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# **Empirical Study of the Impact of Green Certification on the Rental Income**

Do Green Certifications Add Value to Office  
Buildings?

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## Master of Science Thesis

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Title	Empirical Study of the Impact of Green Certification on the Rental Income - Do Green Certifications Add Value to Office Buildings?
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### Abstract

The purpose of this study is to investigate whether or not green certificates have an impact on income-generating commercial buildings' rent compared to similar non-certified commercial buildings. In addition, evaluate if there exists a variation in the rent premium between the different certifications and if the rental premium increases with the distance from city center. To answer the research questions a quantitative approach with hedonic pricing regressions has been conducted. For the purpose of this study, three types of hedonic regressions models have been estimated. To capture the effect of green certificates, the models have controlled for structural, locational and, quality attributes of the buildings. The first model examined whether certified office buildings archive a rent premium compared to non-certified buildings. The second model separated the label into indicator variables to capture the effect of each individual label. Lastly, the third model analyzed the progressive effect of the interaction between distance and certification. This study uses a dataset of rent observations for office buildings from four major Swedish cities – Stockholm, Gothenburg, Malmö and, Uppsala – in order to analyze the rent premium of green certifications. The result of this study indicates that there exists a premium of 4,9 to 5,4 percent for certified buildings. When investigating each certification label the results indicate a rental premium of 10 percent for BREEAM, 5,1 percent for LEED, and 4,4 percent for Miljöbyggnad. Lastly, the finding suggests an incremental premium for certified buildings located farther away from the city center. This study contributes to the rising literature on the topic of green office buildings, as it is the first study to investigate the rental impact of green certification on the Swedish market.

## Examensarbete

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Titel	Empirisk Studie om hur Hyresnivån Påverkas av Miljöcertifieringar. - Tillför miljöcertifieringar ett högre värde för kontorsfastigheter?
Författare	Alexander Köhler & Johan Rydholm
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### Abstrakt

Syftet med denna studie är att undersöka om miljöcertifieringar har en hyrespåverkan på kontorsbyggnader, i jämförelse med liknande icke-certifierade kontorsbyggnader. Vidare, undersöka om hyrespremien skiljer sig mellan de olika miljöcertifieringarna samt om hyrespremien ökar med avståndet från citykärnan. För att kunna besvara forskningsfrågorna har regressionsanalyser genomförts, bestående av tre olika modeller. Modellerna kontrollerar för strukturella, lägesspecifika och kvalitativa attribut. Den första modellen undersöker huruvida certifierade byggnader erhåller en högre hyra i jämförelse med icke-certifierade byggnader. Den andra modellen separerar de olika typerna av miljöcertifieringar för att undersöka vilken certifiering som bidrar med högst hyrespremie. Slutligen, den tredje modellen analyserar den stegvisa effekten av interaktionen mellan avstånd och certifiering. Datasetet som studien baseras på består av hyreskontrakt från de fyra största städerna i Sverige – Stockholm, Göteborg, Malmö och Uppsala. Resultaten påvisar att det existerar en hyrespremie för certifierade byggnader på 4,9 till 5,4 procent. Premien skiljer sig beroende på vilken certifiering byggnader har, resultaten påvisar en hyrespremie på 10 procent för BREEAM, 5,1 procent för LEED och 4,4 procent för Miljöbyggnad. Resultaten visar även att det finns en stegvis hyrespremie för certifierade byggnader som är belägna längre bort från stadens centrum. Avslutningsvis, denna studie bidrar till den befintliga litteraturen gällande gröna byggnader, då det är den första studien i Sverige som undersöker förhållandet mellan hyresnivå och miljöcertifieringar.

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Over and out!

Stockholm, June 2021

*Alexander Köhler & Johan Rydholm*

# Table of Contents

1.	Introduction .....	1
1.1.1	The Swedish Market.....	2
1.1.2	Demand for Green Buildings .....	2
1.1.3	Supply for Green Buildings .....	3
1.1.4	EU Taxonomy .....	4
1.2	Previous research .....	5
1.3	Problematization.....	5
1.4	Research question.....	6
1.5	Purpose and contribution.....	6
1.6	Limitations .....	6
2.	Theory .....	7
2.1	Literature review .....	7
2.1.1	Rental income .....	7
2.1.2	Occupancy .....	8
2.1.3	Operating costs .....	9
2.1.4	Risk .....	9
2.1.5	Sales price .....	10
2.1.6	Studies in Sweden.....	11
2.1.7	Conclusion of literature review .....	11
2.2	Concept of sustainable buildings .....	12
2.2.1	BREEAM .....	14
2.2.2	LEED.....	14
2.2.3	GreenBuilding.....	14
2.2.4	Miljöbyggnad Sweden .....	14
2.2.5	Comparison of the certifications .....	15
2.2.6	Energy assessment system - Energy Performance Certificate .....	16
2.3	Theoretical framework .....	16
2.3.1	Value theory.....	16
2.3.2	Discounted cash flow valuation theory .....	17
2.3.3	Hedonic price model (HPM).....	17
2.4	Conceptual framework .....	18
3.	Methodology.....	19
3.1	Regression analysis.....	19
3.1.1	Linear regression.....	19
3.1.2	Tools in regression analysis.....	21
3.1.3	Propensity score matching .....	22
3.2	Data collection .....	23

3.2.1	Data sorting process .....	24
3.3	Variable definitions.....	25
3.3.1	Dependent variable.....	25
3.3.2	Independent variables .....	25
3.4	Model specification .....	28
3.5	Expected findings .....	30
3.5.1	Limitations.....	30
4.	Results.....	32
4.1	Descriptive statistics .....	32
4.1.1	Full data set.....	32
4.1.2	Stockholm.....	36
4.1.3	Gothenburg, Malmö, and Uppsala .....	36
4.2	Hedonic Regression Results .....	36
4.2.1	Model 1a – Certified and Region .....	37
4.2.2	Model 1b – Certified and Submarket .....	38
4.2.3	Model 2a – Type of certification and region.....	39
4.2.4	Model 2b - Type of certification and submarket .....	40
4.2.5	Model 3a – Distance and Certification and Region .....	40
4.2.6	Model 3b – Distance and Certification and Submarket .....	41
4.3	Sensitivity checks .....	43
4.3.1	Propensity score matching .....	43
4.3.2	Subsampling.....	44
5.	Analysis.....	46
6.	Conclusion.....	52
6.1	Future research .....	52
References	.....	53
Appendix	.....	60

# 1. Introduction

The real estate industry is facing a more environmentally responsible approach because of the sector's big contribution to greenhouse gas emissions and energy usage. The sustainability agenda has increased strongly during the last decades. Today, buildings account for 40 percent of global energy usage and are responsible for over one third of the greenhouse gas emissions (Säynäjoki, Heinonen & Junnila 2012). In Sweden, the construction and real estate sector is responsible for approximately 20 percent of the total national greenhouse gas emissions (Boverket 2021a). In addition, the building's electricity usage and heating account for about 40 percent of Sweden's total energy usage (Naturvårdsverket 2020). It is therefore important to unite a high construction rate with sustainable actions in all different stages, especially to achieve the Swedish government's initiative "Fossil-free Sweden" with net-zero emissions in 2045. The commercial building stock can save up to 30 percent in greenhouse gas emissions and energy usage through the construction of new green buildings or certifying existing buildings (Turner & Frankel 2008). Consequently, the construction and real estate sectors have an important role in reducing climate change and in delivering sustainable energy consumption. A report by McKinsey showed that resource reductions in the property sector are more affordable than in other industries such as manufacturing or transportation (Enkvist, Naucér & Rosander 2007). Hence, sustainable buildings are a cost-efficient way to lower emissions and strive for a more environmentally friendly future.

Green building certification has, for the last decade, gained global prominence for ensuring sustainable development. There are several drivers and benefits of green buildings from a property owners' perspective. According to Darko, Zhang, and Chan (2017) the drivers can be divided into different categories; property-level economic drivers, external drivers, corporate drivers, individual-level drivers, and project-level drivers.

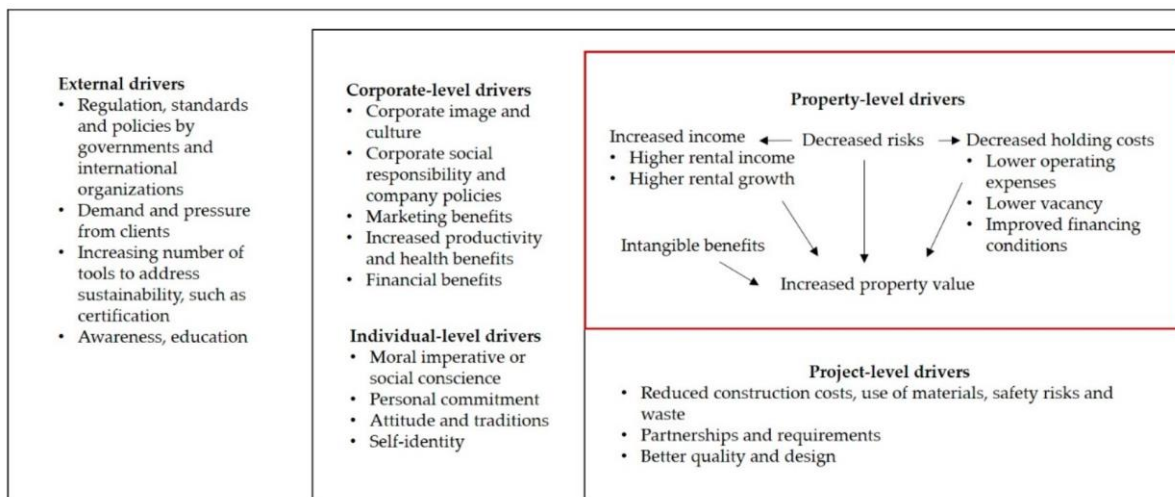


Figure 1. Illustration of drivers for green building (Darko, Zhang & Chan, 2017)

The components from the property-level drivers form the cash flow for an income-generating property, and later the value of the property. They state that green buildings both have higher rental income and higher rental growth. Furthermore, the property investment decision

making must manage to balance the relationship between property valuation, risk analysis, financing, and the growing interest in environmental impact (Lorenz & Lützkendorf 2008).

### 1.1.1 The Swedish Market

Buildings started to get certified in Sweden in 2010 after SGBC was founded as a non-profit association in July 2009. SGBC was founded by companies in Sweden involved in the build environment sector. The founder's vision was to influence the construction sector towards a more sustainable industry. Today, SGBC certifies buildings in Sweden with either LEED, BREEAM, Miljöbyggnad, or GreenBuilding. They also function as an opinion leader to promote green buildings in the Swedish legislation (SGBC 2020a).

In 2017 the Swedish parliament presented a new overall climate policy in order to achieve its parts from the Paris Agreement. To achieve a fossil-free Sweden by 2045, the Swedish building industry has agreed on voluntary targets. The goal is to reduce GHG emissions by 50 percent compared with 2015 by 2030, and by 100 percent by 2045. Due to this, the real estate sector may face climate-related regulators such as energy and CO<sub>2</sub> taxes, building regulations, and energy declarations technology procurement (Danske Bank 2020). Green building certifications can play a role for the industry to achieve this national target by 2045.

### 1.1.2 Demand for Green Buildings

One of the major reasons for improving and constructing energy efficient buildings is the direct economic benefits for real estate investors when considering the sustainability of a portfolio (Chegut, Eichholtz and Kok 2014). The dynamics are straightforward, if the business case is positive then the solutions will grow rapidly. Energy and water efficient solutions result in lower operating costs. Carefully selected building materials reduce risks and costs associated with cleaning, maintenance, and recyclability. Moreover, increased awareness among stakeholders is forcing investors to raise their ambitions of sustainable investments.

The World Green Building Council published a report containing a comprehensive study of the global green building market in which they surveyed how multiple stakeholders view their drivers for sustainable buildings. The top two drivers for stimulating demand for sustainable buildings are "client demand" and "environmental regulation" (Dodge Data & Analytics 2018). The move of tenants towards more sustainable buildings is thanks to enhanced reputation, corporate social responsibility mandates, and productivity gains for the employees (Nelson and Rakau 2010). There are several considerations taken into account when tenants decide on office premises. Important aspects are still location and cost, but tenants are considering green buildings when relocating as a mean of portraying their organizational image and identity (Kim, Lim & Kim 2019). Levy and Peterson (2013) identify some main factors influencing a tenant's choice of a building: location, flexibility, cost, staff needs, external pressure, marketing, sustainable building, and availability. The importance of each of these drivers is affected by the size of the organization and the type of business. Larger organizations tend to be more concerned about how building choice affects their corporate image and satisfies their CSR policy concerning their stakeholders. Smaller organizations are often constrained in terms of costs and the choice for relocating to a sustainable building is often based on how passionate the decision maker is about sustainable practices.

A study investigating why firms lease commercial office space in green buildings found that firms in the service sector admit the productivity benefits of green buildings. Other sectors prioritized the green buildings as a building with guaranteed higher quality, rather than CSR. Moreover, the study also indicated that tenants are more concentrated in green buildings which, according to the authors, can indicate that firms use a certified building as a mark to signal a commitment to CSR. The vast majority of tenants occupied in green buildings were public administration and the mining and construction industry. Where the latest participants in an industry affecting the environment heavily, and to enhance reputation as more environmentally friendly they do strategic decision making for their leases (Eichholtz, Kok, Quigley 2009).

Many municipalities use land allocation as a tool for sustainable urban planning. For instance, Stockholm Stad has implemented sustainability requirements for new constructions which include energy consumption requirements, sustainable communications, sustainable land, water usage, and promoting the usage of toxic-free building materials (Stockholm Stad 2017). These requirements force both constructors and real estate owners to build more sustainably to win land allocations in the cities. Additionally, the government in Sweden has implemented a requirement for residential dwellings to lower their energy consumption with individual debiting for heating and water. This obligation does not include buildings with a low energy consumption nor commercial real estate (Boverket 2020b). However, the government may demand the commercial sector to lower their energy consumption in the future, which may have the same conditions as for the residential sector. Therefore, voluntary labeling buildings green today may be profitable in the future by avoiding the risk of costly litigation later (Kassinis & Vafeas 2002).

### 1.1.3 Supply for Green Buildings

Green building supply can be determined by several factors, and they are also different from conventional buildings because they command a different set of technological and human capital requirements. According to Chegut et al. (2014) can the supply of green buildings be driven by construction costs, other certified buildings price signals, the prices, and availability of raw materials and human capital to construct green buildings, advances in green technology, and government policies mandating energy efficiency. Moreover, Onuoha, Aliagha and Rahman (2018) also state that important supply factors of green commercial property are monetary green tax incentives and green building skills.

The supply for green buildings in Sweden and the number of certified buildings are displayed via the Swedish Green Building Council. As of today, the total number of certified buildings including all building types is approximately 2400 buildings. The total number of certified office buildings in Sweden is 483 buildings. The trend is upgoing for the last couple of years, as expressed in figure 2.

According to SCBC (n.d) most of the certified office buildings are certified with either LEED (185 buildings) or Miljöbyggnad (228 buildings). The remaining office buildings are certified with BREEAM (37 buildings) and GreenBuilding (33 buildings).

Figure 2 visualize the number of executed certifications per year for all building classes in Sweden made by SGBC.

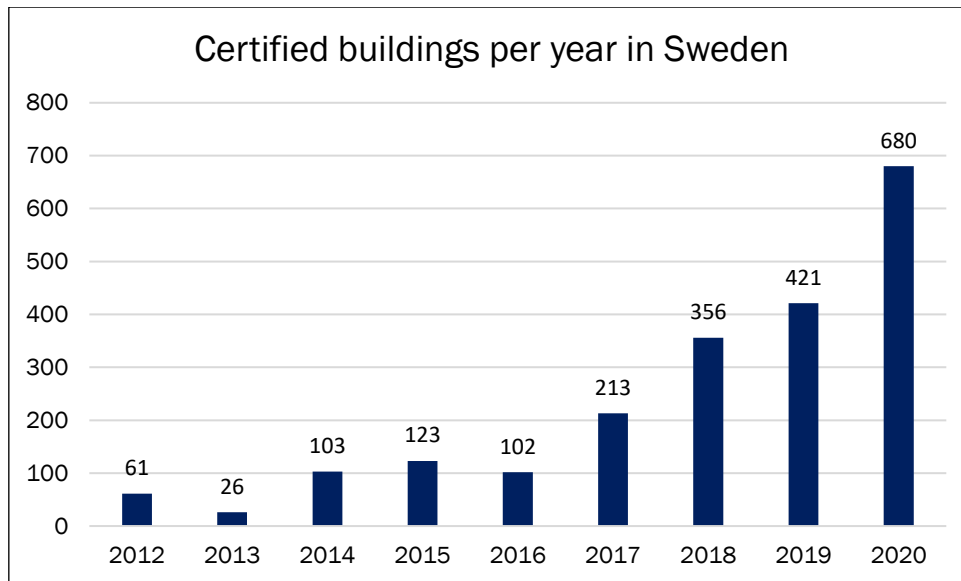


Figure 2. Certified buildings per year by SGBC (SGBC, n.d)

#### 1.1.4 EU Taxonomy

The EU Technical Expert Group on Sustainable Finance (EU TEG) has introduced the EU taxonomy. The EU taxonomy provides a framework and classification system that aims to help market participants determine whether an economic activity can be considered sustainable across all EU countries. There are six environmental objectives, and for an investment to be environmentally sustainable it must contribute to at least one of the six objectives while not harming any of the other five (TEG 2020). The six objectives are: (1) climate change mitigation, (2) climate change adaptation, (3) sustainable use and protection of water and marine resources, (4) transition to a circular economy, waste prevention and recycling, (5) pollution prevention and control and (6) protection and restoration of biodiversity and ecosystems. The taxonomy classifies activities rather than companies and different industries, so therefore can one company have both green and non-green activities within its organization. To facilitate the assessment, all companies covered by the taxonomy must report what percentage of the company's sales, capital investments (CAPEX) and operating costs (OPEX) are "taxonomy-compliant". Increased transparency and comparability make it easier to identify which companies contribute to fulfilling the Paris Agreement and significantly reduce carbon dioxide emissions. To further determine whether economic activities contribute to each environmental objective, the taxonomy has included so called *Technical Screening Criteria (TSC)*. The TSC will therefore be used as a basis for conducting actual lists of environmentally sustainable activities.

The taxonomy includes several sectors that together account for 93,5 percent of all emissions. The real estate and construction industry is included as a sector within the TSC because it is among the largest energy-consuming sectors in the EU. There are several categories included in the TSC for the real estate and construction sector. For instance, construction of new buildings, renovation of existing buildings as well as different forms of maintenance and installation. For each category, the TSC sets out criteria's concerning reducing primary energy demand, the use of sustainable technologies, waste management, etc.

Hence, each economic activity includes a threshold value that determines if the activity is considered green or not. A challenge with threshold values is the difference in climate

between different countries and regions. The technical expert group (TEG) provides a solution for this by referring to national standards and regulations (WFW 2021). For instance, the net primary energy demand for new construction should be at least 20 percent lower compared to the level defined in national regulations in order to be taxonomy-compliant.

The taxonomy is by many considered to be a game-changer and will affect the whole industry and all market participants. The real estate and construction sector seem like an essential element in the transition of making the whole economy sustainable. Therefore, it is expected that companies covered by the taxonomy must further disclose how their operations align with the criteria in order to have a broad investor base and good financial conditions. Property owners may certify their buildings as a mean to show their environmental contribution, although the different labels do not directly contribute to fulfilling the taxonomy's requirements.

### 1.2 Previous research

Research in the field of the impact of green building certification on cash flows and values has been a trending research subject for the last two decades. Rental income is an important topic because it affects the cash flow the property owner receives from their asset and thus is interesting for both property owners and investors. Moreover, studies have also focused on the vacancy rate for certified versus non-certified buildings which can prove if tenants have a higher willingness to pay for a lease in a certified building. This combined can indicate a reason for property owners to not only build with environmentally friendly materials for the purpose of intangible values but also resulting in a higher demand for green-certified office leases and higher rents, leading to a higher profit.

Previous research has shown that rent premium exists, most commonly in rural and low to middle-value areas (See for ex. Eichholtz et al.2010; McAllister 2015). The premium is ranging from 0-23 percent. The vacancy rate is also lower for certified buildings and they may have faster tenant absorption (Appraisal Institute and Institute for Market Transformation 2013) which implies a lower economic and actual vacancy rate (Wiley et al., 2010; Devine & Kok 2015). Lastly, previous research has concluded that the market conditions have a big impact on how green labels influence the property market.

### 1.3 Problematization

Green buildings increasingly become an identity marker for companies striving to lower their environmental impact and contributing to a more sustainable future. Sustainability becomes a factor of hygiene, the new norm. Therefore, the difference between certified and non-certified buildings can be even bigger due to faster obsolescence and tighten regulations for non-green buildings. This can lead to even more value in green buildings.

There is a need for research on the Swedish market and Swedish certification types for the investors to be rational in their decision making. As most of the certifications began in 2012 there is a demand for continuous research on the Swedish market to understand the growing and changing market dynamics.

Previous research has focused on other markets than Sweden, and in fact, there is no research at all for specific Swedish certifications such as Miljöbyggnad or GreenBuilding. Contractors and developers tend to build more sustainably than before due to tightened regulations by governments. However, that does not mean that all new buildings are certified with a label

because of capital and administrative costs. Also, certification authorities themselves claim that their certification provides a higher property value, in which need there is a need for scientific justification.

The research has also been incongruous, and their findings cannot be applicable in the Swedish market. Different green certificate labels can affect the premiums to different degrees. In other words, the premium is uncertain, unpredictable, and the result may vary to the local market (Black, Finlay, Rusin & Mills 2015). Therefore, property owners, investors, and other stakeholders need to know which certification system contributes the most to the property value.

In summary, there is a research gap in the field of green certification as the findings are contradictory and account for a big variance of premium. Additionally, it is a lack of empirical research in Sweden investigating green certificate labels.

#### 1.4 Research question

Demand for certified buildings in the European Union has increased since 2010 by property owners but also by tenants. This study will focus to answer the following questions:

Q1: Do office buildings with green certification receive a rental premium relative to comparable office buildings with no certification?

Q2: Is there a variation in the rent premium among different certifications?

Q3: Do the rental premium of office buildings with green certification increase with the distance from the city center?

#### 1.5 Purpose and contribution

Property owners are interested in the financial performance of the assets and how sustainable measures can contribute to this. Therefore, the impact of sustainability enhancements and particularly green building certificates are important to gain knowledge about.

The study will be conducted from a property-owner perspective and the results can potentially serve as a basis for decisions on investments regarding certification of buildings. If a higher rent level can be identified among certified buildings, this may indicate that there exists a higher willingness to pay for these features among tenants.

#### 1.6 Limitations

The study will be limited to the four biggest cities in Sweden (Stockholm, Gothenburg, Malmö, and Uppsala), which implies that the findings may not be generalizable to the total Swedish market nor smaller cities in Sweden. This is due to the lack of data from the smaller cities. Moreover, the study will only focus on income-generating office properties with two or more tenants. Other types of commercial buildings as well as the residential housings stock will be excluded.

Those active in the real estate sector use both terms such as “sustainable buildings” and “green buildings” interchangeably and do not differentiate between them. Therefore, both terms will be used synonymously in this thesis. As stated later in the thesis, green building can have more than one meaning. The implication of green building and sustainable building in this thesis is a building either certified with LEED, BREEAM, GreenBuilding, or Miljöbyggnad. The terms certification and label will be used synonymously.

## 2. Theory

In the following chapter, a literature review about the benefits of green buildings is conducted, these benefits should contribute to a higher property value, according to real estate valuation methods. The focus is to find what already has been investigated and their findings. Secondly, the different certification systems are described and compared with each other. Lastly, from the previous research, a theoretical framework will be implemented which explains why the research problem under study exists.

### 2.1 Literature review

Studies investigating energy efficiency and environmental certificates of properties have been a prominent topic since the beginning of the 21<sup>st</sup> century and research papers have increased largely in recent years (Porumb & Ion 2020). The phenomena have been studied in different markets around the world. However, most of the studies has investigated the US and UK market since green certificates were introduced early in these markets (Wadu, Mesthrige & Chan 2019). Most of the research and reviewed papers were published between 2010 to 2016. Research identifies different aspects of benefits that may increase the cash flow because of green buildings. The literature review will therefore be based on a framework formed on the parameters when conducting a DCF analysis.

#### 2.1.1 Rental income

Rental premium is an important incentive for investors and property owners when developing and investing in green buildings. The willingness to pay a rental premium in certified buildings is associated with enhanced productivity for the tenants as well as lower operating costs (Eichholtz, Kok & Quigley 2010).

The rental premium varies between different market segments and over time. Eichholtz et al. (2010) concluded that premiums were higher in regions where the economic premium for location is lower. Hence, the percentage increase in rent was higher in smaller or lower cost regions as well as in less expensive parts of metropolitan regions. Another study by Robinson and McAllister (2015) observed that certified buildings in high-value segments do not indicate any rental premium, whereas premiums exist for buildings in low and middle value segments. The reason may be due to lower number of certified buildings in lower value segments compared to the higher value segment. In high value locations, there is no differentiating factor because it is a norm to have certified high-value buildings. Studies have also found that the supply of sustainable buildings affects the rent premium. A higher supply in an area leads to a decrease in rent premium over time (Robinson & McAllister 2015). Therefore, the premium may be higher in less attractive areas with fewer certified buildings. Other studies conducted by Das, Tidwell, and Ziobrowski (2011) and Holtermans and Kok (2019) showed a rental premium for green office buildings over comparable non-green buildings. Additionally, Das et al. (2011) also examined that green premium for rents is countercyclical and not static. The rent level for green buildings tends to stabilize during down-markets and is substantially reduced in up-markets.

The lease structure may also affect tenant's willingness to pay for green features. A tenant is, by all means, only interested in the total amount of rent. In net lease structures, tenants are responsible for operating costs in addition to base rent, and they will be more motivated to pay a premium in order for lower operating costs. Reichhardt (2014) found this relationship in a study investigating the relationship between operating costs and rents for LEED certified

buildings in the US. LEED buildings with a net lease structure had a rent premium of 8,6 percent compared to buildings with a gross lease structure which had no significant premium. Reichardt, Fuerst, Rottke and Zietz (2012) investigated a panel data set of office buildings in the US from 2000 to 2010 and found a rental premium of 2,9 percent for certified buildings with LEED. The study also found a positive relationship between rent premium and time, meaning that a building with a certification grants a higher rent the longer the building is certified.

Some studies found no statistically significant relationship between higher rents and certified buildings. Fuerst and McAllister (2011a) investigated the effect of energy performance ratings on rental values on commercial properties using hedonic regression. The authors found no significant relationship between certified buildings and rental premium. An explanation can be that tenants are not aware of the energy certificates, or that energy costs are small compared to other operating costs. Veld and Vlasveld (2014) also show no evidence for a relationship between green buildings and rental premium. Their study investigates the retail sector in the Netherlands, and the rent level does not depend on the energy label, but instead other factors such as size and catchment area of the city center and size of the property. However, Qiu, Su and Wang (2017) found a higher rent premium than the operating costs savings are which indicate that the tenants are willing to pay for the certification itself.

The willingness to pay higher rents for certified offices can to a certain degree be explained by lower operating cost for the lessee if it is a net lease since they are responsible for the operating expenses. This explains roughly 50 percent of the premium whereby intangible benefits as improved productivity because of better indoor climate or higher demand caused by CSR requirements explains the other part (Eichholtz, Kok & Quigley 2013; Newsham, Veitch & Hu 2018; Livingstone & Ferm 2017; Reichardt 2014).

### 2.1.2 Occupancy

The occupancy rate affects the value of an income-producing property since at the end of the holding period the property is expected to have higher future cash flows if the vacancy rate is low. If a green building has higher occupancy than an otherwise similar building, the green building has an occupancy premium. This premium may result in lower losses in rents, longer lease terms, and lower tenant expenditure. Additionally, new green buildings or newly certified buildings may have faster tenant absorption (Appraisal Institute & Institute for Market Transformation 2013). Therefore, an occupancy premium could increase the value of a property.

An empirical study by Wiley, Benefield, and Johnson (2010), using hedonic price theory, investigated office markets across in the US. They investigated the relationship between green buildings with LEED or Energy Star certificates and occupancy level. The data set was sourced from CoStar and certified buildings were compared to a large sample of non-certified buildings. When controlling for the location, size, and age, they concluded that certified class A office buildings have an occupancy premium of 10 to 11 percent with Energy Star label and 16,2 to 17,9 percent with LEED certified properties. Another study, which used the same data source, but a sample of 200 LEED and 800 Energy Star certified buildings found an occupancy premium of 3 percent for LEED and 8 percent for Energy Star labeled buildings (Fuerst & McAllister 2009). The difference in the studies can be explained through different independent variables. Eichholtz et al. (2010) investigated the vacancy rate in the US and

found a higher occupancy rate for LEED and Energy Star labeled buildings with 9,4 and 10 percent, respectively.

Studies on occupancy rates have more recently been conducted in Canada by Devine & Kok (2015) and by Rahman, Rowlands, and Weber (2017). The first study found a significant increase in occupancy levels for certified buildings. On the contrary, Rahman et al. (2017) could not find a significant relationship, but they found a tendency for a lower vacancy for green buildings in their data.

### 2.1.3 Operating costs

One of the major motivations of green buildings is to decrease operating costs via energy savings (Hopkins 2016). From an investor's perspective, a value statement of owning a green building is lowering utility costs. Furthermore, reducing operating expenses and increasing the net operating income, which may have positive effects on the property value. One might argue that green buildings are more energy-efficient than conventional buildings. Even so, that is not evidence that the total operating expenses in green buildings are lower (Miller, Pogue, Savill & Tu 2010). Studies regarding operation costs are inconclusive, meaning research found both lower and higher operating costs.

A study by Reichardt (2014) examined if green buildings had lower operating expenses than conventional buildings from a dataset from CoStar (US) using hedonic price model. The author found that LEED-certified buildings have significantly lower operating costs. On the contrary, Energy Star certified buildings had a significantly higher operating cost than conventional buildings. Moreover, net leases had lower operation costs by 10,4 to 10,7 percent in green buildings which he explains by the fact that tenants use space and utilities more efficiently if they are responsible for the costs. Another study focused on the four largest cities in the US found surprisingly that green buildings in these areas had on average 11,2 percent higher operating expenditures than non-certified buildings (Szumilo & Fuerst 2013). However, the authors state that increased operating expenses are not a direct link to increased energy bills, instead it can be caused by energy rebound effect, increased maintenance costs, or an increase in the use of utilities. Miller's et al. (2010) study indicates a similar result, that energy certified buildings have higher operating costs, even that the results were not statistically significant, the operating costs tend to be higher according to their data.

On the other hand, Pivo and Fisher (2010) found no significant difference between Energy Star certified buildings and non-certified in the sense of operation costs. Nevertheless, utility expenditures were 12,9 percent lower for Energy Star certified buildings when tested just for utility costs.

### 2.1.4 Risk

Initial yield, also known as capitalization rates, indicates the risk level for an asset. A decrease in initial yield indicates lower risk and is therefore an important determinant for property capital value. The capitalization rates depend on several factors such as the capital markets, the risk associated with the property as well as the investor's expectation about the future value and the market position of the property (Chaney & Hoesli 2012).

The relationship between sustainable buildings and capitalization rates is a somewhat undiscovered field of research. However, McGrath (2013) examined the excess capitalization rates that investors place on increased value for certified buildings compared to non-certified

buildings in the US, using data on commercial office properties certified with LEED and Energy Star. Hedonic regression analysis showed excess capitalization rates on certified properties are 0,364 points lower than non-certified properties.

Extending the research from asset level to portfolio level, and the performance of real estate investment trusts (REIT) shows that portfolios with a higher share of green buildings have lower systematic risk (Eichholtz, Kok & Yonder 2012). A lower systematic risk indicates that green portfolios are better protected against risks such as rising energy prices and changing environmental legislation.

### 2.1.5 Sales price

For green buildings to have a sales price premium over non-certified buildings it has to have either higher rental income, occupancy premium, lower operating cost, and a lower risk premium (lower required rate of return) than conventional ones. However, a sale price premium may come from a higher construction cost caused by the green certification. High development cost has been proven as one of the biggest barriers in green building construction (Zhang, Platten & Shen 2011).

The cost premium has been studied by Matthiesen and Morris (2007) as they analyzed the total price for LEED buildings compared to non-certified ones. They argue that the construction cost varies depending on which program type incorporated and they could not prove significantly that LEED-buildings had a higher cost. On the contrary, many of the green buildings in the data had the same construction cost as non-certified projects. Other studies have found no significant increase at all (Lucuik, 2005). In summary, it seems that there is no or a small cost premium for green buildings.

A study in Finland let professional real estate valuers use discounted cash flow analysis on a hypothetical office building, first without and then with a green certificate. All respondents valued the green building higher than the non-certified building with 9 percent on average. The reason for the higher valuation was a lower initial yield but also a higher net operating income for the building with a green certificate (Vimpari & Junnila 2014).

Sale price premium has been studied extensively. Eichholtz et al. (2010) document a sale price premium of 16 percent for Energy star, whereas LEED had no sales premium at all. From a data sample of more than 13 000 transactions, Fuerst and McAllister (2011b) found a price sale premium of 18 percent for Energy Star and 25 percent for LEED-certified buildings. They point out the fact that the coefficients are sensitive to choice of trimming parameters and outliers can produce an overestimation of sale price premia. Moreover, they anticipate an increase in demand for green buildings in the future that will produce an even higher sale price premium. Miller, Spivey and Florance (2008) investigated the payoff of green investments, more precisely they compared data on Energy Star and LEED-certified office properties in a location in the US. Both labels gave a price premium, where Energy Star had 5,3 percent and LEED 9,9 percent. A study in the UK found a positive and significant price premium of 24 percent after controlling for location and observable differences in building quality (Chegut et al. 2014). A recent study investigated the impact of location on green certification price premiums in three European markets. The study found that investors are willing to pay 19 percent more for an office building with a green certification. Moreover, they also found evidence for an even higher premium for buildings located far from CBD. In cities with less than 200 000 inhabitants the location of the building becomes irrelevant.

(Porumb et al. 2020). The impact of the location seems to have a big influence that can dismiss the benefits from green certificates. Newell, MacFarlane and Kok (2013) study in Australia also strengthens the fact that the sales premium is higher in suburban areas than in the CBD. Their results show a value premium of 8 percent in suburban areas whereas the value premium in the CBD is 4 percent.

Some studies indicate no sales premium or even a discount for green properties or in consideration of energy usage (Furest & McAllister 2011b; Kok & Jennen 2012; Bonde & Song 2013; Surmann, Brunauer & Bienert 2015). The paper by Furest and McAllister (2011b) had a data set for only 24 BREEM-rated buildings and investigated appraised capital value instead of transactional value. Additionally, they used a sustainable property index that was based on a questionnaire by the property owners which can cause a bias. Both Kok And Jennen (2012), Bonde and Song (2013) and Surmann et al. (2015) investigated if EPC labels have an impact on the capital value. The first one had data from 2005 to 2010, where the financial crisis effect can occur and they also had a limited number of A rated buildings in the sample. Whereas the other also investigated EPC ratings and based the property value on estimated market value instead of transactions. Lastly, Surmann et al. (2015) had the same approach, investigating EPC:s from data between 2009 to 2011 in Germany. They could not find clear evidence for the relationship between only energy efficiency and market value.

#### 2.1.6 Studies in Sweden

Sweden has a rather small real estate industry in comparison to the studies presented. However, we could find some studies in Sweden investigating the price premium of green buildings, mostly on residential properties. The impact of energy use has only been investigated by one paper in Sweden, Bonde and Songs research from 2013. Furthermore, we could not find any paper investigating the impact of green certificates e.g., LEED or BREEAM in Sweden. However, there has been several research on energy performance and the residential market in Sweden. These studies found a positive relationship between energy usage and price premium of single-family detached homes (Högberg 2013; Cerin, Hassel & Semenova 2014).

#### 2.1.7 Conclusion of literature review

The literature review aimed to review the empirical research concerning the impact of green certificates on different cash flow parameters that can result in an advantage of certified properties. From the previous research, similarities, and differences can be drawn. First, every paper has the same base method developed by Rosen, *hedonic price model*. The model has been further developed by the authors, where some have focused on the relationship between green buildings and location, others on amenities in the area while some have focused on building density, etc. The literature review also describes that the premiums caused by green certifications depend on which variables are included in the models.

Even that this study will focus on rental income, it is important to look into other aspects which can be advantageous for certified buildings since the property owner has to take more than the rental income into account when deciding to certify their buildings or not.

Furthermore, the premiums vary largely by which certificate a study investigates. As described under the chapter *Sustainable buildings*, the certifications include different indications. This means that one certificate may include more indicators and by that require

more capital and a higher building cost resulting in a higher quality. Another explanation can be that the demand for a specific certification is higher.

Interestingly, it seems that the rental premiums are higher in rural and suburban areas than in CBD/class A locations. Some studies show no premium at all for certified buildings in the most coveted locations whereas buildings in areas with a lower density of certified buildings result in a higher premium. Lastly, the literature review describes that the premium depends substantially on the market and market conditions, and the results tend not to be generalizable from one market to another.

## 2.2 Concept of sustainable buildings

Sustainability has become an important topic over the last decades, not only in the real estate sector but for all industries since sustainability has a broad definition and can be separated into economic, environmental, and social sustainability. Slaper and Hall (2011) elaborated a framework for sustainable development based on economic, social, and environmental performance. Kohler (1999) states that this framework also can be applied to the built environment sector and according to Binert et al. (2010) can this framework also be used as a basis for various green building certification systems as illustrated in figure 3.

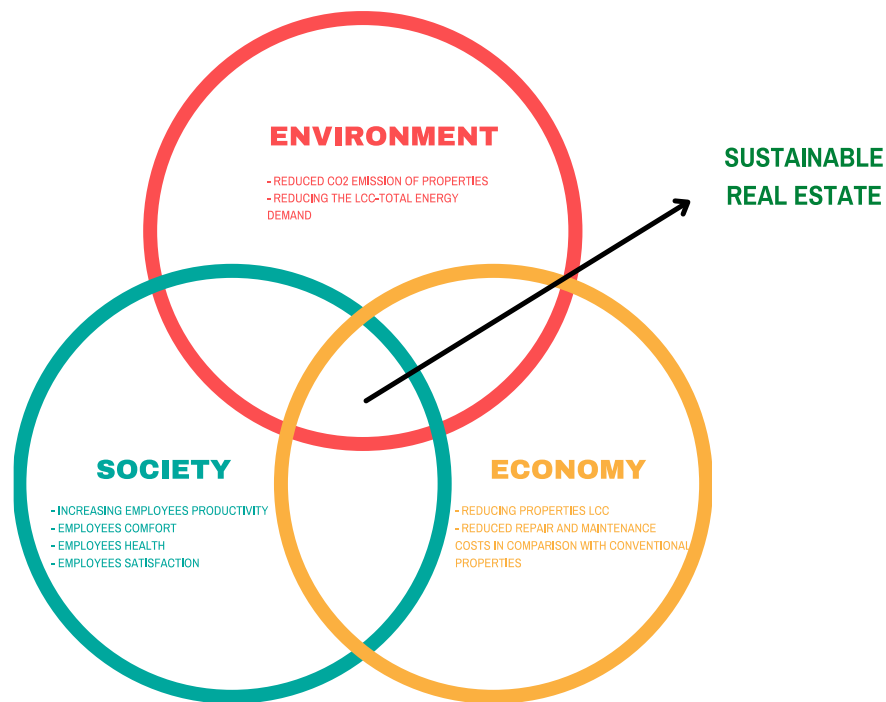


Figure 3. Own illustration of three pillars model of sustainable real estate (Binert et al. 2010)

The concept of green building is a bit ambiguous. There are many terms used for buildings that exhibit more and better sustainable features than conventional buildings. They range from low energy buildings to sustainable buildings and the definitions often overlap with each other. Lützkendorf (2009) provided a range of different terms as illustrated in table 1.

Table 1. Definitions of the concept of green building (Lützkendorf 2009).

Aspect	Functionality	Energy efficiency	Resource intensity	Environmental compability	Health	Sociocultural aspects	Life cycle costs	Value/Earnings	Technical quality
Low energy building		+	+	+	+				
Low emission building		+	+	+	+				
Green building		+	+	+	+	+			
High performance building	+	+	+		+				
Sustainable building	+	+	+	+	+	+	+	+	+

Considering the ambiguity of the terms above, it is obvious that there is a need for clarification. One of the most established definitions for green building is given by The World Green Building Council which defines green building as:

*“A building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources and improve our quality of life”* (World Green Building Council n.d.)

However, Yudelson (2008 p.13) defined a green building as:

*“A high-performance property that considers and reduces the impact on the environment and human health. A green building is designed to use less energy and water and to reduce life-cycle environmental impacts of the materials used”.*

The main focus and purpose of an environmental assessment system are to measure and evaluate a building's environmental performance in an easy manner. The attractiveness of the certification systems is based on comparability and transparency which help to steer the real estate sector into a more sustainable direction. The different certification systems determine a building's green performance and confirm its green building status. A major strength of the certification system is the standard it sets for green building, leading to concrete targets for builders, investors, and occupants (Deutsche Bank Research 2010).

There is a wide variety of different certification systems available for building owners. Briefly, there are three levels for green building when solely focus on the building's characteristics. These three levels also reflect the most common certifications available in Sweden.

Level 1. Only focus on the building's energy performance: A green building is a building whose energy consumption is lower than similar conventional buildings. The certification GreenBuilding reflects this aspect.

Level 2. A broader focus on the building's environmental attributes: This can for example include building material and indoor climate. The certification Miljöbyggnad reflects these aspects.

Level 3. Focus on the building's surroundings from an environmental perspective: This can include attributes such as which type of land being used and the opportunities to travel by public transport. The international certifications LEED and BREEAM are examples of such broader certifications that reflect these aspects.

### 2.2.1 BREEAM

BREEAM (Building Research Establishment Environmental Assessment Method) is a sustainability assessment for infrastructure and buildings developed in the United Kingdom by BRE in 1990. BREEAM is today one of the world's leading certification label for measuring the sustainability of a building. As of today, BREEAM is active in over 80 countries and approximately 595 00 certifications have been made around the world (BREEAM n.d.).

The assessment is based on environmental, social, and economic sustainability performance. BREEAM-SE is the Swedish version of BREEAM and therefore it is possible to certify buildings according to Swedish rules and standards, both for new constructions and for existing buildings. This makes international comparisons possible. The assessment is based on several sustainable categories, ranging from energy to ecology. Every category earns points when the target is reached, leading to a final performance rating (SGBC 2018).

### 2.2.2 LEED

LEED (Leadership in Energy and Environmental Design) is a green building certification system developed by the U.S. Green building council. LEED can be applied to all building types and provides a framework for design, construction operations, and maintenance of new as well as existing buildings. The LEED rating system promotes sustainable strategies to achieve seven prioritized goals:

- To reverse contribution to global **climate change**
- To enhance individual **human health** and well-being
- To protect and restore **water resources**
- To protect, enhance, and restore **biodiversity** and ecosystem services
- To promote sustainable and regenerative **material resources** cycles
- To build a **greener economy**
- To enhance social equity, environmental justice, **community** health, and quality of life

The certification provides a point system for five different categories: sustainable sites, water efficiency, energy and atmosphere, material and resources, and indoor environmental quality. Most of the points are awarded for reducing climate change through energy efficiency measures. Certification is awarded at four different levels – certified, silver, gold, and platinum (SGBC 2020).

### 2.2.3 GreenBuilding

The GreenBuilding certificate only indicates energy efficiency. There are different requirements for existing buildings and new construction. The main condition for existing buildings is to lower energy usage by at least 25 percent with energy efficiency measurements to become certified. For new construction, the requirement is a 25 percent energy usage reduction in comparison to the requirements in Boverket's building regulations. Annual reporting regarding energy management is also demanded to keep the certification (SGBC 2021a).

### 2.2.4 Miljöbyggnad Sweden

Miljöbyggnad is the most common green building certification system in Sweden. It's only developed for the Swedish market and is based on Swedish building rules and regulations. The certification can be used for both new developments as well as existing buildings. There are three different levels gold, silver, and bronze. The certification is based on three major

parameters: energy, indoor environment, and material. Different indicators are used to clarify the building’s environmental characteristics. There are different indicators for newly constructed buildings and already existing buildings. These indicators form the base for the grading of the building and later the level of certification (SGBC 2021b).

### 2.2.5 Comparison of the certifications

As described in table 2, the green certifications and their criteria vary depending on which system is used. The table does not include all categories for the criteria and is simplified, for example, “Indoor Environment” does take many other variables into account as daylight, ventilation, and noise, etc. BREEAM and LEED have more measurements in total, but it also requires property management when the building is used to fulfill obligations. Whereas Miljöbyggnad only includes the energy consumption for the building. In contrast, all other certification system has materials and indoor environment as a parameter. The cost for receiving a certification also varies between the certification systems, whereby GreenBuilding is the cheapest one. Since BREEAM and LEED are internationally recognized they could have an advantage for international tenants when investigating the office market. Lastly, in the tenant's point of view, the certifications that include more parameters should give an advantage if they care about more than just the certification, as the indoor climate, communication, and waste services, etc. Table 3 visualizes the different scores in the certification systems however, these scores are not considered in this study.

Table 2. Green certification comparison.

The green certifications and their criterias				
Criteria	BREEAM	LEED	Miljöbyggnad	GreenBuilding
Energy	X	X	X	X
Materials	X	X	X	
Indoor Enviroment	X	X	X	
Water	X	X		
Facilities Management	X	X		
Waste	X	X		
Infrastructure and communication	X	X		
Ecology and space	X	X		
Pollution	X	X		
Process and innovation	X	X		

Table 3. Classifications in green label systems.

BRREAM	LEED	Miljöbyggnad	GreenBuilding
Unclassidied < 30%	Certified 40- 49 points	Bronze	
Pass ≥ 30%	Silver 50-59 points	Silver	
Good ≥ 45%	Gold 60-79 points	Gold	
Very good ≥ 55%	Platinum ≥ 80 points		
Excellent ≥ 70%			
Outstanding ≥ 85%			

### 2.2.6 Energy assessment system - Energy Performance Certificate

In addition to the environmental certifications mentioned above, there exist schemes that only focus on energy performance. The EU Energy Performance Certifications (EPC) was introduced via the European Union and is mandatory to undertake in Sweden as it has been implemented into Swedish legislation.

An EPC scheme provides information about the building's energy consumption. The main purpose is to display the results and information to different stakeholders in a straightforward manner. The following information is included in an EPC (Boverket, 2021):

- the heated area of the building
- energy consumption for heating, comfort cooling, hot tap water, and the property electricity in the building
- energy performance
- energy requirement for a new building
- the building's heating and ventilation systems
- if obligatory ventilation control has been approved (OVK)
- if radon measurement has been performed, and if so, the determined level.

Energy consumption is described as energy performance, and it includes how much energy is consumed by heating, air-conditioning, hot tap water, and the building's property electricity. Hence, all energy consumption for one year is added up and then divided by the heated surface of the building. The result is expressed by the number of kilowatt-hours (kWh) used per square meter, and the energy performance is therefore expressed in terms of the unit kWh/m<sup>2</sup> and year.

## 2.3 Theoretical framework

Green certifications play an important role as an assessment system to an individual building's performance or its mark of quality. However, questions arise whether the market understands and recognized green certification (Abdullah, Mohd & Sabu 2016) in the sense of the relationship between certification and rent premium. The theoretical framework consists of three parts, in which are formulated to explain, predict and understand the impact of green certifications.

### 2.3.1 Value theory

The value of a property or good is hard to define, in general, the economic concept of value has a relationship to the economic price since the value serves as a justification for prices (Boltanski & Esquerre 2016). Value only happens when the price is inaccessible (Boltanski, Esquerre & Miniesa 2015), as in heterogeneous markets such as the property market. Value is then the expectation of the price and what that good will sell for. However, depending on who is asked, the value will be different since personal views and arguments are judging it. With that said, these discrepancies infer that not only one price has the same value for everyone, but the value acts as a belief about the economic price (Elder-Vass 2019).

Due to that, value as a concept can be hard to define from one point of view. In economic terms, value can be divided into value-in-exchange and value-in-use (Das Gupta 1960). Whereby the first one only takes the price into account in a market when valuing a good whereas the second one includes the satisfying power of a good. The satisfaction can vary

depending on who is consuming it. Historically, the theory has been mainly focused on value-in-exchange and resource exchange. Lately, the focus has shifted to value-in-use and resource integration since the competition in the market has increased (Eggert, Ulaga, Frow & Payne 2018). This implies that the provider must know and fulfill the needs of the customer. Gadd (1989) conducted a concept of how value-in-use can be seen from the real estate appraisal industry. He argues that “Value-in-use is the market value of a going concern that reflects a value to a particular user, recognizing the extent to which the property contributes to the enterprise and/or profitability of the enterprise” (Gadd 1989, p.5). In other words, the value can vary depending on the user, and in the sense of sustainability, the value of the label is not equal to all tenants.

### 2.3.2 Discounted cash flow valuation theory

Discounted cash flow (DCF) valuation is one of the most used property valuation methods and is an income capitalization technique (Bruggeman & Fisher 2019). The DCF method is commonly used in Sweden by professional property valuers when appraising commercial properties (Bellman & Lind 2019). The fundamentals of the DCF approach involve projecting estimated cash flows (rental income minus operating costs and capital expenditure) during an assumed investment holding period and an additional exit value at the end of the period. In other words, an investor will not pay more for a property than the present value of all future NOIs. The exit valuation, or intrinsic value, is derived by using Gordon Growth Model. The model theories a set of cash flows that will continue into infinity, with expected growth at a steady rate. Gordon Growth Model does not take intangible factors into account as customer retention, brand loyalty, or in this case sustainable labels. The cash flow and exit value are then discounted back to get the present value of the property. The discount rate, also known as the desired rate of return, shall reflect the market and property-specific risk (RICS 2010).

### 2.3.3 Hedonic price model (HPM)

Hedonic pricing is a theory that identifies price factors according to the assumption that price is determined both by internal characteristics of the good and external factors affecting it, e.g., the characteristics of a property as well as the neighborhood and amenities in the area. If the model is well-specified, the model will explain each contribution of the total price from the characteristics separately (Sopranzetti 2016; Belniak & Wieczorek 2017).

This model was first originated by Waugh (1928) as a model for valuing price difference between vegetables, and later by Court (1939) constructing a price index for automobiles. These studies focused only on heterogeneous products. Lancaster (1966) presented a theory for hedonic utility. He argued that a good itself may not create utility, but instead, the characteristics of the good create the utility, in other words, the utility is not driven by owning a property but the characteristics of it as increased prestige, attractive architecture, lower energy usage, etc. Moreover, Lancaster (1966) means that goods can be arranged into groups based on the characteristics they contain.

The first article studying pricing and pricing models was Rosen (1974), the study started with the assumption that any good or service can be valued from the sum of its utility generating characteristics. The total price of a good should be the sum of the individual prices of its characteristics, therefore the model can determine how the price of a commodity varies with the set of attributes it possesses. The model is commonly used to analyze various factors that

drive the price of properties. The idea is to break down a price into various characteristics and then estimate the value-added of each characteristic. Since every property has idiosyncratic characteristics (heterogeneity among properties), estimating the price can be challenging. Therefore, HPM can deconstruct the property into its value-adding components; structural, locational, and neighborhood characteristics. These can for example be area, lot size, building year, neighborhood quality, spatial environment, etc.

Rosen’s model can be described as a function where the dependent variable (price) is caused by several independent variables (characteristics), whereby the independent variables drive the price. The model can in its most simplified form be described as:

$$y = m + \beta_1x_1 + \dots + \beta_nx_n + \varepsilon$$

This can be summarized to:

$$y = m + \sum_{i=1}^n \beta_i x_i + \varepsilon$$

Where  $y$  is the dependent variable (price) and  $x_i$  are the independent variables i.e., explanatory variables which characteristics may affect the total price of the asset. The constant  $m$  revealing where the fitted line intercepts the  $y$ -axis.  $\beta$  represents the value added from every characteristic,  $i \in [1, \dots, n]$ ,  $n$  represents the number of characteristics and lastly,  $\varepsilon$  is the standard errors (Hill, Griffiths & Lim 2018).

## 2.4 Conceptual framework

The conceptual framework is based on the literature review and the theories used in research in the field. We can conclude that it is important to control for property attributes that may influence the rent level in a property. Therefore, the study will both include *structural*, *locational*, and *quality* attributes as described in figure 3. Additionally, the various green certification labels that may cause a rental premium will be added to the observations to see if they have any market impact. Lastly, these parameters will be included in a hedonic pricing model to see which one drives the rent level.

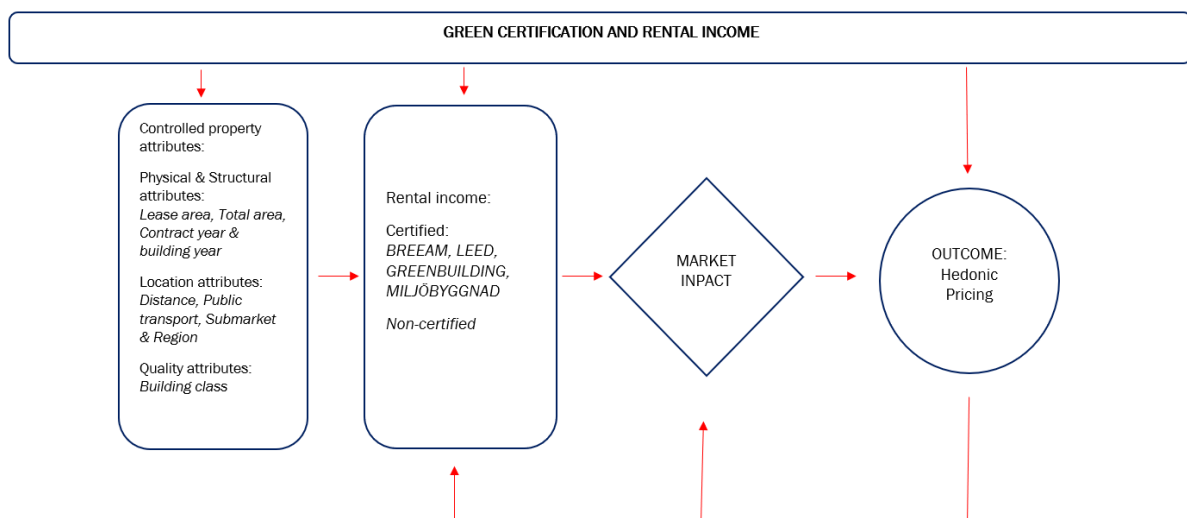


Figure 4. A conceptual framework for assessing the impact of green certificates by Abdullah et.al (2016), modified by the authors.

### 3. Methodology

The study has been conducted using a quantitative approach. More specifically with an econometric method. Real estate econometrics can be defined as the application of statistical techniques to problems in the real estate market and for testing alternative theories to problems (Brooks & Tsolacos 2010). This method is the most suitable approach for the purpose of our research question. Quantitative research examines and investigates the relationship between different variables and in this case, the quantitative research is descriptive. The variables are measured numerically and are analyzed using different statistical techniques (Saunders, Lewis & Thornhill 2016). This is needed for us to investigate the relationship between rent levels and green certificates. An eminent approach to analyze the relationship is to use the computational technique of regression analysis. Regression analysis is used to estimate a relationship and the impact that different parameters may have on a certain variable. Most of the earlier research investigating the green building certificates used this approach (Eichholtz et al. 2010; Robinson & McAllister 2015; Eichholtz et al. 2013; Fuerst & McAllister 2011b; Holtermans & Koks 2017; Holtermans et al. 2019).

Three types of data can be employed in quantitative econometrics real estate analysis: cross-sectional data, time-series data, and panel data. An analysis with data samples from only one single point of time is called cross-sectional data (Brooks & Tsolacos, 2010). A cross-sectional analysis suits this study best since this data sample will only employ rent data from the year when the contract was signed. A cross-sectional analysis can prove our hypothesis that green certificates imply a higher rent at a specific point in time.

#### 3.1 Regression analysis

The study performed a hedonic regression analysis based on a hedonic pricing model. As stated earlier, a price of a commodity being sold is determined by several internal and external factors that affect the commodity. Accordingly, regression analysis helps to explain and describe the relationship between different variables meaning quantifying the relationship between the dependent variable and several explaining (independent) variables (Saunders et al. 2016).

##### 3.1.1 Linear regression

One of the most common and widely used regression techniques is linear regression. For this technique, the dependent variable must be continuous, and the independent variables can be either continuous or discrete (Holmes, Illowsky & Dean 2018). This study included more than one independent variable leading to a multiple linear regression model. A multiple linear regression model quantifies the impact of each independent variable on the dependent variable which is shown by the regression coefficients. A typical equation for multiple regression is shown below.

$$Y_i = \beta_0 + \beta_1 X_{1i} + \dots + \beta_K X_{Ki} + \varepsilon_i$$

Where  $\beta_0$  is the intercept of the  $Y$ -axis and  $\beta_i$ 's is the slope between  $Y$  and the appropriate  $X_i$ ,  $\varepsilon$  is the error term in the measurement of  $Y$  and the effect thereby.

A linear regression model can be adjusted to be more suitable for its purpose. Logarithmically transforming variables in the regression model is a common way to adjust the model. This is useful in situations where a non-linear relationship exists between the independent and dependent variables. Moreover, it is also favorable to use logarithmic

transformations to get a symmetric distribution of the data. Skewed distributions are common for economic variables and therefore a logarithmic transformation is necessary (Hill, Griffiths & Lim 2018). One common adjustment is to use a log-log model which is commonly used in economic research. Similar studies have used log-log models (Porumb et al. 2020; Holtermans & Koks 2019; Fuerst & McAllister 2011b; Eichholtz et al. 2010). An example of a logarithmically transformed model of multiple regression is illustrated below.

$$\ln(Y) = \beta_0 + \beta_1 \ln X_{1i} + \dots + \beta_k \ln X_{ki} + \varepsilon_i$$

Where  $\ln(Y)$  is the dependent variable and in our case the rent per square meter in natural logarithm. The intercept is represented by  $\beta_0$  (the value of  $y$  when  $X=0$ ) and  $\beta_k$  represents all characteristics and the change in rent caused by them. The standard errors are summarized in  $\varepsilon$ .

There are several assumptions of the multiple regression model which should be fulfilled in order to draw conclusions regarding the model. The purpose of the assumptions is also to establish a framework for estimating the unknown parameters of  $\beta_k$ , as well as testing hypotheses about the unknown parameters (Hill, Griffiths & Lim 2018). The assumptions are the following:

*MR1: Econometric model*

*MR2: Strict exogeneity*

*MR3: Conditional homoskedasticity*

*MR4: Conditionally uncorrelated errors*

*MR5: No exact linear relationship exists between the explanatory variables*

One of the primary tools to analyze data is the ordinary least squares (OLS) method. This is an established and simple technique to find the line that best fits the data. The OLS method estimates the relationship between the dependent variable and independent variables and will seek the line that best explains the relationship. The slope and intercept of the regression line are estimated while minimizing the residuals. The residuals are calculated as the difference between the observed  $y$ -values and the fitted  $y$ -values.

$$\varepsilon_i = y_i - \hat{y}_i$$

Where  $y_i - \hat{y}_i$  represents the sum of residuals for the line.

According to the Gauss-Markow theorem under the assumptions of the linear regression model (linearity in parameters, random sampling of observations, conditional mean equal to zero, absence of multicollinearity, homoskedasticity of errors), the OLS estimators are the best linear unbiased estimators (BLUE) of the real values.

The OLS method minimizes the sum of all squared differences between the observed and predicted values. This is called the sum of the squared residuals and can be written as:

$$SSE = \sum_{i=1}^n (y_i - \hat{y}_i)^2$$

### 3.1.2 Tools in regression analysis

#### *T-test*

A t-test (student's T-test) is a method of testing hypotheses, which is used to examine if assumptions apply to a whole population. A t-test investigates how significant the differences (measured in means) between groups are. The test score from a conducted t-test is called t-score. The calculated t-score is a ratio between the difference between two groups and the difference within the groups. A large t-score indicates more difference between the groups and a small t-score shows more similarity between the groups.

Every t-value has a corresponding p-value. A p-value is a probability that the results from the sample data occurred by chance. The p-value is compared to the level of significance and can thereafter determine whether or not it is possible to reject the null hypothesis. The null hypothesis is if the independent variable does not correlate with the dependent variable. Consequently, the lack of correlation between the changes in the independent variable and shifts in the dependent variable concludes that there is no evidence that there is an effect at the population level. If the p-value is *less* than the significance level, the sample data provide enough evidence to reject the null hypothesis for the entire population. A p-value that is *greater* than the significance level indicates that there is insufficient evidence to reject the null hypothesis (Hill et al. 2018).

#### *Coefficient of determination*

The coefficient of determination (denoted  $R^2$  and often referred to as R-squared) is an important output of the regression analysis. It shows the proportion of variance in the dependent variable that is predictable from the independent variables (Hill et al. 2018). The values are given in an interval between 0 to 1. R-squared can be interpreted as how well the model fits the data. However, in a multiple regression model, the adjusted R-squared is better to use. It corrects for the number of predictors (independent variables).

#### *Endogeneity*

Endogeneity refers to situations when the expected error term is not zero and hence correlates with one or more of the explanatory variables (Lang, 2016). In other words when an explanatory variable in the regression model is correlated with the error term. Endogeneity leads to biased and inconsistent parameter estimates which makes reliable inference almost impossible (Constantinides, Harris & Stulz, 2013). Problems with endogeneity can occur by many conditions but the most common is omitted variable bias, which occurs when important variables are omitted from the model. Another problem is simultaneity bias, when the outcome variable is a predictor of  $x$  and not a response to  $x$  (Ferraro & Carr, 2021) i.e., when  $y$  and  $x$  are determined in equilibrium, and either  $x$  causes  $y$  or that  $y$  causes  $x$ .

#### *Multicollinearity*

Multicollinearity appears when the independent variables in a regression model are correlated. This is a problem because the independent variables are supposed to be just independent. A key goal of regression analysis is to isolate the effect and the relationship between each independent variable and the dependent variable. If the grade of correlation is sufficiently high, it can cause problems with the interpretation of the results. When the independent variables are correlated it indicates that changes in one variable are linked with changes in another variable. Consequently, it becomes difficult to estimate the relationship

between each independent variable and the dependent variable independently because the independent variable moves together. In order to construct a reliable regression model, the highly correlated independent variables have to be excluded. This is generally a problem associated with models including dummy variables (Hill et al. 2018). To avoid this, one dummy variable is normally omitted. It is also important to analyze the correlation matrix to investigate whether there is a presence of multicollinearity and if there is, possibly exclude one of the independent variables.

### *Heteroskedasticity*

Heteroscedasticity is a well-known problem with cross-sectional models and may affect t-ratios and standard errors. One of the assumptions for the use of OLS is constant error variance (i.e., homoskedasticity). The existence of heteroskedasticity violates this assumption. There are two major implications when violating this assumption (Hill et al. 2018):

1. The least square estimator is still a linear and unbiased estimator, but it is no longer best. There is another estimator with a smaller variance.
2. The standard errors usually computed for the least squares estimator are incorrect. Confidence intervals and hypothesis tests that use these standard errors will be misleading.

The most usual method for detecting heteroskedasticity is to plot the sample residuals against the fitted values and look for patterns. If the plot looks random and no pattern can be detected, then there is no violation of the constant error variance assumption. But if there is any kind of clustering or trend detected, then the assumption is violated and needs further assessment.

### *Interaction term*

An interaction or relation between independent variables is called an interaction effect. This effect happens when one independent variable interacts with another independent variable. Hence, when they interact with each other, the effects might indicate that a third variable influences the relationship between the dependent variable and the independent variable. If this is the case, then it is important to consider it and incorporate it into the model. Adding an interaction term can greatly expand the understanding of the regression model, and consequently allows for more hypotheses to be tested as it captures the interaction effect between two independent variables (Hill et al. 2018).

#### 3.1.3 Propensity score matching

Certified and non-certified buildings may be considerably different regarding important building features. To determine the effect of certification on rental income properly, it is important to achieve comparability between certified buildings and non-certified buildings. For this purpose, a common approach is to use a matching technique called propensity score matching (PSM). Using propensity scores makes us able to perform valid comparisons between a treatment group and a control group (Rosenbaum & Rubin, 1983). The advantage of PSM is that certified buildings and non-certified buildings are matched using only a single propensity score. It is much more convenient than matching it based on all observed building characteristics individually. This method also reduces selection bias because of randomization and by balancing the covariates (characteristics) between the treatment group and control group. The PSM method is also highly adopted amongst other studies within the

research field (Eichholtz et al. 2013; Porumb et al. 2020; Chegut et al. 2014; Robinson & McAllister 2015).

The certified buildings constitute the treatment group, and the non-certified buildings constitute the control group. The first step in the propensity score matching technique is to estimate the variables propensity scores in order to reduce selection bias. Selection bias can be a major limitation if the sample is not randomized properly, but the process of dividing the sample into control and treatments group will increase the reliability of the study. The propensity score can be estimated using different types of methods, but the most eminent method is by using probit regression model (Austin 2011). The propensity score is defined as each observation conditional probability of receiving treatment, given the pretreatment characteristics. Hence, probit regression is used to determine the probability, and the probability of treatment is bounded in the interval between zero and one. Each certified building is matched with its nearest observation in terms of propensity scores. A benefit when matching on nearest matches is that it is straightforward and yields close matches while using a limited amount of data. Once the matching is finished and the treatment group and control group are defined, a linear regression model can be conducted.

### 3.2 Data collection

The data was gathered from secondary sources as Datsha, CityMark Analys, Green Building Council Sweden (GBCS), and US Green Building Council (USGBC). Secondary data is data collected by others than the researchers themselves (Cowton 1998). Using secondary data has advantages since it is time-efficient, cost-effective, and gives access to data otherwise impractical to gather. Furthermore, it opens different ways of interpretation, and the quality of the data can be higher because the original designers may have higher expertise (Smith, 2011).

Most of the data is either categorical or numerical. Numerical data and can be broken into two types: discrete or continuous (Rumsey 2015). Categorical data represents characteristics and can take on numerical values, but the values do not have any meaning by themselves. The study will include a combination of both numerical and categorical data. The numerical data is pretty straightforward containing values such as different rental price levels and vacancy rates and is continuous i.e., the data can take any value. While the categorical data include other characteristics and qualities such as location, certification label, and submarket. To be able to transform the categorical data into numerical values one can use a dummy variable (also called indicator variable). Technically, dummy variables can only take two quantitative values, 1 or 0. Where 1 typically represents the presence of an attribute, and 0 represents the absence. Therefore, all the categorical data has been converted into dummy variables.

The reasons for using secondary data for this research are the practical considerations and the requirements of big numbers of observations. Gathering all data by ourselves would be impractical and thus we were able to achieve access to data from companies and organizations.

CityMark Analys contributed to most of the data and formed the basis for the data collection. CityMark Analys maps the office market through interviews over phone with property owners and property managers of office properties in Stockholm, Gothenburg, Malmö, and Uppsala. All office properties with a stock of at least 350 sqm are identified and mapped

(CityMark Analys 2021). The data from CityMark Analys consists of rent level, vacancy rate, building class, lease area, total leasable area, construction year, and certification label. The information is of high quality thanks to interviews directly with property owners. When interviews have been unable to perform, other channels have been used to get updates. For example, the websites of the property owners or the websites of local agencies.

SGBC had data for all certified buildings in Sweden with either GreenBuilding, BREEAM, or Miljöbyggnad whereas USGBC had an open database for all LEED-certified buildings. CityMark Analys also provided data on the different certification labels. We used the information from GBSC and USGBC as a measure for comparison with the dataset from CityMark Analys. Random spot checks were conducted to verify the data for the certifications between the two datasets in order to achieve higher reliability.

Datscha’s database had information regarding location, construction year, and value year. For some observations, data on construction year was missing. In those cases, we searched the property owners’ websites or ordered energy performance certificates to get the correct construction year. Datscha also provides area information and therefore we performed random spot checks conducted to verify CityMark Analys data to achieve higher reliability. Lastly, we added the distance to CBD in Stockholm and the central train station for Gothenburg, Malmö, and Uppsala from the property. The distance is measured in kilometers (linear distance) and collected with BatchGeo<sup>1</sup>.

### 3.2.1 Data sorting process

The original dataset consisted of approximately 17 000 observations but due to missing data for some parameters, outliers, and an investigated period between 2010 and 2021 we ended up with 7427 (1566 properties) observations consisting of 2241 (319 properties) observations with a certification label. 89 properties with BREEAM, 125 properties with LEED, 78 properties with Miljöbyggnad, and lastly, 74 Properties with GreenBuilding. The number of observations for each label is illustrated in the table below. The properties summarize to 2679, and the reason for this is because some properties have more than one certification.

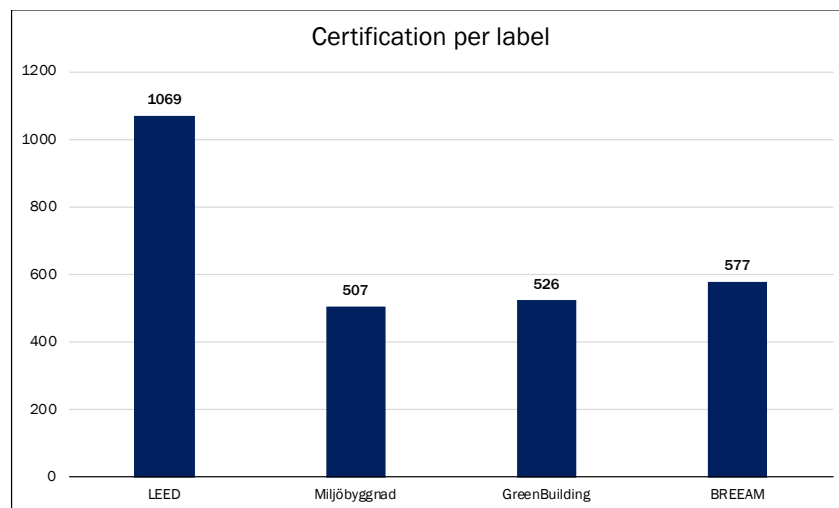


Figure 5. The number of certified buildings per label (SGBC, n.d)

<sup>1</sup> BatchGeo is a service that provides bulk distance from addresses in a spreadsheet.

The certified buildings make for approximately 36 percent of the overall sample with the following distribution: LEED of 39.9 percent, Miljöbyggnad of 18.92 percent, GreenBuilding of 19.63 percent and lastly BREEAM of 21,54 percent (table 5). This proportion is greater than other influential articles about the subject. For example, Eicholtz et al. (2010) had an 8,48 percent green sample, and Fuerst and McAllister (2011b) had a 6,25 percent green sample. The total number of certified buildings in Sweden is 479, as of 2021, according to SGBC, and our dataset includes 319 properties leading to a good representation of the total population. As a comparison, Wadu Mesthrige & Chan (2018) had a sample of 46 certified properties from a total of 321 certified properties in Hong Kong.

### 3.3 Variable definitions

All variables are listed and presented in this section, the chosen variables are commonly used by previous research regarding certified buildings and rental premium.

#### 3.3.1 Dependent variable

##### *Rental income*

To investigate if certified buildings have a higher rental income than non-certified buildings, the rental income will be used as the dependent variable for all models. Rental income refers to new rental agreements between property owners and tenants who have not rented from the property owner's office stock the last rental period. The rental statistics refer to base rent, meaning without VAT, property tax, or other additions. For the observation to be included in the statistics the office space needs to be at least 50 sqm and the duration of the lease must be at least 1 year. The data is collected from CityMark Analys and expressed as rent per square meter.

#### 3.3.2 Independent variables

##### *Construction year*

Since the age of the property can influence the value of the commercial property (Huffman & Longhofer, 2016), the construction year was included as a variable in the model. The construction year of the properties has been divided into groups with specific time intervals for each dummy variable. For example, if a property was constructed in 1955, it would be included in a group with buildings built between 1930 to 1964. The information for the construction year was gathered from Datscha. See table 4 for the specific time intervals of the building year.

Table 4. Intervals for construction year.

<1900	1900-1929	1930-1964	1965-1974	1975-1989	1990-1999	2000-2010	>2010
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##### *Value year*

In Sweden, the Swedish Tax Agency assigns a value year to all taxable commercial properties. The value year is based on the construction year. However, if the property has been redeveloped or highly refurbished since its construction year, the renovation year will be used as a new value year. Research has shown that the price of office rents is affected by buildings construction quality (Wheaton & Torto 1994; Bollinger, Ihanfeldr & Bowes 1998). In this study, the value year should be seen as an indicator of the quality of the property and is expressed in a categorical variable. The value year from every observation was collected from Datscha. See table 5 for the specific time intervals regarding value year.

Table 5. Intervals for value year.

<1900	1900-1929	1930-1964	1965-1974	1975-1989	1990-1999	2000-2010	>2010
-------	-----------	-----------	-----------	-----------	-----------	-----------	-------

*Vacancy*

A vacant space is unoccupied at a particular time. The information regarding vacant space was given at a property level and later divided with the total leasable to get the percentage number. Hence, the vacancy rate was then applied to all observations within the property. For example, if there are five contracted tenants within a property, they all get the same vacancy rate. This data was collected from Citymark Analys, and they specify all spaces vacant by the time of measurement or which will be vacant within the next three-month period.

*Distance*

The location of the building affects the rental income since land is more competitive closer to CBD also cities with more inhabitants have higher rents (Brennan, Cannaday & Colwell, 1984; Clapp, 1980). In this study, the location variable will be based on the linear distance from CBD or the central train station from the property.

*Submarket*

All investigated regions have submarkets consisting of areas within the cities where properties have higher or lower demand and different vacancy levels. Therefore, the reason for categorizing this is to capture the locational effect on willingness to pay for leases. The submarket variable will be based on the different location parameters such as AA, A, B, etc. There is a disparity for the location depending on which borage firm asked, therefore all location classifications in all cities are from Newsec. All observations were classified with a specified location provided from Newsec via Datscha. All contracts within a property are provided with the same location. In order to have a smaller amount of location variables, they are later divided into larger submarkets. The selection for the larger submarkets is mainly based on the number of observations in each location. For a specified list of all locations and which submarket they belong to, see appendix 1 (table A-1). See table 6 for the distinction for the submarkets. Furthermore, a map presenting all borders for each submarket can be found in appendix 1.

Table 6. Submarket locations

Submarkets					
Stockholm	Stockholm	Other	Gothenburg	Malmö	Uppsala
AA	A		AA	AA	A
A	B		A	A	B
B	C		B	B	C
C			Mölnadal	C	D
D					

*Total leasable area*

The total leasable area was based on the total office area for each property. Every observation for each property will be given the same total leasable area. For example, if a building has five contracts, they all get the same total leasable area. The data was gathered from Citymark Analys.

### *Green Certification*

The green certification variable is categorical and includes all certification labels. To be able to measure its impact it was converted into a dummy variable. The green certification variable indicates if the property where the lease contract is located is certified or not. All observations in every property get the same number. The data was provided from Swedish Green Building Council and Citymark Analys.

### *Label system*

To investigate more in detail which certification affects the rental income, all certifications are separated into dummy variables. The reason for this was to discern which one contributes the most to the rental premium. However, the scores in LEED, BREEAM, and Miljöbyggnad are classified as one, to minimize the number of variables. Additionally, according to Jang, Kim, and Kim (2018), higher scores do not lead to higher willingness to rent and therefore it may not add statistical power to separate the scores.

### *Contract year*

The contraction year was separated into dummy variables, one for each contract year, ranging from 2012 to 2021. Consequently, a property with several contracts has different contract years. This parameter also catches market conditions for each year. The data was collected from Citymark Analys.

### *Building class*

CityMark Analys classes all properties that are part of the mapping based on the quality of the building. These factors subsequently determine a combined classification. The classes are defined as A+, A, B+, B, and C, where A+ is the highest classification. See table 7 for a distinction between them.

Table 7. Building classifications

Classification	
A+	New construction or completely renovated. The property retains it's A+ for five years
A	New production standard or comparable. Retained for 10 years if no thorough renovation is made.
B+	Fully modern offices, but older than offices included in A.
B	Fully modern offices, but slightly worse than B+.
C	Outdated offices.

### *Lease area*

The lease area variable specifies how many square meters are included in the lease term for each observation. The data for this variable is collected from Citymark Analys.

### *Distance to public transport*

The distance to public transport variable retains the distance in minutes by foot to nearest public transport from the building. It can either be subway, bus stop, light train, or tram, depending on the city.

### *Certification\*Distance*

The interaction variable between certification and distance measures the incremental effect of distance from city center on the green certification premium.

### 3.4 Model specification

In this study, several multiple regression models were analyzed to answer the research questions. Furthermore, we tested additional independent variables to see if a particular characteristic created a higher explanation of the rent level. Model 1a examined whether certified office buildings achieve a rent premium compared to non-certified buildings over the full dataset within the regions, regardless certification. Model 1b separated the regions into submarkets to capture the effect of each determined submarket. Model 2a separated the label systems into indicator variables to capture the effect on the individual labels on a regional level. Model 2b investigated the same as Model 2a, but instead of region submarkets was used. Lastly, model 3a and 3b analyzed the progressive effect of the interaction between distance and certification.

First, we tested to include additional independent variables in the models to increase the explanation of the rent and the robustness. However, these variables did not increase the robustness nor was statistically significant. The variable was *value year*, intended to capture effects of building quality. The reason why value year could not be proven to affect the rent is that it does not capture the quality of a specific office. Additionally, the value year is not updated frequently. The other one was *vacancy*, expected to control for occupancy differences between properties. Nevertheless, the R-squared did not increase, and the variable was dropped. Although the vacancy rate affects the rent, this variable had missing data and was not accurate for all observations. A variable with the age of the building in its natural logarithm was also tested, still, the models were more significant with construction year separated into indicator variables.

Interaction variables between certification and submarket were included at first, to capture the effect of certification and submarket to see if a particular submarket gained a higher premium. This regression had a low number of significant variables and a low R-squared, therefore these variables were excluded. Instead, a variable measuring the interaction between certification and distance was applied and had a higher explanation degree. This interaction term describes the progressive effect of distance from CBD on the green certification. Hence, if the results are positive and significant, the variable suggests that the premium from green certification increases with distance from CBD.

To avoid multicollinearity the variance inflation (VIF) was examined and interpreted for all regressions. VIF measures the correlation among independent variables if more than two variables showing VIFs greater than five, collinearity exists. All variables had a value of between 1 to 4 in the regressions, meaning no multicollinearity existed according to VIF-tests.

As described earlier in this chapter, heteroscedasticity is a common problem when conducting a cross-sectional analysis since many of the variables are ranging from a small value to a large value. To avoid heteroscedasticity, all continuous variables in the model have been log-transformed, both for the dependent and independent variables. The transformation also infers control for non-normality. Lastly, a log-log regression makes it easy to interpret the coefficients as elasticities for all variables i.e., “if we change x by one percent, we’d expect y to change by  $\beta_1$  percent”.

Since the model has a log-transformed Y variable the coefficient on a dummy variable is interpreted as the percentage change in Y associated with having the dummy variable relative

to the omitted category, with all other included  $X$  variables held fixed. Additionally, interpretation of the variable can be done in two ways. First, only looking at the regression output the dummy coefficient shows an approximate value since the  $Y$  variable is transformed. To get a more accurate interpretation, the coefficient can be transformed back with anti-log (Halvorsen & Palmquist 1980). However, it matters more to do anti-log if the coefficient is large. The smaller the coefficient value, the closer the approximation will be to the computation since  $x$  gets closer to  $\exp(x)-1$ . Therefore, the result and analysis for the regressions will not be transformed back.

For the purpose of this study, the following three types of hedonic regression models will be estimated:

**Model 1a:**

$$\begin{aligned} \ln Rent_{it} = \alpha + \beta_1 \ln Lease Area_{it} + \beta_2 \ln Total Area_{it} + \beta_3 \ln Distance_{it} \\ + \beta_4 \ln Public Transport_{it} + \beta_5 DCertified_{it} + \beta_6 DBuilding Class_{it} \\ + \beta_7 DContract Year_{it} + \beta_8 DBuilding Year_{it} + \beta_9 DRegion_{it} \end{aligned} \quad (1)$$

**Model 1b:**

$$\begin{aligned} \ln Rent_{it} = \alpha + \beta_1 \ln Lease Area_{it} + \beta_2 \ln Total Area_{it} + \beta_3 \ln Distance_{it} \\ + \beta_4 \ln Public Transport_{it} + \beta_5 DCertified_{it} + \beta_6 DBuilding Class_{it} \\ + \beta_7 DContract Year_{it} + \beta_8 DBuilding Year_{it} + \beta_9 DSubmarket_{it} \end{aligned} \quad (2)$$

**Model 2a:**

$$\begin{aligned} \ln Rent_{it} = \alpha + \beta_1 \ln Lease Area_{it} + \beta_2 \ln Total Area_{it} + \beta_3 \ln Distance_{it} \\ + \beta_4 \ln Public Transport_{it} + \beta_5 DBREEAM_{it} + \beta_6 DLEED_{it} \\ + \beta_7 DMiljöbyggnad_{it} + \beta_8 DGreenBuilding_{it} + \beta_9 DBuilding Class_{it} \\ + \beta_{10} DContract Year_{it} + \beta_{11} DBuilding Year_{it} + \beta_{12} DRegion_{it} \end{aligned} \quad (3)$$

**Model 2b:**

$$\begin{aligned} \ln Rent_{it} = \alpha + \beta_1 \ln Lease Area_{it} + \beta_2 \ln Total Area_{it} + \beta_3 \ln Distance_{it} \\ + \beta_4 \ln Public Transport_{it} + \beta_5 DBREEAM_{it} + \beta_6 DLEED_{it} \\ + \beta_7 DMiljöbyggnad_{it} + \beta_8 DGreenBuilding_{it} + \beta_9 DBuilding Class_{it} \\ + \beta_{10} DContract Year_{it} + \beta_{11} DBuilding Year_{it} + \beta_{12} DSubmarket_{it} \end{aligned} \quad (4)$$

**Model 3a:**

$$\begin{aligned} \ln Rent_{it} = \alpha + \beta_1 \ln Lease Area_{it} + \beta_2 \ln Total Area_{it} + \beta_3 \ln Distance_{it} \\ + \beta_4 \ln Public Transport_{it} + \beta_5 DCertified_{it} + \beta_6 Certified \\ * \ln Distance_{it} + \beta_7 DBuilding Class_{it} + \beta_8 DContract Year_{it} \\ + \beta_9 DBuilding Year_{it} + \beta_{10} DRegion_{it} \end{aligned} \quad (5)$$

**Model 3b:**

$$\begin{aligned} \ln Rent_{it} = \alpha + \beta_1 \ln Lease Area_{it} + \beta_2 \ln Total Area_{it} + \beta_3 \ln Distance_{it} \\ + \beta_4 \ln Public Transport_{it} + \beta_5 DCertified_{it} + \beta_6 Certified \\ * \ln Distance_{it} + \beta_7 DBuilding Class_{it} + \beta_8 DContract Year_{it} \\ + \beta_9 DBuilding Year_{it} + \beta_{10} DSubmarket_{it} \end{aligned} \quad (6)$$

### 3.5 Expected findings

Table 8 is a summarization of all variables included in the model. In addition, the expected sign for the coefficient is provided. The building year is expected to have a positive sign if the building is newer. Although, there may be some exceptions for buildings that were built in a highly demanded building era. The area of the building is also expected to have a positive sign because it is plausible to believe that they have more important amenities than smaller buildings. The building class is a proxy for building quality and thereof it is expected to have a positive sign. Higher building quality should lead to a higher rent level. Since the office market has been strong in all regions for the investigated time, the contract year is expected to be positive.

Regarding the locational attributes, the distance to the city center should have a negative sign. In contrast, the submarket variable should vary between the different submarkets leading to a higher rent level in the central parts of each city. Lastly, the closeness to public transport is expected to have a positive impact on the rent level.

Controlling for all the included variables in the model and making the model robust, we believe that the effect caused by certification will be rightfully estimated.

Table 8. An explanation for variables and expected findings

Explanation and expected findings for all variables in the model				
	Abbreviation	Characteristics	Definition	Expected sign (+/-)
Rental income	<i>LN_rent</i>	Rental income	Base rent (SEK) per square meter in log form	/
Physical/ structural	<i>LN_Lease_area</i>	Lease area in sqm	A continuous variable for the number of square meters included in the lease term	+
	<i>LN_Total_area</i>	Total office area	Total office area for the building the lease area is located in	+
	<i>Building_class</i>	Quality of building	Classification based on the structural quality of the building. A dummy variable for each class; 1 if the building is included in the building	-
	<i>Contract_year</i>	The year the lease started	The year the lease was signed. A dummy variable for each year; 1 if the building is included in the year; 0 otherwise	+
	<i>Building_year</i>	The building year of construction	The year of construction. A dummy variable for each building interval; 1 if the building is included in the interval; 0 otherwise	+
Location	<i>LN_Distance</i>	Distance to center	The distance to city center or train station from the building expressed in kilometers	+
	<i>LN_Public_transport</i>	Distance to public transport	The distance to nearest public transportation expressed in minutes	+
	<i>Location_submarket</i>	The submarket the building is located in	Location parameter for each submarket. A dummy variable for each submarket; 1 if the building is included in the submarket; 0 otherwise	+/-
	<i>Location_region</i>	Region	Location parameter for each region. A dummy variable for each region; 1 if the building is included in the region; 0 otherwise	+/-
Green certification	<i>GREEN</i>	Green certification	A dummy variable; 1 if the building is certified; 0 otherwise	To be estimated
	<i>CERT_LABEL</i>	Label system	A dummy variable for each certification label; 1 if the building is certified; 0 otherwise	To be estimated
	<i>Certified_LN_Distance</i>	interaction between certification and distance	Interaction term for the effect of distance from city center on green certification	To be estimated

#### 3.5.1 Limitations

There are also limitations with this type of data collection approach. Since it is collected by others, there is a lack of control over the creation of the data and there is a risk of inaccurate interpretations of it. The internal and external validity can also be questioned due to insufficient knowledge on how conscientious the original collection process was (Cowton 1998). Therefore, all sources must be carefully evaluated.

A key issue is the existence and quality of the market data. The access of data for properties in Sweden is often characterized by being limited and fragmented over several public and

private databases (often subscription-based). Consequently, the data collection is time-consuming and dependent on other organization's internal processes and methods.

A major limitation of this study is the lack of certification dates for the different properties. The transparency for the correct certification date is rather low. Many property owners do not provide the information on their websites. For those who do provide the information, the date tends to differ from the information on SGBC's database. Another reason for difficulties with the correct date is that the certification is given on a building level, not for the whole property making it challenging to interpret the correct date for a specific contract. Also, there is no possibility to export the given certification dates directly to a spreadsheet making the data collection extremely time consuming.

A consequence of the lack of certification date is the impracticability of conducting fixed effects models with time series data. Several studies measured the effect of green certification labels by examining the effect after the certification was given. This empirical study will instead provide a cross-sectional snapshot of possible rent premium for certified buildings for a specific sample in a specific time period. Hence, the source of the possible premium or other effects may not be fully examined but it is expected that the dummy variables for contraction year will capture the current market conditions.

Some buildings also have received more than one green label, leading to additional observations for the different contracts. The most common occurrence of this is from the GreenBuilding label which often is an additional label. One solution for this is to exclude the GreenBuilding variable to investigate its impact.

Another limitation that similar empirical studies face is the controls for inherent heterogeneity between certified and non-certified buildings. Even when applying the most diligent sample selection process and matching techniques as well as including a comprehensive set of control variables, it is challenging to achieve comparability between different buildings. Therefore, descriptive statistics are useful to achieve a deeper understanding of the data and by that gain knowledge about the current market for certified buildings.

## 4. Results

In this chapter, the descriptive statistics and the results from the regressions are presented. Firstly, the descriptive statistics is presented for the full data set and includes summary statistics and exploratory graphs followed by a summary of the data set for each region. Secondly, the output from the regression analysis is presented.

### 4.1 Descriptive statistics

When analyzing big data sets, it is useful to describe the most important characteristics of the series with summary measurements. A summary of the descriptive statistics for the full sample data is exhibited in table 9. This analysis focus to explain the different parameters in the dataset as rent level, lease area, building year, distance, etc. The observations are also separated into regions to show an overview of all markets investigated. A plotted map showing the exact location for every observation for both the certified group and the non-certified group can be found in appendix 1.

#### 4.1.1 Full data set

In table 9 the summary statistics for the full data set are presented. The distribution of certified per region, observations per year, and building class will be presented in histograms. There is a variation of observations between 6643-7427 in the descriptive statistics. The reason for that is because all observations in the sample did not have data for the contract lengths. Moreover, the vacancy ranges from 0 (0%) to 1 (100%), that is because a property with more types of areas as industrial can have a minor share office area.

Table 9. Descriptive statistics - All regions

<b>Full sample All regions</b>	<i>Rent/ sq. m</i>	<i>Lease area</i>	<i>Contract length</i>	<i>Vacancy [%]</i>	<i>Total leasable area</i>	<i>Distance</i>	<i>Value year</i>	<i>Bulding Year</i>	<i>Age</i>
Mean	2868,254	603,145	3,748	0,105	11806,313	2,904	1974,818	1944,987	75,013
Median	2540	297	3	0,058	6363	1,320	1984	1962	58
Std. Dev.	1363,489	1519,570	1,898	0,146	16018,344	3,618	52,215	86,679	86,679
Min.	800	13	0	0	313	0	1500	1500	0
Max.	9645	72200	36	1,000	109574	59,210	2020	2020	520
Observations	7427	7427	6643	7427	7427	7427	7427	7427	7427

<b>Certified All regions</b>	<i>Rent/ sq. m</i>	<i>Lease area</i>	<i>Contract length</i>	<i>Vacancy [%]</i>	<i>Total leasable area</i>	<i>Distance</i>	<i>Value year</i>	<i>Bulding Year</i>	<i>Age</i>
Mean	3205,628	845,428	4,120	0,116	20832,663	2,924	1977,249	1948,676	71,324
Median	2800	380	3	0,078	13444	1,78	1990	1972	48
Std. Dev.	1380,358	2313,001	2,031	0,127	23222,184	3,151	73,920	100,446	100,446
Min.	1050	13	0	0	829	0,03	1500	1500	0
Max.	9620	72200	36	1	109574	23,27	2020	2020	520
Observations	2251	2251	2076	2251	2251	2251	2251	2251	2251

<b>Non-certified All regions</b>	<i>Rent/ sq. m</i>	<i>Lease area</i>	<i>Contract length</i>	<i>Vacancy [%]</i>	<i>Total leasable area</i>	<i>Distance</i>	<i>Value year</i>	<i>Bulding Year</i>	<i>Age</i>
Mean	2721,532	497,778	3,580	0,10	7880,827	2,895	1973,761	1943,382	76,618
Median	2410	262	3	0,0438	4500	1,21	1980	1958	62
Std. Dev.	1329,772	975,078	1,809	0,153	9103,815	3,803	39,153	79,913	79,913
Min.	800	20	0	0	313	0	1500	1500	0
Max.	9645	26979	25	1	86000	59,21	2020	2020	520
Observations	5176	5176	4567	5176	5176	5176	5176	5176	5176

From the tables above, one can observe that the number of leases in green certified buildings is approximately 30 percent, which is a notable number of observations and well in line with similar research. The average rent for the full sample is 2868 SEK per sq. m, the average

lease area is 603 sq. m, and the average vacancy rate is 10,5 percent. Regarding the total leasable office area, the mean is 11 806 sq. m. The distance to CBD/ train station is 2,9 kilometers. The mean value year is 1975 and the mean building year is 1944. Lastly, the average age of the budlings in the dataset is 75 years.

Separating the full sample into two groups containing certified and uncertified buildings makes it possible to observe differences between the certified and non-certified groups. Even that the certified office leases have a bit higher vacancy rate than the uncertified group the rent per sq. m is higher in the certified group by 484 SEK per sq. m. The tenants in certified buildings also lease more area, on average 347 sq. m more. The contract length is slightly longer by 0,54 years for the certified group. Another interesting outcome is that the total leasable area in buildings is bigger for the certified group. Meaning that the buildings with green certification are bigger on average. However, this can have a connection to the fact that the leases in certified buildings are also bigger. Regarding the age and value year, the lease in certified buildings is both slightly younger and has a newer value year.

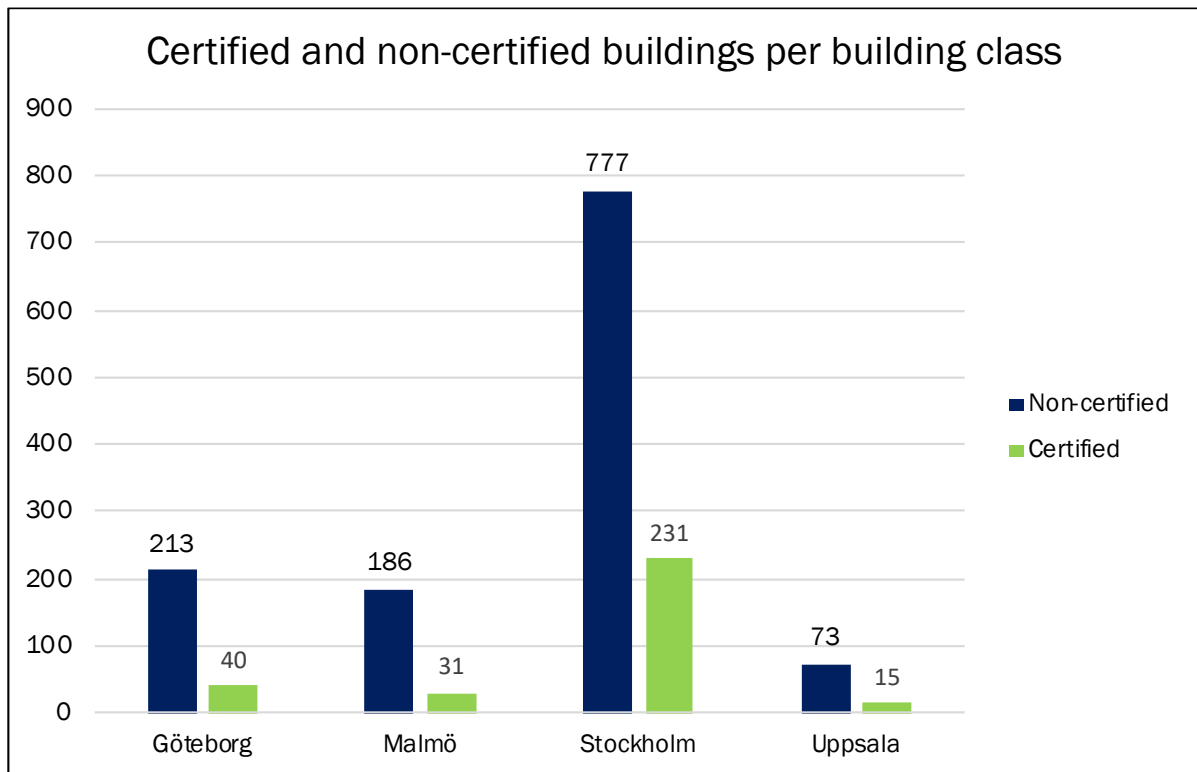


Figure 6. Certified and non-certified buildings per building class

In figure 6 the distribution of observations and city is exhibited. Not surprisingly, Stockholm has most buildings represented in the sample of 1008 buildings where 231 are certified and 777 are non-certified. There are 253 buildings in Gothenburg (213 cert. & 40 non-cert.), followed by Malmö with 217 buildings (186 cert. & 31 non-cert.) and lastly, Uppsala with the least number of buildings represented in the dataset of 88 (73 cert. & 15 non-cert.).

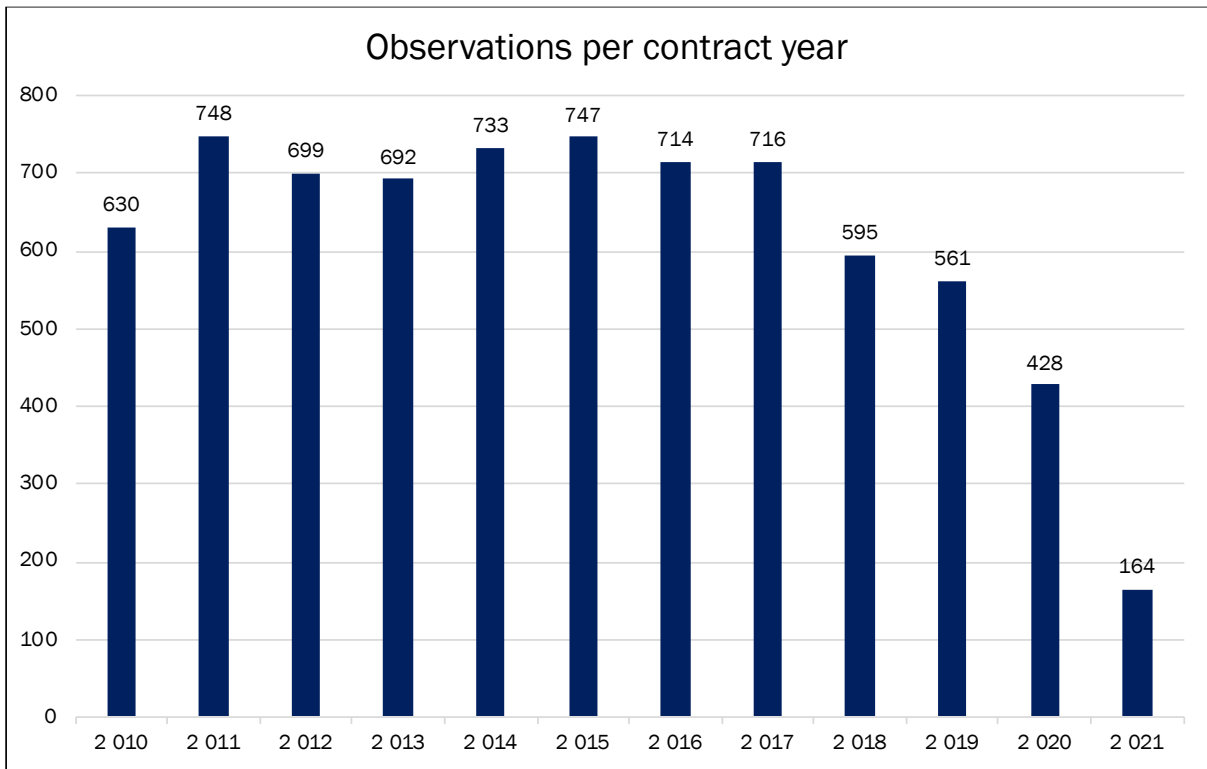


Figure 7. Distribution for observations per contract year.

Above, figure 7 is presented with the year when the lease started. Most of the important data were gathered at the same time when the contract lease was signed, as rent level and area. The mean is almost in the middle, 2014,8. As expected, the number of contracts for 2021 is less since its only consists of data for the first quarter.

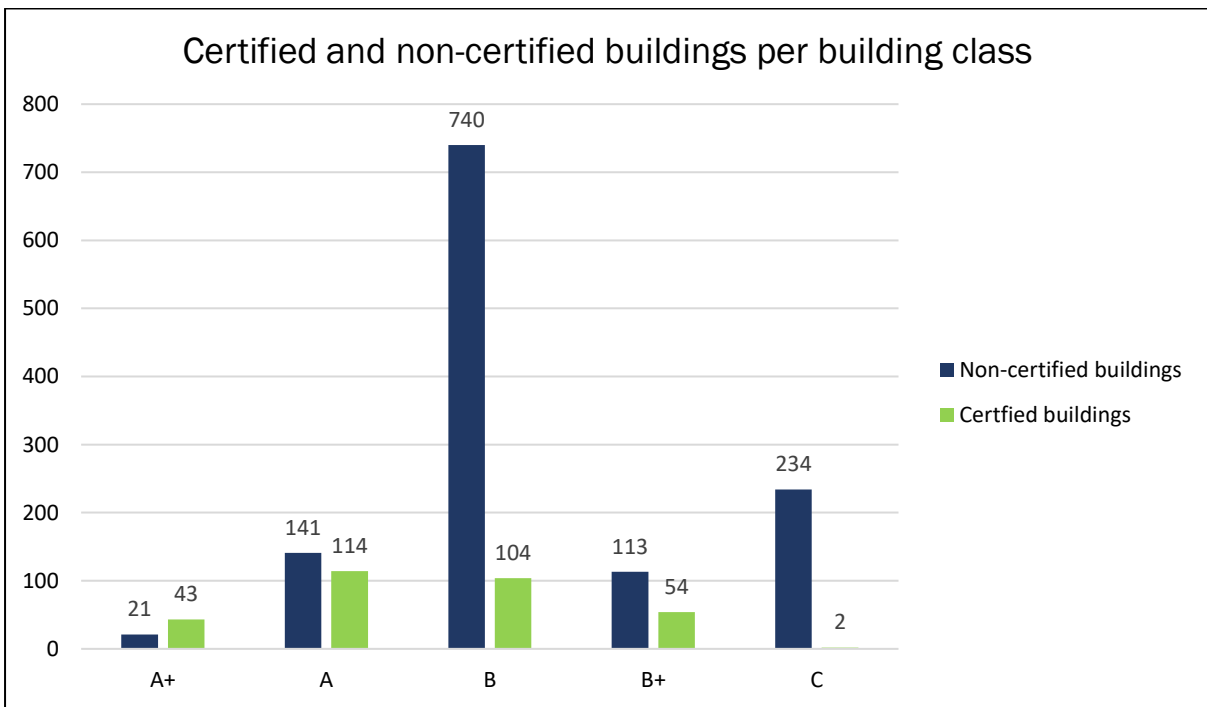


Figure 8. Distribution of building quality for the two groups.

Figure 8 shows the distribution of the budling classes in the data sample for certified and non-certified budlings. Building class functions as a measure of the quality of the building and impacts the rent of the premises. Therefore, the study must have enough observations for both groups in all classes. Certified budlings have a higher share of high classified budlings (A+ and A) than the non-certified group. The highly classified budlings respond to almost 50 percent of the total in the certified group whereas the non-certified response to only 13 percent of the total. Nevertheless, the data sample consists of observations for all classes for both groups, which makes the groups comparable.

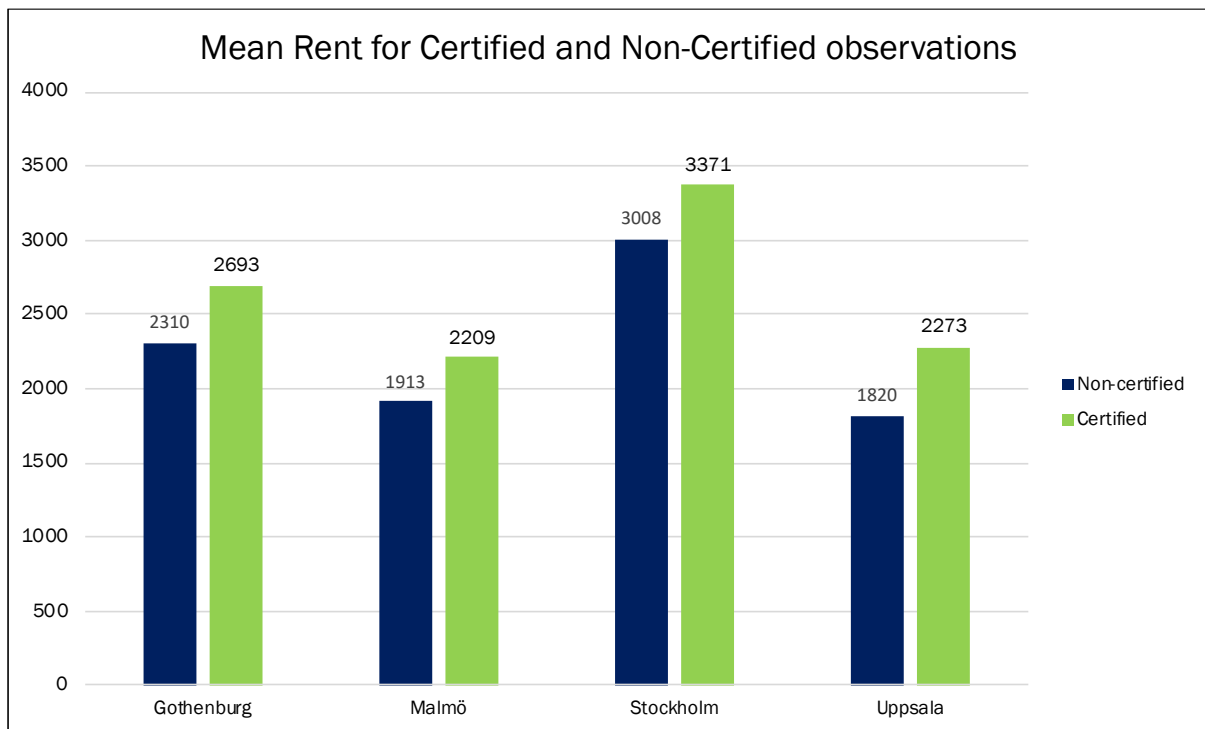


Figure 9. Mean rent for non-certified and certified buildings.

Figure 9 shows the mean rent per region for the certified and non-certified buildings in our sample. The mean is consistently higher for the green certified buildings as compared to the non-certified group. Take in mind that this rent is not adjusted concerning the economic effect from the contract year. The premium for certified budlings ranging from 12 percent (Stockholm) to 25 percent (Uppsala).

### 4.1.2 Stockholm

Table 10 presents the descriptive statistics for Stockholm. *Certified Stockholm* compared with the summary measurements for *non-certified Stockholm* have the same arrangement as for the full sample. For example, certified observations have higher rent, lease area, and longer contract length than non-certified. A difference from the full sample is that the certified buildings have a shorter distance to CBD, where it was the opposite of the full sample. Additionally, it is a greater difference between value year and age when only investigating data from Stockholm.

Table 10. Descriptive statistics - Stockholm

<b>Certified Stockholm</b>	<i>Rent/ sq. m</i>	<i>Lease area</i>	<i>Contract length</i>	<i>Vacancy [%]</i>	<i>Total leasable area</i>	<i>Distance</i>	<i>Value year</i>	<i>Building Year</i>	<i>Age</i>
<i>Mean</i>	3371,304	874,547	4,142	0,122	23334,796	3,427	1978,334	1948,505	71,495
<i>Median</i>	2940	400	3,5	0,084	16000	2,265	1990	1972	48
<i>Std. Dev.</i>	1459,756	2471,813	1,892	0,133	24572,331	3,279	73,090	103,189	103,189
<i>Min.</i>	1050	13	0	0	1016	0,11	1500	1500	0
<i>Max.</i>	9620	72200	20	1	109574	23,27	2020	2020	520
<i>Observations</i>	1830	1830	1694	1830	1830	1830	1830	1830	1830
<b>Non-Certified Stockholm</b>	<i>Rent/ sq. m</i>	<i>Lease area</i>	<i>Contract length</i>	<i>Vacancy [%]</i>	<i>Total leasable area</i>	<i>Distance</i>	<i>Value year</i>	<i>Building Year</i>	<i>Age</i>
<i>Mean</i>	3007,614	494,791	3,626	0,098	8561,999	3,636	1972,390	1941,644	78,356
<i>Median</i>	2740	269	3	0,043707317	4778	1,8	1979	1957	63
<i>Std. Dev.</i>	1475,032	961,033	1,747	0,150	9643,872	4,322	39,714	81,349	81,349
<i>Min.</i>	800	20	0	0	350	0,05	1500	1500	0
<i>Max.</i>	9645	26979	25	1	86000	59,21	2020	2020	520
<i>Observations</i>	3535	3535	3159	3535	3535	3535	3535	3535	3535

### 4.1.3 Gothenburg, Malmö, and Uppsala

The tables containing descriptive statistics for Gothenburg, Malmö, and Uppsala can be found in appendix 2. Stockholm is the greatest contributor to the data set and influencing the other markets when investigated the summary statistics for the full sample. Analyzing the other markets as themselves gives specific information regarding the other markets.

Gothenburg, Malmö, and Uppsala all have in common that the rent level for certified buildings is higher, ranging from a premium of 293 SEK (Malmö) to 454 SEK (Uppsala). Uppsala is the only market where the certified group has both an older value year and an older building year. Although, the distance to the city center is lower for certified buildings and the standard deviation is also lower, meaning that the cluster of certified buildings is more narrow than non-certified.

## 4.2 Hedonic Regression Results

To further investigate the research questions, different regression models have been conducted. The following section will display the results for the rental sample, relating the logarithmic of rent per square meter in office buildings to a set of hedonic and other characteristics of the buildings. As stated in the methodology chapter, continuous numeric variables were transformed to logarithmic values to reduce heteroskedasticity and nonnormality distributions found in the initial examinations of the dataset. The logarithmic transformation also makes it possible to interpret the results as elasticities. The omitted variables will be presented in each section for the regression output, and also serve as a benchmark for each variable.

#### 4.2.1 Model 1a – Certified and Region

Model 1a includes control for building class, contract year, region, and building year. For full regression output, see appendix 3. All observations are included in this model, and the following dummy variables have been omitted due to collinearity:

- Building\_class\_B
- Contract\_year\_2011
- Building\_year\_1900to1929
- Region\_Uppsala

Table 11. Regression output - Model 1a

<i>LN_rent_per_sqm</i>	<i>Coefficient</i>	<i>Standard Error</i>	<i>t stat</i>	<i>Sig.</i>
<i>Constant</i>	7,414	0,031	238,818	0
<i>LN_Lease_area</i>	0.005*	0,003	1,878	0,06
<i>LN_Total_Area</i>	0.006**	0,003	2,044	0,041
<i>LN_Distance</i>	-0.255***	0,003	-91,824	0
<i>LN_Public_Transport</i>	-0.113***	0,008	-13,349	0
<i>Certified</i>	0.054***	0,006	8,766	0
<i>Building class control included</i>	Yes			
<i>Contract year control included</i>	Yes			
<i>Region control included</i>	Yes			
<i>Building year control included</i>	Yes			
<i>R<sup>2</sup></i>	0,771			
<i>Adjusted R<sup>2</sup></i>	0,77			
<i>Observations</i>	7426			

Note \*\*\*, \*\*, \* Significant at 1, 5, 10 percent levels, respectively

When controlling for important rent determinants, we find a statistically significant rent premium of 5,4 percent for certified buildings when examining the whole dataset without any matching between certified and non-certified buildings. The continuous control variables *LN\_Lease\_area*, *LN\_Total\_area*, *LN\_Distance*, and *LN\_Public\_Transport* shows the expected sign and are all significant. The leasable area for each contract has a minor impact on the rent level as it only affects it by 0,5 percent. The control variable for total area indicates that larger buildings receive a higher rent of 0,6 percent. The variable for distance and closeness to public transport indicates a negative impact of 25,5 percent and 11,3 percent, respectively.

Building class has a positive and significant impact on the rent level as displayed by the coefficients *Building\_class\_Aplus* and *Building\_class\_A*, which indicates a positive impact of 15,6 percent for building class A-plus and 17,1 percent for building class A when comparing them to the omitted variable *Building\_class\_B*.

The control variables for each contract year, ranging from 2010 to 2021, shows that contract signed more recently receives a higher rent. They are statistically significant, and the contract signed in 2019, 2020, and 2021 shows an effect of 39,9 percent, 43,3 percent, and 44,3 percent, respectively. These coefficients are compared to the omitted variable *Contract\_year\_2011*.

Moreover, the dummy variables for building years indicate higher rent for newer buildings as well as buildings built before 1900. Buildings constructed between 1965 and 1999 negatively impact the rent level by about 10,5 percent to 16,8 percent compared to the omitted variable *Building\_year\_1900to1929*.

Overall, important control variables show the expected signs and are statistically significant at the desired significance levels. The adjusted R-square of the model is 0,77 meaning that this regression explains 77 percent of the variation in rents for the full sample.

#### 4.2.2 Model 1b – Certified and Submarket

Model 1b includes control for building class, contract year, and building year. The difference is the control for submarkets instead of regions. This will provide more details about the effect of each submarket within its region. For full regression output, see appendix 3. All observations are included, and the following dummy variables have been omitted due to collinearity:

- Building\_class\_B
- Contract\_year\_2011
- Building\_year\_1900to1929
- Location\_B\_Stockholm

Table 12. Regression output - Model 1b

<i>LN_rent_per_sqm</i>	<i>Coefficient</i>	<i>Standard Error</i>	<i>t stat</i>	<i>Sig.</i>
<i>Constant</i>	7,801	0,029	270,889	0
<i>LN_Lease_area</i>	0.006**	0,003	2,493	0,013
<i>LN_Total_Area</i>	0.01***	0,003	3,861	0
<i>LN_Distance</i>	-0.14***	0,004	-35,959	0
<i>LN_Public_Transport</i>	-0.051***	0,008	-6,617	0
<i>Certified</i>	0.049***	0,006	8,863	0
<i>Building class control included</i>	Yes			
<i>Contract year control included</i>	Yes			
<i>Submarket control included</i>	Yes			
<i>Building year control included</i>	Yes			
<i>R<sup>2</sup></i>	0,773			
<i>Adjusted R<sup>2</sup></i>	0,772			
<i>Observations</i>	7426			

Note \*\*\*,\*\*, \* Significant at 1, 5, 10 percent levels, respectively

When controlling for submarket instead of regions, the rental premium for certified buildings is 4,9 percent and the coefficient is statistically significant. The premium is slightly lower compared to the first part of the model. The continuous variables show the expected sign and are statistically significant and are very similar to the output in model 1a. LN\_Lease\_area indicates a positive effect of 0,6 percent and LN\_Total\_area a positive effect of 1 percent. The effect decreases for LN\_Distance and LN\_Public\_transport when controlling for submarket, and they indicate a negative impact of 14 percent and 5,1 percent, respectively.

The control variables for building class indicate a positive impact for a higher class. They differ slightly from model 1a. For instance, Building\_class\_Aplus indicates a positive impact of 15,9 percent and Building\_class\_A indicates a positive impact of 13,9 percent compared to the omitted variable Building\_class\_B.

The dummy variables for contract year also shows that more recently signed contract receives a higher rent. This is clearly displayed by the coefficients for 2019, 2020, and 2021 which indicates a positive impact of 39,1 percent, 44 percent, and 42,6 percent.

Moreover, the control variables for building years show the expected outcome and the results are consistent with the output in model 1a. Newer buildings gain a higher rent level, as well

as buildings constructed before 1900. All variables for building year are statistically significant, except Building\_year\_below1900.

The different dummy variables for each submarket specifies results coherent to the expected outcome. The omitted variable Location\_B\_Stockholm serves as the benchmark for the submarket variables. Location\_AA\_Stockholm has the most positive impact on the rent level, followed by Location\_A\_Stockholm. The positive impact is 28,9 percent for AA location in Stockholm and 15 percent for A location in Stockholm.

The adjusted R-square has increased to 0,822. When controlling for submarkets and thereof more variables, the regression explains 82% of the variation for the dependent variable. This is not surprising as additional control variables strengthen the explanatory power of the model.

#### 4.2.3 Model 2a – Type of certification and region

Model 2a includes control for building class, contract year, region, and building year. For full regression output, see Appendix 3. Model 2 also shows the results of the regression with separate dichotomous variables for each certification. All observations are included in this regression, and the following dummy variables have been omitted due to collinearity:

- Building\_class\_B
- Contract\_year\_2011
- Building\_year\_1900to1929
- Region\_Stockholm

Table 13. Regression output - Model 2a

LN_rent_per_sqm	Coefficient	Standard Error	t stat	Sig.
Constant	7,414	0,031	238,818	0
LN_Lease_area	0,005*	0,003	1,878	0,06
LN_Total_Area	0,006**	0,003	2,044	0,041
LN_Distance	-0,255***	0,003	-91,824	0
LN_Public_Transport	-0,113***	0,008	-13,349	0
Certified_BREEAM	0,1***	0,01	10,19	0
Certified_LEED	0,051***	0,008	6,508	0
Certified_Miljöbyggnad	0,044***	0,011	4,113	0
Certified_GreenBuilding	-7,90E-05	0,011	-0,007	0,994
Building class control included	Yes			
Contract year control included	Yes			
Region control included	Yes			
Building year control included	Yes			
R <sup>2</sup>	0,773			
Adjusted R <sup>2</sup>	0,772			
Observations	7426			

Note \*\*\*,\*\*,\* Significant at 1, 5, 10 percent levels, respectively

When separating the certified variable into separate control variables for each certification type, BREEAM indicates a premium of 10 percent, LEED indicates a premium of 5,1 percent and Miljöbyggnad indicates a premium of 4,4 percent. The variables for BREEAM, LEED, and Miljöbyggnad are all statistically significant at desired levels. However, GreenBuilding is not significant, and no conclusions can be drawn from the coefficient. The other control variables are consistent with model 1 and show expected signs as well as being statistically significant.

The adjusted R square is 0,772 and is also consistent with model 1 and has an explanatory power of about 77 percent.

#### 4.2.4 Model 2b - Type of certification and submarket

Model 2b controls for building class, contract year, and building year. The difference is the control for specific submarket rather than regions. For full regression output, see Appendix 3. All observations are included in this model, and the following dummy variables have been omitted due to collinearity:

- Building\_class\_B
- Contract\_year\_2011
- Building\_year\_1900to1929
- Location\_B\_Stockholm

Table 14. Regression output - Model 2b

<i>LN_rent_per_sqm</i>	<i>Coefficient</i>	<i>Standard Error</i>	<i>t stat</i>	<i>Sig.</i>
<i>Constant</i>	7,79	0,029	270,097	0
<i>LN_Lease_area</i>	0.006**	0,003	2,449	0,014
<i>LN_Total_Area</i>	0.012***	0,003	4,35	0
<i>LN_Distance</i>	-0.142***	0,004	-36,58	0
<i>LN_Public_Transport</i>	-0.051***	0,008	-6,489	0
<i>Certified_BREEAM</i>	0.088***	0,009	9,962	0
<i>Certified_LEED</i>	0.035***	0,007	4,944	0
<i>Certified_Miljöbyggnad</i>	0.03***	0,009	3,216	0,001
<i>Certified_GreenBuilding</i>	-0,003	0,009	-0,281	0,779
<i>Building class control included</i>	Yes			
<i>Contract year control included</i>	Yes			
<i>Submarket control included</i>	Yes			
<i>Building year control included</i>	Yes			
R <sup>2</sup>	0,824			
Adjusted R <sup>2</sup>	0,822			
Observations	7426			

Note \*\*\*, \*\*, \* Significant at 1, 5, 10 percent levels, respectively

When controlling for submarkets instead of regions, the rental premium changes. BREEAM receives a premium of 8,8 percent, LEED receives a premium of 3,5 percent and Miljöbyggnad receives a premium of 3 percent. BREEAM, LEED, and Miljöbyggnad are statistically significant, but GreenBuilding is not significant. Compared to the first part of the model, all of the significant certification parameters are somewhat lower. All of the other control variables are consistent with the first part of the model and show expected signs.

The adjusted R-square increases when adding more dummy variables for the separate locations within each region. The adjusted R-square is 0,822 which is the same value as for model 1 with control for submarkets.

#### 4.2.5 Model 3a – Distance and Certification and Region

Model 3a is controlling for building class, contract year, region, and building year. For full regression output, see Appendix 3. In addition to model 1, an interaction term between distance and certified named Certified\_LN\_Distance is included. All observations are included in this model, and the following dummy variables have been omitted due to collinearity:

- Building\_class\_B
- Contract\_year\_2011

- Building\_year\_1900to1929
- Region\_Stockholm

Table 15. Regression output - Model 3a

<i>LN_rent_per_sqm</i>	<i>Coefficient</i>	<i>Standard Error</i>	<i>t stat</i>	<i>Sig.</i>
<i>Constant</i>	8,074***	0,030	271,943	0
<i>LN_Lease_area</i>	0,006**	0,003	2,132	0,033
<i>LN_Total_Area</i>	0,004	0,003	1,273	0,203
<i>LN_Distance</i>	-0,269***	0,003	-84,231	0
<i>LN_Public_Transport</i>	-0,111***	0,008	-13,254	0
<i>Certified_LN_Distance</i>	0,040***	0,005	8,412	0
<i>Certified</i>	0,038***	0,006	6,042	0
<i>Building class control included</i>	Yes			
<i>Contract year control included</i>	Yes			
<i>Region control included</i>	Yes			
<i>Building year control included</i>	Yes			
<i>R<sup>2</sup></i>	0,773			
<i>Adjusted R<sup>2</sup></i>	0,773			
<i>Observations</i>	7426			

Note \*\*\*,\*\*,\* Significant at 1, 5, 10 percent levels, respectively

The coefficient certified indicates a premium of 3,8 percent and is statistically significant. This is lower than the premium in model 1. The most important variable in this model is the interaction term Certified\_LN\_Distance which is positive and measures the incremental effect of distance from the city center on the premium of green certification. The value of the coefficient indicates a premium of 3,8 percent and is statistically significant. This value indicates that for the certified buildings that are located further away relative to other certified buildings, there is a premium of 3,8 percent.

The adjusted R-square 0,773 and indicating that the explanatory power of the regression is 77,3 percent. This is consistent with the R-square in the first part of model 1 which also controls for regions.

#### 4.2.6 Model 3b – Distance and Certification and Submarket

Model 3b controlling for building class, contract year, and building year. The difference is the control for specific submarket rather than regions. For full regression output, see Appendix 3. In addition to model 1, an interaction term between distance and certified named Certified\_LN\_Distance is included. All observations are included in this model, and the following dummy variables have been omitted due to collinearity:

- Building\_class\_B
- Contract\_year\_2011
- Building\_year\_1900to1929
- Location\_B\_Stockholm

Table 16. Regression output - Model 3b

<i>LN_rent_per_sqm</i>	<i>Coefficient</i>	<i>Standard Error</i>	<i>t stat</i>	<i>Sig.</i>
<i>Constant</i>	7,414	0,031	238,818	0
<i>LN_Lease_area</i>	0.005*	0,003	1,878	0,06
<i>LN_Total_Area</i>	0.006**	0,003	2,044	0,041
<i>LN_Distance</i>	-0.255***	0,003	-91,824	0
<i>LN_Public_Transport</i>	-0.113***	0,008	-13,349	0
<i>Certified_LN_Distance</i>	0.019***	0,004	4,361	0
<i>Certified</i>	0.054***	0,006	8,766	0
<i>Building class control included</i>	Yes			
<i>Contract year control included</i>	Yes			
<i>Submarket control included</i>	Yes			
<i>Building year control included</i>	Yes			
<i>R<sup>2</sup></i>	0,823			
<i>Adjusted R<sup>2</sup></i>	0,822			
<i>Observations</i>	7426			

Note \*\*\*, \*\*, \* Significant at 1, 5, 10 percent levels, respectively

The coefficient certified indicates a rent premium of 5,4 percent when controlling for submarkets. This is the same value as displayed in model 1 when controlling for the same variables. The most important variable in this model is the interaction term *Certified\_LN\_Distance* which is positive and measures the incremental effect of distance from the city center on the premium of green certification. The value of the coefficient indicates a premium of 1,9 percent and is statistically significant. In other words, this value indicates that there is a premium of 1,9 percent for the certified buildings that are located further away relative to other certified buildings.

The adjusted R-square 0,822 and indicating that the explanatory power of the regression is 88,2 percent. This is consistent with the R-square in model 1b which also controls for submarkets.

### 4.3 Sensitivity checks

To test the robustness of the findings and to further explore the impact of the green certification on the buildings' rent level, three additional tests are performed on the data set and presented in this section.

#### 4.3.1 Propensity score matching

To assure robustness of the results and the empirical inferences, a propensity score matching approach is employed. A propensity score matching (PSM) was employed for all regressions to check for selection bias, because certified buildings may have a higher quality than non-certified buildings. The matching was based on the probability that an observation has a green label. In other words, the probability of having a green label given observed characteristics (treatment group) is matched with the nearest neighbor in the control group (non-certified). After the PSM, the regressions were re-runned to find if the results changed. The results were overall similar to the main regressions. The only parameter that changed signed was the interaction term Certified\_LN\_Distance. Therefore, the main models can be argued to not be biased and having high robustness. The output for each model after the propensity score matching is stated below in table 17.

Table 17. Regression output - Propensity score matching (1:1)

Propensity Score Matching (1:1)	<u>LN_Rent</u> (1a)	<u>LN_Rent</u> (1b)	<u>LN_Rent</u> (2a)	<u>LN_Rent</u> (2b)	<u>LN_Rent</u> (3a)	<u>LN_Rent</u> (3b)
Constant	7,805*** (0,004)	8,157*** (0,106)	8,140*** (0,106)	7,786*** (0,049)	8,192*** (0,050)	8,323*** (0,126)
LN_Lease_area	0,004 (0,003)	0,013*** (0,003)	0,014*** (0,003)	0,006** (0,003)	0,011*** (0,003)	0,012*** (0,003)
LN_Total_Area	-0,015*** (0,004)	-0,007** (0,003)	-0,006* (0,003)	-0,015*** (0,004)	-0,019*** (0,004)	-0,016*** (0,003)
LN_Distance	-0,223*** (0,003)	-0,122*** (0,004)	-0,124*** (0,004)	-0,223*** (0,003)	-0,161*** (0,004)	-0,076*** (0,004)
LN_Public_Transport	-0,08*** (0,010)	-0,017*** (0,009)	-0,017*** (0,009)	-0,078*** (0,010)	-0,093*** (0,012)	0,001 (0,010)
Certified	0,045*** (0,006)	0,052*** (0,005)			0,050*** (0,007)	0,062*** (0,005)
Certified_BREEAM			0,086*** (0,008)	0,082*** (0,009)		
Certified_LEED			0,045*** (0,006)	0,054*** (0,007)		
Certified_Miljobyggnad			0,034*** (0,008)	0,036*** (0,010)		
Certified_GreenBuilding			-0,007 (0,008)	-0,014 (0,010)		
Certified_LN_Distance					-0,066*** (0,005)	-0,026*** (0,004)
Building class controll included	yes	yes	yes	yes	yes	yes
Contract year controll included	yes	yes	yes	yes	yes	yes
Region controll included	yes	no	yes	no	yes	no
Submarket contol included	no	yes	no	yes	no	yes
Bulding year controll included	yes	yes	yes	yes	yes	yes
Observations	4502	4486	4486	4502	4502	4502
R <sup>2</sup>	0,7678	0,8308	0,8324	0,7707	0,7746	0,8433
Adjusted R <sup>2</sup>	0,7662	0,8292	0,8307	0,7690	0,7731	0,8418

Robust standard errors in parentheses. Note \*\*\*,\*\*,\* Significant at 1, 5, 10 percent levels, respectively

### 4.3.2 Subsampling

To further control for selection bias, two different subsamples are used for repeating and testing the models. The subsamples are chosen based on the best observable characteristics of certified buildings – large buildings and newer buildings. Based on the descriptive statistics in table 9, the sample averages for certified buildings act as the base for the subsamples. The sample averages for the full dataset are then modified to get a sufficiently large dataset. The first subsample only includes buildings larger than 10 000 sqm and the second subsample only includes buildings younger than 50 years. When restricting the sample to buildings larger than 10 000 sqm, the results are not very different from the full sample. The major difference is that some important variables are not statistically significant anymore, for instance, Certified\_LEED in model 2b and Certified\_LN\_Distance in model 3b. When restricting the sample to observations in buildings that are younger than 50 years, the results follow the same pattern as the other datasets. The output for the subsamples is stated in table 18 and table 19 below.

Table 18. Subsample - Buildings larger than 10 000 sqm

Larger than 10 000 sqm	<u>LN_Rent</u> (1a)	<u>LN_Rent</u> (1b)	<u>LN_Rent</u> (2a)	<u>LN_Rent</u> (2b)	<u>LN_Rent</u> (3a)	<u>LN_Rent</u> (3b)
Constant	7,958*** (0,076)	7,807*** (0,720)	7,939*** (0,790)	7,769*** (0,074)	8,013*** (0,076)	7,808*** (0,073)
LN_Lease_area	0,001 (0,004)	0,004 (0,003)	0,000 (0,004)	0,003 (0,003)	0,002 (0,004)	0,004 (0,003)
LN_Total_Area	0,240*** (0,008)	0,019** (0,007)	0,025*** (0,008)	0,024*** (0,007)	0,019** (0,008)	0,019*** (0,007)
LN_Distance	-0,231*** (0,004)	-0,131*** (0,006)	-0,232*** (0,004)	-0,135*** (0,006)	-0,251*** (0,005)	-0,131*** (0,007)
LN_Public_Transport	-0,074*** (0,011)	-0,024*** (0,011)	-0,070*** (0,011)	-0,022*** (0,011)	-0,070*** (0,011)	-0,070** (0,011)
Certified	0,028*** (0,008)	0,035*** (0,008)			0,001 (0,009)	0,034*** (0,009)
Certified_BREEAM			0,084*** (0,013)	0,075*** (0,012)		
Certified_LEED			0,026*** (0,009)	0,013 (0,009)		
Certified_Miljobyggnad			0,023** (0,012)	0,028** (0,011)		
Certified_GreenBuilding			-0,004 (0,011)	0,001 (0,010)		
Certified_LN_Distance					0,035*** (0,007)	0,000 (0,006)
Building class controll included	yes	yes	yes	yes	yes	yes
Contract year controll included	yes	yes	yes	yes	yes	yes
Region controll included	yes	no	yes	no	yes	no
Submarket contol included	no	yes	no	yes	no	yes
Building year controll included	yes	yes	yes	yes	yes	yes
Observations	2634	2634	2634	2634	2634	2634
R <sup>2</sup>	0,783	0,829	0,785	0,831	0,785	0,829
Adjusted R <sup>2</sup>	0,78	0,826	0,783	0,827	0,782	0,826

Robust standard errors in parentheses. Note \*\*\*, \*\*, \* Significant at 1, 5, 10 percent levels, respectively

Table 19. Subsample - Buildings younger than 50 years

Less than 50 years	<u>LN_Rent</u> (1a)	<u>LN_Rent</u> (1b)	<u>LN_Rent</u> (2a)	<u>LN_Rent</u> (2b)	<u>LN_Rent</u> (3a)	<u>LN_Rent</u> (3b)
Constant	7,867*** (0,050)	7,620*** (0,048)	7,882*** (0,051)	7,596*** (0,050)	7,892*** (0,076)	7,619*** (0,048)
LN_Lease_area	0,008** (0,004)	0,005 (0,004)	0,010** (0,004)	0,005 (0,004)	0,010** (0,004)	0,006* (0,004)
LN_Total_Area	0,030*** (0,005)	0,035** (0,004)	0,026*** (0,005)	0,038*** (0,004)	0,027*** (0,005)	0,034*** (0,004)
LN_Distance	-0,236*** (0,004)	-0,132*** (0,010)	-0,238*** (0,012)	-0,135*** (0,005)	-0,256*** (0,005)	-0,145*** (0,006)
LN_Public_Transport	-0,126*** (0,012)	-0,070*** (0,005)	-0,129*** (0,012)	-0,069*** (0,011)	-0,120*** (0,011)	-0,066*** (0,010)
Certified	0,031*** (0,009)	0,032*** (0,008)			-0,010 (0,011)	0,007 (0,009)
Certified_BREEAM			0,075*** (0,016)	0,074*** (0,014)		
Certified_LEED			0,052*** (0,012)	0,023** (0,011)		
Certified_Miljobyggnad			0,045** (0,014)	0,053*** (0,012)		
Certified_GreenBuilding			-0,004 (0,014)	-0,016 (0,012)		
Certified_LN_Distance					0,049*** (0,007)	0,031*** (0,006)
Building class controll included	yes	yes	yes	yes	yes	yes
Contract year controll included	yes	yes	yes	yes	yes	yes
Region controll included	yes	no	yes	no	yes	no
Submarket contol included	no	yes	no	yes	no	yes
Bulding year controll included	yes	yes	yes	yes	yes	yes
Observations	3082	3082	3082	3082	3082	3082
R <sup>2</sup>	0,749	0,82	0,743	0,813	0,754	0,822
Adjusted R <sup>2</sup>	0,747	0,818	0,741	0,811	0,752	0,819

Robust standard errors in parentheses. Note \*\*\*, \*\*, \* Significant at 1, 5, 10 percent levels, respectively

## 5. Analysis

Overall, the results confirm earlier findings that certified buildings command higher levels of rent. The results from the models using the full sample show that there exists a premium for certified buildings between 4,9 to 5,4 percent. The output for the regression with propensity scores indicates a premium of 4,5 to 5,2 percent. The matching lowers the impact marginally, and both results indicate that there is a substantial premium associated with certified buildings compared to non-certified buildings. When restricting the sample based on two important characteristics, total area, and age, the results still indicate a premium for certified buildings. The expected findings regarding certified buildings are confirmed since all regression indicate a positive effect on the rent level.

When estimating the effect of each certification label, the results are consistent through all models. The impact for BREEAM, LEED, and Miljöbyggnad is positive and statistically significant when analyzing the full sample. When applying propensity scores and dividing the sample, the results are coherent. Although there are some differences when controlling for region and submarket, it is possible to conclude that BREEAM is associated with the highest premium followed by LEED and Miljöbyggnad.

The interaction term for certified and distance is the only variable that is inconclusive. For the full sample and subsample, it shows a positive impact. But for the regression with propensity scores, it has a negative impact on the rent level. A possible explanation for this is that the observations that are sorted out when conducting the matching are located in submarkets surrounding the city center. Therefore, the interaction term is consistent with the output of the ordinary distance variable when applying propensity scores. Given this, it is still possible to draw the conclusion that green buildings situated further away from the city center are associated with a positive effect on the rental income.

A summarized view of the essential parameters regarding the certification is stated in table 10. The output tends to follow a pattern where the regressions on the full sample provide the biggest coefficients. When applying propensity score the effect slightly decreases, although the difference is almost not observable. The subsample is a good measure for reference because the certified buildings tend to both bigger and younger.

Table 20. Summarized results (only significant values included).

Certified Parameter	Effect	Full sample	PSM	Total Area	Age
Certified	Increased	4,9% - 5,4%	4,5% - 5,2%	2,8% - 3,5%	3,1% - 3,2%
BREEAM	Increased	8,8% - 10%	8,2% - 8,6%	7,5% - 8,4%	7,4%-7,5%
LEED	Increased	3,5% - 5,1%	4,5% - 5,4%	2,6%	2,3% - 5,2%
Miljöbyggnad	Increased	3% - 4,4%	3,4% - 3,6%	2,3%- 2,8%	4,5% - 5,3%
GreenBuilding	Not significant				
Certified*Distance	Inconclusive	1,9% - 4%	-2,6% - -6,6%	3,5%	3,1% - 4,9%

From the descriptive statistics, one can conclude that there are clear differences between the certified and non-certified buildings. In the data sample, without controlling for differences between the samples, certified buildings have a higher rent level than non-certified buildings. Although the quality of the buildings, regarding when the buildings were refurbished, was more in the non-certified group. However, separating the observations into regions, the certified group was located closer to CDB, which can be the explanation why the rent level is

higher since the most important factor influencing the rent level is the location. Furthermore, not only new buildings get a certification. In contrast, it seems that many property owners choose to certify existing buildings in Sweden since the difference in building year for the groups is not striking. In general, the age of buildings in other studies has been younger and specially certified buildings. In countries like the US, it is common to use Energy Star when certifying existing buildings, and BREEAM or LEED for new constructions (Fuerst & McAllister 2011b). Whereas in Sweden, all certification systems are used for existing buildings. Additionally, certified buildings in the dataset are bigger than non-certified buildings by approximately 12 000 sqm. Similar studies have also shown that certified buildings have a bigger area (Porumb et.al, 2020; Fuerst & McAllister 2011b). The explanation for this could be that buildings located near CBD tend to have a bigger share of office areas or that it is more cost-effective to certifying big buildings. The share of certified buildings follows the size of the city. In other words, the density of certified buildings tends to be higher in main cities.

The results from model 1 (a & b) reveals that a rental premium exists for certified office buildings, regardless of the certification label. Hence, certifying both new and existing buildings grants higher office rents for the property owner, compared to non-certified buildings by 5,4 percent controlling for regions alternatively 4,9 percent controlling by submarkets. These numbers may seem quite low, however applying this effect to the average non-certified building in the dataset would command an increase in rental income of 1 158 000 SEK<sup>2</sup> per year if it were certified which is arguably a big number. The results from model 1 are in line with previous research, which indicated a rental premium between 2,5 to 10 percent (Fuerst & McAllister 2009; Fuerst & McAllister 2011b; Reichardt et al. 2012; Eichholtz et al. 2010; Devine & Kok 2015; Holtermans & Kok 2019). Other studies have found a significantly higher rent premium up to 19,7 percent (Wiley et al. 2010; Chegut et al. 2014). However, that premium can possibly be explained by net leases whereas this study focused on gross leases.

Model 2, which distinguishes the certification labels to own variables to investigate the effect of a certain labels contribution to rental income reveals that BREEAM increases the rent level by 8,8 to 10 percent, followed by LEED of 3,5 to 5,1 percent and lastly Miljöbyggnad by 3 to 4,4 percent. That result is not surprising since both BREEAM and LEED are more internationally recognized which may attract more international tenants, resulting in higher demand, and have more criteria to fulfill to get their certifications. Hence, uncontrollable reasons as facility management or pollution requirements can explain why they contribute a higher rent. Besides, GreenBuilding was not significant in either model 2 a or b and no conclusions can be drawn regarding the effect of properties certified with GreenBuilding. Apart from the other certifications, GreenBuilding only take the energy consumption for the building into account. Hence, an old building with a high energy consumption can get this certification only with a 25 percent decrease in energy usage, the building can still have a high energy consumption compared to peers. This may not affect the rent level to the extent that the other certifications do when investigating gross leases. Another explanation can also be that the market is simply ignorant of the GreenBuilding label. In comparison, GreenBuilding is most comparable to the label Energy Star which is commonly used in the US. Studies have

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<sup>2</sup> This is a theoretical effect of increased rent by 5,4 percent of the average non-certified building in our dataset. In reality, the rent is determined by several other aspects and the rent level will be different.

shown a low premium for buildings with Energy Star (Holtermans & Kok, 2019). Moreover, buildings in Sweden have a high construction quality and the standards are tight for new constructions compared to other countries, which may make certifications as GreenBuilding less valuable.

In model 3, investigating the effect of distance on the rent premium, the results indicate that there exists a significant incremental effect of distance on the rent premium for certified buildings. Regression 3 indicates a green rent premium to increase by 1,9 to 3,8 percent for a building located 1 km away from the city center. In other words, green certification grants a bigger premium for properties located away from the city center. This is also consistent with previous research. For instance, Robinson and McAllister (2015) found no rental premiums in high value areas whereas buildings in the low and middle segments had premiums. Eichholtz et al. (2010) observed that buildings with a certification located in low-cost regions had higher premiums. The explanation for this can be that the density of certified buildings is lower away from CBD, resulting in a lower supply. Still, tenants in surrounding submarkets may seek after occupancy in green buildings. Although, in CBD the rent parameters are affected mostly by locational price premiums. Additionally, as more buildings are certified in the central districts, it has become a factor of hygiene, a norm. Tenants take certification for granted and other amenities may drive the rent level more.

Although it is not a central part of the study, it is interesting to compare and analyze the outcome of the other control variables with the findings of other studies of office rent determinants. It is important to evaluate and investigate the variations in data sources and model specifications among previous studies as they do not always provide consistent findings. Especially for the relationship between variables such as area and age, *inter alia*, and office rents. For instance, the variables for lease area and total area are positive and significant for all models, which is consistent with Holtermans and Kok (2019), but Fuerst and McAllister (2011b) found a negative relationship. The variable for distance is consistent among every model and every dataset. Distance from city center does provide a negative impact on the rent level, which is highly expected. Porumb et. al (2020), Fuerst and McAllister (2011b) examine the same results.

The results for the building class variables are expected and indicate the same impact among all models. The higher building classes (A+ and A) provide a higher positive impact on the rent level. When comparing the results for building class between studies, it is important to be assured of the different criteria for receiving a higher grade. Most studies include a control variable for the quality of the building, where some studies use well-established building class rankings while other use a proxy variable instead. However, the findings for building class are in line with the results documented by Eichholtz et al. (2013) and Holtermans and Kok (2019).

The control variables for each contract year are not very common in other studies. But the results indicate that the rent level is higher for each year. This is also expected since the economic development has been favorable since 2010. This variable aims to capture the conditions for each year, and the state of the office market has been stable.

Furthermore, when evaluating and interpreting the findings for building year it is important to be observant of the implications and which attributes it is associated with. Building year is associated with more than quality and building characteristics. Also, building year can be

seen as a proxy for the location as the older buildings are often located in the more central parts. For instance, the variables for buildings constructed before 1900 and between 1900 and 1929 as well as buildings constructed after 2010 have a rather high impact on the rent level. An explanation for this can be that the older buildings are in the central parts, and hence associated with the location. However, newer buildings may be associated with their quality rather than their location which also is reflected by their positive impact on rent level.

Region and submarket indicate the impact for the location the buildings are situated in. The results regarding region are not surprising since Stockholm has the highest impact on rent followed by Gothenburg, Malmö, and Uppsala. The findings for the submarket parameters are overall expected. However, one must consider cluster effects when evaluating the results. Solna Business Park and Arenastaden are examples of office-cluster, which have a relatively high rent level and thus reflected in the output for their location variable.

A green certification is associated with a higher rent level. However, the value of green certification for the tenant is hard to define. As the value depends on personal preference, the value might differ because of personal views and arguments (Elder-Vass 2019). Das Gupta (1960) separated value into value-in-exchange and value-in-use, whereas the second includes the satisfying power of a good. The satisfying power by tenants may be higher when a certification label that considers other aspects than only the energy usage. The rent levels, as combined, are a proxy for the market rent level. Yet, by investigating one contract by itself it is impossible to know if the rent is the final amount someone is willing to pay, or if it is a result of a tenant valuing specific characteristics more. Gadd (1989) conceptualized that value-in-use reflects a value to a particular user and how the property contributes to the profitability of the enterprise. This paper has used a quantitative approach and the individual view and arguments are thereof limited. Therefore, the result from this thesis is on how the market values green certifications and not on solely tenant preferences.

From the property owner's perspective, a higher NOI leads to a higher income and in the long turn, it may provide a higher valuation of the property. As pointed out, if a non-certified building were certified the rental income would increase by approximately 1 158 000 SEK per building and year, and the value for the average building in our sample would increase by 21 million SEK<sup>3</sup>. Although it is not a central part of the study or a result, certified buildings do have lower risks according to research, in the sense of lower capitalization rates and higher occupancy numbers (Appraisal Institute and Institute for Market Transformation 2013; Wiley et al. 2010; Devine & Kok 2015; Chaney & Hoesli 2012; McGrath and Karen M 2013). Additionally, operating costs may also be lower for certified buildings, leading to a higher NOI than non-certified buildings (Reichardt 2014). However, this study has not proven a connection for this in the Swedish market, but if those findings hold, certified buildings do not only have a higher rent level but also increases the property value and lower the risk. Additionally, an increasing supply of certified buildings tends to decrease the rent premium over time (Chegut et al. 2014; Robinson & McAllister 2015). Thereof by doing a market analysis of the supply of certified buildings and prioritize to certify buildings in areas with a low density of certified buildings can be a proper strategy for the property owner.

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<sup>3</sup> This is a theoretical valuation of the average building in our dataset done to visualize the effect of higher rent thanks to a green certification. By applying a capitalization rate of 5,5 percent for the additional rental income the added property value is summarized to approx. 21 million SEK. In reality, the added value will be different.

The EU Taxonomy is a tool for classifying which investments can be considered environmentally sustainable. If the real estate and construction sector are to reach the goals of the Paris Agreement, a significant shift towards a more sustainable and low-carbon society is needed. A shift must be financed, not only by government funding but also institutional and private capital is needed. Since 2018, large companies in the EU must report non-financial sustainability measures and key figures. However, due to the lack of common standards, there is a risk of potential greenwashing, as well as picking only favorable metrics in the reporting. Consequently, an absence of comparable reporting could lead to a misallocation of sustainable funding. The EU Taxonomy is a common ground to stand on and focuses on consistent reporting of sustainability data by the market participants. The main purpose of green certification systems is to provide a clear and consistent framework to assess how environmentally sustainable a building is. Green certifications are therefore likely to be an even more useful measure and tool for property owners to demonstrate their commitment to sustainability and their level of taxonomy-aligned investments. The two major parts of the taxonomy are that the energy usage in the property must correspond to defined requirements, and in addition the “do no significant harm” objective relates to several climate measures. For instance, limitation of water usage, preparedness for extreme weather conditions and reuse of materials, etc. Moreover, the purpose of the taxonomy is to drive the development so that all buildings strive to be green. The different certifications system includes several conditions that must be fulfilled to receive the label. These conditions may have to be evaluated and harmonized as the EU taxonomy implements. Otherwise, they may lose their relevance, and property owners focus solely on the requirements stated in the taxonomy.

Hedonic pricing is a theory with the assumption that price is determined both by internal and external characteristics. Put in the context of rental levels, the price is determined by property as well as neighborhood characteristics (Sopranzetti 2016). In our models, we have controlled for both structural characteristics as quality, locational characteristics as distance to CBD, and neighborhood characteristics as distance to public transport. In general, all models have a high adjusted R-square value fluctuating between 77,3 to 82,2 percent. Compared to similar studies, their R-squared has been between 69 to 94,5 percent (Eichholtz et al. 2010; Robinson & McAllister 2015; Das et al. 2011; Reichhardt 2014). Normally, a high R-squared value indicates a good fit of the model and interprets how many percent of the variation is explained by the variables included. A common problem with regression analysis is overfitting the model, which leads to a misleading R-squared. However, this problem occurs mostly when the number of observations in the sample is low, and the model has a high number of independent variables. Moreover, our HPMs only indicates that a certified building has a higher rent level comparable to non-certified buildings and not why. Therefore, it is uncertain what the certified variable actually comprises. In other words, the reason why certified buildings have a higher rent level could be caused by something else than the label itself, certified buildings can have other characteristics impacting rent that is unobserved and unknown. For instance, this could be because of social responsibility mandates (Nelson & Raku 2010) or the type of tenants located in the building and availability (Levy & Peterson 2013), which is not included in the model. The information on the buildings in our sample is limited to observable attributes, not intangible information as property management or the presence of valuable characteristics that may correlate with the certification. This problem is called omitted variable bias and occurs when important

variables are omitted from the model (Ferraro & Carr 2021). Hence, certified buildings can correlate with attributes that we have not considered.

## 6. Conclusion

With environmental building certifications reaching significant adoption levels and becoming an identity marker for property owners, the implications for the market participants are becoming more important. The sustainability agenda has increased strongly during the last decades, and the real estate industry is contributing highly to greenhouse gas emissions and energy usage. Green building certification has, for the last decade, gained global prominence for ensuring sustainable development. Therefore, the impact of sustainability enhancements and particularly green building certificates are important to gain knowledge about. The purpose of this study is to investigate whether or not green certificates have an impact on income-generating commercial properties' rent compared to similar non-certified commercial properties. In addition, evaluate if there exists a variation in the rent premium between the different certifications and if the rental premium increases with the distance from city center.

The results of this thesis indicate that there exists a premium of between 4,9 and 5,4 percent. This is in line with earlier research. When investigating each certification label, the hedonic regression results indicate that there is a rental premium of 10 percent for BREEAM, 5,1 percent for LEED, and 4,4 percent for Miljöbyggnad. Lastly, the results indicate a 3,8 percent incremental premium for certified buildings located farther away from the city center.

Overall, the results of this paper indicate that a green certification not only adds benefits for the tenant, in the sense of better indoor quality and higher productivity, etc. But also adds value for the property owner since certified buildings receive a higher rental income. Interestingly, property owners seem to gain from certifying existing buildings which opens an opportunity when refurbishing buildings. As of today, the majority of the buildings that get certification are new constructions, and only around 670 existing buildings in Sweden are certified (SGBC, n.d). Hence, certifying the existing building stock is an enormous potentiality for property owners. Additionally, property owners can capitalize from certifying buildings, especially in markets away from CBD. To succeed the national target of a fossil-free Sweden by 2045, certification labels matter. The accelerating rate of certified buildings will without a doubt continue to increase as a certification becoming a factor of hygiene when tenants are seeking new locations as well as when investors seek green investments.

This study contributes in multiple ways to the literature as it, to the authors' knowledge, is the first empirical assessment of green certifications using data for specific contracts for four cities in Sweden using an econometric approach. Hence, the study is both timely and relevant as the development within sustainability is increasing enormously. There is also a regulatory push from the EU and the Swedish government for sustainable development. The findings suggest that clear benefits are emerging from investing in green buildings.

### 6.1 Future research

Future research can complement this thesis by investigating intangible reasons as if property owners with certified buildings have a higher quality in the property management which leads to higher rent. As refurbishing existing buildings is less harmful to the environment, it would be interesting to investigate if a property owner can capitalize more from certifying existing buildings over building new ones.

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# Appendix

## Appendix 1. Information for all investigated markets with the submarkets separated

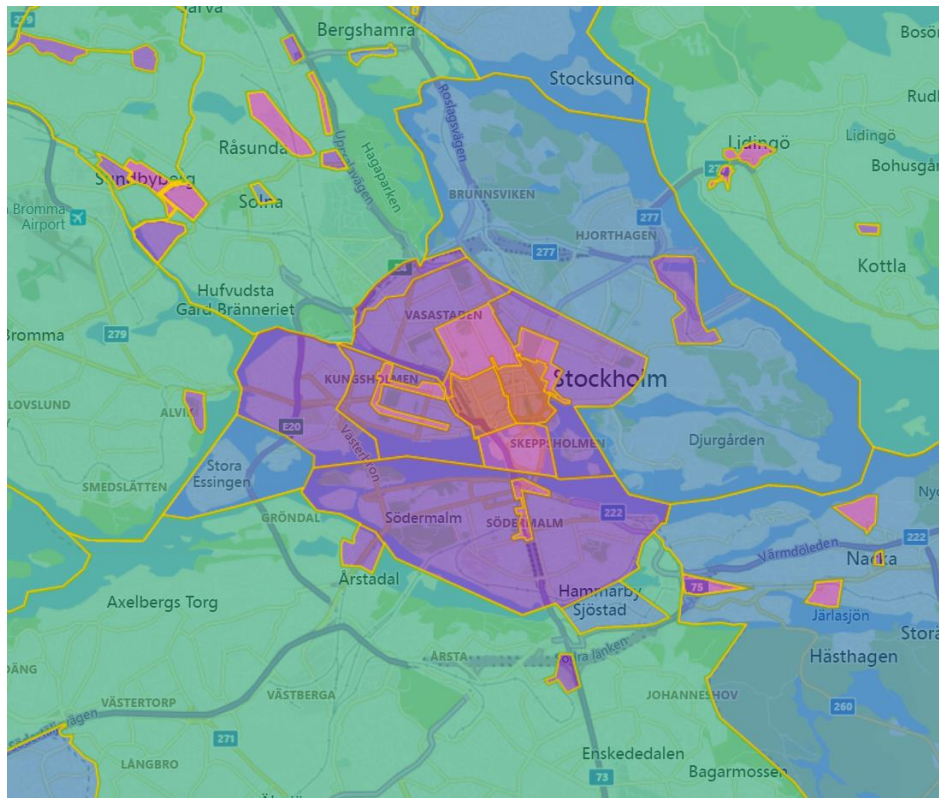


Figure A-1. Stockholm submarkets

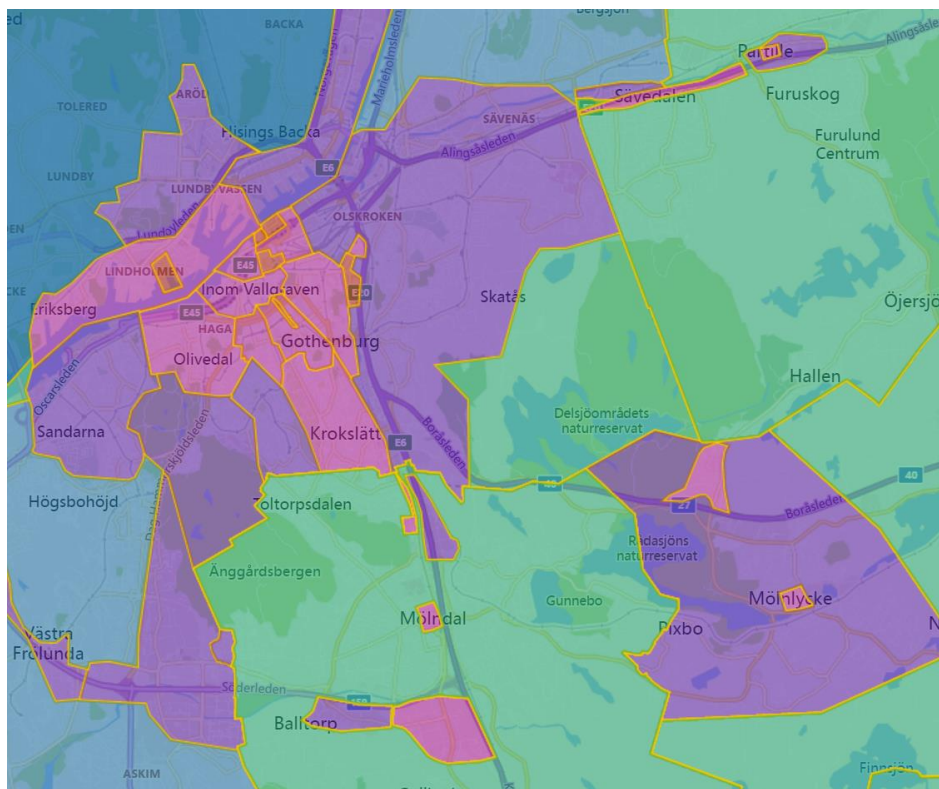


Figure A-2. Gothenburg submarkets

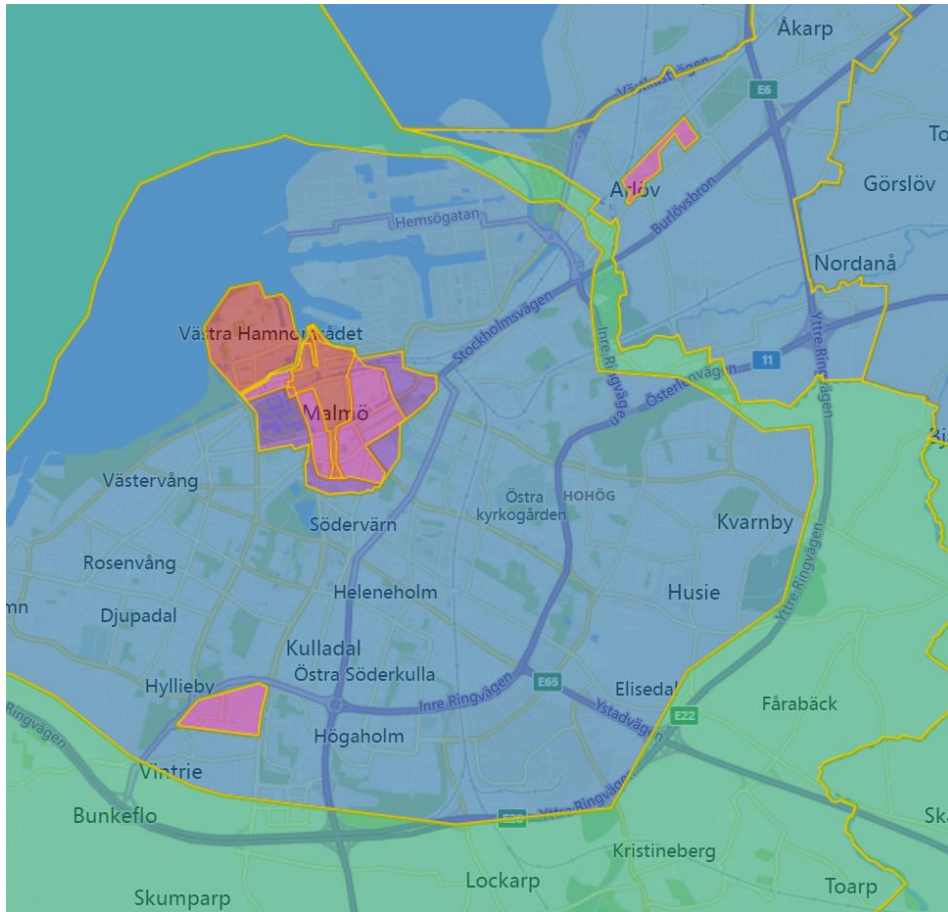


Figure A-3. Malmö submarkets

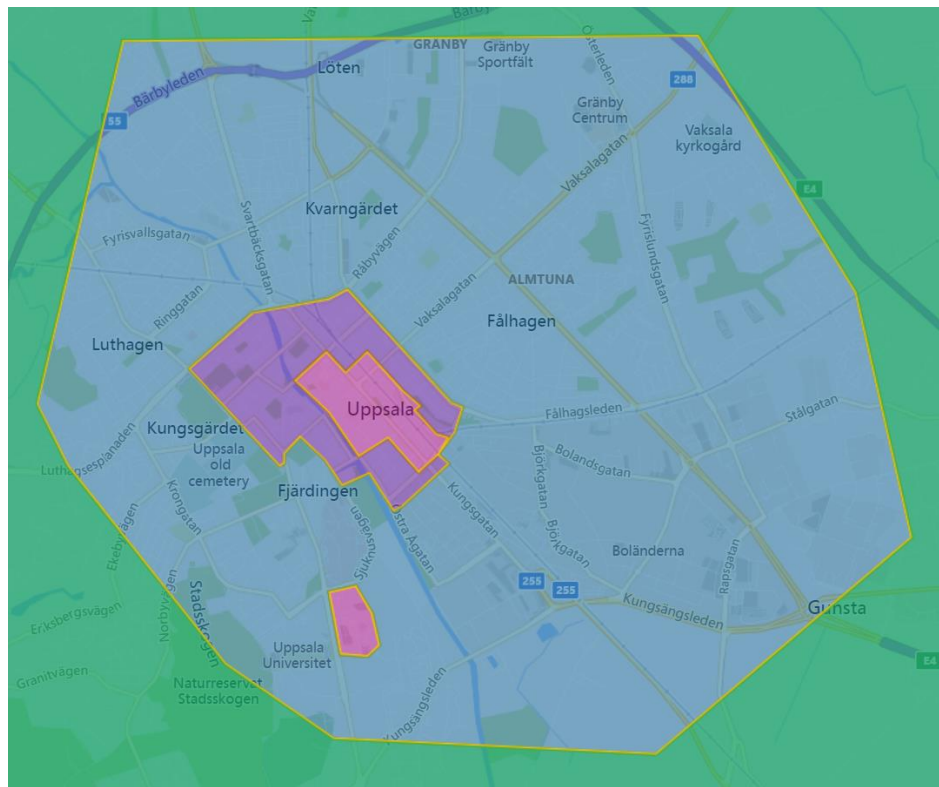


Figure A-4. Uppsala submarkets

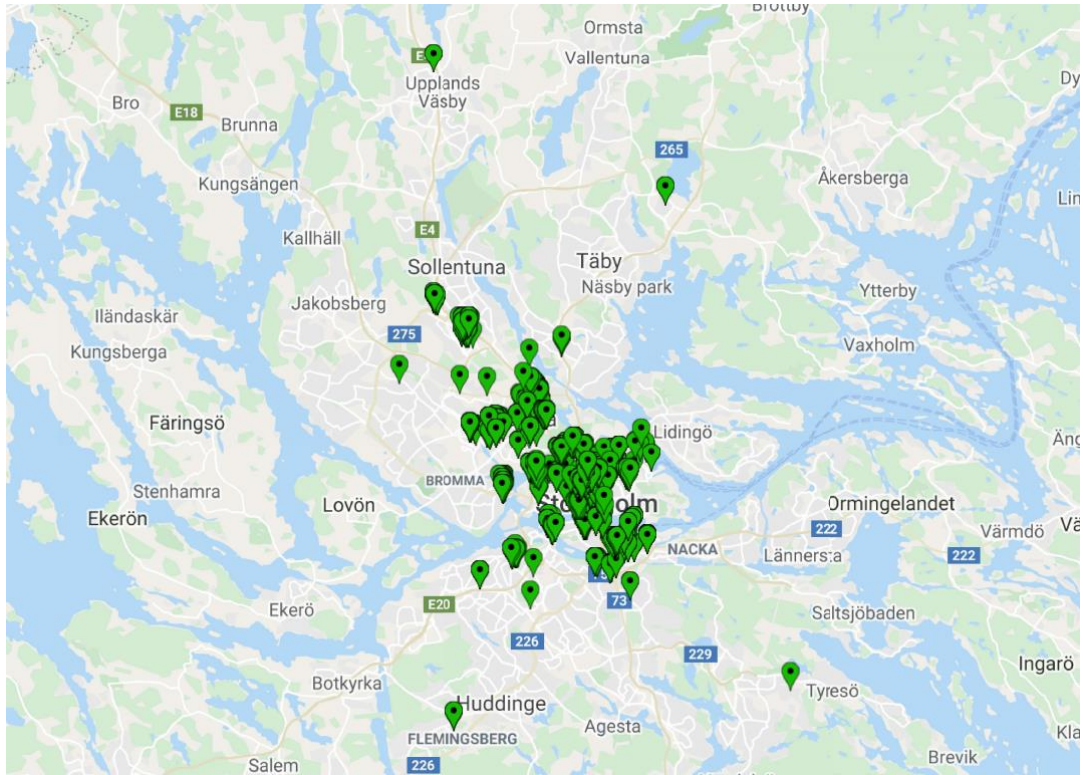


Figure A-5. Certified observations in Stockholm



Figure A-6. Non-certified observations in Stockholm

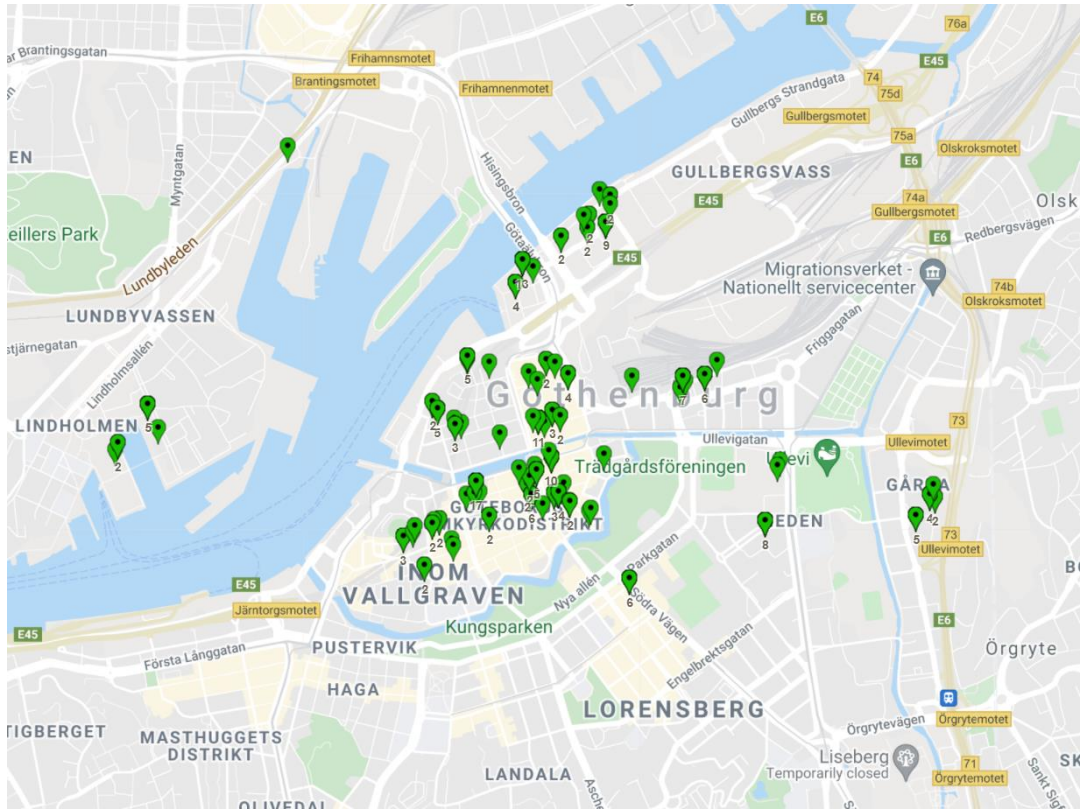


Figure A-7. Certified observations in Gothenburg

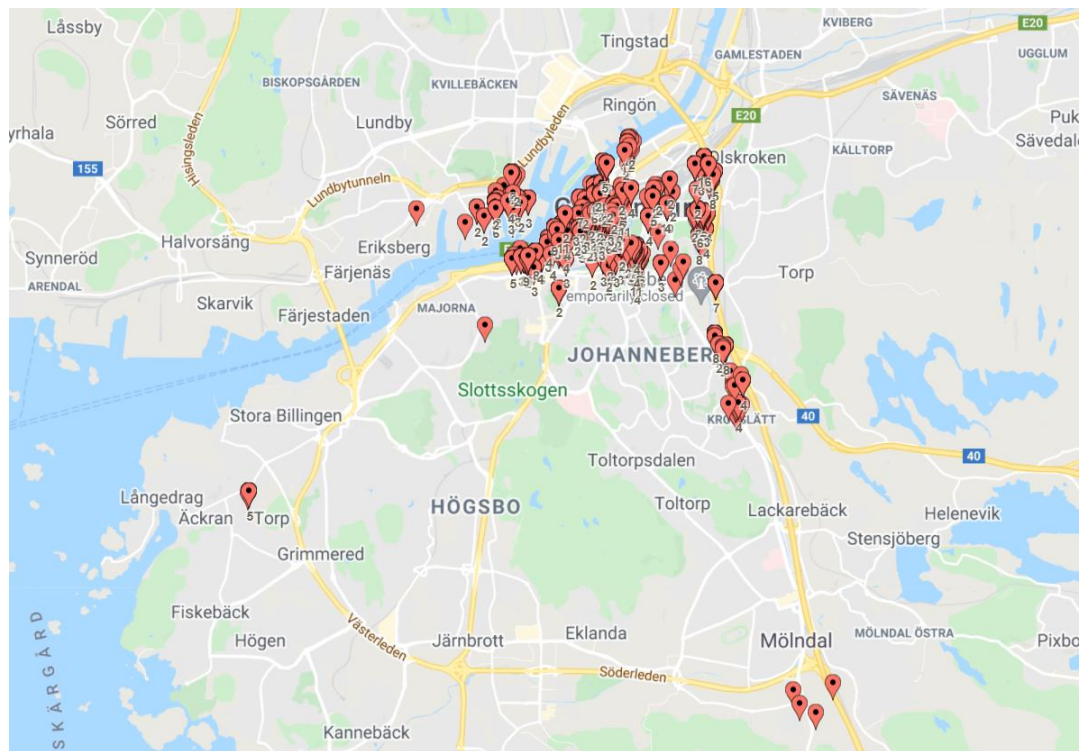


Figure A-8. Non-certified observations in Gothenburg

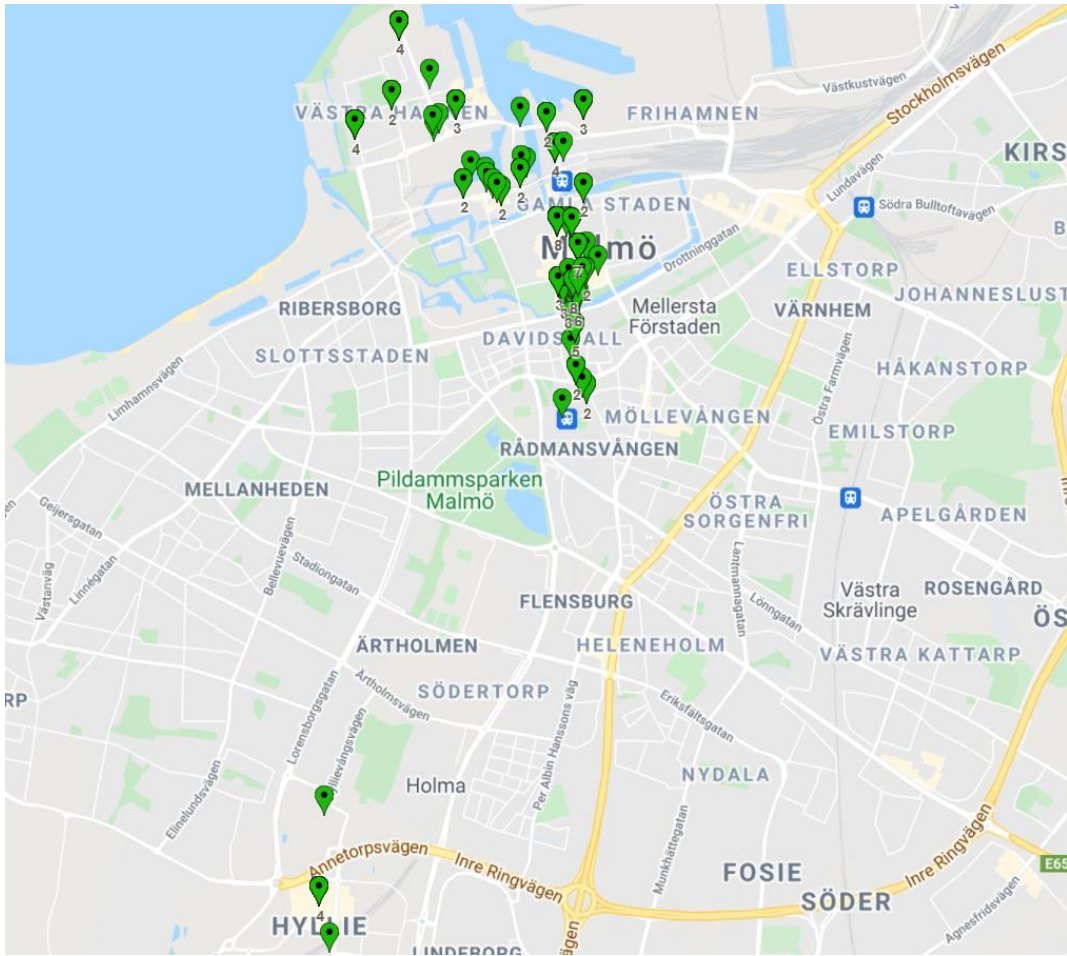


Figure A-9. Certified observations in Malmö

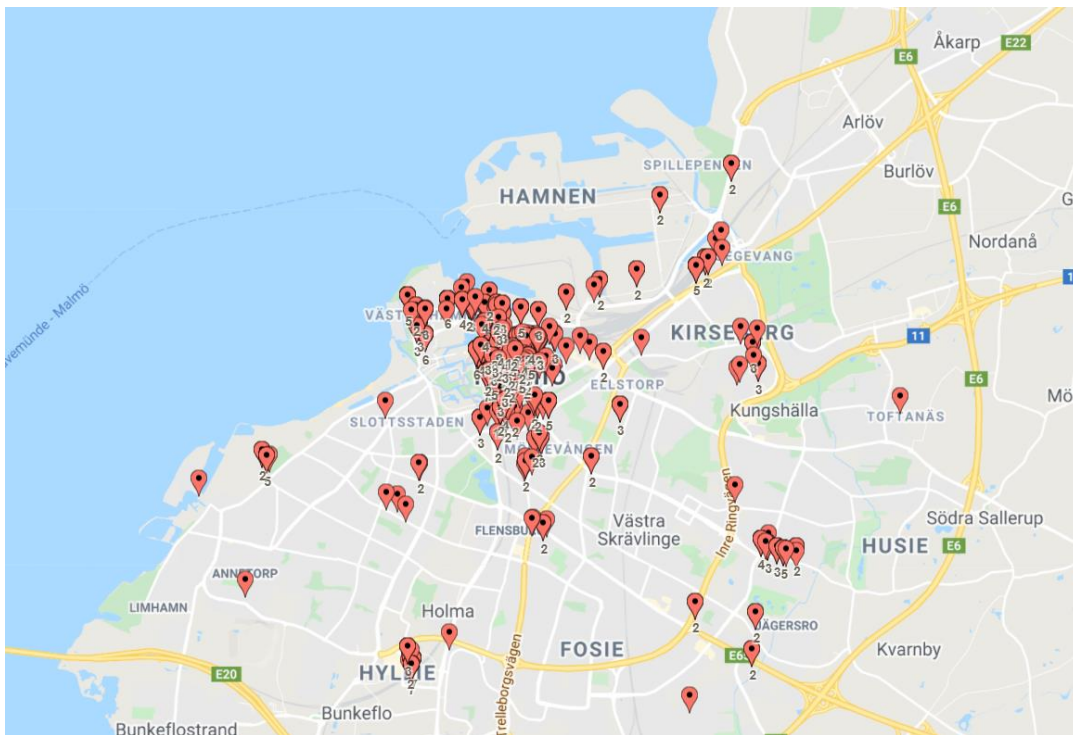


Figure A-10. Non-certified observations in Malmö

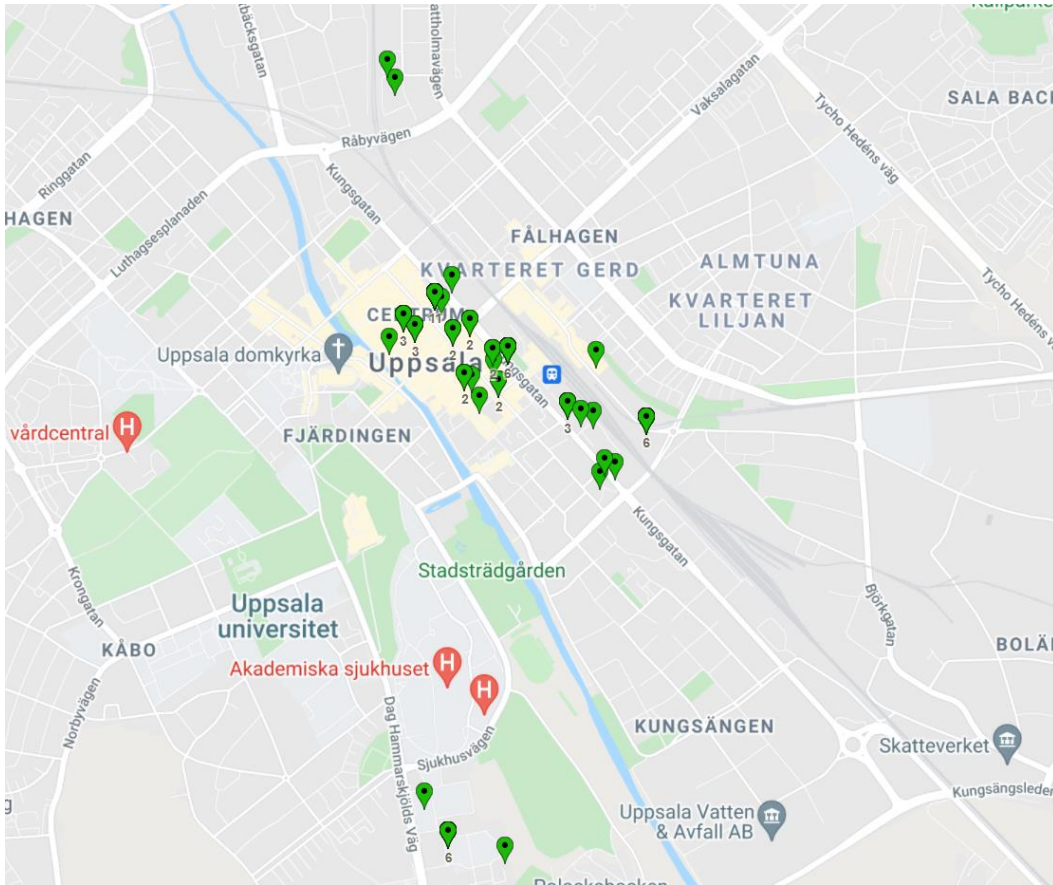


Figure A-11. Certified observations in Uppsala

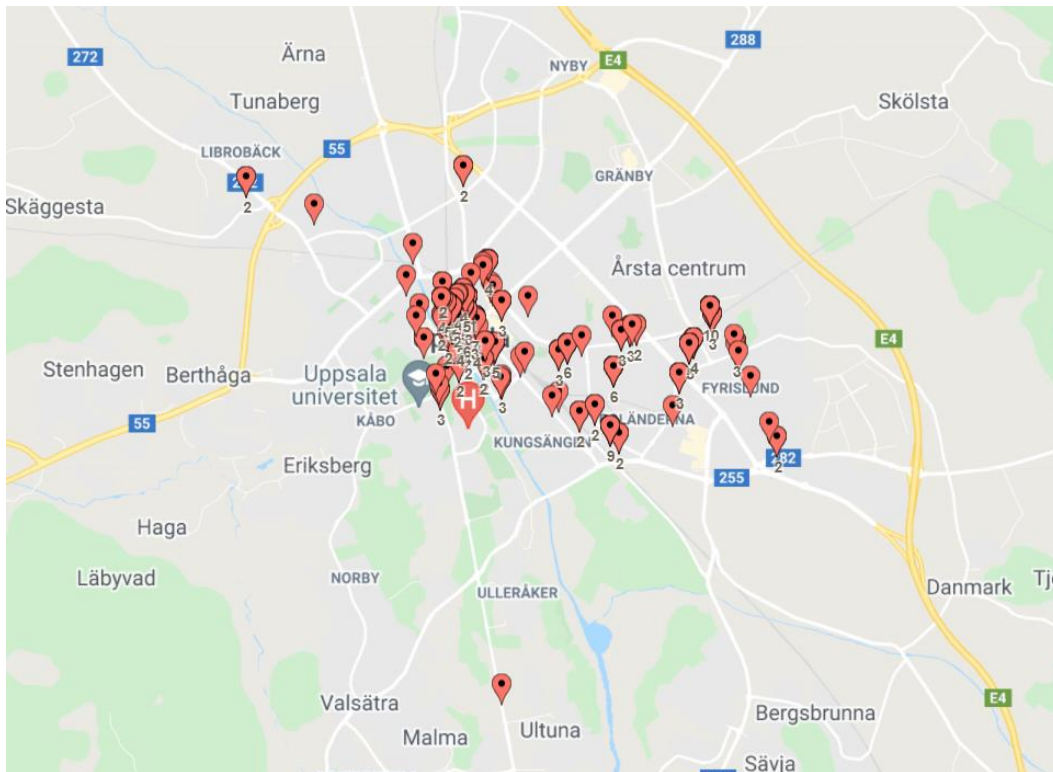


Figure A-12. Non-certified observations in Uppsala

Table A-1. List of all submarkets and locations

Location	Location	Municipality	Region	Submarket
A Norra Gärdar	A	Göteborg	Göteborg	A Göteborg
A Övriga Gullbergsvass	A	Göteborg	Göteborg	A Göteborg
A Annedal-Masthugget	A	Göteborg	Göteborg	A Göteborg
A Heden, Stampen	A	Göteborg	Göteborg	A Göteborg
A Lorensberg	A	Göteborg	Göteborg	A Göteborg
A Inom Vallgraven	A	Göteborg	Göteborg	A Göteborg
A Johanneberg, Krokslätt	A	Göteborg	Göteborg	A Göteborg
A Norra Älvstranden	A	Göteborg	Göteborg	A Göteborg
A Västra Nordstan	A	Göteborg	Göteborg	A Göteborg
A Vasastan	A	Göteborg	Göteborg	A Göteborg
A Åbro	A	Möndal	Göteborg	Möndal
A Mölndalsvägen, Krokslätt	A	Möndal	Göteborg	Möndal
A Övriga centrum	A	Malmö	Malmö	A Malmö
A Hyllie	A	Malmö	Malmö	A Malmö
A Mörby Centrum	A	Danderyd	Stockholm	A Stockholm Other
A Jakobsberg Centrum	A	Järfälla	Stockholm	A Stockholm Other
A Nacka Strand	A	Nacka	Stockholm	A Stockholm Other
A Sickla	A	Nacka	Stockholm	A Stockholm Other
A Sollentuna Centrum	A	Sollentuna	Stockholm	A Stockholm Other
A Arenastaden	A	Solna	Stockholm	A Stockholm Other
A Solna Business Park	A	Solna	Stockholm	A Stockholm Other
A Frösunda	A	Solna	Stockholm	A Stockholm Other
A Gamla Stan	A	Stockholm	Stockholm	A Stockholm
A Norrmalm	A	Stockholm	Stockholm	A Stockholm
A Kungsholmen	A	Stockholm	Stockholm	A Stockholm
A Södermalm - Slussen	A	Stockholm	Stockholm	A Stockholm
A Östermalm	A	Stockholm	Stockholm	A Stockholm
A Centrum	A	Sundbyberg	Stockholm	A Stockholm Other
A Täby Centrum	A	Täby	Stockholm	A Stockholm Other
A Centrala Uppsala	A	Uppsala	Uppsala	A Uppsala
A Uppsala Science park	A	Uppsala	Uppsala	A Uppsala
AA Gärdar	AA	Göteborg	Göteborg	AA Göteborg
AA Lilla Bommen	AA	Göteborg	Göteborg	AA Göteborg
AA Gullbergsvass	AA	Göteborg	Göteborg	AA Göteborg
AA Östra Nordstan och Centralstation	AA	Göteborg	Göteborg	AA Göteborg
AA Lindholmen	AA	Göteborg	Göteborg	AA Göteborg
AA Kungssportsavenyn	AA	Göteborg	Göteborg	AA Göteborg
AA Centrum	AA	Malmö	Malmö	AA Malmö
AA Va Hamnen	AA	Malmö	Malmö	AA Malmö
AA Västra CBD	AA	Stockholm	Stockholm	AA Stockholm
AA Östra CBD	AA	Stockholm	Stockholm	AA Stockholm
B Östra Göteborg	B	Göteborg	Göteborg	B Göteborg
B Riskulla	B	Möndal	Göteborg	Möndal
B Lackarebäck	B	Möndal	Göteborg	Möndal
B Övriga innerstaden	B	Malmö	Malmö	B Malmö
B Berga Backe	B	Danderyd	Stockholm	B Stockholm Other
B Veddesta	B	Järfälla	Stockholm	B Stockholm Other
B Forum Nacka	B	Nacka	Stockholm	B Stockholm Other
B Edsberg	B	Sollentuna	Stockholm	B Stockholm Other
B Norrviken	B	Sollentuna	Stockholm	B Stockholm Other
B Bredden	B	Sollentuna	Stockholm	B Stockholm Other
B Rotebro	B	Sollentuna	Stockholm	B Stockholm Other
B Solna Strand	B	Solna	Stockholm	B Stockholm Other
B Haga norra	B	Solna	Stockholm	B Stockholm Other
B Övriga Östermalm	B	Stockholm	Stockholm	B Stockholm
B Vasastaden	B	Stockholm	Stockholm	B Stockholm
B Övriga Södermalm	B	Stockholm	Stockholm	B Stockholm
B Kista	B	Stockholm	Stockholm	B Stockholm
B Kungens Kurva	B	Stockholm	Stockholm	B Stockholm
B Alvik	B	Stockholm	Stockholm	B Stockholm
B Globen	B	Stockholm	Stockholm	B Stockholm
B Norra Station- Rosalagstull	B	Stockholm	Stockholm	B Stockholm
B Övriga Kungsholmen	B	Stockholm	Stockholm	B Stockholm
B Västra Kungsholmen	B	Stockholm	Stockholm	B Stockholm
B Rissne/Hallonbergen	B	Stockholm	Stockholm	B Stockholm
B Järva	B	Stockholm	Stockholm	B Stockholm
B Värtahamnen/Frihamnen	B	Stockholm	Stockholm	B Stockholm
B Marievik/Liljeholmen	B	Stockholm	Stockholm	B Stockholm
B Allén	B	Sundbyberg	Stockholm	B Stockholm Other
B Brandstation	B	Täby	Stockholm	B Stockholm Other
B Tibble	B	Täby	Stockholm	B Stockholm Other
B Roslags Näsby	B	Täby	Stockholm	B Stockholm Other
B Infra City	B	Upplands Väsby	Stockholm	B Stockholm Other
B Innerstaden	B	Uppsala	Uppsala	B Uppsala
C Övriga tätorten	C	Malmö	Malmö	C Malmö
C Inverness	C	Danderyd	Stockholm	C Stockholm Other
C Övriga kommunen	C	Järfälla	Stockholm	C Stockholm Other
C Nacka	C	Nacka	Stockholm	C Stockholm Other
C Solna Centrum	C	Solna	Stockholm	C Stockholm Other
C Hammarby Sjöstad	C	Stockholm	Stockholm	C Stockholm
C Djurgården	C	Stockholm	Stockholm	C Stockholm
C Essingeöarna	C	Stockholm	Stockholm	C Stockholm
C Uppsala tätort	C	Uppsala	Uppsala	C Uppsala
D Övriga kommunen	D	Möndal	Göteborg	Möndal
D Övriga kommunen	D	Malmö	Malmö	D Malmö
D Övriga kommunen	D	Stockholm	Stockholm	D Stockholm
D Söderort	D	Stockholm	Stockholm	D Stockholm
D Västerort	D	Stockholm	Stockholm	D Stockholm
D Övriga kommunen	D	Uppsala	Uppsala	D Uppsala

## Appendix 2. Descriptive statistics

Table A-2. Descriptive statistics - Gothenburg

<b>Certified Gothenburg</b>	Rent/ sq. m	Lease area	Contract length	Vacancy [%]	Total leasable area	Distance	Value year	Bulding Year	Age
Mean	2692.672	725.599	4.119	0.097	10381.422	0.635	1982.897	1949.246	70.754
Median	2640	271.5	3	0.06877296	7936.5	0.61	1988	1969	51
Std. Dev.	528.662	1512.505	4.516	0.091	569.394	0.354	23.036	63.082	63.082
Min.	1440	30	0	0	1012	0.08	1937	1500	2
Max.	4210	12648	15	0.51420993	37178	1.95	2018	2018	520
Observations	232	232	232	232	232	232	232	232	232

<b>Non-Certified Gothenburg</b>	Rent/ sq. m	Lease area	Contract length	Vacancy [%]	Total leasable area	Distance	Value year	Bulding Year	Age
Mean	2310.115	511.372	3.481	0.078	7294.221	1.237	1977.987	1937.016	82.984
Median	2300	265	3	0.02072727	4202	0.94	1986	1943	77
Std. Dev.	581.714	768.405	1.719	0.119	307.219	1.101	25.180	89.940	89.940
Min.	840	23	0	0	356	0	1870	1500	3
Max.	4797	8000	18	0.79567155	41100	8.39	2018	2017	520
Observations	854	854	769	854	854	854	854	854	854

Table A-3. Descriptive statistics - Malmö

<b>Certified Malmö</b>	Rent/ sq. m	Lease area	Contract length	Vacancy [%]	Total leasable area	Distance	Value year	Bulding Year	Age
Mean	2208.968	726.129	3.668	0.101	6453.476	1.013	1983.427	1970.855	49.145
Median	2140	278	3	0.085	5891	0.83	1981	1967	53
Std. Dev.	397.939	1430.773	1.512	0.098	4127.032	1.039	26.793	34.488	34.488
Min.	1540	40	0	0	829	0.03	1930	1925	0
Max.	3645	12300	10	0.359	18600	5.61	2020	2020	95
Observations	124	124	110	124	124	124	124	124	124

<b>Non-Certified Malmö</b>	Rent/ sq. m	Lease area	Contract length	Vacancy [%]	Total leasable area	Distance	Value year	Bulding Year	Age
Mean	1912.738	531.615	3.594	0.149	5231.250	1.532	1972.639	1954.021	65.979
Median	1940	240	3	0.097	4000	0.76	1979	1961	59
Std. Dev.	472.449	1392.445	2.279	0.205	5041.340	1.647	55.125	64.534	64.534
Min.	900	23	0	0	313	0	1500	1500	3
Max.	3640	25300	25	1	54898	6.58	2017	2017	520
Observations	535	535	435	535	535	535	535	535	535

Table A-4. Descriptive statistics - Uppsala

<b>Certified Uppsala</b>	Rent/ sq. m	Lease area	Contract length	Vacancy [%]	Total leasable area	Distance	Value year	Bulding Year	Age
Mean	2273.385	680.908	4.345	0.037	15121.969	0.591	1914.754	1909.154	110.846
Median	2152	300	3	0	7500	0.41	1980	1974	46
Std. Dev.	480.109	1074.217	4.809	0.082	19756.983	0.732	178.735	176.683	176.683
Min.	1430	57	0	0	940	0.14	1500	1500	4
Max.	3439	7194	36	0.27482353	63043	5.13	2016	2016	520
Observations	65	65	55	65	65	65	65	65	65

<b>Non-Certified Uppsala</b>	Rent/ sq. m	Lease area	Contract length	Vacancy [%]	Total leasable area	Distance	Value year	Bulding Year	Age
Mean	1819.778	421.778	3.195	0.101	5938.544	1.009	1981.052	1966.758	53.242
Median	1800	237	3	0.02986189	3000	0.615	1989	1971	49
Std. Dev.	510.210	676.997	1.898	0.149	6696.850	0.846	25.220	34.184	34.184
Min.	1000	29	0	0	404	0.2	1740	1740	2
Max.	3600	6600	12	0.7	28661	4.3	2019	2018	280
Observations	252	252	204	252	252	252	252	252	252

### Appendix 3. Regression outputs

Model 1a:

<i>LN_rent_per_sqm</i>	Coefficient	Standard Error	t stat	Sig.
Constant	7.414	0.031	238.818	0
<i>LN_Lease_area</i>	0.005*	0.003	1.878	0.06
<i>LN_Total_Area</i>	0.006**	0.003	2.044	0.041
<i>LN_Distance</i>	-0.255***	0.003	-91.824	0
<i>LN_Public_Transport</i>	-0.113***	0.008	-13.349	0
Certified	0.054***	0.006	8.766	0
<i>Bulding_class_Aplus</i>	0.156***	0.019	8.152	0
<i>Building_class_A</i>	0.171***	0.007	23.046	0
<i>Building_class_Bplus</i>	0.12***	0.009	13.525	0
<i>Building_class_B</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_class_C</i>	-0.176***	0.009	-19.598	0
<i>Contract_year_2010</i>	-0.058***	0.012	-5.05	0
<i>Contract_year_2011</i>	Omitted	Omitted	Omitted	Omitted
<i>Contract_year_2012</i>	0.044***	0.011	3.947	0
<i>Contract_year_2013</i>	0.072***	0.011	6.373	0
<i>Contract_year_2014</i>	0.103***	0.011	9.252	0
<i>Contract_year_2015</i>	0.157***	0.011	14.12	0
<i>Contract_year_2016</i>	0.208***	0.011	18.491	0
<i>Contract_year_2017</i>	0.26***	0.011	23.195	0
<i>Contract_year_2018</i>	0.35***	0.012	29.641	0
<i>Contract_year_2019</i>	0.399***	0.012	33.237	0
<i>Contract_year_2020</i>	0.433***	0.013	33.231	0
<i>Contract_year_2021</i>	0.443***	0.018	23.986	0
<i>Building_year_below1900</i>	-0.024**	0.012	-2.058	0.04
<i>Building_year_1900to1929</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_year_1930to1964</i>	-0.048***	0.008	-6.314	0
<i>Building_year_1965to1974</i>	-0.111***	0.01	-11.282	0
<i>Building_year_1975to1989</i>	-0.105***	0.009	-11.765	0
<i>Building_year_1990to1999</i>	-0.168***	0.011	-15.409	0
<i>Building_year_2000to2010</i>	-0.045***	0.013	-3.588	0
<i>Building_year_over2010</i>	0.01	0.017	0.578	0.564
<i>Region_Stockholm</i>	0.645***	0.013	49.094	0
<i>Region_Gothenburg</i>	0.227***	0.014	16.282	0
<i>Region_Malmo</i>	0.06***	0.015	4.026	0
<i>Region_Uppsala</i>	Omitted	Omitted	Omitted	Omitted
R <sup>2</sup>	0.771			
Adjusted R <sup>2</sup>	0.77			
Observations	7426			

Note \*\*\*, \*\*, \* Significant at 1, 5, 10 percent levels, respectively

Model 1b:

<i>LN_rent_per_sqm</i>	<i>Coefficient</i>	<i>Standard Error</i>	<i>t stat</i>	<i>Sig.</i>
(Constant)	7.801	0.029	270.889	0
<i>LN_Lease_area</i>	0.006**	0.003	2.493	0.013
<i>LN_Total_Area</i>	0.01***	0.003	3.861	0
<i>LN_Distance</i>	-0.14***	0.004	-35.959	0
<i>LN_Public_Transport</i>	-0.051***	0.008	-6.617	0
<i>Certified</i>	0.049***	0.006	8.863	0
<i>Building_class_Aplus</i>	0.159***	0.017	9.277	0
<i>Building_class_A</i>	0.139***	0.007	20.897	0
<i>Building_class_B</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_class_Bplus</i>	0.095***	0.008	12.111	0
<i>Building_class_C</i>	-0.146***	0.008	-18.181	0
<i>Contract_year_2010</i>	-0.068***	0.01	-6.63	0
<i>Contract_year_2011</i>	Omitted	Omitted	Omitted	Omitted
<i>Contract_year_2012</i>	0.048***	0.01	4.837	0
<i>Contract_year_2013</i>	0.07***	0.01	7.001	0
<i>Contract_year_2014</i>	0.099***	0.01	10.033	0
<i>Contract_year_2015</i>	0.148***	0.01	15.119	0
<i>Contract_year_2016</i>	0.205***	0.01	20.637	0
<i>Contract_year_2017</i>	0.263***	0.01	26.552	0
<i>Contract_year_2018</i>	0.342***	0.01	32.732	0
<i>Contract_year_2019</i>	0.391***	0.011	36.835	0
<i>Contract_year_2020</i>	0.44***	0.012	38.179	0
<i>Contract_year_2021</i>	0.426***	0.016	26.072	0
<i>Building_year_below1900</i>	-0.012	0.01	-1.126	0.26
<i>Building_year_1900to1929</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_year_1930to1964</i>	-0.019***	0.007	-2.816	0.005
<i>Building_year_1965to1974</i>	-0.059***	0.009	-6.595	0
<i>Building_year_1975to1989</i>	-0.089***	0.008	-11.048	0
<i>Building_year_1990to1999</i>	-0.14***	0.01	-14.221	0
<i>Building_year_2000to2010</i>	-0.034***	0.011	-3.031	0.002
<i>Building_year_over2010</i>	0.04***	0.016	2.573	0.01
<i>Location_AA_Stockholm</i>	0.289***	0.011	27.448	0
<i>Location_A_Stockholm</i>	0.15***	0.009	16.395	0
<i>Location_B_Stockholm</i>	Omitted	Omitted	Omitted	Omitted
<i>Location_C_Stockholm</i>	-0.097***	0.015	-6.335	0
<i>Location_D_Stockholm</i>	-0.305***	0.009	-34.344	0
<i>Location_A_Stockholm_Other</i>	-0.098***	0.014	-6.852	0
<i>Location_B_Stockholm_Other</i>	-0.2***	0.013	-14.882	0
<i>Location_C_Stockholm_Other</i>	-0.235***	0.019	-12.359	0
<i>Location_AA_Gothenburg</i>	-0.293***	0.014	-20.203	0
<i>Location_A_Gothenburg</i>	-0.276***	0.01	-27.442	0
<i>Location_B_Gothenburg</i>	-0.403***	0.025	-16.28	0
<i>Location_Gothenburg_Molndal</i>	-0.537***	0.036	-14.783	0
<i>Location_AA_Malmo</i>	-0.464***	0.013	-36.735	0
<i>Location_A_Malmo</i>	-0.416***	0.018	-23.243	0
<i>Location_B_Malmo</i>	-0.504***	0.042	-12.084	0
<i>Location_C_Malmo</i>	-0.554***	0.019	-28.669	0
<i>Location_D_Malmo</i>	-0.514***	0.134	-3.847	0
<i>Location_A_Uppsala</i>	-0.443***	0.018	-25.196	0
<i>Location_B_Uppsala</i>	-0.547***	0.029	-18.923	0
<i>Location_C_Uppsala</i>	-0.56***	0.02	-28.053	0
<i>Location_D_Uppsala</i>	-0.509***	0.134	-3.815	0
R <sup>2</sup>	0.823			
Adjusted R <sup>2</sup>	0.822			
Observations	7426			

Note \*\*\*,\*\*,\* Significant at 1, 5, 10 percent levels, respectively

Model 2a:

<i>LN_rent_per_sqm</i>	Coefficient	Standard Error	t stat	Sig.
(Constant)	8.048	0.03	269.229	0
<i>LN_Lease_area</i>	0.006**	0.003	1.979	0.048
<i>LN_Total_Area</i>	0.006**	0.003	2.035	0.042
<i>LN_Distance</i>	-0.256***	0.003	-92.356	0
<i>LN_Public_Transport</i>	-0.11***	0.008	-13.014	0
<i>Certified_BREEAM</i>	0.1***	0.01	10.19	0
<i>Certified_LEED</i>	0.051***	0.008	6.508	0
<i>Certified_Miljobyggnad</i>	0.044***	0.011	4.113	0
<i>Certified_GreenBuilding</i>	-7.90E-05	0.011	-0.007	0.994
<i>Bulding_class_Aplus</i>	0.143***	0.019	7.459	0
<i>Building_class_A</i>	0.17***	0.007	22.94	0
<i>Building_class_B</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_class_Bplus</i>	0.119***	0.009	13.451	0
<i>Building_class_C</i>	-0.175***	0.009	-19.613	0
<i>Contract_year_2010</i>	-0.058***	0.012	-5.033	0
<i>Contract_year_2011</i>	Omitted	Omitted	Omitted	Omitted
<i>Contract_year_2012</i>	0.046***	0.011	4.114	0
<i>Contract_year_2013</i>	0.072***	0.011	6.397	0
<i>Contract_year_2014</i>	0.104***	0.011	9.392	0
<i>Contract_year_2015</i>	0.158***	0.011	14.313	0
<i>Contract_year_2016</i>	0.207***	0.011	18.438	0
<i>Contract_year_2017</i>	0.259***	0.011	23.21	0
<i>Contract_year_2018</i>	0.348***	0.012	29.617	0
<i>Contract_year_2019</i>	0.399***	0.012	33.318	0
<i>Contract_year_2020</i>	0.433***	0.013	33.413	0
<i>Contract_year_2021</i>	0.443***	0.018	24.069	0
<i>Building_year_below1900</i>	-0.024**	0.012	-1.999	0.046
<i>Building_year_1900to1929</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_year_1930to1964</i>	-0.049***	0.008	-6.465	0
<i>Building_year_1965to1974</i>	-0.109***	0.01	-11.074	0
<i>Building_year_1975to1989</i>	-0.1***	0.009	-11.282	0
<i>Building_year_1990to1999</i>	-0.164***	0.011	-15.067	0
<i>Building_year_2000to2010</i>	-0.049***	0.013	-3.866	0
<i>Building_year_over2010</i>	0.004	0.017	0.253	0.801
<i>Region_Stockholm</i>	Omitted	Omitted	Omitted	Omitted
<i>Region_Gothenburg</i>	-0.412***	0.008	-53.988	0
<i>Region_Malmo</i>	-0.58***	0.009	-61.719	0
<i>Region_Uppsala</i>	-0.642***	0.013	-48.967	0
R <sup>2</sup>	0.773			
Adjusted R <sup>2</sup>	0.772			
Observations	7426			

Note \*\*\*, \*\*, \* Significant at 1, 5, 10 percent levels, respectively

Model 2b:

LN_rent_per_sqm	Coefficient	Standard Error	t stat	Sig.
(Constant)	7.79	0.029	270.097	0
LN_Lease_area	0.006**	0.003	2.449	0.014
LN_Total_Area	0.012***	0.003	4.35	0
LN_Distance	-0.142***	0.004	-36.58	0
LN_Public_Transport	-0.051***	0.008	-6.489	0
Certified_BREEAM	0.088***	0.009	9.962	0
Certified_LEED	0.035***	0.007	4.944	0
Certified_Miljobyggnad	0.03***	0.009	3.216	0.001
Certified_GreenBuilding	-0.003	0.009	-0.281	0.779
Building_class_Aplus	0.151***	0.017	8.797	0
Building_class_A	0.14***	0.007	20.975	0
Building_class_B	Omitted	Omitted	Omitted	Omitted
Building_class_Bplus	0.096***	0.008	12.178	0
Building_class_C	-0.146***	0.008	-18.252	0
Contract_year_2010	-0.067***	0.01	-6.58	0
Contract_year_2011	Omitted	Omitted	Omitted	Omitted
Contract_year_2012	0.049***	0.01	4.99	0
Contract_year_2013	0.07***	0.01	7.022	0
Contract_year_2014	0.1***	0.01	10.203	0
Contract_year_2015	0.15***	0.01	15.297	0
Contract_year_2016	0.204***	0.01	20.546	0
Contract_year_2017	0.263***	0.01	26.54	0
Contract_year_2018	0.34***	0.01	32.65	0
Contract_year_2019	0.391***	0.011	36.899	0
Contract_year_2020	0.441***	0.011	38.337	0
Contract_year_2021	0.426***	0.016	26.086	0
Building_year_below1900	-0.01	0.01	-0.969	0.332
Building_year_1900to1929	Omitted	Omitted	Omitted	Omitted
Building_year_1930to1964	-0.021**	0.007	-3.067	0.002
Building_year_1965to1974	-0.058***	0.009	-6.446	0
Building_year_1975to1989	-0.085***	0.008	-10.589	0
Building_year_1990to1999	-0.137***	0.01	-13.875	0
Building_year_2000to2010	-0.035**	0.011	-3.061	0.002
Building_year_over2010	0.037**	0.016	2.361	0.018
Location_AA_Stockholm	0.283***	0.011	26.918	0
Location_A_Stockholm	0.145***	0.009	15.806	0
Location_B_Stockholm	Omitted	Omitted	Omitted	Omitted
Location_C_Stockholm	-0.108***	0.016	-6.924	0
Location_D_Stockholm	-0.304***	0.009	-34.15	0
Location_A_Stockholm_Other	-0.105***	0.014	-7.328	0
Location_B_Stockholm_Other	-0.206***	0.013	-15.277	0
Location_C_Stockholm_Other	-0.238***	0.019	-12.519	0
Location_AA_Gothenburg	-0.291***	0.014	-20.037	0
Location_A_Gothenburg	-0.275***	0.01	-27.331	0
Location_B_Gothenburg	-0.405***	0.025	-16.393	0
Location_Gothenburg_Molndal	-0.538***	0.036	-14.853	0
Location_AA_Malmo	-0.464***	0.013	-36.72	0
Location_A_Malmo	-0.417***	0.018	-23.385	0
Location_B_Malmo	-0.504***	0.042	-12.122	0
Location_C_Malmo	-0.555***	0.019	-28.789	0
Location_D_Malmo	-0.513***	0.133	-3.852	0
Location_A_Uppsala	-0.442***	0.018	-25.193	0
Location_B_Uppsala	-0.552***	0.029	-19.148	0
Location_C_Uppsala	-0.565***	0.02	-28.367	0
Location_D_Uppsala	-0.51***	0.133	-3.828	0
R <sup>2</sup>	.824			
Adjusted R <sup>2</sup>	.822			
Observations	7426			

Note \*\*\*, \*\*, \* Significant at 1, 5, 10 percent levels, respectively

Model 3a:

<i>LN_rent_per_sqm</i>	Coefficient	Standard Error	t stat	Sig.
Constant	8,074***	0.030	271.943	0
<i>LN_Lease_area</i>	0,006**	0.003	2.132	0.033
<i>LN_Total_Area</i>	0.004	0.003	1.273	0.203
<i>LN_Distance</i>	-0,269***	0.003	-84.231	0
<i>LN_Public_Transport</i>	-0,111***	0.008	-13.254	0
<i>Certified_LN_Distance</i>	0,040***	0.005	8.412	0
<i>Certified</i>	0,038***	0.006	6.042	0
<i>Building_class_Aplus</i>	0,152***	0.019	7.978	0
<i>Building_class_A</i>	0,169***	0.007	22.836	0
<i>Building_class_Bplus</i>	0,009***	0.085	13.933	0
<i>Building_class_B</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_class_C</i>	-0,179***	0.009	-19.965	0.0
<i>Contract_year_2010</i>	-0,057***	0.012	-4.991	0.0
<i>Contract_year_2011</i>	Omitted	Omitted	Omitted	Omitted
<i>Contract_year_2012</i>	0,045***	0.011	4.005	0
<i>Contract_year_2013</i>	0,072***	0.011	6.429	0
<i>Contract_year_2014</i>	0,105***	0.011	9.460	0
<i>Contract_year_2015</i>	0,158***	0.011	14.285	0
<i>Contract_year_2016</i>	0,207***	0.011	18.461	0
<i>Contract_year_2017</i>	0,261***	0.011	23.337	0
<i>Contract_year_2018</i>	0,349***	0.012	29.678	0
<i>Contract_year_2019</i>	0,398***	0.012	33.237	0
<i>Contract_year_2020</i>	0,431***	0.013	33.217	0
<i>Contract_year_2021</i>	0,440***	0.018	23.919	0
<i>Building_year_below1900</i>	-0,026**	0.012	-2.170	0.030
<i>Building_year_1900to1929</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_year_1930to1964</i>	-0,042***	0.008	-5.480	0
<i>Building_year_1965to1974</i>	-0,101***	0.010	-10.191	0
<i>Building_year_1975to1989</i>	-0,097***	0.009	-10.826	0
<i>Building_year_1990to1999</i>	-0,163***	0.011	-15.010	0
<i>Building_year_2000to2010</i>	-0,051***	0.013	-4.024	0
<i>Building_year_over2010</i>	0,017	0.017	1.009	0.313
<i>Region_Stockholm</i>	Omitted	Omitted	Omitted	Omitted
<i>Region_Gothenburg</i>	-0,417***	0.008	-55.571	0
<i>Region_Malmo</i>	-0,586***	0.009	-62.831	0
<i>Region_Uppsala</i>	-0,648***	0.013	-49.561	0
R <sup>2</sup>	0.773			
Adjusted R <sup>2</sup>	0.773			
Observations	7426			

Note \*\*\*,\*\*,\* Significant at 1, 5, 10 percent levels, respectively

Model 3b:

<i>LN_rent_per_sqm</i>	<i>Coefficient</i>	<i>Standrad Error</i>	<i>t stat</i>	<i>Sig.</i>
(Constant)	7.806	0.029	271.166	0
<i>LN_Lease_area</i>	0.007***	0.003	2.651	0.008
<i>LN_Total_Area</i>	0.009***	0.003	3.444	0.001
<i>LN_Distance</i>	-0.147***	0.004	-34.917	0
<i>LN_Public_Transport</i>	-0.051***	0.008	-6.526	0
<i>Certified_LN_Distance</i>	0.019***	0.004	4.361	0
<i>Certified</i>	0.043***	0.006	7.507	0
<i>Bulding_class_Aplus</i>	0.157***	0.017	9.206	0
<i>Building_class_A</i>	0.138***	0.007	20.81	0
<i>Building_class_Bplus</i>	0.097***	0.008	12.336	0
<i>Building_class_B</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_class_C</i>	-0.147***	0.008	-18.313	0
<i>Contract_year_2010</i>	-0.067***	0.01	-6.602	0
<i>Contract_year_2011</i>	Omitted	Omitted	Omitted	Omitted
<i>Contract_year_2012</i>	0.048***	0.01	4.836	0
<i>Contract_year_2013</i>	0.07***	0.01	7.001	0
<i>Contract_year_2014</i>	0.099***	0.01	10.101	0
<i>Contract_year_2015</i>	0.149***	0.01	15.149	0
<i>Contract_year_2016</i>	0.204***	0.01	20.568	0
<i>Contract_year_2017</i>	0.263***	0.01	26.562	0
<i>Contract_year_2018</i>	0.341***	0.01	32.66	0
<i>Contract_year_2019</i>	0.39***	0.011	36.756	0
<i>Contract_year_2020</i>	0.438***	0.012	38.049	0
<i>Contract_year_2021</i>	0.425***	0.016	25.98	0
<i>Building_year_below1900</i>	-0.012	0.01	-1.151	0.25
<i>Building_year_1900to1929</i>	Omitted	Omitted	Omitted	Omitted
<i>Building_year_1930to1964</i>	-0.017**	0.007	-2.441	0.015
<i>Building_year_1965to1974</i>	-0.055***	0.009	-6.188	0
<i>Building_year_1975to1989</i>	-0.086***	0.008	-10.695	0
<i>Building_year_1990to1999</i>	-0.139***	0.01	-14.068	0
<i>Building_year_2000to2010</i>	-0.037***	0.011	-3.229	0.001
<i>Building_year_over2010</i>	0.044***	0.016	2.826	0.005
<i>Location_AA_Stockholm</i>	0.291***	0.011	27.664	0
<i>Location_A_Stockholm</i>	0.151***	0.009	16.508	0
<i>Location_B_Stockholm</i>	Omitted	Omitted	Omitted	Omitted
<i>Location_C_Stockholm</i>	-0.099***	0.015	-6.458	0
<i>Location_D_Stockholm</i>	-0.298***	0.009	-33.09	0
<i>Location_A_Stockholm_Other</i>	-0.102***	0.014	-7.155	0
<i>Location_B_Stockholm_Other</i>	-0.191***	0.014	-14.101	0
<i>Location_C_Stockholm_Other</i>	-0.226***	0.019	-11.814	0
<i>Location_AA_Gothenburg</i>	-0.288***	0.015	-19.863	0
<i>Location_A_Gothenburg</i>	-0.275***	0.01	-27.38	0
<i>Location_B_Gothenburg</i>	-0.4***	0.025	-16.168	0
<i>Location_Gothenburg_Molndal</i>	-0.526***	0.036	-14.459	0
<i>Location_AA_Malmo</i>	-0.464***	0.013	-36.805	0
<i>Location_A_Malmo</i>	-0.417***	0.018	-23.319	0
<i>Location_B_Malmo</i>	-0.5***	0.042	-12.007	0
<i>Location_C_Malmo</i>	-0.547***	0.019	-28.248	0
<i>Location_D_Malmo</i>	-0.5***	0.133	-3.747	0
<i>Location_A_Uppsala</i>	-0.442***	0.018	-25.179	0
<i>Location_B_Uppsala</i>	-0.553***	0.029	-19.136	0
<i>Location_C_Uppsala</i>	-0.559***	0.02	-27.99	0
<i>Location_D_Uppsala</i>	-0.505***	0.133	-3.789	0
R <sup>2</sup>	0.823			
Adjusted R <sup>2</sup>	0.822			
Observations	7426			

Note \*\*\*, \*\*, \* Significant at 1, 5, 10 percent levels, respectively



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