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Leadership in Energy and Environmental Design (LEED)

Exploring Its Price Premium and Inflation-Hedging Potential in the Swedish Commercial Property Market

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MASTER OF SCIENCE THESIS

Title:	Leadership in Energy and Environmental Design (LEED) Exploring Its Price Premium and Inflation-Hedging Potential in the Swedish Commercial Property Market
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ABSTRACT

The primary objective of the thesis is to investigate whether there exists a price premium for LEED-certified buildings in Sweden's commercial property market. Furthermore, the thesis investigates the inflation-hedging potential of commercial real estate in Sweden, aiming to determine if LEED-certified buildings are a more effective hedge against inflation. The thesis aims to contribute to the existing body of knowledge on ESG and sustainability practices, offering valuable insights to investors, occupiers, and other stakeholders to make more informed decisions. To determine these relationships, the thesis employed a quantitative approach and constructed four hedonic regression models in R-Studio. One model examines the price premiums of LEED-certified buildings, while the other model focuses on the price growth of these buildings in relation to inflation. Transactional data was obtained from Cushman & Wakefield Sweden, consisting of 412 observations ranging from the second quarter of 2013 to the first quarter of 2024. Data has been collected from various sources, including MSCI Property Intel, the U.S. Green Building Council, and the SCB Statistical Database. According to the results, there is a significant price premium of 40.1% for LEED-certified buildings in Sweden's commercial property market. In addition, buildings with a Platinum-level command a price premium of 103%, while those with a Silver-level carry a price premium of 80%. Buildings with a Gold-level did not demonstrate any statistical significance. Additionally, the findings indicate that LEED-certified buildings outperform non-certified ones in terms of price growth during inflationary periods, at 5.8% per 1% increase in CPIF. The latter is more in line with the CPIF, indicating that LEED-certified buildings may serve as a more efficient inflation hedge in Sweden's commercial property market. The results suggest that the null hypothesis for both models can be rejected and the alternative hypothesis can be accepted.

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MASTERUPPSATS

Titel:	Leadership in Energy and Environmental Design (LEED) En undersökning om dess pris premie och inflationssäkringspotential på den svenska kommersiella fastighetsmarknaden
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SAMMANFATTNING

Det primära syftet med avhandlingen är att undersöka om det finns en prispremie för LEED-certifierade byggnader på den svenska kommersiella fastighetsmarknaden. Dessutom undersöker avhandlingen inflationssäkringspotentialen hos kommersiella fastigheter i Sverige, med målet att avgöra om LEED-certifierade byggnader är ett effektivare skydd mot inflation. Avhandlingen syftar till att bidra till den befintliga kunskapen om ESG och hållbarhet praxis, vilket ger värdefulla insikter till investerare, ockupanter och andra intressenter för att fatta mer informerade beslut. För att fastställa dessa relationer använde avhandlingen ett kvantitativt tillvägagångssätt och konstruerade fyra hedoniska regressionsmodeller i R-Studio. En modell undersöker prispremier för LEED-certifierade byggnader, medan den andra modellen fokuserar på prisökningen av dessa byggnader i förhållande till inflationen. Transaktionsdata erhölls från Cushman & Wakefield Sverige, bestående av 412 observationer som sträckte sig från det andra kvartalet 2013 till det första kvartalet 2024. Data har samlats från olika källor, bland annat MSCI Property Intel, U.S. Green Building Council och SCB statistikdatabas. Enligt resultaten finns det en signifikant pris premie på 40,1% för LEED-certifierade byggnader på den svenska kommersiella fastighetsmarknaden. Vidare erhåller byggnader med en Platinum-nivå en prispremie på 103%, medan de med en Silver-nivå erhåller en prispremie på 80%. Byggnader med Guld-nivå visade ingen statistisk betydelse. Dessutom visar resultaten att LEED-certifierade byggnader överträffar konventionella byggnader avseende prisökning under inflation, med 5,8% per 1% ökning i KPIF. Det senare är mer i linje med KPIF, vilket tyder på att LEED-certifierade byggnader kan fungera som en effektivare inflationssäkring på den svenska kommersiella fastighetsmarknaden. Resultaten tyder på att nollhypotesen för båda modellerna kan förkastas och den alternativa hypotesen kan accepteras.

FÖRORD

Denna masteruppsats skrevs under vårterminen 2024. Detta är den slutgiltiga examinationen på programmet fastigheter och byggande, med inriktning bygg- och fastighetsekonomi, vid Kungliga Tekniska Högskolan i Stockholm. Avhandlingen omfattar 30 poäng.

Jag vill uttrycka min tacksamhet till Cushman & Wakefield Sverige för att ha givit mig tillgång till deras transaktionsdatabas samt givit mig tillåtelse att använda den i min avhandling.

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1 INTRODUCTION

The chapter provides a description of green buildings and introduces the concept of LEED. It explores commercial real estate as a potential hedge against inflation and presents the research gap. The chapter provides an overview of the research's objectives, research questions, delimitations, and the disposition of the thesis.

1.1 Background and Research Gap

Environmental, Social, and Governance (ESG) investing has gained significant recognition in recent years, driven by growing investor interest. Considering the environmental, social, and governance factors, the ESG criteria focus on organizational practices that aim for long-term sustainability (Sultana et al., 2018). Integrating ESG into investment decisions can help investors make informed decisions by considering non-financial performances. According to a study by Schramade (2016), incorporating ESG factors into valuation and investment decisions increases the asset's value. Assessing the environmental dimension includes evaluating carbon footprint, energy consumption and efficiency, recycling policies, waste management, and initiatives to minimize environmental impacts (Rajesh, 2019). The environmental factor thus captures the aspect of green building practices.

Green building certifications serve as a valuable tool for evaluating and acknowledging buildings that commit to specific sustainable criteria. The particular criteria may vary depending on the rating system employed (World Green Building Council, 2024). Green building certifications have become widely recognized worldwide and are constantly evolving to tackle net-zero emissions and sustainability concerns. Energy, water, waste, transport, materials, pollution, land use, and health are all important factors to consider when addressing sustainability issues. In 2021, there were a total of 74 green building certification systems worldwide, with certification systems being implemented in buildings across at least 184 countries. Green building certifications may serve as an essential resource for enhancing understanding and raising awareness about climate change and sustainability initiatives (United Environment Programme, 2022).

Leadership in Energy and Environmental Design (LEED) is a widely recognized and used green building certification system. LEED certification offers a framework for creating green buildings that are healthy, highly efficient, and cost-saving, providing a range of ESG benefits. LEED certification is widely acknowledged as a symbol of accomplishment in sustainability. LEED-certified buildings play a crucial role in tackling climate change and achieving ESG goals while also improving resilience. The objective of LEED is to promote more efficient buildings that minimize their impact on global climate change, improve human health, safeguard and restore water resources, preserve and enhance biodiversity and ecosystem services, and encourage sustainable and regenerative material cycles. In regards to LEED credits, 35% are dedicated to addressing climate change, 20% directly focus on improving human health, 15% of the credits aim to positively impact water resources, and 10% are dedicated to preserving biodiversity. Another 10% are related to promoting the green economy, and finally, 5% are aimed at benefiting both the community and natural resources. To achieve LEED certification, a project can accumulate points by meeting prerequisites and credits that cover various aspects such as carbon, energy, water, waste, transportation, materials, health, and indoor environmental quality. Projects undergo a verification and review process by Green Business Certification, Inc. The allocation of points—Certified (40–49 points), Silver (50–59 points), Gold (60–79 points), and Platinum (80+ points)—determines the rating level of LEED certification (USGBC, 2020).

Green premiums, or the increased value of green buildings compared to non-certified ones, have been extensively discussed in the literature. Investors, occupiers, and stakeholders recognize the importance of sustainability as a key driver of value creation. These consider green buildings as a strong indication of dedication to environmentally responsible practices and sustainable innovation (Matisoff et al., 2014). This perspective suggests the importance of investing in green buildings and highlights ESG and sustainability as valuable investment characteristics (Eichholtz et al., 2010). Market signaling through certifications has a significant impact on perceptions and decisions, suggesting reduced operational costs and increased asset liquidity (Matisoff et al., 2014). Investors are increasingly attracted to green buildings for their ability to generate higher rents, maintain lower vacancy rates, and withstand market fluctuations. This recognition of the financial benefits has been supported by research (Fuerst & McAllister, 2008; Fuerst & McAllister, 2009; Fuerst & McAllister, 2011). In addition, a stronger corporate reputation, influenced by the perception of social responsibility, has the potential to attract investors and demand higher rents from occupiers of green buildings (Fombrun & Shanley, 1990; Milgrom & Roberts, 1986; Klein & Leffler, 1981).

Exploring the relationship between inflation and commercial real estate returns has revealed an extensive range of dynamics and interactions between the two factors. Inflation can be considered a risk due to its potential negative impact. Investors may look for assets that can provide protection against or help manage the risk of inflation, commonly known as inflation hedges. These inflation hedges demonstrate a positive correlation with inflation, unlike assets that may not be effective in hedging against inflation. The objective of inflation hedges is to mitigate the decrease in purchasing power caused by inflation (Charles et al., 1991). Bodie (1976) presents three potential definitions of inflation hedging. The first definition suggests that an asset can be considered an inflation hedge if it helps prevent the real return on the asset from dropping below a certain floor value, like zero. The second definition highlights the efficiency of the asset, determining the hedging efficiency of a security as the percentage decrease in the variability of the real returns on a risk-free bond achieved by combining the security and the bond. The third definition denotes that an asset is considered a potential inflation hedge if its real return is not affected by fluctuations in the rate of inflation. This implies that there is a positive correlation between the nominal return and inflation.

The consumer price index (CPI) is widely recognized as the most well-known price index in Sweden. The index presents insights into the cost of living in Sweden and its trends over time. The Swedish Central Bank aims to achieve an annual inflation rate of 2%, which is measured by the annual percentage change in the consumer price index with a fixed interest rate (CPIF). The CPIF is calculated using the same data and in the same manner as the CPI, but it does not consider the impact of changed mortgage rates (Sweden's Central Bank, 2015).

There is a prominent lack of comprehensive analysis of the correlation between LEED certification and price premiums in the Swedish real estate market, which presents considerable challenges for investors and other stakeholders. The concept of LEED certification and its potential as an inflation hedge in the Swedish real estate market remain largely unexplored. Although there is a global interest in green building practices, there is a noticeable gap in research and discussion regarding the use of LEED certification to address inflation risks. Thus, it is crucial to conduct empirical research that investigates the correlation between LEED certification, price premiums, and inflation hedges in the Swedish commercial property market. Addressing this knowledge gap is crucial for providing insights into investment strategies, decision-making, and embracing ESG and sustainability practices in the Swedish real estate market.

1.2 Purpose and Research Questions

The thesis objective is to examine and gain insight into the integration of ESG and sustainability practices into commercial property values. The thesis intends to provide a comprehensive overview of drivers for green building price premiums. It seeks to analyze the correlation between LEED certification, including its rating levels, and price premiums in the Swedish commercial property market. Sweden's commercial property market is represented by Stockholm, Gothenburg, Uppsala, and Malmö.

Additionally, the thesis intends to examine the effectiveness of LEED-certified buildings as an inflation hedge to assess the long-term financial performance and stability of ESG investments. The thesis will examine whether LEED-certified buildings offer stronger resilience against actual inflation compared to non-certified buildings in the Swedish commercial property market. By investigating the inflation-hedging potential of green buildings, the thesis contributes to an understanding of ESG investments, addressing inflation uncertainties. By comparing the price growth of LEED-certified buildings and non-certified buildings to the CPIF, the aim is to understand whether LEED-certified buildings are a more effective inflation hedge compared to non-certified buildings.

The research questions seek to determine the impact of LEED certification on commercial property values in Sweden. The first research question prompts an examination of how LEED certification, with its different rating levels, may influence the price. By exploring these relationships, the thesis can provide insights into the relationship between sustainability and property valuation. The second research question addresses the relationship between LEED-certified buildings and actual inflation, contributing to a better understanding of the performance and resilience of green buildings in varying market conditions.

1. *Is there an evident LEED price premium in Sweden's commercial property market, and is there a positive correlation between its rating levels and price premium?*
2. *Do LEED-certified buildings provide a more effective inflation hedge than non-certified buildings in Sweden's commercial property market?*

By addressing these research questions, this thesis aims to contribute to the existing body of knowledge on green buildings and property valuation, providing insights that can inform investors, market participants, and other stakeholders in the Swedish commercial property market.

1.3 Delimitations

The thesis focuses solely on the Swedish commercial property market. The four major cities representing Sweden are Stockholm, Uppsala, Gothenburg, and Malmö. Transactions from Q2 2013 to Q1 2024 have been included in the dataset. Real estate portfolios and transactions lacking sufficient information have been excluded. In addition, the thesis focuses on the green building certificate LEED. Buildings certified under alternative green building certification systems have been excluded from the dataset. The CPIF rates have a time limit that corresponds to the quarter and year of each transaction. Only transactions conducted by Cushman & Wakefield Sweden have been observed.

1.4 Disposition

1 INTRODUCTION

The first chapter provides essential background information on the topic as well as presents the research gap. Furthermore, it outlines the purpose of the thesis and the research questions and concludes by acknowledging the limitations of the thesis.

2 LITERATURE REVIEW

The second chapter aims to provide an overview of previous research relevant to the thesis and research questions. The literature review aims to examine previous research to identify any gaps in the current literature.

3 THEORETICAL FRAMEWORK

The third chapter presents the Discounted Cash Flow (DCF) Analysis, followed by an introduction of the two first quadrants of the Four-Quadrant (4Q) Model, which explains the results.

4 METHODOLOGY

The fourth chapter outlines the methodology employed to address the research questions. The chapter presents the data collection and its shortcomings. In addition, it provides the choice of statistical method.

5 RESULTS

The fifth chapter presents the regression results with an interpretation of the coefficients.

6 ANALYSIS

The sixth chapter aims to analyze the literature review and the results separately to then integrate the findings to identify similarities. The analysis aims to examine the outcomes and understand the reasons behind the results.

7 CONCLUSIONS

The final chapter concludes the thesis by providing a comprehensive summary of the findings and addressing the research questions. The thesis ends with a recommendation for further research on the topic.

2 LITERATURE REVIEW

The chapter provides an overview of the existing research. It examines the factors that contribute to a price premium as well as the empirical evidence of a LEED premium. It presents commercial real estate as a hedge against inflation.

2.1 ESG in Commercial Property Valuation

The most recent edition of the International Valuation Standards (IVS) was published on January 31, 2024, and will take effect on January 31, 2025. In the latest edition, one notable change is the increased focus on integrating ESG factors into valuation practices (Stokes, 2024). In regards to the previous version of IVS, the integration of ESG factors was not explicitly addressed. Under IVS 101 20.1, "all valuation advice and the work undertaken in its preparation must be appropriate for the intended purpose." Further established in IVS 102 20.1, "investigations made during the course of a valuation assignment must be appropriate for the purpose of the valuation assignment and the basis(es) of value" (Aronsohn, 2021, p. 5). During the valuation process, the appraiser will need to consider trends and emerging issues. There will be difficulties in addressing the inclusion of ESG factors and ensuring transparency in the valuation report. The impact of ESG can be measured by observing the market and analyzing the actions of market participants and other stakeholders. The influence of ESG is expected to change over time as it becomes increasingly attractive and better comprehended by market participants, including appraisers (Aronsohn, 2021). The acknowledgment that ESG factors can significantly affect an asset's value and viability is observed in the RICS Sustainability Report 2023 (Zehra, 2023).

Various buildings are incorporating ESG factors, leading to increased rents and cash flows and consequently higher property values. ESG factors are evident in various inputs of the discounted cash flow (DCF) analysis. The DCF analysis is a powerful tool for quantifying ESG factors because it can explicitly reflect certain factors, such as income, costs, and vacancies. This enhances the level of transparency as the appraiser can directly forecast anticipated trends and fluctuations in income and cost (Aronsohn, 2021). However, there are still challenges to establishing a direct correlation between ESG and sustainability characteristics and increased property values. Concrete evidence of the impact of ESG on property value is necessary. Market participants and stakeholders might face difficulties in addressing price premiums associated with sustainable features or other value-creating attributes without a clear correlation. There are certain limitations and gaps in integrating ESG factors into property valuation. Concrete data and transparency are lacking, making it challenging to effectively evaluate ESG factors. Whereas investors and appraisers are increasingly requesting transparency in ESG impact data (Konialidis & Luo, 2023).

Several European markets have noticed a scarcity of green buildings, causing investors to prioritize their ESG portfolio, driving up demand. This is associated with a decreased vacancy rate, which is a factor the appraiser needs to consider in the DCF analysis. Buildings with higher ESG ratings are more attractive to occupiers and investors, as they seek to enhance their overall ESG performance. The importance of ESG resilience should not be overlooked. The forecasted cash flows are expected to be less risky, which increases the willingness to pay for the resilience factor of ESG. There will be a continuous commitment to integrate ESG factors and sustainability in the real estate market as we cooperate towards achieving a net-zero carbon emission goal (Aronsohn, 2021).

Exploring the integration of ESG into valuation practices involves delving into unknown knowledge to fully understand the various effects of ESG and sustainability factors, both direct and indirect. This will result in the development of methodologies and frameworks to accurately incorporate ESG factors into valuation practices (Konialidis & Luo, 2023). If the appraiser has the ability to identify market conditions and recognize market participants' acknowledgment of ESG, they are able to incorporate the preferences of market participants and other stakeholders. In order to develop a forward-thinking perspective, the appraiser needs to take a consultative approach, providing directions for strategic advice and assessing various scenarios while taking ESG factors into account. The appraiser will need to consistently enhance their knowledge to effectively and accurately assess and evaluate ESG factors (Aronsohn, 2021).

2.2 Drivers for Green Premiums in Commercial Real Estate

Various studies support the recognition by investors of the value of green buildings. According to Eichholtz et al. (2010), there is evidence that occupiers are willing to pay higher rents for green buildings, suggesting an increasing demand for green buildings. Wiencke (2013) presents empirical evidence that demonstrates firms' willingness to pay a premium for green buildings, which confirms the notion that investors value sustainability in the real estate sector. Addae-Dapaah and Wilkinson (2020) suggest that eco-investors tend to overbid, resulting in a price premium of approximately 5% for certified buildings.

According to a Knight Frank study (Brookes et al., 2021), certified buildings command higher prices than non-certified ones, demonstrating the positive impact of green buildings on property values. Combining data from London, Sydney, and Melbourne, the study suggests price premiums for certified office buildings ranging from

8%-18%. This implies that investors recognize the long-term value and benefits associated with acquiring green buildings, which increases the asset's value and reduces perceived risk. Additionally, the Knight Frank study observed that the value of these price premiums varies according to building location and certification system. A case study by EY (Johnson & Miller, 2022) observed that in Chicago, green buildings command price premiums ranging from 10% to 21%. The study quantified the impact of ESG and sustainability factors on property prices. Furthermore, in countries like China and India, where sustainability is included in urban planning and development policies, green building price premiums are emerging as investors recognize the resilience and long-term value of green buildings (Zhang et al., 2018).

The literature examines green building premiums in different regions and countries, highlighting variations in market demand, regulations, and cultural attitudes towards sustainability. Research has shown that there are variations in the price premiums based on factors such as the age of the building, the size, and the certification rating level (Harrison & Seiler, 2011). It is important to take into account the characteristics of newer and larger buildings compared to older, medium-sized ones when assessing the green building price premium, as Harison and Seiler (2011) suggest that price premiums tend to be higher in smaller regions or less expensive parts of metropolitan areas. This can be explained by the scarcity of certified buildings in these areas, which increases their perceived value. Eichholtz et al. (2010) highlight the importance of market dynamics and local supply-demand conditions in determining the green building price premium.

Moreover, buildings that are certified are more likely to be occupied than non-certified ones (Fuerst & McAllister, 2009). Investors tend to find green buildings more attractive due to their higher occupancy rates, which reduce vacancy risk and generate stable cash flows (Fuerst & McAllister, 2011). Because of the reduced risk perception, green buildings have lower required returns and thus lower capitalization rates (Johnson & Miller, 2022).

There are several drivers that contribute to the green building price premium. Investors are increasingly demanding green buildings for investment, while occupiers are showing an increasing demand for renting office space in green buildings over non-certified ones (Eichholtz et al., 2010; Muir et al., 2023). Research by Darko et al. (2017) examined the drivers that influence the adoption of green building practices among various construction stakeholders, including architects, construction units, engineers, developers, designers, and government authorities, among others. There were a total of 64 drivers identified for implementing green building practices, which were divided into five categories: external, corporate, project, individual, and property-level. External-level drivers refer to drivers influenced by external parties, such as governments and the European Union (EU). These drivers are outside of the company's control. Corporate-level drivers, on the other hand, are internal drivers within the company that can contribute to long-term business sustainability. At this level, sustainability factors are viewed as a marketing benefit since they contribute to corporate responsibility and culture. One of the most common drivers that companies often consider in green building practices is the enhanced image benefit of having a green portfolio (Falkenbach et al., 2010). Project-level drivers are compelled by the construction and operating phases. The cost of construction is an essential consideration in determining the viability of implementing green buildings. The majority of previous research suggests that there is no significant evidence of a cost premium for green buildings. On average, the additional cost of constructing green buildings is approximately 2% higher than non-certified buildings (Kats, 2003; Matthiessen & Morris, 2004). Individual-level drivers are closely related to motivation and the drivers that influence people's adoption of green building practices. Property-level drivers are the main drivers that contribute to an increased property value. These drivers are derived from factors such as increased rental income, decreased risk and costs, and an increasing demand. Darko et al. (2017) note that drivers in one category can influence drivers in other categories.

Leskinen et al. (2020) observed parameters related to the cash flow. Increased rents, decreased risk, and low vacancy rates are factors contributing to increased property values. When examining the rent premium, the occupancy rate, and the price premium for green buildings, it was found that the rent premium varies between 0-23%, with a mean of 6.3%. The occupancy premium can reach up to 17%, with an estimated mean of 6%. Estimates for the sales price show the highest estimates, with a price premium that can vary from 0–43%, with a mean of 14.8%.

In regards to LEED certification, Devine and Kok (2015) discovered a 10.2% rent premium and a 4% occupancy premium in the U.S. and a 3.7% rent premium and an 8.5% occupancy premium in Canada. Research by Fuerst and McAllister (2009) found a 6% rent premium and an 8% occupancy premium in the U.S. However, further research by Fuerst and McAllister (2011) indicated a 5% rent premium. Eichholtz et al. (2013) discovered a greater rent premium in the U.S., at 7.9%. Additionally, research by Holtermans and Kok (2017) found a minimum rent premium of 1.9% in the U.S. One could argue that LEED-certified buildings have both a rent premium and an occupancy premium. However, the literature does not cover the global perspective of rent and occupancy premiums.

The notion of green premiums in the real estate market highlights the economic value of sustainability. However, with the increasing adoption of green building practices, the green building premium may decrease as the market becomes saturated (Chegut et al., 2013). The future of green building price premiums is uncertain given the evolving market and shifting supply and demand dynamics for green buildings. With the growing recognition of sustainability, it is anticipated that green buildings will become more common. In the future, non-certified buildings could experience penalties instead of the current practice of rewarding green buildings with premiums (Muir et al., 2023; Zehra, 2023). Some studies argue that green building premiums may have adverse effects on the real estate market (Kotchen, 2006;

Grolleau et al., 2009). The research notes that while green building premiums encourage sustainable practices, there is a risk of increased prices for all buildings, including those that are not ESG and sustainability-integrated, causing adverse effects.

In conclusion, the literature highlights the complex factors that contribute to the green building premiums observed in the commercial property market. By exploring the variety of green building premiums and their variations in different contexts, the thesis contributes to the understanding of sustainable integration and the shift towards green building practices. Investors and occupiers are willing to pay premiums for green buildings due to the benefits they offer, including enhanced corporate reputation, higher occupancy rates, lower operational costs, and reduced risk perceptions. Given the growing recognition of sustainability in the real estate sector, it becomes increasingly important for stakeholders to understand the underlying factors that drive this shift. This understanding is essential for stakeholders seeking opportunities in ESG investments and striving to achieve sustainability goals.

2.2.1 Evidence of LEED Price Premiums

Previous studies employed an ordinary least squares (OLS) regression model to assess the price effects of LEED certification. Eichholtz et al. (2010) present compelling evidence on the price premium of LEED-certified buildings. By observing 286 transactions of LEED-certified buildings in the U.S. from 2004 to 2007, it suggests an 11.3% price premium. However, the price premium failed to demonstrate any statistical significance. Similar evidence was found at a 1% significance level in a study by Eichholtz et al. (2010a), indicating an 11.1% price premium in a sample of 49 LEED-certified buildings from transactions in 2009. Miller et al. (2008) discovered a similar price premium. By observing 380 LEED-certified buildings in the U.S., the findings indicate a price premium of 9.94%. The similarity in the findings can be attributed to the transactions occurring during a similar time period. Miller et al. (2008) observed transactions from 2003 to 2007, although they included a greater number of transactions compared to Eichholtz et al. (2010) and Eichholtz et al. (2010a).

Other studies found a greater price premium, ranging from 20–30%. Robinson and McAllister (2015) conducted a study on the price effects of LEED-certified buildings in the U.S., analyzing transactions from 158 LEED-certified buildings between 2007 and 2012. The results indicated a price premium of 31.6% at a 1% significance level. Fuerst and McAllister (2008) and Fuerst and McAllister (2011) observed a similar price premium. Fuerst and Mcallister (2008) observed 30 LEED-certified buildings in Chicago between 1996 and 2007 and found a price premium of 31.4%. Fuerst and Mcallister (2011) found a price premium of 25% observed in 313 LEED-certified buildings in the

U.S. between 1999 and 2009.

Fuerst and Mcallister (2009) examined the correlation between LEED certification and its rating levels; Certified, Silver, Gold, and Platinum. By observing 626 LEED-certified buildings in the U.S., of which 192 are Platinum-level, 180 are Silver-level, 201 are Gold-level, and 45 are Certified-level. The results implied a 35% price premium for LEED-certified buildings. The study found that there are notable price premiums associated with each rating level; 20% for Certified, 38% for Silver, 36% for Gold, and 100% for Platinum. It is important to note that the sample size of 8 Platinum-level buildings may not be sufficient to accurately determine the true effect of the Platinum-level. This led to a result that was inconclusive and unreliable. Research conducted by Mangialardo et al. (2018) analyzed 30 transactions of LEED-certified buildings in Italy between 2009 and 2018 at different rating levels. The findings suggest a LEED price premium of 11%, which aligns with the findings of Eichholtz et al. (2010) and Eichholtz et al. (2010a). The regression also suggests that there is a 3.69% increase in price for each rating level upgrade, such as from Certified to Silver, Silver to Gold, and so forth. It is worth noting that the price premium Silver-level buildings do not demonstrate a statistically significant price premium, primarily because there is a limited amount of transactional data available, consisting of 6% of the sample size for LEED-certified buildings. In terms of Gold-level, there is a 7.38% price premium and a corresponding 11.08% price premium for Platinum-level. Statistical evidence supports the existence of a price premium for LEED-certified buildings, with indications that the price premium increases as the rating level upgrades (Mangialardo et al., 2018). According to a study conducted by Holtermans and Kok (2017), there is a 14.8% price premium for LEED-certified buildings in the U.S. The study observed 195 LEED-certified building transactions from 1999 to 2013. However, it was evident that Certified-level and Silver-level does not exhibit any significant positive correlation with an increased price premium. Gold and Platinum, on the other hand, have a significant price premium of 13.5% and 49.1%, respectively.

There is a noticeable gap in research regarding the price effects of LEED certification in the Swedish real estate market, as most studies have primarily concentrated on the U.S. context. Given Sweden's strong dedication to ESG and sustainability initiatives, including its ambitious climate goals, it is essential to investigate whether comparable price premiums exist for LEED-certified buildings in Sweden. Conducting research in Sweden would offer valuable insights into the economic viability of LEED certification in various contexts, contributing to a broader understanding of green building price premiums worldwide.

TABLE 1—SUMMARY OF EMPIRICAL EVIDENCE—PRICE PREMIUM

Literature	Geography	Observed Period	Sample size	Price premium
Mangialardo et al. (2018)	Italy	2009-2018	30	11% 7.38%*** 11.08%****
Holtermans & Kok (2017)	U.S.	1999-2013	195	14.8% 13.5%*** 49.1%****
Robinson & McAllister (2015)	U.S.	2007-2012	158	31.6%
Fuerst & McAllister (2011)	U.S.	1999-2009	313	25%
Eichholtz et al. (2010)	U.S.	2004-2007	286	11.3%
Eichholtz et al. (2010a)	U.S.	2009	49	11.1%
Fuerst & McAllister (2009)	U.S.	-	626	35% 20%* 38%** 36%*** 100%****
Miller et al. (2008)	U.S.	2003-2007	380	9.94%
Fuerst & McAllister (2008)	Chicago	1996-2007	30	31.4%

* Certified
** Silver
*** Gold
**** Platinum

2.3 Commercial Real Estate as Inflation Hedges

Literature has examined the correlation between the CPI and the price growth of commercial real estate. However, Arnold and Auer (2015) point out that there are significant shortcomings in using the CPI as a measure of inflation, such as lagging and international measurement differences, and that it is unlikely that the CPI estimates will adequately capture the relevant price changes for a given investor.

Li and Chiang (2012) analyzed the increase in commercial real estate prices in China from 1998 to 2009. Through the use of a cointegration analysis, it has been found that there is compelling evidence suggesting a positive correlation between real estate returns and the CPI. In a recent study conducted by Wolski (2023) in Poland, quarterly inflation data and property prices were examined in a cointegration test. The findings revealed that the commercial property market in question is only capable of effectively hedging the asset from long-term inflation. This suggests that commercial real estate may not be an effective hedge against short-term inflation. Fleischmann et al. (2019) examined commercial real estate returns in Hong Kong and Japan from 1986 to 2009. Employing two datasets to capture the dynamics of both an inflationary and a deflationary period, the findings indicated that commercial real estate provided a hedge against fluctuations in consumer prices. Hoesli (1994) found that commercial real estate can serve as an effective hedge against inflation, observing the Swiss commercial property market from 1943 to 1991. However, the analysis focused on long-term inflation, leaving room for interpretation of the short-term dynamics. Hoesli's (1994) observation is consistent with the findings of Gunasekarage et al. (2008), who examined the long-term correlation between commercial real estate returns and the rate of inflation in New Zealand. Through the use of cointegration tests on quarterly data from 1979 to 2003, the results indicate a positive correlation between commercial real estate returns and inflation. No observation was made regarding short-term inflation. A recent study conducted by Salisu et al. (2020) examined the inflation-hedging potential of various assets, including commercial real estate, in the U.S. before and after the global financial crisis (GFC) in 2007–2008. Through a calculation of the monthly CPI in logarithmic form and the analysis of its correlation with real estate returns, it was found that there is a positive correlation. This suggests that commercial real estate returns are independent of fluctuations in inflation. Suggesting that commercial real estate served as a hedge against inflation prior to and following the GFC. Obereiner and Kurzrock (2012) conducted a study on the German commercial property market and inflation indices from 1992 to 2009. Through the application of cointegration tests, compelling evidence was discovered indicating that commercial real estate returns are independent of short-term inflation. However, no evidence was found observing long-term inflation, suggesting that commercial real estate may only serve as a hedge against short-term inflation.

However, empirical evidence also suggests that there is no positive correlation between commercial real estate returns and inflation. Tarbert (1996) employed quarterly and semi-annual data from 1978 to 1995 in a cointegration test. The results implied that there is no indication of a long-term inflation hedge potential for commercial real estate in the UK. Similarly, Stevenson (1999) conducted a cointegration analysis of inflation rates from 1983 to 1995 in the UK. The results failed to demonstrate any independent relationship between commercial real estate and inflation.

In conclusion, there are discrepancies in the literature regarding the efficiency and consistency of the relationship between commercial real estate returns and inflation. The impact of inflation on commercial real estate returns can vary depending on the geography and time period. Some studies suggest a positive correlation between commercial real estate returns and inflation, while others demonstrate the complexity of hedging against short-term and long-term inflation.

However, there is a lack of understanding of green buildings; as an emerging trend, there may be a noticeable change in their price growth. It has been observed that green buildings have a price premium and are in more demand compared to non-certified ones. However, it is still uncertain whether there is any difference in their effectiveness as an inflation hedge.

TABLE 2—SUMMARY OF EMPIRICAL EVIDENCE—INFLATION

Literature	Geography	Observed Period	Inflation Hedge
Wolski (2023)	Poland	2008-2022	Yes, long-term
Salisu et al. (2020)	U.S.	2007-2008	Yes
Fleischmann et al. (2019)	Hong Kong & Japan	1986-2009	Yes, long-term
Jing & Chiang (2012)	China	1998-2009	Yes, long-term
Obereiner & Kurzrock (2012)	Germany	1992-2009	Yes, short-term
Gunasekarage et al. (2008)	New Zealand	1979-2003	Yes, long-term
Stevenson (1999)	UK	1983-1995	No
Tarbert (1996)	UK	1978-1995	No
Hoesli (1994)	Switzerland	1943-1991	Yes, long-term

3 THEORETICAL FRAMEWORK

The chapter provides an overview of the theories and framework used to explain the results. It introduces the fundamentals of The Discounted Cash Flow (DCF) Analysis, followed by an illustration of The Four-Quadrant Model.

3.1 The Discounted Cash Flow (DCF) Analysis

The Discounted Cash Flow (DCF) Analysis is a valuation method for valuing regular or irregular cash flows. The DCF analysis identifies market conditions investors are anticipating as of the valuation date. The method estimates an asset's value based on expected future cash flows converted to a present value (Appraisal Institute, 2020)

The estimation is based on annual or monthly income, expenses, and cash flows occurring over a projected time period. The cash flows, including the net resale, are then discounted at a discount rate to derive a present value. This approach will include the recognition of the time value of money. However, some criticism has been made of the DCF analysis. It could be noted that projections that are not warranted by market evidence may result in an unsupported indication of the market value and that the value can change significantly with small changes in the projection. Others refer to the uncertainty of forecasting cash flows. The DCF analysis can only provide accurate estimations if the forecasted cash flows are based on accurate and reliable foundations (Appraisal Institute, 2020).

3.2 The Four-Quadrant (4Q) Model

The Four-Quadrant Model, also referred to as the 4Q Model, is a static model that examines the relationship between the property market and the asset market and the adjustments to establish market equilibrium between the supply and demand of real estate. The model is based on the principles of demand and supply. Therefore, the primary objective of the model is to establish a market equilibrium between space demand and the given rent or price (Du Toit & Cloete, 2004). The asset market provides the supply of office space, and the property market determines the rent for that space. As rent is one of many economic factors that affect the demand for space, the objective of the property market is to determine a rent level where the demand for space corresponds to the supply of space (Dipasquale & Wheaton, 1992).

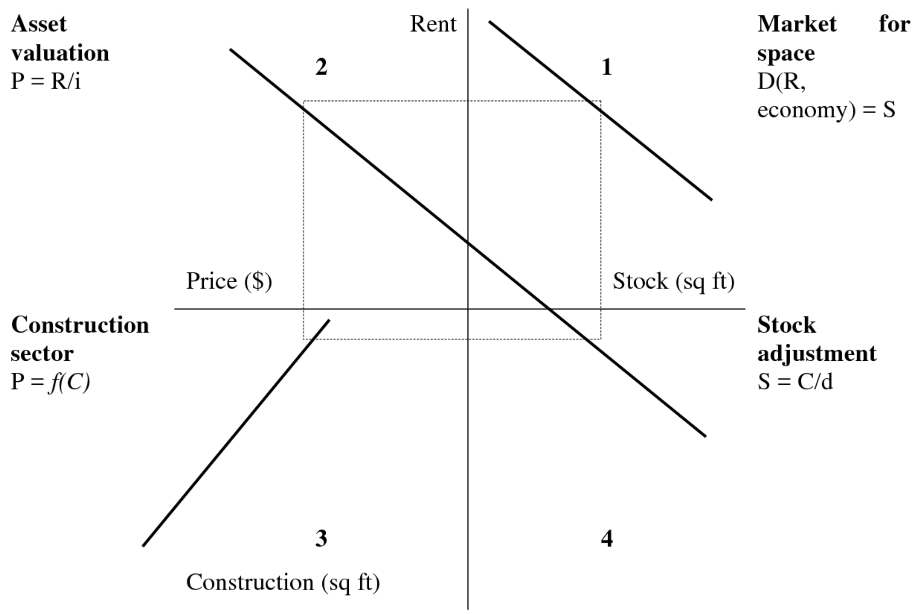

FIGURE 1—4Q MODEL. Source: (Du Toit & Cloete, 2004).

The equilibrium is established by the interplay of supply and demand for real estate space at a given price level, as shown in Quadrant 1. The rent translates into a property value in the asset market when rents are capitalized at an appropriate capitalization rate, as observed in Quadrant 2 (Du Toit & Cloete, 2004).

The property market and the asset market intersect at two points: first, the rent levels in the property market are essential in determining the demand for real assets. The investor is making investments based on the asset's future or existing cash flows, which means that changes in the rents in the property market will have a direct impact on the demand for assets in the asset market. Second, there is an interaction between the markets through the construction sector. When the supply increases, prices and rents are driven down (Dipasquale & Wheaton, 1992).

4 METHODOLOGY

The chapter addresses the process of data collection and acknowledges its shortcomings. It provides an overview of the variables used in the regression analysis and the selected statistical method.

The thesis will employ a quantitative approach, interpreting numerical data to address the research questions. This approach explores the relationship between selected variables. To ensure the reliability of the results and the validity of the data collection, it is important to use a large data sample for generalizing the data set (Saunders et al., 2016). To test the statistical relationships, the statistical software R-Studio has been used. A hedonic regression model based on the ordinary least squares (OLS) method has been employed to analyze the variables, both numerical and categorical.

4.1 Data Collection

All data employed is secondary material that has been carefully processed and collected to align with the objectives of the thesis. The data has been provided by Cushman & Wakefield and consists of 412 transactions from the Swedish commercial property market from Q2 2013 to Q1 2024. Additional data regarding the building year and location class has been obtained from MSCI Property Intel. The database from the U.S. Green Building Council was used to filter buildings that have a LEED certification and match them to transactional data. As a result, a total of 49 buildings with LEED certification were identified within the dataset. The CPIF indices were obtained from the SCB statistical database. These indices were then matched to the corresponding quarter and year from the transactional data.

The dataset includes a combination of numerical and categorical data. The categorical data represents characteristics associated with the property that are not explicable by numerical values. These include LEED, City, Level, and Class. The latter two are known as ordinal data, where the data is organized in a hierarchical order. In order to accurately measure the impact of these attributes on the price, they are transformed into numerical values. The numerical data can be further divided into discrete values and continuous values. While converting categorical data into discrete data values, dummy variables are created. If the property possesses the characteristic, the dummy variable is set to 1, and if not, it is set to 0. Continuous data values are defined as values that can fall anywhere within a range of measures, such as year, age, and size (University of Adelaide, 2023).

4.1.1 Shortcomings

According to Sharma (2017), it is recommended to use a random sampling method for data samples in quantitative research methods. The method highlights the importance of ensuring that every data point in the population has an equal probability of being selected for the sample, resulting in a sample that accurately represents the population. However, there is a possibility of selection bias occurring when the sample used does not accurately represent the entire population. This occurs when there has been an unsuccessful attempt to randomize a population sample. This can result in a group in the population being less likely to be included in the sample. Such factors can have a significant impact on the statistical outcome, leading to a distortion in the overall statistical analysis (Hill et al., 2018).

It is important to proceed with caution when interpreting the transactions used in this thesis, as they only represent a portion of the Swedish commercial property market. The dataset provided by Cushman & Wakefield is secondary data that has been collected for a different purpose than the thesis objective. This can be described as an uncontrolled experiment (Hill et al., 2018). Thus, it is crucial to accurately determine the data's quality and carefully evaluate its sources (Saunders et al., 2016). Unlike a controlled experiment, an uncontrolled experiment is unable to determine the impact of each independent variable, potentially leading to collinearity. Indicating that the variables are systematically shifting in the same direction, which causes difficulties in explaining the relationship between the independent and dependent variables (Hill et al., 2018). Another statistical concept to consider is multicollinearity, which occurs when multiple independent variables in a model are correlated. This correlation can lead to a misinterpretation of the results in the hedonic pricing model (Kim, 2019). When carrying out a regression analysis, it is important to exclude independent variables that are multicollinear in order to ensure the reliability of the results. This concept can be understood by examining the use of dummy variables in the regression model, as described by Hill et al. (2018) as falling into the dummy trap. Collinearity can lead to certain outcomes, but it is possible to prevent this by considering omitted variables. The omitted variable will determine the reference group in the hedonic pricing model.

Another possible shortcoming could be heteroskedasticity, a statistical phenomenon where all variables demonstrate disparities from one another. Indicating that the variability of the residuals, or error terms, differs among the observations. Heteroskedasticity violates the assumption of homoscedasticity in the OLS regression. This assumption assumes that the variance of the residuals remains constant across all the observations of the independent variables (Hill et al., 2018). To ensure accurate results in the regression models, it is important to account for unmodeled heteroskedasticity.

Breusch-Pagan is a statistical test used to address heteroskedasticity in a regression model. The test determines weather or not heteroskedasticity is present in the model by employing a null hypothesis suggesting homoscedasticity and an alternative hypothesis suggesting heteroskedasticity (Breusch & Pagan, 1979). A Breusch-Pagan test has been conducted to address any heteroskedasticity in the regression models.

TABLE 3—STUDENTIZED BREUSCH-PAGAN TEST

Test	Statistics
BP	82.574
df	15
p-value	0.00000000002356

Employing an α value of 0.1, the p-value from the Breusch-Pagan test indicates that the null hypothesis can be rejected and the alternative hypothesis accepted. Indicating the presence of heteroskedasticity in the regression models.

4.1.2 Variables in the Regression Analysis

All variables included in the regression analysis are defined below, along with their respective purposes and the process by which they were collected.

Price

The price is the dependent variable in the regression model and is expressed in price per square meter in SEK. All transactional data has been gathered by Cushman & Wakefield.

Year

The year represents the transaction year of each transaction, covering from Q2 2013 to Q1 2024, as included in Cushman and Wakefield's dataset. This is used to incorporate the given market conditions.

Age

The age of the buildings is determined by the building year or the construction year, whichever occurs at the latest. Building age is employed to capture value effects. Data on the age of each building was collected from MSCI Property Intel.

Size

Size is expressed in square meters and includes the lettable area of each property in the transaction. This information is included in the dataset provided by Cushman & Wakefield. Size is used to estimate the transaction price per square meter.

LEED

LEED is a dummy variable used to indicate whether a property is LEED-certified. The USGBC database has been employed to match the corresponding property to a LEED certification.

Level

The different rating levels of LEED—Platinum, Gold, Silver, and Certified—are displayed as dummy variables. Information regarding the building's rating level was found in the USGBC database.

City

The four major cities in Sweden—Stockholm, Uppsala, Gothenburg, and Malmö—have been included in the regression analysis to represent Sweden's commercial property market. To differentiate them, they have been converted into dummy variables.

Class

Class refers to the locational attribute of the property at distances from the central business district (CBD) and is included since it is a value-creating attribute. The variable includes classes AA, A, B, C, and D, which have been converted into dummy variables. Locational attributes were collected in MSCI Intel Property using Cushman & Wakefield's estimates.

CPIF

The Consumer Price Index with a fixed interest rate is used to measure inflation in relation to the price per square meter for LEED-certified buildings and non-certified buildings in the dataset. The CPIF was obtained from SCB statistical database and matched with the quarter and year of each transaction.

Omitted Variables

To solve the problem of collinearity, so-called dummy traps, omitted variables have been employed. The following variables have been omitted: Certified, Malmö, and D.

4.1.3 Hedonic Pricing Model and Regression Analysis

Given the nature of the research question, four hedonic regression models have been constructed. A hedonic regression model is used to estimate the influence of different attributes and characteristics on the price of heterogeneous goods. A hedonic regression model is a multiple regression model that enables a deeper understanding of the relationship between multiple variables (Hill et al., 2018). This model is often used in the real estate market, where the price—a dependent variable—is determined by various attributes such as location, structure, and neighborhood characteristics (Freeman, 1979).

A variation often used in the multiple regression model is the log-log model. Using the log relationship is a common method of decreasing and regularizing skewed data. Numerical values such as price, age, size, etc. engage in a logarithmic conversion. Log-log characteristics typically have a positive value and are skewed to the right, suggesting that a small portion of the population consists of larger values. Applying the natural logarithm to the values helps reduce their extremity and brings them closer to a normal distribution. The log-log model is favorable in the regression analysis as the natural logarithm enables the data distribution to become more symmetric, allowing the model to better fit the regression curves (Hill et al., 2018).

To address the research questions, two hedonic pricing models have been constructed. Model 1 composes regression models (1a) and (1b) with the purpose of examining whether a LEED price premium exists and, if so, whether it varies by rating level. Model 2 composes regression models (2a) and (2b) and seeks to examine whether there is a different inflation-hedging potential between LEED-certified buildings and non-certified buildings.

$$\text{(1a)} \qquad \ln(\text{Price}) = \beta_0 + \beta_1 \ln(\text{Year}) + \beta_2 \ln(\text{Age}) + \beta_3 \ln(\text{Size}) + \beta_4 \text{LEED} + \beta_5 \textstyle\sum_{i=5}^{8} \text{City} + \beta_6 \sum_{i=9}^{13} \text{Class} + \epsilon$$

$$\text{(1b)} \qquad \ln(\text{Price}) = \beta_0 + \beta_1 \ln(\text{Year}) + \beta_2 \ln(\text{Age}) + \beta_3 \ln(\text{Size}) + \beta_4 \text{LEED} + \beta_5 \textstyle\sum_{i=5}^{8} \text{Level} + \beta_6 \sum_{i=9}^{12} \text{City} + \beta_7 \sum_{i=13}^{17} \text{Class} + \epsilon$$

$$\text{(2a)} \qquad \ln(\text{Price})_{\text{leed}} = \beta_0 + \beta_1 \ln(\text{Year}) + \beta_2 \ln(\text{Age}) + \beta_3 \ln(\text{Size}) + \beta_4 \ln(\text{CPIF}) + \beta_5 \textstyle\sum_{i=5}^{8} \text{City} + \beta_6 \sum_{i=9}^{13} \text{Class} + \epsilon$$

$$\text{(2b)} \qquad \ln(\text{Price})_{\text{non}} = \beta_0 + \beta_1 \ln(\text{Year}) + \beta_2 \ln(\text{Age}) + \beta_3 \ln(\text{Size}) + \beta_4 \ln(\text{CPIF}) + \beta_5 \textstyle\sum_{i=5}^{8} \text{City} + \beta_6 \sum_{i=9}^{13} \text{Class} + \epsilon$$

Model (1a) investigates whether there exists a price premium for LEED-certified buildings, which is captured on the transaction price. Given that there is a positive coefficient for the variable LEED and that there is statistical significance, it would imply that a LEED price premium exists.

Model (1b) is further an examination of the LEED certificates' different rating levels; Certified, Silver, Gold, and Platinum.

Model (2a) examines the effect of a 1% increase in CPIF on LEED-certified buildings. Along with the estimated price effect of City and Class.

Model (2b) examines the effect of a 1% increase in CPIF on non-certified buildings. Along with the estimated price effect of City and Class.

TABLE 4—VARIABLE DESCRIPTION

Variable	Type	Definition
ln(Price)	Numerical	Logarithmic value of the price per square meter in SEK
ln(year)	Numerical	Logarithmic value of the transaction year
ln(Age)	Numerical	Logarithmic value of the building age or construction year
ln(Size)	Numerical	Logarithmic value of the buildings size in square metre
LEED	Categorical	Dummy variable for LEED certification
Level	Categorical	Dummy variable indicating the buildings LEED rating level
City	Categorical	Dummy variable indicating the buildings city location
Class	Categorical	Dummy variable indicating the location class of the building
ln(CPIF)	Numerical	Logarithmic value of the CPIF indices

5 RESULTS

The chapter addresses the hypotheses and provides a description of the observations. It presents the results from the regression models and interprets the hedonic pricing models.

In Model 1 and Model 2, prices and premiums are employed to represent the price per square meter interpretations.

The purpose of Model 1 is to examine if there exists a price premium for LEED-certified buildings and if it differs depending on rating level.

$H_0 : \beta = 0$ No LEED Price Premium exists
$H_1 : \beta \neq 0$ A LEED Price Premium exists

To test whether to accept or reject the null hypothesis, the beta coefficients for the variables LEED, Platinum, Gold, Silver, and Certified are estimated.

The purpose of Model 2 is to examine whether there is a different inflation-hedging potential between LEED-certified buildings and non-certified buildings.

$H_0 : \beta = 0$ LEED is not a more effective inflation hedge than non-certified buildings
$H_1 : \beta \neq 0$ LEED is a more effective inflation hedge than non-certified buildings

To test whether to accept or reject the null hypothesis, the beta coefficients for the variable ln(CPIF) are estimated.

When assessing the significance of each variable, an α value of 0.1 has been applied. There is a greater risk of making a Type I error, meaning incorrectly rejecting the null hypothesis. However, using a lower α value in the hedonic pricing model allows for the recognition of smaller effects.

5.1 Descriptive Statistics and Variable Frequency

The regression analysis consists of a total of 412 observations, with 49 of them being LEED-certified buildings and the remaining 363 being non-certified buildings. Transactions from 2013 to 2024 have been observed, with the majority occurring in 2021 for LEED-certified buildings and in 2014 for non-certified buildings. The most recent transaction was influenced by market conditions in Q1 2024. The mean size of LEED-certified buildings is the highest, although there is a non-certified building with the maximum size per square meter. LEED-certified buildings have a significantly higher mean price per square meter compared to non-certified buildings, with a difference of 16,735 SEK per square meter. The difference in the CPIF mean is 0.35%, which is relatively small compared to the range of values observed in the buildings. Providing an unbiased base for its evaluation when comparing it to price per square meter in regression models (2a) and (2b).

TABLE 5—DESCRIPTIVE STATISTICS

Variable	Mean	Median	Mode	SD	Min	Max	N
LEED							
Year	2018	2017	2021	3	2013	2023	49
Age	1992	1991	2013	26	1929	2021	49
Size	54,319	10,000	10,000	295,194	3,000	2,077,369	49
CPIF	215.67	211.54	228.33	13.71	200.81	257.69	49
Price (sq.m)	53,736	47,679	62,318	40,977	14,925	211,111	49
Non-certified							
Year	2018	2018	2014	3	2013	2024	363
Age	1979	1988	1929	33	1750	2022	363
Size	43,496	9,892	22,000	232,802	572	2,367,100	363
CPIF	216.43	213.98	202.74	14.61	199.75	260.65	363
Price (sq.m)	37,001	28,866	110,000	25,972	2,000	163,934	363

A frequency table has been constructed to gain a deeper understanding of the categorical data. The 49 LEED observations are divided into four different rating levels, with Silver having the lowest number of occurrences and Gold having the most number of occurrences. Stockholm has a total of 241 buildings, with 22 of them being LEED-certified. Most buildings are located in Class B.

TABLE 6—VARIABLE FREQUENCY

Variable	LEED	Non-certified
Level		
Platinum	13	-
Gold	24	-
Silver	4	-
Certified	8	-
City		
Stockholm	22	219
Gothenburg	9	72
Uppsala	5	19
Malmö	13	53
Class		
AA	11	45
A	11	78
B	18	146
C	6	46
D	3	48

5.1.1 Model 1

Presented below is the hedonic pricing model testing the evidence of a LEED price premium and price premiums for its rating levels. Model 1 is represented by regression models (1a) and (1b).

TABLE 7—REGRESSION RESULTS—MODEL 1

		Dependent variable:	
		ln(Price sq.m)	
		LEED Premium	**Level Premium**
		(1a)	(1b)
ln(Year)		13.426	10.980
		(18.032)	(17.809)
ln(Age)		2.255	1.900
		(1.445)	(1.427)
ln(Size)		0.413***	0.410***
		(0.025)	(0.025)
LEED		**0.337*****	**−0.043**
		(0.073)	(0.168)
Level			
	Platinum		**0.751*****
			(0.213)
	Gold		**0.284**
			(0.192)
	Silver		**0.631****
			(0.288)
	Certified		
City			
	Stockholm	0.103	0.122
		(0.092)	(0.091)
	Gothenburg	−0.092	−0.061
		(0.081)	(0.081)
	Uppsala	0.085	0.108
		(0.113)	(0.112)
	Malmö		
Class			
	AA	0.194**	0.160
		(0.104)	(0.103)
	A	0.148*	0.148*
		(0.088)	(0.087)
	B	0.144**	0.151*
		(0.079)	(0.078)
	C	−0.049	−0.024
		(0.097)	(0.095)
	D		
Constant		−112.913	−91.601
		(137.603)	(135.915)
Observations		412	412
R^2		0.598	0.613
Adjusted R^2		0.587	0.599
Residual Std. Error		0.471 (df = 400)	0.464 (df = 397)
F Statistic		54.172*** (df = 11; 400)	44.894*** (df = 14; 397)
Note:			*p<0.1; **p<0.05; ***p<0.01

The adjusted R^2 calculates the R^2 of the regression model, taking into account the number of independent variables. The R^2 is a measure that evaluates the overall quality of fit for the regression model. Model (1a) has an adjusted R^2 of 0.587, which is slightly lower than the adjusted R^2 of 0.599 for Model (1b). Adding another variable in Model (1b) will significantly improve the explanation of the variance of the independent variables, not only because of the increased number of predators.

The variable of interest in Model (1a) is the variable LEED. The coefficient has a value of 0.337 with a significance level of 1%. Based on the statistical significance, it is highly likely that the observed coefficient is real and not a result of random variability or sampling error. Given that the variables LEED, Level, City, and Class are not expressed in logarithmic form, the coefficients are converted into percentages by exponentiating the values. The price per square meter for LEED-certified buildings is 40.1% higher than the observed non-certified buildings.

The coefficients in the variable City are not statistically significant, so there is no compelling reason for further investigation. The variable Class, which takes into account the locational attribute, has multiple coefficients that are statistically significant. Model (1a) demonstrates a statistically significant price premium of 21.4% for Class AA in comparison to observations in Class D. In the same model, Class A, and B both show a significant price premium of 15.9% and 15.4%, respectively.

The variables of interest in Model (1b) are the variables Platinum, Gold, and Silver. The LEED coefficient in Model (1b) represents the baseline effect of LEED certification and must therefore be considered in addition to the specific rating level's effect. The coefficient Platinum indicates a value of 0.751 at a 1% significance level, indicating a price premium of 103% for Platinum-level buildings. Gold has a value of 0.284, but it fails to show statistical significance. Lastly, Silver has a value of 0.631 at a 5% significance level, suggesting a price premium of 80% for Silver-level buildings. With regards to Certified being the omitted variable, all other rating levels are estimated against Certified-level buildings. As mentioned earlier in Section 5.1, Silver-level buildings had only a small number of observations; therefore, it is important to interpret the results with caution. While the coefficient Silver is statistically significant, it is important to note that the price premium for Silver-level buildings may not accurately reflect the overall Swedish commercial property market. This is primarily due to the limited number of observations available.

In Model (1b), the coefficients for the variable Class do not exhibit the same positive correlation as in Model (1a). Class B has a higher price premium of 16.3% compared to Class A, which has a price premium of 15.9%.

It can be concluded that Model 1 suggests a significant price premium of 40.1% for LEED-certified buildings , with even higher price premiums of 103% for Platinum-level buildings and 80% for Silver-level buildings.

5.1.2 Model 2

Presented below is the hedonic pricing model testing the inflation-hedging potential of LEED-certified buildings and non-certified buildings. Model 2 is represented by regression Models (2a) and (2b).

TABLE 8—REGRESSION RESULTS—MODEL 2

		Dependent variable: ln(Price sq.m)	
		LEED (2a)	**Non-certified** (2b)
ln(Year)		−164.803	−6.655
		(147.987)	(47.204)
ln(Age)		2.278	2.316
		(6.800)	(1.475)
ln(Size)		0.286***	0.439***
		(0.090)	(0.026)
ln(CPIF)		**5.839***	**1.207***
		(2.404)	(0.989)
City			
	Stockholm	−0.222*	0.053**
		(0.222)	(0.078)
	Gothenburg	−0.369	−0.042
		(0.245)	(0.088)
	Uppsala	0.223**	0.015
		(0.282)	(0.124)
	Malmö		
Class			
	AA	0.474**	0.552***
		(0.278)	(0.079)
	A	0.125	0.161*
		(0.360)	(0.090)
	B	0.142	0.126
		(0.341)	(0.080)
	C	0.018	−0.004*
		(0.373)	(0.100)
	D		
Constant		1,213.418	38.076
		(1,124.200)	(354.970)
Observations		49	363
R^2		0.492	0.618
Adjusted R^2		0.341	0.606
Residual Std. Error		0.513 (df = 37)	0.461 (df = 351)
F Statistic		3.258*** (df = 11; 37)	51.578*** (df = 11; 351)
Note:			*p<0.1; **p<0.05; ***p<0.01

Model (2a) has an adjusted R^2 of 0.341, which is slightly lower than the adjusted R^2 of 0.606 for Model (2b). As in Model 1, it suggests that adding another variable in Model (2b) will significantly improve the explanation of the variance of the independent variables, not only because of the increased number of predators.

The variable of interest in Model 2 is the variable ln(CPIF). In Model (2a), the coefficient has a value of 5.839, which is statistically significant at a 10% level. In Model (2b), the coefficient is significantly lower, with a value of 1.207, also at a 10% significance level. The variable ln(CPIF) is expressed in logarithmic form, allowing it to capture the percentage change. Meaning that in Model (1a), if the CPIF increases by 1%, the price growth for LEED-certified buildings is 5.839%. Similarly, in Model (2b), a 1% increase in the CPIF results in a 1.207% price increase for non-certified buildings.

In the variable City it is found that LEED-certified buildings in Stockholm have 19.9% lower prices than in Malmö, at a 10% significance level. While comparing non-certified buildings, the prices showed a substantial increase of 73.7% at a 1% significance level. Furthermore, the model suggests, at a 5% significance level, that LEED-certified buildings in Uppsala demonstrate a 25% price increase. No other coefficient in the variable City is statistically significant and will therefore not be discussed.

The coefficients in the variable Class indicate that LEED-certified buildings in Class AA sell at 60.6% higher prices than those located in Class D, at a 5% significance level. In terms of non-certified buildings, Class AA has a 73.7% higher prices than Class D, with a significance level of 1%. Additional coefficients with a significance level of 10% demonstrate that Class A non-certified buildings experience a price increase of 17.4%, while Class C non-certified buildings observe a price decrease of 0.4%.

It can be concluded that Model 2 suggests that LEED-certified buildings exhibit a more robust positive correlation to the CPIF compared to non-certified buildings. When the CPIF increases by 1%, LEED-certified buildings experience a price growth of 5.839%, while non-certified buildings experience a price growth of 1.207%.

6 ANALYSIS

The chapter discusses the findings and establishes connections with previous research and the theoretical framework.

6.1 Is there an evident LEED price premium in Sweden's commercial property market, and is there a positive correlation between its rating levels and price premium?

From the literature review, it is clear that green building certifications have gained importance in the real estate sector for their role in verifying ESG and sustainable practices, as well as social responsibility. In addition, research delves into the long-term financial advantages that investors have observed in green buildings, such as increased rental income, lower vacancy rates, and decreased risks. There is empirical evidence in the literature that supports a positive correlation between green buildings and property values (Fuerst & McAllister, 2008; Fuerst & McAllister, 2009; Fuerst & McAllister, 2011), reinforcing the idea that investors value sustainability in real estate. Multiple studies support the acknowledgment by investors of the importance of green buildings. Research highlights the willingness to pay higher rents and prices for green buildings and the correlation between ESG factors, sustainability, and property values (Eichholtz et al., 2010; Wiencke, 2013; Addae-Dapaah & Wilkinson, 2020; Heinzle et al., 2013; Robinson & McAllister, 2015).

Multiple studies have found that there exists a price premium ranging from 10% to 11% (Mangialardo et al., 2018; Eichholtz et al., 2010; Eichholtz et al., 2010a; Miller et al., 2008). Additional studies have found that there are higher price premiums, ranging from 25% to 35% (Robinson & McAllister, 2015; Fuerst & McAllister, 2008; Fuerst & McAllister, 2009; Fuerst & McAllister, 2011).

Furthermore, research has examined the correlation between the rating levels of LEED certification and price premiums. In a study conducted by Managialardo et al. (2018), it was discovered that there is a positive correlation between LEED's rating levels and the price premium. This finding was also observed by Holtermans and Kok (2017). However, a study conducted by Fuerst and McAllister (2009) found no positive correlation, as Gold-level buildings had a lower price premium compared to Silver-level buildings.

Model (1a) demonstrated an evident LEED price premium of 40.1% in the Swedish commercial property market.

The sample of LEED-certified buildings only represents about 13% of the total observations, which may not be enough to adequately cover the Swedish representation. Model (1b) considers the different rating levels of LEED; Silver, Gold, and Platinum. Platinum and Silver demonstrated significant coefficients, indicating a price premium of 103% and 80%, respectively.

The results imply that investors tend to pay approximately 40% more for a LEED-certified building compared to a non-certified building. When examining the rating levels of LEED certification—Silver, Gold, and Platinum—it becomes clear that there is a positive correlation between the certification level and the price premium. This suggests that as the rating level increases, so does the price. It is important to note that the sample size of 4 Silver-level buildings is relatively small compared to the dataset of 412 observations. The imbalance raises significant concerns regarding the representativeness and reliability of the findings. Most of the LEED-certified buildings are located in Class AA, A, and B when considering locational attributes. Buildings located closer to the CBD tend to sell at higher prices, which is why Class AA buildings have a higher price premium.

The variations in the reported price premiums for LEED-certified buildings across different studies can be attributed to several factors, including disparities in sample size, observed time period, and geographical location. The sample size of the transactions analyzed in each study is essential in determining the accuracy and reliability of the findings. Research that includes a greater number of LEED-certified buildings—over 200 (Fuerst & McAllister, 2009; Fuerst & McAllister, 2011; Eichholtz et al., 2010; Eichholtz et al., 2010a; Miller et al., 2008)—tends to provide more reliable estimates of price premiums. This is because larger sample sizes offer increased statistical power and reduced sampling variability. On the other hand, research that includes a smaller number of LEED-certified buildings—around 30 (Mangialardo et al., 2018; Fuerst & McAllister, 2008)—may generate more conflicting findings and less accurate estimates. The time period during which the transactions were observed can have an impact on the price premiums that are reported. Research that covers a longer period can capture market fluctuations and demand-supply dynamics, offering a broader understanding of the correlation between LEED certification and property values. On the other hand, studies that focus on shorter time frames may fail to account for these variations, which can result in inaccurate estimates of price premiums. In addition, variations in real estate markets across different locations can lead to differences in the reported price premiums. It is difficult to determine the exact location class of the observations with certainty. It is uncertain whether they are located in the CBD or surrounding areas. Buildings in the CBD have a higher price due to their location, indicating that the price premium may also be influenced by the location rather than sustainable attributes. Methodological differences in the estimation of price premiums and the incorporation of hedonic characteristics in the regression models can also have an impact on the findings. There may be a disparity in price premiums across studies due to variations in the selection of control variables, treatment of outliers, and statistical methods used for estimation.

There is uncertainty regarding the sustainability of the price premiums. The findings of significant price premiums may suggest that they are likely a result of a short-term increase in demand from both occupiers and investors due to the scarcity of green buildings. Understanding the pricing process in the market for green buildings will become increasingly important as it continues to develop. Others suggest that green building practices could become more common in the future. As a result, the market may not place as much value on green buildings if supply and demand become more balanced (Chegut et al., 2013; Muir et al., 2023; Zehra, 2023). This could be a futuristic aspect of the existing price premium that might change or diminish over time.

When analyzing the results in relation to previous studies, there are certain similarities observed in the price premiums. Model 1 demonstrated a significant price premium of approximately 40%, which aligns closely with previous research (Robinson & McAllister, 2015; Fuerst & McAllister, 2009; Fuerst & McAllister, 2008). When analyzing the rating levels, it is worth noting that only Platinum-level aligns with the findings of Fuerst and McAllister (2009). They discovered a relatively high Platinum-level price premium of 100%, which represented 7% of the LEED sample. This can be compared to the 103% Platinum-level price premium in Model 1. Platinum-level buildings may have a relatively high price premium, based on these indications.

The existence of a LEED price premium raises the question of what the drivers are that cause the increased property values. In previous studies, researchers divided the drivers for green building implementation into different levels (Darko et al., 2017). However, the factors that directly contribute to an increased property value are only listed at property-level, as these drivers focus on what affects the cash flow. One factor explicitly included in the DCF analysis is rental income. With reference to the 4Q Model, the rental income from occupiers determined in Quadrant 1 has an immediate impact on the value of the property in the asset market. With the supply remaining constant and the investors benefiting from the increased cash flow, this will result in a flatter slope in Quadrant 2, which will raise the asset's price. This effect can contribute to the price premium for green buildings.

According to Leskinen et al. (2020), the primary factors influencing property-level performance are higher income, reduced risk, and improved occupancy rates. Research has examined the impact of rent premiums and occupancy premiums on property prices (Devine & Kok, 2015; Fuerst & McAllister, 2009; Fuerst & McAllister, 2011; Eichholtz et al., 2013). Referring to the DCF analysis, the premiums contribute to an increased property value through calculations within the cash flow. The rent premium is captured by the increased rental income, and the occupancy premium is captured by the decreased vacancy rate.

Indirect effects on the property value can be demonstrated at various levels, including corporate, individual, project, and external-levels. These metrics do not impact the cash flows directly but rather increase awareness of ESG factors and green buildings. Furthermore, an enhanced corporate reputation, influenced by perceptions of social responsibility, is widely acknowledged for its ability to attract investors and enable higher rents from occupiers in green buildings (Fombrun & Shanley, 1990; Milgrom & Roberts, 1986; Klein & Leffler, 1981). Understanding the various factors' interactions and their impact on property values can be somewhat complex. It is difficult to identify the exact cause of the increased property value due to a variety of factors across different categories. According to Darko et al. (2017), it is challenging to attribute price premiums to a single factor since factors within different categories can influence each other.

In summary, several drivers contribute to the existence of green building price premiums, regardless of the certification system. These drivers remain consistent across studies examining drivers on a property-level. The key factors that increase property values include higher rent, reduced risk, and increased occupancy rates.

6.2 Do LEED-certified buildings provide a more effective inflation hedge than non-certified buildings in Sweden's commercial property market?

Previous research has investigated the relationship between commercial real estate and inflation, examining whether commercial real estate is independent of short-term and long-term inflation. Based on the literature, it has been suggested that commercial real estate can act as a hedge against long-term inflation, although there may be some variation in the findings. Salisu et al. (2020) observed an interesting insight while conducting time-sampling observations before and after the GFC. Commercial real estate has been shown to hedge against inflation, both before and after economic downturns. In a study conducted by Wolski (2023), Poland was examined after the GFC. The research suggested that commercial real estate serves as a long-term inflation hedge. In various studies ranging from the 1940s to the 2010s, researchers have found a positive correlation between inflation and commercial real estate returns. This suggests that commercial real estate may serve as an effective long-term hedge against inflation on a global basis (Fleischmann et al., 2019; Li & Chiang, 2012; Gunasekarage et al., 2008; Hoesli, 1994). However, Obereiner and Kurzrock (2012) found that commercial real estate is independent only from short-term inflation and not long-term inflation. Implying that commercial real estate only serves as a short-term hedge against inflation. On the other hand, there are conflicting findings that suggest there is no positive correlation between inflation and commercial real estate returns, as suggested by Stevenson (1999) and Tarbert (1996). It appears that commercial real estate may not always act as an effective hedge against inflation, depending on certain conditions and time periods.

However, there has been no additional research conducted on the potential of green buildings as inflation hedges. The literature aims to investigate the correlation between inflation and commercial real estate without explicitly addressing ESG and sustainability practices. It is still uncertain whether green buildings alone can serve as a hedge against inflation. It could potentially be included in the analysis of commercial real estate, but due to conflicting empirical evidence, it is difficult to draw conclusions regarding green buildings as an inflation hedge. The observations in this thesis could function as a guideline for future research on the topic of green buildings as an inflation hedge.

Model 2 indicated that, when comparing the CPIF from Q2 2013 to Q1 2024, LEED-certified buildings had greater price growth than non-certified buildings, suggesting that LEED-certified buildings have a stronger potential to hedge against inflation. The coefficients in Model 2 demonstrated that, while non-certified building prices increase by 1.2%, closely corresponding to the CPIF rate, LEED-certified building prices increase by 5.8% in response to a 1% increase in the CPIF. It suggests that commercial real estate returns tend to outpace inflation rate growth. These findings align with those previously concluded by Fleischmann et al. (2019), Li and Chiang (2012), Gunasekarage et al. (2008), Hoesli (1994), Wolski (2023), and Salisu et al. (2020).

The price growth disparity between LEED-certified buildings and non-certified buildings in Model 2 highlights the effectiveness of ESG and sustainable building practices in inflation hedging. LEED-certified buildings demonstrate resilience to inflationary periods, potentially due to their focus on energy efficiency, environmental sustainability, and occupant health. The higher price appreciation observed in LEED-certified buildings during inflationary periods may contribute to the observed price premium.

The findings in this thesis have significant implications for real estate investors and other stakeholders. Investing in LEED-certified buildings may serve as a more effective inflation hedge than investing in non-certified buildings. This may provide investors with greater stability and the possibility of long-term value appreciation. Developers may benefit from prioritizing ESG and sustainable building practices in order to capitalize on the growing demand for green buildings. Analyzing the results, it is evident that LEED-certified buildings have a significant impact on mitigating the effects of inflation in the commercial property market.

In summary, the evidence that exists does not discuss the notion of green buildings as inflation hedges. There are compelling indications that green buildings provide a more effective hedge against inflation. As highlighted by Eichholtz et al. (2010) and Darko et al. (2017), investing in green buildings carries less risk and takes on higher demand.

7 CONCLUSIONS

The chapter concludes the findings of the thesis along with a recommendation for future research.

The thesis has examined whether there exists a price premium for LEED-certified buildings in Sweden's commercial property market. Furthermore, it has investigated if there is a positive correlation between LEED's rating levels and price premiums. In addition, the thesis has investigated commercial real estate as an inflation hedge while differentiating between LEED-certified buildings and non-certified buildings. Four hedonic regression models have been constructed to answer the research questions.

The differences in the discovered price premiums for LEED-certified buildings can be explained by factors such as disparities in sample sizes, observed time periods, geography, etc. Commercial real estate's effectiveness as an inflation hedge differs based on geographical locations, time periods, and methodologies. Previous research provides empirical evidence that commercial real estate serves as an inflation hedge; however, there are disparities in the literature regarding the consistency of this relationship.

The findings in Model 1 indicate that there is a 40.1% price premium for LEED-certified buildings in Sweden. In addition, Silver-level buildings command a price premium of 80%, while Platinum-level buildings command a price premium of 103%. The null hypothesis can be rejected, and the alternative hypothesis can be accepted.

The findings in Model 2 suggest that commercial real estate provides a hedge against inflation, whereas LEED-certified buildings showed a more effective hedge, with a 5.8% price growth per 1% increase in the CPIF. Compared to non-certified buildings, which were slightly higher than the CPIF, at 1.2%. The null hypothesis can be rejected, and the alternative hypothesis can be accepted.

The price premium for green buildings can be explained by several drivers. Increased demand for green buildings, along with investor behavior, suggests a willingness to pay premiums. This can explain the price growth observed in LEED-certified buildings, even during inflationary periods.

A recommendation for further research on the topic suggests examining green buildings as an inflation hedge against expected inflation, using an OLS regression based on Fisher's hypothesis, to capture the correlation between inflation and real estate returns. The findings will provide valuable insights to investors seeking to expand their green portfolio and invest in assets that may protect against inflation.

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