards and is therefore not able to make a comparison over a longer period of time. Additionally, the studied timeframe faced great uncertainty due to the COVID-19 pandemic and geopolitical issues. To test the effect of the novelty of the label, an independent t-test is conducted between green (A-C) and red (D-F) energy labels. The results are presented in table 12. Office buildings with a red energy label have significantly higher occupancy rates for every timeframe. This is surprisingly as from 2023 every office building must be labelled with energy label C or higher.

Table 12: Independent t-test for equality of means – occupancy rate energy label (source: author)

	Levene's Test			**Significance**				
	F	**sig**	**t**	**One-Sided p**	**Two-Sided P**	**Group**	**Group mean**	**Mean difference**
Mean occupancy rate 2020 H1	30.093	0.001	3.643	0.001	0.001	Red label	0.9523	
						Green label	0.9326	-0.01973
Mean occupancy rate 2020 H2	29.128	0.001	3.769	0.001	0.001	Red label	0.9490	
						Green label	0.9282	-0.02082
Mean occupancy rate 2021 H1	45.141	0.001	4.726	0.001	0.001	Red label	0.9506	
						Green label	0.9237	-0.02698
Mean occupancy rate 2021 H2	30.521	0.001	3.745	0.001	0.001	Red label	0.9518	
						Green label	0.9291	-0.02267
Mean occupancy rate 2022 H1	44.071	0.001	4.299	0.001	0.001	Red label	0.9588	
						Green label	0.9343	-0.02447

A second analysis assessed the effect of a BREEAM-NL certification by comparing the average occupancy rate before and after the certification date. For every building, the average occupancy rate of the year prior to the certification is compared to the average occupancy rate one year after certification. A visualization of the analysis is depicted in figure 22 below. By analysing every building separately, no control variables are needed.

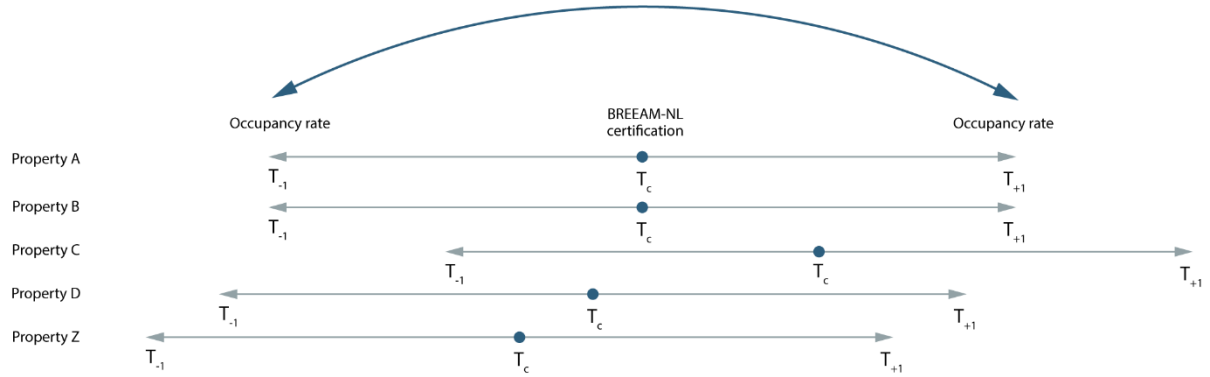


Figure 22: Concept of occupancy rate analysis on comparable basis (source: author)

Table 13: Sample of occupancy rate analysis (source: author)

T_{-Q4}	T_{-Q3}	T_{-Q2}	T_{-Q1}	T_0	T_{Q1}	T_{Q2}	T_{Q3}	T_{Q4}
100%	100%	78%	78%	78%	76%	76%	--	--
100%	100%	100%	100%	100%	100%	100%	100%	100%
90%	90%	95%	93%	93%	98%	100%	--	--

A sample of the comparable analysis is depicted in table 13 and the entire model is available upon request. Due to the high number of certifications issued in 2021 and 2022, it was not always possible to compute the average occupancy rate over period T_{+1} (see table 13). The first analysis ignored missing values and computed the average occupancy rate over the available quarters. The comparable analysis shows a decline in occupancy rate of 1 percentage point in relation to the yearly occupancy rate before certification. Model 2 excluded buildings which are certified after Q2 2021 and which do not have data available on the occupancy rate over the entire year after certification. This comparable analysis shows that on average the occupancy rate neither declines nor increases.

Finally, a multiple regression analysis on occupancy rate is conducted. The abovementioned timeframes have been used as dependent variable, resulting in 5 different models testing the effect of BREEAM-NL certification on occupancy rate. The adjusted R2 score did not exceed 0.080 and did not have high explanatory power. The regression coefficient of BREEAM-NL certified dummy variable was only significant at 2020 H1 and indicates an increase of +0.04 (4%) occupancy rate. However, with an adjusted R2 score of 0.048 it does not provide compelling evidence of the existence of occupancy premium.

Concluding, the analysis do not show compelling evidence on the existence of occupancy premiums for BREEAM-NL certified buildings in the Dutch office market. As said, the analysis does include frictional vacancy and therefore lower occupancy rates does not necessarily have to lead to lower rent levels or a decreased market value.

4.4. Circle of blame

Occupier's perspective

RICS (2008) concluded that investors are willing to invest in sustainable buildings as long as there is also demand from the end users. A more recent report of RICS (2022) surveyed more than 4,000 professionals on important sustainability topics in the construction and real estate sector. Approximately 75% of the European respondents perceived an increase in occupier demand for green and environmentally friendly buildings in the last twelve months. More than 20% thinks the occupier demand has significantly risen. To test the applicability in the Dutch office market, two interviews with transaction managers and two interviews with real estate investors were conducted. All interviewees are active in the playing field between end-users (tenants) and investors (owners). According to RICS (2009), incentives for sustainable buildings are misaligned between the occupiers, those who occupy the building, and the owner, those who invest in the building. Therefore, different actors were asked the same questions to examine the Vicious Circle of Blame within the dynamics of the Dutch office market.

The RICS study (2008) pointed out multiple reasons for tenants to occupy green buildings rather than conventional comparable buildings such as improved well-being and productivity but also more tangible benefits such as lower operating costs, lower vacancy risks and stable returns. Eichholtz et al. (2009) concluded similar benefits of green buildings and marked public image and corporate social responsibility as main advantages of green buildings from owner-perspective. The interviews with transaction managers showed that green buildings command varying advantages for their clients, from which the alignment with internal strategies is the most prominent present. A transaction manager in the greater region Amsterdam (A) emphasized that the office is a resource which can help to execute and align larger corporate strategies, in general and in sustainability strategies specific. The transaction manager in the greater region Eindhoven (B) mentioned that the benefits mainly serve the ambitions the organizations have, both on sustainability and larger, societal ambitions. Although the advantages seem present in the Dutch real estate market, it differs largely across organisations. Transaction manager A pointed out that *''there are organizations with an intrinsic motivation and organizations which only use green buildings for marketing purposes''*. Both transaction managers confirmed the more intangible benefits as concluded by Eichholtz et al. (2009). One of them pointed out that *''continuous refreshment of air contributes to the employee's productivity*'' and that, especially with the new generation, *''green buildings help to attract and retain talent*''. The other one confirmed the role of green buildings in the war for talent and said that *''conventional buildings are less appealing than offices which are known as sustainable''*. In terms of health and well-being, he also confirmed that green buildings contribute to employees' productivity.

> *'Especially with the new generation, green buildings help to attract and retain talent'' – Transaction Manager A*

The investor's point of view in the Vicious Circle of Blame suggests that there is no demand from (owner)occupiers for green buildings. Meanwhile, the end-users blame developers and investors for too little supply of green buildings. Interviews with tenant representatives show that sustainability and ESG is increasingly included in client's demands. The former is internally-focused and focuses on how the organisation impacts the world, the latter is externally-focused and focuses on how the world impacts the organisation. According to transaction manager B, larger, international organisations (e.g., Philips and Deloitte) have integrated sustainability strictly in their annual reports and real estate strategy more often. Also, smaller organisations have developed the awareness for sustainability and environment. Transaction Manager B also argued that there is decreasing *appetite* for buildings which do not comply with sustainability and ESG requirements, which would confirm the increased demand for green buildings. The company size highly influences the demand for green buildings. Investor B distinguishes small, mid-sized and corporate tenants, mainly driven by the EU directives. The former NFRD was eligible for public entities

with more than 500 employees. The new CSRD is required for small-, and mid-sized companies with more than 250 employees and/if more than 40-million-euro turnover and/or 20-million-euro worth of total assets (European Committee, 2021). Among corporates, sustainability, and green buildings, is a hot topic for varying reasons. The Corporate Sustainability Reporting Directive demand larger organisations to publicly report on their sustainability issues. Additionally, larger and listed companies need to publish yearly sustainability reports. These requirements contribute to the awareness of climate change and sustainability performance. Large business services are also more sensitive to the advantages of occupying green buildings and can therefore better rationalize the choice to pay incremental rent for green buildings. Mid-sized companies have integrated sustainability to a lesser extent. However, investor B experiences an increasing awareness among these companies due to the recent energy crisis. For smaller, local companies, location and price are much more important and therefore sustainability measures are not yet fully integrated in their housing strategy.

The new 1 billion dollar Google London Headquarter is the perfect example of organisations deploying green buildings as an internal resource. Tech companies generally have very short employee tenures. The average tenure of Google employees is just over a year (Peterson, 2017; Haden, 2022). Despite the size of the companies, it appears that large international tech companies also have difficulties with employee retention. Google's recent development, their new Headquarters adjacent to King's Cross Station London, might be the result of their efforts in the war for talent. Currently, all Google's staff is spread across several satellite offices in London (Brian, 2017). With the new HQ, they realize a new, central Campus for their 4,000 employees. The new Google Campus is equipped with a parking garage for approximately 700 bikes and only 4 cars, sport facilities, recreational areas, and a swimming pool to promote a healthy lifestyle among their employees. The new building will be able to generate 20,000 kWh electricity using solar panels (Spaen, 2019). Additionally, a recycle station and rooftop garden will minimize the environmental footprint (Brian, 2017).

Google's motivation for opening this new headquarters is understood and in line with the intangible benefits of green buildings. Google, as owner-occupier, uses this headquarters as a resource to implement larger organisational strategies as pointed out in the interviews conducted for this study. The building should be a sign of confidence in returning to the office (Partridge, 2022) and should promote co-working. Employees are pushed to use the central staircase to promote co-working and the entire lay-out is designed to increase employee satisfaction. All materials are selected on BREEAM and LEED criteria and have received an Environmental Product Declaration (Senatore, 2017) to increase health and well-being among end-users.

Both transaction managers indicate costs as main barrier towards environmentally friendly offices. One of them argued that owners are willing to partly cover the costs, however occupiers should also be responsible for parts of the costs. According to transaction manager A, occupiers are willing to pay a bit more for green buildings, as long as it does not lead to major increases in expenditure Transaction Manager A never experienced sustainability as a deal-breaker in negotiations, other factors such as space, timing, location and price seems still most important. Although it is a more prominent topic in the negotiations, Transaction Manager A still sees organisations reduce their sustainability ambitions for the sake of the business case.

Both transaction managers carefully confirm a green premium in the occupier market. However, transaction manager B perceives the premium more in a reduced vacancy risk. He argued that in the last three years most of the transactions have taken place in central business districts, with newer and renovated buildings with on average higher sustainability standards. According to transaction manager A, historically seen, there was always a certain rent ceiling in North Brabant with average rents around €140 - €150, both in central areas as in the periphery. However, since three years, sustainable buildings slowly generate a rental premium compared to conventional buildings in central areas. Both transaction managers mentioned this rent ceiling in certain peripheral areas as a barrier to certify a building: the marginal costs cannot always be covered by a rental premium.

Investor's perspective

According to the RICS Sustainability Report (2022), more than 80% of the European respondents thinks the investor demand for green buildings has risen in the last twelve months. 35% of the respondents even think the investor demand has significantly risen. The results for Europe are significantly higher than the global average. On the general RICS Sustainability Building Index, which indicates the average appetite for green buildings among investors and occupiers, Europe also outpaces the other continents with a score of 75%. All other continents do not score above 50%. Two national real estate investors and one BREEAM-NL In-Use Expert, who primarily advices building owners and investors on environmental certification, are interviewed to examine the investor's point of view in the Dutch office market.

The real estate market consists of a variety type of investors. Each investor has its own strategy, vision and structure and therefore the type of investor largely influences the way they operate. The conclusions from the interviews are far from exhaustive. A number of regulatory developments pushed listed companies, banks and insurance companies to publicly reporting on environmental and social matters (European Committee, n.d.). The newly adopted proposal Corporate Sustainability Reporting Directive and the older Sustainable Finance Disclosures Regulation (SFDR) stimulate sustainable investment and increase the transparency on the sustainability performance of investments and organisations.

According to a BREEAM-NL In-Use Expert, there has been a shift from investors which are truly intrinsically motivated towards more investors who aim for the commercial benefits of green buildings as organisations increasingly recognize the (monetary) value of green buildings. In the event of an intended sale, transaction managers now first ask owners and investors to certify their buildings with a BREEAM-NL label. According to them, buildings will be sold quicker on a higher price and it helps in attracting future occupiers. The extent to which sustainability is integrated in investor's behaviour largely depends on the nature of the investor. Both real estate investors argued that the investment market shifted from sustainability as a nice-to-have to a demand or even requirement. Investor A argued that the difference is driven by the demands coming from the capital market. Since EU directives decide that the capital market can only mark themselves as sustainable when they can prove it, large institutional investors have fully focused themselves on high-quality, certified asset investments. The new requirement regarding energy label C put this also in motion on a smaller, more national level. Additionally, the influence of the capital market also has its effect on obtaining financing. Banks do measure the sustainability performance of their portfolio as well. Investor A therefore argued that investors only receive their desired funding conditions if they commit to sustainable investments, whereby labelling can play a major role.

Interestingly, both real estate investors acknowledged that investors first need a *stick*, as the *carrot* is still perceived to be limited. Investor B argued that most companies are cost-driven businesses and therefore intrinsic motivation plays a limited role in the transition towards a sustainable built environment. Core business is priority number one and organisations are more conservative in investing in sustainability measures if this leaves less money for the business itself.

> *''On the one hand, there is less money for the core business. On the other hand, it can be the reason to become more sustainable as it is the only way to survive'' – Real Estate investor B*

As real estate markets are still demand-driven, the need to invest towards green buildings is limited as long as occupiers are still asking for buildings with energy label B or C. According to investor B, as long as these buildings stay occupied, mostly private investors continue with the maintaining these buildings because there is no need to go that extra mile. Transaction manager A also argued that there should always be a place for smaller occupiers with a smaller budget. Investor A argued that the occupiers are very conservative in sustainability measures when it cost them money. Therefore, both investors point out regulation as an important *stick* or incentive to push investors and occupiers towards greener buildings.

Another barrier are the costs to renovate existing real estate to the current sustainability requirements. After the relatively easy investments, such as LED-lightning and climate installations, the next investment to upgrade the building is replacing the façade. Although one could argue that this is accompanied with an increase in rent, occupiers can still demand a certain rent level due to the demand-driven character of the real estate market. When it comes to relatively small investments for an A-label, investor A argues that a saving on service costs can justify a similar increase in rent. However, the occupier market is not willing to fully cover the costs for energy neutral renovations. The recent economic developments are conceived as an extra barrier towards sustainable buildings. Investor A argued that one the one hand the increase in prices for materials and labour made capital expenditures more expensive and on the other the required capital has become more expensive. This together hampers owners and investors to invest in the sustainability performance of their buildings. Real estate investor B confirms the difficult economic times.

Conclusion

One can conclude that the positions of investors and occupiers have changed since the report of RICS in 2008. The interviews support the recent RICS Sustainability report (2022) and show increasing demand for green buildings from both occupiers and investors. The interviews show that European regulations are an important driver for organisations to use green buildings as a resource for wider organisational purposes. The results of the recent RICS report (2022) show the effectiveness of the abovementioned EU directives on the appetite for green buildings as Europe show significantly higher changes in demand for green and sustainable buildings.

However, the Circle of Blame seems still partly present in the Dutch real estate market. Demand is closely related to the willingness to pay for green buildings. Investor A pointed out that occupiers are still conservative in sustainability measures when it costs them money, especially in major renovations towards energy neutral buildings. Investor B also argued that there is still enough demand for offices labelled with energy label B or C and therefore the occupier market is not always asking for green and highly sustainable buildings. Both argued that the capacity to recover the costs for green buildings with a rental premium is rather limited. Especially in more peripheral areas, the rent ceiling does not cover the incremental costs. Transaction managers argue that occupiers are willing to pay a certain premium, however it should not lead to excessive expenditures. They acknowledged that occupiers frequently reduce their sustainability ambitions for the sake of the business case.

The increasing awareness of green building advantages pushed organisations more towards green and sustainable buildings. Also, the effect of European regulation on the general demand for green buildings is acknowledged by all interviewees. The shift is also widely acknowledged by the RICS report of 2022. The obligation to report on environmental topics pushed organisations to more sustainable business models whereby green buildings can play a significant role. However, the findings show that intrinsic motivation still plays only a minor role in the choice for sustainable offices. Despite the awareness of the benefits, *carrot*, of green buildings, organisations are still driven by regulation, as the *stick*.

5. Conclusion

5.1 Conclusion

The construction and real estate sector accounts for 38% of the total national CO2 emission in 2020. However, the increasing number of benchmarks and variety of acronyms show the growing awareness of climate change in the industry. The growing demand for green buildings emphasizes the importance of voluntary environmental certification systems. In the Netherlands, the DGBC program BREEAM-NL, USGBC's program LEED and WELL are the most important extra-legal environmental certification systems. The study documents a significant increase in market adoption of environmentally certified offices. In 2021, more than 30% of the total leased floor area was BREEAM-NL certified.

The aim of this study was to test the effect of environmental certification on market value within the dynamics of the Dutch office market. This study contributes to the current literature body by providing practical evidence from the Dutch occupier market on the willingness to pay for environmentally certified offices. Based on 4,244 lease transactions ranging from 2015 to mid-2022 it can be concluded that BREEAM-NL certification positively influence market value in the Dutch office market. After controlling for important location and building characteristics, the average premium for BREEAM-NL certified offices is 10.30%. The effects highly differ across submarkets and this is confirmed by the rental premium varying between 5.13% and 12.64% in the G5. Label scores positively influence the property's market value with a significant positive correlation between BREEAM-NL label score and rents. This shows that better performing buildings generally command higher rent and suggests that tenants do value the tangible benefits of green buildings as environmentally friendly buildings can significantly reduce energy bills and service costs. The results do not show a significant occupancy premium for BREEAM-NL certified offices. However, as frictional vacancy is also included in the analysis, this does not necessarily negatively affect the market value. Despite the rental premiums, BREEAM-NL buildings do not yet result in a significant value premiums at the beginning of the project. The economic attractiveness and the investment feasibility of BREEAM-NL Excellent labelled office buildings highly depends on the location of the development.

Additionally, it seems that tenants in the Dutch office market do value the intangible benefits accompanied with occupying green buildings as well. The literature study argued that green buildings cause higher employee productivity and satisfaction rates, increased health and comfort, and an improved public image and these intangible benefits are confirmed in interviews with Dutch real estate professionals. The empirical analysis showed that industries who are more sensitive to these intangible benefits are willing to pay an additional premium for occupying BREEAM-NL buildings. Labour-intensive companies with a large workforce, such as Finance & Business Services, and environmentally harmful industries, such as Energy & Utilities, tend to pay more for certified office buildings.

The qualitative and quantitative analysis showed that end-users are increasingly adopting sustainability in their overall strategy, from which their real estate strategy is only a part of. The interviews show that the willingness to pay the green premium differs across business sector and size, but that (inter)national policy is the main driver, or *stick*, for organisations to move towards green buildings. Organisations are also increasingly aware of the *carrot* (economic advantages) of green buildings such as better marketability, higher prices and attractiveness. The Vicious Circle of Blame is still partly present in the Dutch real estate market. Occupiers remain conservative in sustainability measures when it is accompanied with increases in expenditures. Although the results show an increasing occupier demand for green buildings, the occupier demand should be accompanied with an increasing willingness to pay the incremental rent. This counterpart perfectly characterizes the current problem in the playing field of the Vicious Circle of Blame. A lacking willingness to pay for green buildings hampers the economic feasibility of these sustainable investments and causes reluctance in the investor's behaviour.

5.2. Limitations

The empirical results of this study are exposed to certain potential limitations. While the methodology limits the generalisability of the study, the results clearly illustrate the existence of a green premium in the Dutch office market. Although the sample size was large enough to draw proper conclusions, real estate price indices highly differ across the country and can therefore not be broken down to one single relation. As indicated in figure 23, rent levels are highly dependent on the geographical location of the property, creating dependency in the data. A regression analysis assumes the residuals are independent, however, with dependency in the data structure, the residuals are correlated. In real estate research, the minimum rent level (intercept) and the effect of certain rent determinants (relationships) highly differ across (sub)markets. A multi-level linear model can overcome this limitation by including random effects in the model. This study partly overcomes this limitation by including interaction factors for the largest office markets in the Netherlands.

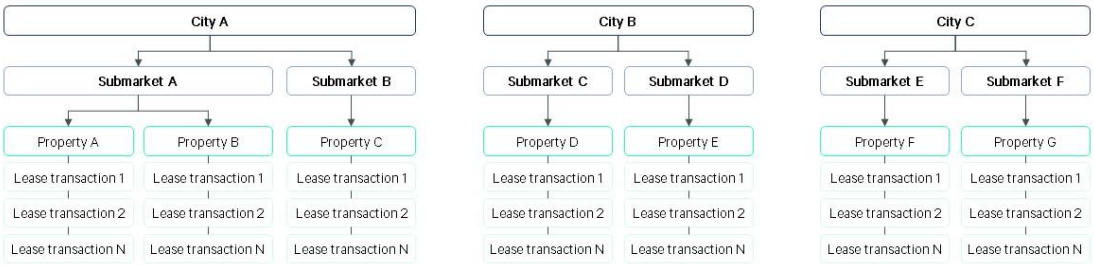


Figure 23: 4-level hierarchical data (adapted from Field, 2013)

The lack of transparency and the availability of control variable bring another limitation to this study. The adjusted R2 score shows a high level of explanatory power. However, it is not possible to include all important rent determinants in the regression analysis. This can result in either overestimating or underestimating the effect of the independent variable, in his case a BREEAM-NL certification. Despite the fact that most important rent determinants are incorporated this remains a limitation of regression modelling in general. Although the final dataset included more than 4,000 lease transactions across the Netherlands, some areas are underrepresented in the set. The geographical clustering around the larger office markets in the Netherlands can result in biased results regarding the effect of BREEAM-NL certification on rent and occupancy levels. Finally, rent levels are based on transaction rent and excluded any incentives. The study is based on approximately 6.4 million square meter transacted floor area in the period of 2015 – 2020 and validates the generalisability of the results. However, the heterogeneity of real estate makes that the results should be interpreted with caution.

5.3. Implications

The results provide insights in the behaviour of investors and tenants in the context of green buildings and contribute to the literature body on green building economics. As the literature concluded, the lack of evidence of the economic feasibility of environmentally certified offices causes reluctance in sustainable investments. This study proves empirical evidence on the existence of economic benefits for occupiers, owners and investors and show a quantitative premium for environmentally certified offices. The results are contingent upon the growth of certified stock, building- and European regulatory developments and it should therefore be noted that the results are a snapshot of the current situation. Nevertheless, this study can be a practical contribution to the integration of sustainability measures in the valuation profession. The findings show regulators that sustainable regulations is an important and effective policy tool to reach climate goals by 2030 as the Vicious Circle of Blame is still present among owners and tenants.

5.4. Recommendations

Although the study is based on a fair number of lease transactions, it only represents a minor share of the entire commercial real estate sector. As more data becomes available, more comprehensive empirical research is needed to provide reliable and robust evidence on green premiums in the Dutch real estate sector. As the certified stock is growing, it is interesting to examine the effect of the number of certified buildings in the area on rental premium. Research tends to focus only on rental premiums and occasionally on cost premiums and neglects the economic benefits during the building's life cycle. An interesting research area is to analyse the total costs of housing of green buildings and include savings on energy and operating costs. By including the abovementioned cost items, one can assess the economic feasibility of green buildings in a comprehensive manner and test the existence of a value premium as is incited to in this study.

National and European regulations were proven to be critically important in stimulating green building development and market adoption. A qualitative, holistic analysis of the Vicious Circle of Blame could reveal investors and developer's behaviour and contribute to the effectiveness of the regulatory developments.

The current body of knowledge is mainly focused on the office market as the most mature commercial real estate sector. Research on green premia in other commercial real estate sectors, most notably retail, industrial and logistic properties, makes it able to compare the economic benefits intersectoral and might give more insights in the share of individual benefits in the rental premium.

6. References

Baas, L. (2013). The Incorporation of sustainability into the real estate portfolio [Master's Thesis, Delft University of Technology]. Delft University of Technology Repository. https://repository.tudelft.nl/islandora/object/uuid%3A6c26d5ab-9da0-4e96-a3af-97fddec54685?collection=education

Blaikie, N. & Priest, J. (2019). *Designing Social Research*. Polity Press.

Building Research Establishment Ltd (2018). Assessing Health and Wellbeing in Buildings. https://www.bregroup.com/brebreeam/wp-content/uploads/sites/3/2017/06/BREEAM-Briefing-Assessing-Health-and-Wellbeing-in-Buildings-Updated-January-2018.pdf

Building Research Establishment Ltd (2022). BREEAM. Retrieved March 14, 2022 from https://www.breeam.com/

Brian, M. (2017, June 1). Google's 'innovative' new London HQ features giant moving blinds. Engadget. https://www.greenmatters.com/news/2017/06/01/1aDLnU/google-london-headquarters-solar-energy#:~:text=Employees%20will%20be%20able%20to,sustainability%20aspect%20of%20the%20building.

Briscoe, E. & Fieldman, J. (2011). Conceptual complexity and the bias/variance tradeoff. *Cognition*, 118, 2-16.

CBRE (n.d.-a.). About Us. Retrieved May 16, 2022, from https://www.cbre.com/about-us

CBRE (n.d.-b.). Over CBRE. Retrieved May 16, 2022, from https://www.cbre.nl/nl-nl/over-cbre

CBRE (2021a). *Is Sustainability Certification in Real Estate worth it?* https://www.cbre.com/insights/reports/is-sustainability-certification-in-real-estate-worth-it

CBRE (2021b). *Nederlandse kantoren naderen belangrijk klimaatstation: De C-labelverplichting als eerste horde richting 2050*. https://insights.cbre.nl/nederlandse-kantorenmarkt/

CBRE (2022). Sustainability Legislation. Retrieved November 30, 2022, from https://www.cbre.co.uk/insights/articles/sustainability-legislation.

CBS (n.d.). *Welke sectoren stoten broeikasgassen uit?* Retrieved December 4, 2022, from https://www.cbs.nl/nl-nl/dossier/dossier-broeikasgassen/welke-sectoren-stoten-broeikasgassen-uit-#:~:text=In%202021%20werd%20van%20de,het%20stoken%20van%20aardgas%20voor

Chegut, A., Eichholtz, P. & Kok, N. (2014). Supply, Demand and the Value of Green Buildings. Urban Studies, 51(1), 22-43.

Chegut, a., Eichholtz, P. & Kok, N. (2019). The price of innovation: An analysis of the marginal cost of green buildings. Journal of Environmental Economics and Management, 98, 1-18.

Chin, T. & Chau, K. (2003). A Critical Review of Literature on the Hedonic Price Model. International Journal for Housing Science and Its Applications, 27(2), 145-165.

CoreNet (2015). The essential guide to corporate real estate.

De Jong, J.C. (2016). *Basisboek Vastgoedrekenen* (3e ed.). Spryg Real Estate Academy.
DiPasquale, D. & Wheaton, W. (1992). The markets for real estate assets and space: A conceptual framework. Journal of the American Real Estate and Urban Economics Association, 20(1), 181-197.

Dunse, N. & Jones, C. (1998). A hedonic price model of office rents. Journal of Property Valuation & Investment, 16(3), 297-312.

Dutch Green Building Council (n.d.-a.). BREEAM-NL. Retrieved March 31, 2022, from https://www.breeam.nl/

Dutch Green Building Council (n.d.-b.). Dutch Green Building Council. Retrieved March 31, 2022, from https://www.dgbc.nl/

Dutch Green Building Council (2020). BREEAM-NL Nieuwbouw Utiliteitsbouw 2020 v1.0. https://richtlijn.breeam.nl/1-inleiding-383

Dutch Green Building Council (2021). BREEAM-NL In-Use Utiliteitsbouw V6.0.0. https://richtlijn.breeam.nl/1-inleiding-in-breeam-508

Dutch Green Building Council (2021). *Whole Life Carbon Position Paper*. https://www.dgbc.nl/upload/files/Publicaties/circulariteit/Position%20Paper%20Whole%20Life%20Carbon%20v1.1%20-%20DGBC.pdf

Devine, A. & Kok, N. (2015). Green Certification and Building Performance: Implications for Tangibles and Intangibles. The Journal of Portfolio Management.

Eichholtz, P., Kok, N., & Quigley, J.M. (2009). Why Do Companies Rent Green? Real Property and Corporate Social Responsibility.

Eichholtz, P., Kok, N. & Quigley, J.M. (2010). Doing well by doing? Green office buildings. American Economic Review, 100(5), 2492-2509.

Eichholtz, P., Kok, N. & Quigley, J.M. (2013). The economics of green building. Review of Economics and Statistics, 95(1), 50-63.

European Committee (n.d.-a.). Corporate Sustainability Reporting. Retrieved May 24, 2022, from https://ec.europa.eu/info/business-economy-euro/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

European Committee (n.d.-b). Energy Performance of Buildings Directive. Retrieved March 14, 2022 from https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

European Committee (n.d.-c). France announces rooftops must be covered in plats or solar panels. Retrieved November 30, 2022, from https://ec.europa.eu/environment/europeangreencapital/france-green-roofs/

European Committee (n.d.-d.). Sustainable finance package. Retrieved from May 24, 2022, from https://ec.europa.eu/info/publications/210421-sustainable-finance-communication_en#csrd

European Committee (2014). *DIRECTIVE 2014/95/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups*. http://data.europa.eu/eli/dir/2014/95/oj

European Committee (2020). REGULATION (EU) 2020/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0852&from=EN

European Committee (2021). DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2013/34/EU, Directive 2004/109/EC, Directive 2006/43/EC and Regulation (EU) No 537/2014, as regards corporate sustainability reporting. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0189&from=EN

Eurostat (2022). Renewable energy statistics. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Renewable_energy_statistics#:~:text=Among%20the%20EU%20Member%20States%2C%20the%20share%20of%20renewable%20energy,Croatia%20(both%206.6%20%25).

Freemen, M. (1979). Hedonic Prices, Property Values and Measuring Environmental Benefits: A Survey of the Issues. The Scandinavian Journal of Economics, 81(2), 154-173.

Field, A. (2013). *Discovering Statistics Using SPSS* (4th ed.). SAGE Publications Ltd.

Fuerst, F. & McAllister, P. (2011). Eco-labeling in commercial office markets: Do LEED and Energy Star offices obtain multiple premiums? Ecological Economics, 70(6), 1220-1230.

Fuerst, F. & McAllister, P. (2011). Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Values. Real Estate Economics, 39(1), 45-69.

Fuerst, F., McAllister, P. & Murray, C.B. (2011). Designer Buildings: Estimating the Economic Value of 'Signature' Architecture. Environment and Planning A: Economy and Space, 43(1). https://doi.org/10.1016/0094-1190(83)90028-1

Geltner, D.M., Miller, N.G., Clayton, J. & Eichholtz, P. (2007). *Commercial real estate: analysis & investments*.

Gemeente Amsterdam (n.d.). *Duurzaam Ontwikkelen*. Retrieved December 5, 2022, from https://www.amsterdam.nl/wonen-leefomgeving/duurzaam-amsterdam/duurzaam-ontwikkelen/.

Haden, J. (2022, June 16). Why Google's High Turnover Rate is Great for Employees – and Possibly Even for Google. Inc. https://www.inc.com/jeff-haden/why-googles-high-turnover-rate-is-great-for-employees-and-possibly-even-for-google.html#:~:text=Yet%20a%20recent%20study%20conducted,don't%20want%20to%20stay.

Harvard Gazette (2017). Study Opens Door to Better Sleep, Work, Health. Retrieved November 24, 2022, from https://news.harvard.edu/gazette/story/2017/02/study-opens-the-door-to-better-sleep-work-and-health/

Herath, S. K. & Maier, G. (2010). The hedonic price method in real estate and housing market research. A review of the literature..Institute for Regional Development and Environment (pp. 1-21). Vienna, Austria: University of Economics and Business.

Hastie, T., Tibshirani, R. & Friedman, J. (2017). *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*. Springer.

Holtermans, R. & Kok, N. (2017). On the Value of Environmental Certification in the Commercial Real Estate Market. Real Estate Economics, 47(3), 685-722.

Hough, D.E., & Kratz, C.G. (1983). Can "good" architecture meet the market test? Journal of Urban Economics, 14(1), 40-54. https://doi.org/10.1016/0094-1190(83)90028-1

Hui, E. C., Chan, E. W., & Ka-hung, Y. (2015). The effect of LEED certification on Shanghai's prime office rental value. Journal of Facilities Management, 13(3), 297-310. http://dx.doi.org/10.1108/JFM-10-2014-0033

IGG Bouweconomie (n.d.). BouwkostenKompas. Retrieved November 18, 2022, from www.bouwkostenkompas.nl

IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change[Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896

Ishaak, F., Van Schie, R. & De Haan, J. (2021). The effect of real estate share deals on commercial property price indicators. Annual European Real Estate Society Conference

Jones, K (2000), A Regrettable Oversight or a Significant Omission? Ethical considerations in quantitative research in education. In: H. Simons and R. Usher (Eds), Situated Ethics in Educational Research. London: Routledge. pp147-61. ISBN: 0415206669

Kok, N. & Jennen, M. (2010). De waarde van energiezuinigheid en bereikbaarheid.

Koster, H. R. A. (2013). The Internal Structure of Cities: The Economics of Agglomeration, Amenities and Accessibility. Tinbergen Institute.

Lawson, A. (2022, November 9). France to require all large car parks to be covered by solar panels. The Guardian. https://www.theguardian.com/world/2022/nov/09/france-to-require-all-large-car-parks-to-be-covered-by-solar-panels

Leijen, T. (2014). Het effect van technische duurzaamheid op de huurprijs van kantoorgebouwen [Master's Thesis, Delft University of Technology]. Delft University of Technology Repository. https://repository.tudelft.nl/islandora/object/uuid%3A6d1ce3e5-a3a3-445c-8a72-dfe1436aab3f?collection=education

Li, W., Fang, G. & Yang, L. (2021). The effect of LEED certification on office rental values in China. Sustainable Energy Technologies and Assessments, 45. https://doi.org/10.1016/j.seta.2021.101182

Ling, D. & Archer, W. (2013). *Real Estate Principles: A Value Approach.* McGraw-Hill Education; 4th edition.

McDonald, J.F., & McMillen, D. P. (2011). Urban Economics and Real Estate.

Miller, K.C. (2010). Commercial Real Estate. Background and Issues. Nova Science Publishers, Inc.

Netherlands Environmental Assessment Agency (2020). *Klimaat- en Energieverkenning 2020.* https://open.overheid.nl/repository/ronl-6a042d8f-41f5-4275-a733-52223ca41cd6/1/pdf/Klimaat-%20en%20energieverkenning%202020.pdf

Netherlands Environmental Assessment Agency (2022). *Klimaat- en Energieverkenning 2022.* https://open.overheid.nl/repository/ronl-5a9dcec34fbd3fb7e7e494534297157396d6ef06/1/pdf/pbl-klimaat-en-energieverkenning-2022.pdf

NVM (2021). *Kantoren in cijfers 2021.* https://www.nvm.nl/media/dnin504s/20210630-web-spread-nvm-kantoren-in-cijfers-2021.pdf

NVM (2022). *Stand van zaken Kantorenmarkt 2022. De belangrijkste ontwikkelingen op nationaal en provinciaal niveau.* https://www.nvm.nl/media/1zxhvpi5/nvm_kantorenmarkt_2022_5.pdf

Onishi, J., Deng, Y., & Shimizu, C. (2021). Green premium in the tokyo office rent market. Sustainability (Switzerland), 13(21). DOI:10.3390/su132112227

Partridge, J. (2022, July 1). Behold London's 'landscraper'! Google's new UK HQ – as long as the Shard is tall. The Guardian. https://www.theguardian.com/business/2022/jul/01/behold-londons-landscraper-googles-new-uk-hq-as-long-as-the-shard-is-tall

Peterson, B. (2017, August 20). Travis Kalanick lasted in his role for 6.5 years – five times longer than the average Uber employee. BusinessInsider. https://www.businessinsider.com/employee-retention-rate-top-tech-companies-2017-8?r=US&IR=T

Pirounakis, N.G. (2013). Real Estate Economics. A point-to-point handbook. Routledge.

Porumb, V., Maier, G. & Anghel, I. (2020). The impact of building location on green certification price premiums: Evidence from three European countries. Journal of Cleaner Production, 272,

Reichardt, A. (2014). Operating Expenses and the Rent Premium of Energy Star and LEED Certified Buildings in the Central and Eastern U.S.. The Journal of Real Estate Finance and Economics, 49(3), 413-433.

Robinson, S.J. & Sanderford, A. (2015). Green Buildings: Similar to Other Premium Buildings? The Journal of Real Estate Finance and Economics, 52(2), 1-19.

Royal Institution of Chartered Surveyors (2008). Breaking the Vicious Circle of Blame-Making the Business Case for Sustainable Buildings.

Royal Institution of Chartered Surveyors (2021). RICS Valuation – Global Standards. https://www.rics.org/globalassets/rics-website/media/upholding-professional-standards/sector-standards/valuation/2021-11-25_rics-valuation--global-standards-effective-2022.pdf

Rijksdienst voor Ondernemend Nederland (2022a). Energielabel C kantoren. Retrieved March 14, 2022 from https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/wetten-en-regels/bestaande-bouw/energielabel-c-kantoren

Rijksdienst voor Ondernemend Nederland (2022b). Energy Performance of Buildings Directive (EPBD III). Retrieved March 14, 2022 from https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/gebouwen/wetten-en-regels/nieuwbouw/epbd-iii

Rosen, S. (1974). Hedonic Prices and Implicit Market: Product Differentiation in Pure Competition. Journal of Political Economy, 82(1), 34-55.

Rottke, N.B. & Mutl, J. (2015). Development of Hedonic Office Rent Indices. Examples for German Metropolitan Areas. Springer Gabler.

Saunders, T. (2008). A discussion document comparing international environmental assessment methods for buildings. Building Research Establishment Environmental Assessment Method.

Senatore, A. (2017, August 16). Google's new £1bn Campus in London. Ongreening. http://www.ongreening.com/en/News/google-new-campus-in-london-1319

Spaen, B. (2019, May 17). Google's New Headquarters in London Focuses On Solar Energy. Greenmatters. https://www.greenmatters.com/news/2017/06/01/1aDLnU/google-london-headquarters-solar-energy#:~:text=Employees%20will%20be%20able%20to,sustainability%20aspect%20of%20the%20building

Turan, I., Chegut, A., Fink, D. & Reinhart, C. (2020). The value of daylight in office spaces. Building and Environment, 168, 1-13. https://doi.org/10.1016/j.buildenv.2019.106503

United Nations Environment Programme (2022). *Emissions Gap Report 2022: The Closing Window — Climate crisis calls for rapid transformation of societies*. Nairobi. https://www.unep.org/emissions-gap-report-2022

Qiu, Y., Su, X. & Wang, Y. (2017). Factors influencing commercial buildings to obtain green certificates. Applied Economics, 49(20), 1937-1949.

Van Den Broek, J. (2010). Groen licht voor duurzame kantoren? Een onderzoek naar de relatie tussen duurzame kantoren en hun financiële prestaties [MRE Master Proof, Amsterdam School of Real Estate]. Amsterdam School of Real Estate.

Van Der Pol, L. & Woutersen, E. (2022, November 29). *Zelfs Europa's groenste fondsen beleggen miljarden in kolen en gas (geannoteerd verhaal)*. Investico. https://www.platform-investico.nl/artikel/zelfs-europas-groenste-fondsen-beleggen-miljarden-in-kolen-en-gas-geannoteerd-verhaal/

Van Gool, P., Jager, P., Theebe, M. & Weisz, R. (2013). *Onroerend goed als belegging*. Noordhoff Uitgevers.

Van Manen, H. (2019). Energiezuinige kantoren. Een onderzoek naar het empirische bewijs van de bereidheid om te betalen voor energiezuinige kantoorgebouwen in de Randstad [Master's Thesis, Delft University of Technology]. Delft University of Technology Repository. https://repository.tudelft.nl/islandora/object/uuid%3A84809100-8577-4c77-a406-a46aa282e281?collection=education

VVD, D66, CDA & ChristenUnie (2021). Coalitieakkoord 2021 – 2025: Omzien naar elkaar, vooruitkijken naar de toekomst.

W/E Adviseurs (2019). *Inijking energielabel utiliteitsbouw*. https://open.overheid.nl/repository/ronl-410b3d61-10db-4fd8-9512-f64bf063e6e1/1/pdf/Eindrapportage%20inijking%20energielabels%20utiliteit.pdf?utm_campaign=boo_duurzaam_nac22&utm_medium=publisher&utm_source=foleon&utm_content=ybc_report_nl

Wiley, J., Benefield, J. & Johnson, K. (2010). Green design and the market for commercial office space. Journal of Real Estate Finance and Economics, 41(2), 228-243.

Willuhn, M. (2022, January 3). Seit Neujahr gilt neue Photovoltaik-Pflicht in Nordrhein-Westfalen und Baden-Württemberg. PV Magazine. https://www.pv-magazine.de/2022/01/03/seit-neujahr-gilt-neue-photovoltaik-pflicht-in-nordrhein-westfalen-und-baden-wuerttemberg/

Zhang, L., Wu, J. & Liu, H. (2018). Turning green into gold: A review on the economics of green buildings. Journal of Cleaner Production, 172, 2234-2245.

Appendices

Average rent by BREEAM-NL certification.

CERTIFIED	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
Arithmetic mean	€202,00	€234,94	€209,50	€223,85	€258,92	€272,56	€276,40	€276,16	€296,78
Geomatric mean	€191,85	€225,70	€207,72	€216,39	€249,22	€252,87	€255,45	€254,14	€269,14
YTY arithmetic mean	9%	16%	-11%	7%	16%	5%	1%	0%	7%
YTY geometric mean		18%	-8%	4%	15%	1%	1%	-1%	6%

NOT CERTIFIED	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
Arithmatic mean	€153,86	€158,65	€166,73	€164,66	€173,91	€180,21	€175,14	€201,23	€194,11
Geometric mean	€142,60	€147,39	€152,69	€153,36	€160,63	€162,43	€161,36	€183,78	€175,93
YTY arithmetic mean	-4%	3%	5%	-1%	6%	4%	-3%	15%	-4%
YTY geometric mean		3%	4%	0%	5%	1%	-1%	14%	-4%

DIFFERENCE	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*
Abs. diff. arithmetic mean	€48,14	€76,29	€42,77	€59,19	€85,01	€92,35	€101,26	€74,93	€102,67
Abs. diff. geometric mean	€49,24	€78,31	€55,03	€63,03	€88,59	€90,44	€94,09	€70,35	€93,22
% diff. arithmetic mean	31%	48%	26%	36%	49%	51%	58%	37%	53%
% diff. geometric mean	35%	53%	36%	41%	55%	56%	58%	38%	53%

Overview of variables

Variable	Explanation
BREEAM-NL certified	Binary variable to indicate if the building was certified with BREEAM-NL at moment of lease
Lease Rent (€ / sqm)	The transaction rent per square meter lettable floor area office space.
Ln Lease Rent (€ / sqm)	The natural logarithm of the transaction rent per square meter lettable floor area office space.
Lease Floor Area (sqm)	The total transaction size in square meter lettable floor area.
Ln Lease Floor Area (sqm)	The natural logarithm of the total transaction size in square meter lettable floor area.
Occupancy rate at moment of lease (%)	The occupancy rate of the building at moment of lease.
Building Size (sqm)	The total building size in square meter gross floor area.
Ln Building Size (sqm)	The natural logarithm of the total building size in gross floor area.
Building Age	The age of the building measured in years from construction year.
Building Height	The maximum height of the building measured in meters from ground level.
Renovation dummy	Binary variable to indicate if the building had a major refurbishment after the building is constructed.
Energy Label	Indicates the energy label of the building, coded as G = 1 and A+ - A+++ is 8.
Property Grade	Indicates the overall quality of the building. Properties <10 years are graded as A, properties of 10-20 years are graded as B, and properties of >20 years are graded as C.
Number of restaurants	The number of restaurants in the direct proximity of the building.
Number of sport facilities	The number of sport facilities in the direct proximity of the building.
Distance to train station	The distance to the closest NS station, measured point to point.
Walk time to train station	The total walk time to the closest NS train station.
Walk time to subway station	The total walk time to the closest subway station.

Interview outline – transaction manager

Inleiding
Kunt u in het kort wat meer vertellen over XXXX en uw rol binnen XXXX?

Definities
Waarde is een breed begrip en wordt door verschillende beroepen anders gedefinieerd. Hoe definieert u waarde en wat is hierbij het belangrijke verschil tussen waarde en prijs?

Wat beschouwen jullie als een duurzaam/groen kantoor? Wat zijn de belangrijkste aspecten van een dergelijk kantoor?

Intangible benefits
Wat zijn volgens jullie de meest genoten voordelen van het huisvesten in groene kantoorgebouwen ten opzichte van conventionele kantoorgebouwen?

> VERVOLG: Zijn er nog meer belangrijke immateriële voordelen met het huisvesten in groene kantoorgebouwen (CSR, productiviteit, kosten)? Wat zijn de belangrijkste voordelen die u hoort in uw werk binnen XXXX?

Huurdersmarkt perspectief
Hoe en in welke mate is duurzaamheid geïntegreerd in de huisvestingsstrategie van huurders?

Wat zijn de meest belangrijke criteria / variabelen in de huisvestigingsstrategie van huurders?

In welke mate wordt er gevraagd naar groene kantoren vanuit de huurdersmarkt? Is dit de laatste jaren erg veranderd en wat zouden de concrete drivers zijn voor deze toename?

> VERVOLG: Mits ervaring in de investeringsmarkt. Zit er een verschil tussen de huurdersmarkt en de investeringsmarkt?

In welke mate is de urgentie om te verduurzamen aanwezig in de huurdersmarkt?

Tangible benefits:
In welke mate merken jullie vanuit de huurdersmarkt een verhoogde betalingsbereidheid voor groene kantoren over conventionele kantoren?

> VERVOLG: Mits ervaring in de investeringsmarkt. Zit er een verschil tussen de huurdersmarkt en de investeringsmarkt?
> VERVOLG: Verschilt deze betalingsbereidheid tussen bedrijfssectoren, zoals publieke sector, milieubelastende of arbeidsintensieve sectoren?

In welke mate merken jullie verschil in verhuurbaarheid en risicoprofiel tussen groene kantoorgebouwen en conventionele kantoorgebouwen?

In welke mate merken jullie een verband tussen de locatie van het kantoor, centrum of periferie, en de urgentie om te certificeren?

Concluderend
Hoe kijkt u naar de klimaatdoelen en de huidige staat van de gebouwde omgeving? Zijn we goed op weg of is de haalbaarheid daarvan erg in het geding?

> VERVOLG: Wat is er nodig vanuit de vastgoedmarkt om als gebouwde omgeving de klimaatdoelen te behalen?

Heeft u nog op- of aanmerkingen of zijn er volgens u belangrijke zaken nog niet belicht?

Een van uw expertises was rent levels. Heeft u nog belangrijke toevoegingen die vanuit uw oogpunt meegenomen moeten worden in de statistische analyse? (zie tabel)

Interview outline – transaction manager

Inleiding
Kunt u in het kort wat meer vertellen over XXXX binnen XXXX en uw rol als XXXX binnen XXXX?

Definities
Wat beschouwen jullie als een duurzaam/groen kantoor? Wat zijn de belangrijkste aspecten van een dergelijk kantoor?

Intangible benefits
Wat zijn volgens jullie de meest genoten voordelen van het huisvesten / investeren in groene kantoorgebouwen ten opzichte van conventionele kantoorgebouwen?

> VERVOLG: Zijn er nog meer belangrijke immateriële voordelen bij het huisvesten / investeren in groene kantoorgebouwen (CSR, productiviteit, kosten)?

Huurdersmarkt perspectief
In welke mate wordt duurzaamheid meegenomen in investeringskeuzes van XXXX?

Wat zijn de huidige eisen van NSI en welke asset kenmerken zijn essentieel in jullie investeringskeuzes?

In welke mate wordt er gevraagd naar groene kantoren vanuit de gebruikersmarkt? Is dit de laatste jaren erg veranderd en wat zouden de concrete drivers zijn voor deze toename?

> VERVOLG: Zit er een verschil tussen de huurdersmarkt en de investeringsmarkt?

In welke mate is de urgentie om te verduurzamen aanwezig in de investeringsmarkt? En waar wordt die door gedreven? Push/pull factoren, zijn dit tangible benefits, regelgeving, less risico, meer opbrengst, intrinsieke?

Tangible benefits:
In welke mate merken jullie verschil in verhuurbaarheid/verkoopbaarheid en risicoprofiel (yields) tussen groene kantoorgebouwen en conventionele kantoorgebouwen?

In welke mate merken jullie vanuit de investeringsmarkt een verhoogde betalingsbereidheid voor groene kantoren over conventionele kantoren?

> VERVOLG: Zit er een verschil tussen de huurdersmarkt en de investeringsmarkt?
> VERVOLG: Verschilt deze betalingsbereidheid tussen bedrijfssectoren, zoals publieke sector, milieubelastende of arbeidsintensieve sectoren?
> VERVOLG: Verschilt deze betalingsbereidheid tussen soorten investeerders, zoals maatschappelijke of private investeerders?

Merken jullie verschil in het soort buyer tussen groene kantoorgebouwen en conventionele kantoorgebouwen?
Merken jullie verschil in het soort tenant tussen groene kantoorgebouwen en conventionele kantoorgebouwen?

In welke mate merken jullie een verband tussen de locatie van het kantoor, centrum of periferie, en de urgentie om te certificeren?

Concluderend
Ondanks alle tangible and intangible voordelen, wat is de reden dat er nog weinig volledig duurzame gebouwen worden ontworpen, gebouwd of getransformeerd? Waarom zijn volledig duurzame gebouwen nog niet gebruikelijk? Wat zijn de drivers en barriers van dit proces?

Hoe kijkt u naar de klimaatdoelen en de huidige staat van de gebouwde omgeving? Zijn we goed op weg of is de haalbaarheid daarvan erg in het geding?

> VERVOLG: Wat is er nodig vanuit de vastgoedmarkt om als gebouwde omgeving de klimaatdoelen te behalen?

Heeft u nog op- of aanmerkingen of zijn er volgens u belangrijke zaken nog niet belicht?

Interview outline – BREEAM-NL Expert

Inleiding
Kunt u in het kort wat meer vertellen over jouw rol binnen DGBC?

Wat is het hoofddoel van BREEAM-NL vanuit DGBC?

Definities
Wat beschouw jij/jullie bij DGBC als een duurzaam/groen kantoor? Wat zijn de belangrijkste aspecten van een dergelijk kantoor?

Zijn er nog meer noemenswaardige vrijwillige ESG/duurzaamheid labels actief in de Nederlandse vastgoedmarkt en hoe hebben deze vrijwillige labels zich de laatste jaren ontwikkeld?

Perspectief en realiteit
Tot welke mate voelt men de urgentie om te verduurzamen in de gebouwde omgeving? Welke rol speelt vrijwillige certificering, zoals BREEAM-NL, hierin?

Welke drivers hebben [marktpartijen/eigenaren/investeerder] voornamelijk om assets te laten certificeren met BREEAM-NL? Ziet u de ambities van de gebouweigenaren stijgen?

Wat zijn [BREEAM-NL/duurzaamheids] aspecten waar een groot deel van de Nederlandse kantorenvoorraad momenteel nog in achter loopt? Waar vind jij dat de Nederlandse kantorenvoorraad het meeste in achterloopt?

Tangible benefits:
In welke mate merken jij een verband tussen de locatie van het kantoor, centrum of periferie, en de urgentie om te certificeren?

Welke trends heb jij de laatste jaren ontdekt bij het certificeren?

BREEAM-NL In-Use
BREEAM-NL In-Use geeft een score voor Asset en Beheer, welke ook beide apart beoordeeld kunnen worden? Hoe zit dit in de praktijk? Wordt het vaak gecombineerd of wordt ook regelmatig maar een van de twee delen beoordeeld?

> VERVOLG: Wat vind je van deze vrijblijvigheid? Geeft dit dan wel de juiste score weer? Brengt dit niet te veel verwarring?
>
> VERVOLG: Kiezen veel eigenaren om na BREEAM-NL Nieuwbouw hun portfolio ook te certificeren met BREEAM-NL In-Use? Hoe verhouden deze twee labels zich tegenover elkaar, worden ze vaak gecombineerd, of is het hebben van een BREEAM-NL certificaat meer een box die afgestreept moet worden ten aanzien van gebouwmarketing waarbij het optimaliseren van de echte duurzaamheidsprestaties van het gebouw vaker op de tweede plek staat?

In multi-tenant gebouwen kan er ook maar een deel van het gebouw gecertificeerd worden met BREEAM-NL In-Use. Hoe is dit in de praktijk?

> VERVOLG: Wat vind je van deze vrijblijvigheid? Geeft dit dan wel de juiste score weer? Brengt dit niet te veel verwarring?

Einde
Hoe kijkt u naar het label BREEAM-NL In-Use (en Nieuwbouw)? Wat is volgens jou de strength van het label en wat is de grootste weakness van het label? Wat mist het in jouw ogen nog?

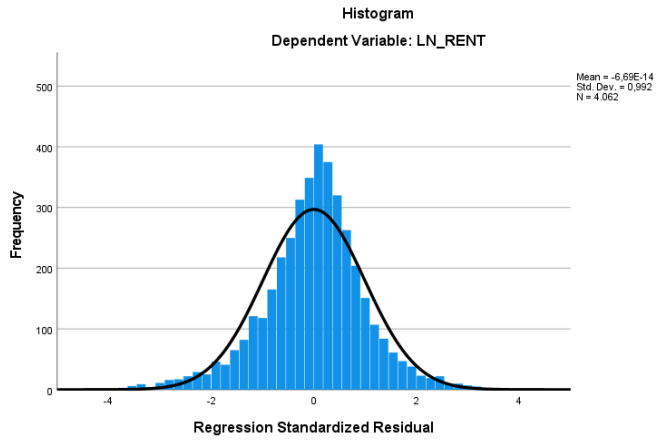
Hoe kijkt u naar de klimaatdoelen en de huidige staat van de gebouwde omgeving? Zijn we goed op weg of is de haalbaarheid daarvan erg in het geding?

> VERVOLG: Wat is er nodig vanuit de vastgoedmarkt om als gebouwde omgeving de klimaatdoelen te behalen?

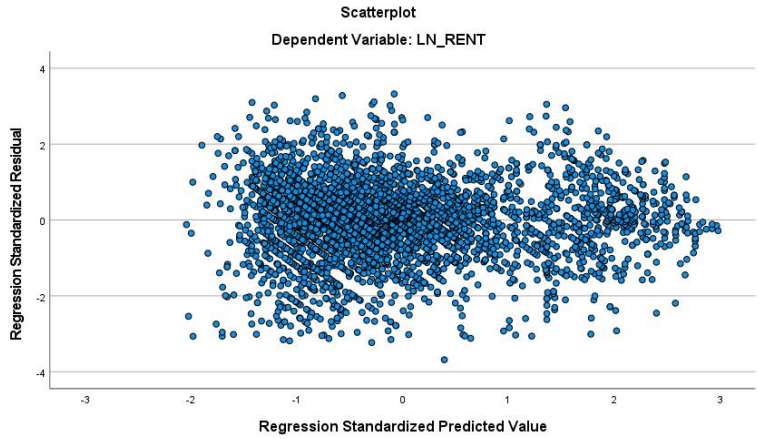
Heeft u nog op- of aanmerkingen of zijn er volgens u belangrijke zaken nog niet belicht?

Assumption testing – Multiple linear regression

Table 6 column (5).
Histogram residuals dependent variable – LN rent



Scatterplot standardized residuals again standardized predicted values



Normal probability plot