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Impact Of Green Building Certification On The Rent Of Commercial Properties: A Review

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Abstract - The world is currently facing two major problems, namely, increasing energy costs and global warming. As a result, it is crucial to take proactive measures to effectively address and mitigate the detrimental impacts arising from elevated energy costs, the pressing issue of global warming, and various types of environmental degradation. As a reaction, international organizations are advocating for the development of eco-friendly, sustainable, or green buildings as a strategy to reduce the harmful effects of the construction sector on the environment. While green development may entail higher costs for developers, it is imperative to evaluate the return on investment from their perspective. As such, this study initially delves into the global landscape of green building certifications and their associated institutions by thoroughly examining relevant literature published between 2003 and 2021. Following that, the study scrutinizes the advancement of research on green building practices across diverse office building sectors and over the course of time. Following that, the study explores green incentives in property markets worldwide, with a particular emphasis on the United States and Europe, as well as other regions. Ultimately, the paper assesses the efficacy of green incentives in driving sustainable building practices in diverse real estate markets. The findings from the review suggest that green certification is associated with higher commercial building rents as opposed to buildings without certifications, with 77% of the research demonstrating a significant positive correlation between green certification and rental rates. Nevertheless, the study recommends that relative rent should be regarded as an endogenous variable in future research, as investment profitability is jointly influenced by both occupancy rate and rental value, underscoring the need for careful consideration in analytical analyses.

Keywords— commercial property, green office, sustainable buildings, green certification, rental rate

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I. INTRODUCTION

During the 27th United Nations Climate Change Session, it was determined that the anticipated temperature increase of 2.8°C by the end of the century is significantly higher than previously estimated during the 26th conference [1]. An immediate and comprehensive system-wide change is necessary to limit the emission of greenhouse gases and maintain the increase in temperature of 1.5°C by 2030. The analysis emphasises the crucial importance of transformative measures in critical sectors, such as electrical supply, industry, transportation, buildings, food, and finance.

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Therefore, it is crucial to focus on low-energy buildings, also known as sustainable, eco-, or green buildings, to reduce the strain on environmental resources and limit negative impacts on human health by using natural resources efficiently. Apart from global warming, the need for energy-efficient structures is necessary due to resource scarcity and other factors. Additionally, constructing eco-friendly buildings that provide a healthy environment has become critical for increasing human productivity and curbing the spread of COVID-19 by promoting virus prevention and transmission control. These drivers, illustrated in Table 1 below alongside those recognized by [2] for green buildings in the United States, emphasize the various reasons for adopting sustainable construction practices. Therefore, the transformation of traditional buildings into eco-friendly structures is widely acknowledged as crucial on a global scale. However, there is some confusion as terms such as sustainable and green are often used interchangeably, despite having distinct connotations. For instance, [3] provides a definition of green which refers to building design principles that are less harmful to the environment and ecology compared to traditional methods. Similarly, [4] defined sustainable development as a form of development that caters to the current generation's requirements while ensuring that future generations can meet their own needs without any difficulties. Multiple independent organizations worldwide offer green building certification, and developers need to be familiar with them and their green ranking systems. As per [5], about 600 green or sustainable ratings are in use around the world, with LEED being the most adaptive and generally available rating system, used in 160 countries, while BREEAM is used in just 77 countries but was reported to have the most authorised buildings as of 2017. Table 2 summarizes a widely acknowledge popular green rating system that is well-documented in the literature.

Table 1. Drivers for Green Buildings (Adopted from [2])

Description of Drivers
A surge in average crude oil prices
Rising oil prices, geopolitical factors leading to supply uncertainty, and mounting evidence of human-caused global warming
US - Energy Policy Act of 2005, which offers robust backing for energy conservation in both new and existing buildings.
Introduction of new law reducing property taxes on green buildings
Embracing policies and initiatives that encourage the development of environmentally friendly private-sector buildings.
Relationship between engineers, architects and design firms and Green Building Council of United States
The effectiveness of green building practices in mitigating the spread of COVID-19.
The efficacy of green building in enhancing human productivity.

Table 2. Popular Green Rating Systems

Region	Country	Abbreviations	Description
United States	USA	LEED	Leadership in Energy and Environmental Design, introduced by USGBC (United States Green Building Council) in 1998
	USA	WELL	WELL Building Standard (USA), introduced by International WELL Building Institute (IWBI) in the United States

Region	Country	Abbreviations	Description
	USA	SITES	Sustainable Sites Initiative. Introduced by American Society of Landscape Architects (ASLA)
	USA	LBC	Living Building Challenge, introduced by the International Living Future Institute (ILFI) in 2006.
Europe	UK	BREEAM	Building Research Establishment Environmental Assessment Method. introduced in 1990
	Canada	LEED	Leadership in Energy and Environmental Design. Introduced in 1998
	France	HQE	High Environmental Quality, introduced in in the early 1990s
	Germany	DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen
Asia Pacific	Australia	Green Star	Green Star System
	New Zealand	Green Star	Green Star system launched in 2007
	Japan	CASBEE	Comprehensive Assessment System for Building Environmental Efficiency, introduced in 2001
	Hong Kong	BEAM	Building Environmental Assessment Method
	Singapore	BCA	Building and Construction Authority
	Korea	G-SEED	Green Standards for Energy and Environmental Design
	Malaysia	GBI	Green Building Index
	India	GRIHA	Green Rating for Integrated Habitat Assessment. Introduced by the Energy and Resources Institute (TERI)
	Sri Lanka	GBRS	Green Building Rating System - Sri Lanka, introduced by Sri Lanka Green Building Council (SLGBC)
International	No border	EDGE	Excellence in Design for Greater Efficiencies, introduced by the International Finance Corporation (IFC)

A. Areas covered by Green Building Research

The realm of Green Building Research encompasses a diverse array of subjects, such as the influence of indoor air quality on the cognitive performance of employees [6], satisfaction with benchmarks for indoor environmental quality [7], and the well-being of occupants [8]. In addition to what was previously mentioned, Cedeño-Laurent et al. have outlined nine essential elements that contribute to the well-being of occupants. These include factors such as indoor air quality, ventilation, thermal comfort, water quality, moisture levels, safety and security measures, lighting and views, noise control, and management of dust and pests. Research has shown that Green Plus Buildings can significantly enhance cognitive function scores in comparison to conventional building conditions, as demonstrated by [9].

Apart from what was mentioned earlier, there are numerous review articles accessible that delve into the subject of innovative Green Building practices. The United States has the most publications in this field, followed by China and the United Kingdom, and publications on Green Building-related topics grew the most between 2004 and 2007 [10]. According to Li et al., between 2004 and 2007, the number of publications related to Green Building grew significantly. The establishment of the United States Green Building Council (USGBC) and the United Kingdom Green Building Council (UKGBC) has been instrumental in accelerating the advancement of Green Buildings, and the Energy Policy Act 2005 in the USA has played a vital role in driving this progress.

B. Internet of Things (IoT) and Green Certification

Green certification institutions have established scorecards that must be met to obtain certification. The LEED rating system, for instance, consists of mandatory prerequisites and optional credits across seven categories. The categories include energy and atmosphere, which receive the most credit at 35 out of 100, and indoor air quality, which receives the next highest credit at 22 [11]. To achieve these credits, it is necessary to connect mechanical systems with information technology. For example, IoT sensors can be used to monitor a building's energy consumption, water usage, and other environmental metrics in real time, providing valuable data that can be used to optimize its performance and reduce its environmental impact. Smart building technology can also help optimise energy usage by altering lighting, heating, and cooling systems based on occupancy and environmental conditions, lowering energy waste and costs even more.

Recently, there has been a surge of interest in leveraging Internet of Things (IoT) applications for managing and optimizing energy usage in commercial buildings [12]. This energy-focused IoT concept is sometimes called the Internet of Energy (IoE). IoE involves implementing IoT technology into distributed energy systems with the aim of improving energy efficiency, decreasing energy waste, and enhancing environmental conditions. It concentrates on various aspects of building infrastructure such as heating, ventilation, and air conditioning (HVAC), lighting, and energy production and storage management [13]. [12] proposed a cost-effective IoT-based architecture that is compatible with the widely recognized LEED certification. Similarly, [14] validated that artificial intelligence (AI) combined with green building practices improves efficiency, reduces costs and time, improves reliability, and enhances accuracy in energy optimization. Additionally, [15] found that integrating Ontology, BIM, IoT, and Blockchain can enhance the assessment process of the green building certification system (GBCS). Similarly, [16] confirmed through a systematic review that integrating BIM and GBCS enhances the sustainability assessment process by 71% in energy assessment procedures, which is a critical aspect of environmental sustainability. Apart from these studies, other research in the literature supports the role of IoT in obtaining green certification, specifically in the area of energy optimization. [13] outlined smart building solutions in the literature that employ smart technology and IoT solutions to achieve energy efficiency in all mechanical, electrical, and plumbing (MEP) services, as illustrated in Table 3 below. The study confirmed that IoE and IoT can help cities become more sustainable or green. Furthermore, elevated digital readiness translates to higher revenue and profitability, as digitally proficient companies attain significantly greater financial success compared to those with lower levels of digital preparedness [17].

Table 3. Technical systems and smart solutions (adapted from [13]).

MEP system	Smart tool	Smart solution
Electric energy	Sensor controllers and solar energy Wireless sensor network PV generator connected with storage units and heat pumps	The utility grid over a time period is zero. Notice unnecessary electric consumption. Minimises the use of the electric grid
MVAC	Infrared sensors, IoT thermostat	Controls the AC by monitoring temperature and humidity. Monitor occupancy and adjust room energy mode. Based on the outside temperature adjust the equipment to optimize energy use

Lighting	Sensors and controllers in luminaires	Based on the daylight decides operating lights. Monitor occupancy and operate lights accordingly
Water	Sensors	Turn off taps etc. automatically preventing wastage.
Hot water	Sensors and actuators	The unused areas are not supplied with hot water
Elevators	Sensors	Based on the occupancy adjust the operating mode

Furthermore, in addition to the above economic benefits of green certifications, the Internet of Things (IoT) has the potential to reduce various forms of waste. For instance, by implementing IoT technologies such as the installation of ultrasonic sensors in each parking slot, the time and fuel wasted in searching for available parking spots in buildings can be significantly minimized, as highlighted in the research conducted by [18].

II. MOTIVATION FOR THE LITERATURE REVIEW

Frankie the Dinosaur effectively communicated the urgent message of "don't choose extinction" at the Climate Change Conference, which took place in Egypt, from November 6 to 20, 2022, and was conducted by the United Nations. During the 27th United Nations Climate Change Conference held in Sharm El Sheikh, Egypt from November 6 to November 20, 2022, Frankie the Dinosaur conveyed a clear message of "Don't Choose Extinction" [19]. This message highlighted the significant amount of money spent annually to support fossil fuels for global energy, as well as the increased frequency and intensity of natural disasters such as fires, floods, storms, hurricanes, droughts, and heatwaves due to human-induced climate change. Despite the growing concerns about sustainability, energy remains an indispensable requirement for nations across the globe. Projections suggest that primary energy consumption for pivotal sectors could soar to 17,487 Mtoe, while final energy consumption could reach 11,775 Mtoe by 2040, according to research by [20]. Researchers have defined that Mtoe, which is a unit of measurement that denotes the amount of energy released from burning one metric ton of oil, is crucial to understanding global energy usage. Additionally, these experts have observed that urbanization has led to a substantial increase in energy consumption within buildings. According to a study by [21], the building sector is responsible for 68% of total energy consumption in the United States and 39% of global energy consumption worldwide. In line with the above finding, research conducted by [22] revealed that the building sector is a major contributor to global energy consumption, representing over 30% of the world's total energy usage.

The discussion above illustrates the significance of substituting traditional structures with eco-friendly constructions worldwide. Further to the above, [23] demonstrated that utilizing IoT-based green building management can be cost-effective and facilitate monitoring and controlling energy usage. [24] took green certification and IoT to new heights by emphasizing the advancement of Green Internet of Things (G-IoT) efforts in promoting sustainability and protecting the environment through technological progress. Green IoT refers to the production, design, and disposal of computers and servers, as well as their more efficient and frequent use, with a less negative impact on both society and the environment [25]. However, constructing green buildings requires more investment compared to conventional building construction, and in the Massachusetts market, it costs between 0.7% to 6.5% more [26]. Further to the previous finding, a different study showed that the building type, project location, regional climate, site conditions, and the design team's expertise all have an impact on how much it costs to incorporate sustainable design elements into a conventional building construction [27]. Hence, it is crucial to evaluate the economic feasibility of investing in green buildings through a comprehensive analysis of their value and viability.

On the other hand, the advantages of green building incentives are either speculative or challenging to quantify [28]. However, [29] reported that IoT can help overcome some of these challenges by providing real-time data on building performance and facilitating better decision-making. Furthermore, [30] reported that IoT technologies can enable real-time monitoring and optimization of building systems, leading to significant energy savings and reduced environmental impact. A systematic review undertaken by [31], divided green building incentives into two primary forms, namely external and internal rewards. Internal rewards are provided to recipients willingly, as opposed to

external incentives, which require creators to meet particular criteria in order to receive rewards. Financial and non-financial incentives fall under external incentives, which are all related to monetary gain. Non-financial incentives in developed markets include accelerated building permit licenses, a higher buildable area in comparison to land area, and increased rentable area in proportion to the total floor area.

As previously mentioned, there are multiple avenues through which tenants can reap financial and other advantages by occupying a green building. However, the number of green developments is still relatively low in comparison to total projects. Therefore, it is crucial to determine whether developers who invested in green buildings received the promised incentives from governments and the market, such as a special incentive from tenants. The available literature on the anticipated incentives for green building development is evaluated critically in this study, with an emphasis on elements such as higher occupancy rates and increased rental rates.

III. RESEARCH METHODOLOGY

The objective of this literature review study is to explore the anticipated reward for the development of green building through the lens of premium rates for rentals. The study involves an examination and analysis of existing research publications that correlate rental rates between green-certified buildings and non-green-certified buildings. The geographical scope of this review study is not limited but rather based on literature data from published sources spanning from 2003 to 2021. The paper utilizes a systematic review methodology, illustrated in Figure 1. [32] utilized a similar methodology in their study conducted in the USA, which aimed to investigate "the impact of green certification on the cash flow and values of commercial buildings" through a review study. The initial step involved conducting an electronic search using Google Scholar and Scopus, utilizing keywords such as "effect of green building certification on rental rate office space" in various combinations of Boolean operators as shown below.

- Green certification, green label, eco-labelling
- Commercial property, business premises, office space or office buildings
- Rental prices, green premium

The titles and abstracts of the articles were carefully examined, and keywords were identified in many of them. Duplicates and false positives were eliminated after a thorough review of the topic and abstract. Then, a rejection process was employed to exclude articles that were not pertinent to the relationship between any form of green certification and rent. Finally, the remaining articles were analyzed using the following systematic approach.

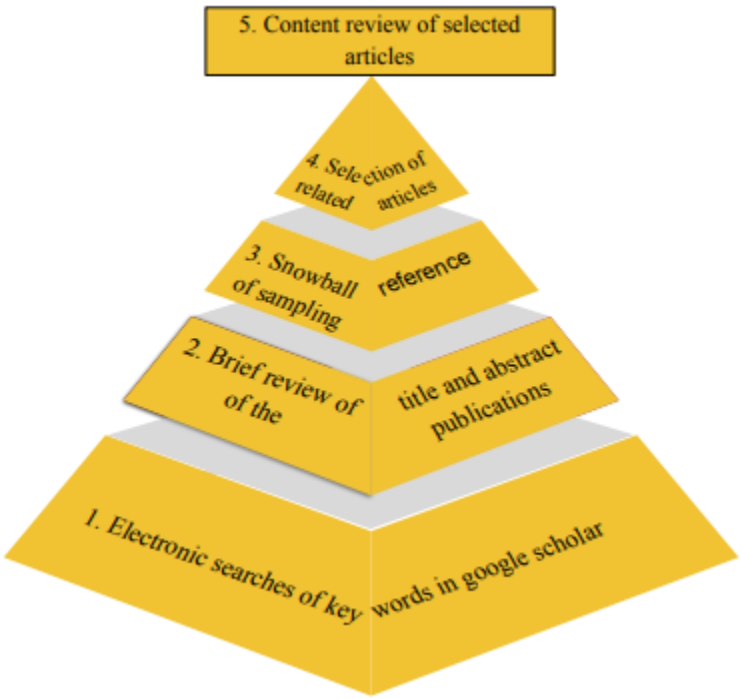

Figure 1. Search Strategy Process

At first, a total of 256 articles were retrieved from the electronic search. Afterwards, by reviewing the abstracts, the number was reduced to 83. Eventually, the search was narrowed down to only 47 articles that exclusively examined how green building certification affected the rental prices of office buildings on a global scale. These chosen articles were limited to the time frame between 2003 and 2021, based on their year of publication.

IV. RESULTS

Between 2003 and 2021, there were a significant number of research papers published on the topic of green or sustainable office buildings. Out of those publications, 83 were examined to explore the financial advantages of green certification. Within that same time frame, 49 of the 83 papers focused on the correlation between green certification and rental prices. In these studies, the rent per square area was the only dependent variable considered. The year 2018 had the highest number of research publications, as illustrated in Figure 2.

Furthermore, this study has classified several research papers according to their geographic regions, as presented in Figure 3. According to research by [10], who carried out a thorough bibliometric assessment of green commercial structures by examining publications published from 1998 to 2018, the US market had the most total number of publications.

The findings were mixed, but the majority of the studies, 36 out of 47 (77%), indicated that any form of green certification had a positive effect on rental rates for office buildings. Conversely, only 11 out of the 47 studies (23%) discovered no significant link. Figure 4 and Table 4 provide a concise overview of the findings across different geopolitical regions.

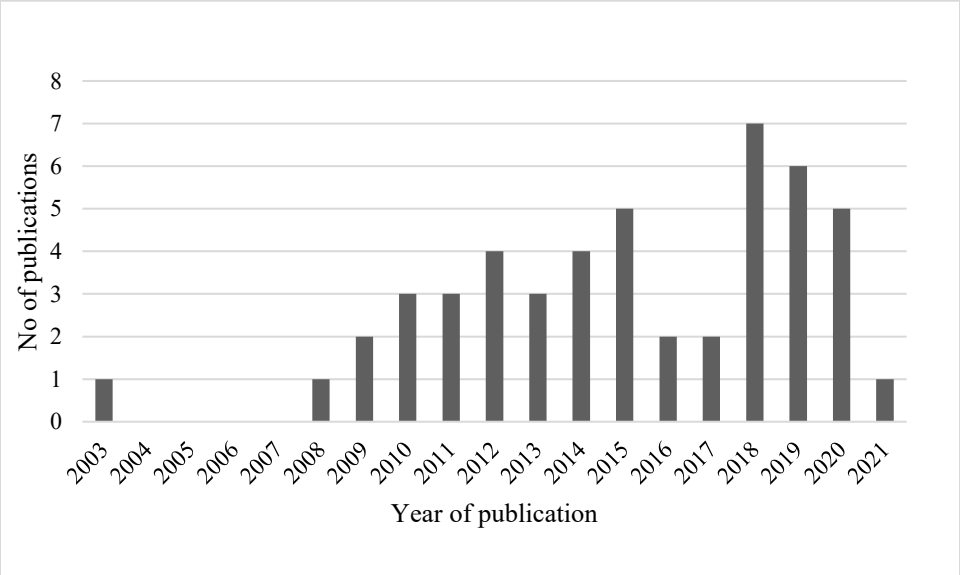

Figure 2. Number of Publications Conducted Over Time

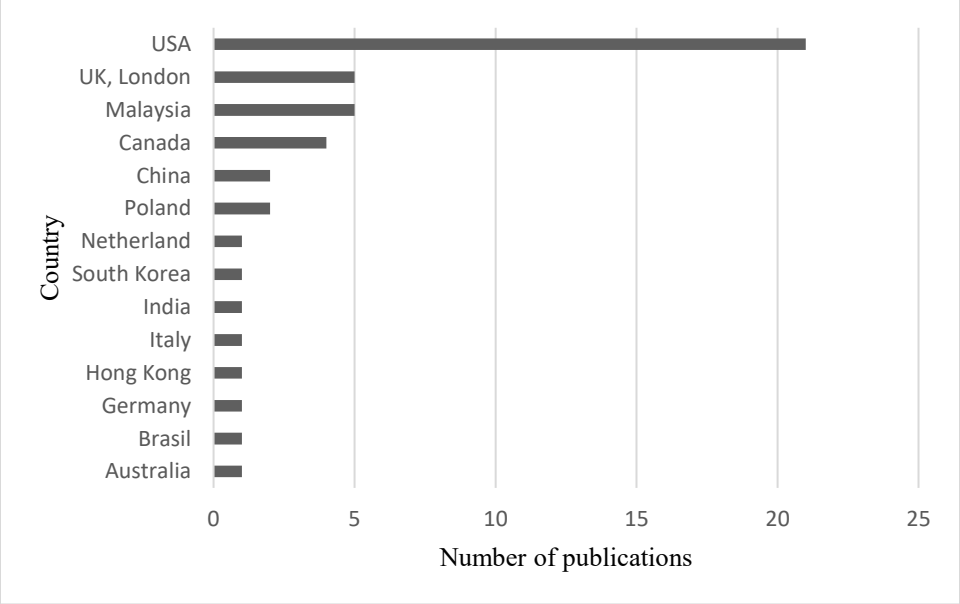

Figure 3. Number of Studies Conducted in Different Country

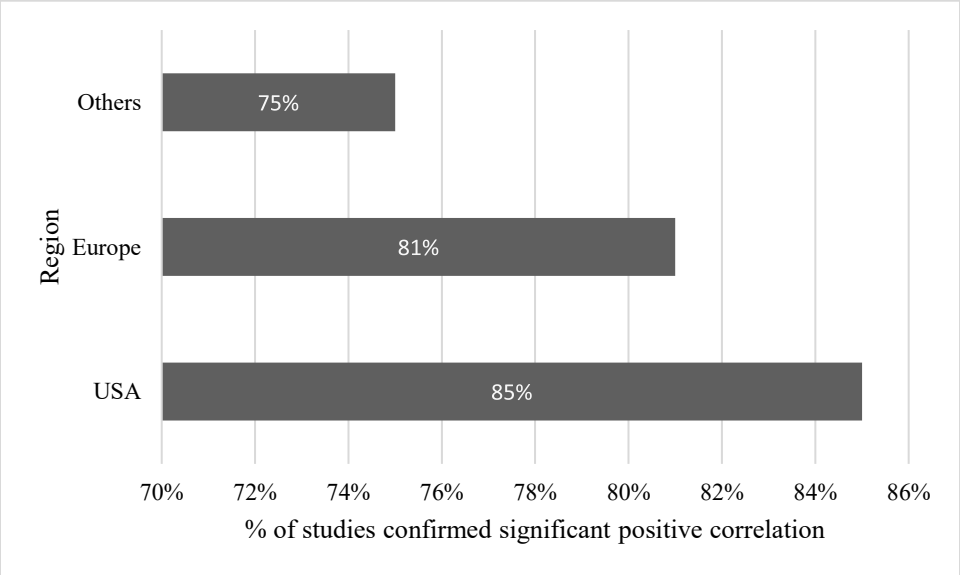

Figure 4. The Percentage of Studies Confirmed A Positive Correlation In Each Geopolitical Region

Table 4. Main Green Certification In Each Region

The geopolitical location of the publication	Main certification type
USA	LEED, Energy Star
Europe	BREEAM, DGNB
Other parts of the world	LEED, Country-specific certifications

V. DISCUSSION

The outcomes indicate that distinct geopolitical regions implement various green certifications. Nevertheless, all of these certifications demand an added investment in MEP, especially in IoT, to attain green status, regardless of the geopolitical zone. Consequently, the aim of this review study was to determine how green certification impacted the rental prices of office buildings. The rental premiums that green-certified buildings received in comparison to non-certified buildings in various geopolitical regions are presented in Tables 5, 6 and 7. Overall, the findings confirmed that tenants in the USA and Europe placed a high value on green office development and were willing to pay a higher rental premium for certified buildings over non-certified ones. This trend also extended to other parts of the world, including Latin America and Asia. However, the green premium varied according to the type of certification within the same geopolitical region. The outcomes of the sample reviews are thoroughly analyzed and scored individually for important geopolitical zones in the next section.

A. Studies conducted in the USA

[33] conducted a notable study in the United States, reporting rent premiums of 5.2% and 3.3% for LEED and Energy Star-rated buildings, respectively, between 2004 and 2007. [34] conducted a similar study, covering data from 1999 to 2009, and found that the buildings with the certification of LEED and Energy Star had increased rent by 3% to 5%, which was consistent with Eichholtz et al.'s earlier findings. Furthermore, the study indicated that a building with dual certification garnered a 9% incremental rent. [35] conducted a study between 2000 to 2010 in the US, which showed

that the buildings certified with Energy Star and LEED commanded a rental premium, and the premium increased between 2006 and 2008 but decreased after 2008, likely due to the economic downturn. [36] obtained similar results, showing that the effective rent remained constant between green and non-green buildings, but both experienced a decrease in rent due to the economic crisis between 2007 and 2009. The evidence suggests that the economic crisis was the sole factor responsible for the decline in rental rates, which impacted both green-certified and non-green buildings.

Green buildings offer significant economic advantages beyond rental premiums. According to research conducted by [37], there is a clear positive correlation between LEED and Energy Star-certified buildings and rental rates, occupancy levels, and selling prices. Corroborating the aforementioned point, several studies conducted in the US market have confirmed that green certification positively impacts occupancy rates [32] [38]. An interesting discovery from an independent study conducted by [39] indicated that commercial mortgage-backed securities (CMBS) for buildings with green certifications demonstrated a 34% lower default rate in loan repayment when compared to conventional office buildings. This indicates that green-rated buildings perform better than their non-certified counterparts. Furthermore, green buildings have been shown to help stabilise rental prices in different real estate market circumstances, mitigating or potentially eliminating certain adverse impacts of economic downturns. [40]. Furthermore, various studies have been published that compare the effectiveness of different green rating systems. One such study, conducted by [41], examined the efficacy of LEED certification and Energy Star ratings and found that the premium associated with Energy Star certifications decreases as buildings age, whereas the premium for LEED-certified buildings remains constant. This suggests that LEED certification is more effective than Energy Star in mitigating the negative consequences of the market, as noted by [40]. This could potentially elucidate the greater popularity of LEED certification over Energy Star in the United States.

It should be noted that not all green features promoted by certification bodies are viewed positively by the public or tenants. To investigate the above, the preferences of renters and their willingness to pay (WTP) for green building amenities were looked at in a study by [42]. The findings revealed that enhanced indoor air quality and abundant access to natural light were identified as the topmost significant features of green buildings, with a reported willingness-to-pay (WTP) premium of 9.3% in total. To determine which green feature increases the rental premium, another study was conducted by [43]. In this study, the floors were categorized into extremely high, high, and low natural daylight levels based on lux level, coverage, and duration, as determined by the researchers. The findings showed that regions with high levels of natural daylight were associated with a premium of 5% compared to regions with low natural daylight levels, while regions with extremely high natural daylight levels commanded a premium of 6.1% over spaces with low natural daylight levels. Furthermore, [44] conducted a study to identify favoured green qualities. They discovered that when tenants see green certification marketed by advertisements, they generally assume that the green qualities are there, and their responses reflect this view.

Despite the preponderance of research conducted in the United States demonstrating a favourable association between green certification and rental rates, [45] revealed that this green premium was evident only in smaller buildings during the period from 2001 to 2011, with limited evidence of such a premium for larger buildings. Adding to this, another study emphasized the need to exercise caution when generalizing findings across various markets within the same country [46]. The authors conducted a targeted investigation into the influence of the political economy on green developments, with a particular focus on A-grade offices. In summary, their findings indicated that rental rates were higher for both green-certified and structures without green certification in blue counties (Democratic) compared to red counties (Republican), as supported by the 2008 election results. This underscores the significant impact of political and economic factors on the rental premiums associated with green certification and highlights the potential influence of market-specific dynamics on the observed outcomes.

In addition, there have been other review studies conducted in the US market to investigate the green premium. For instance, [47] substantiated the existence of green premiums associated with green building certification in the US market. Their research also documented that out of 39 studies, 27 published research papers confirmed a positive correlation between rent and certification, as affirmed by the US Department of Energy. The aforementioned research study revealed that the estimated rental premium ranges from approximately 5% and can even reach up to 20% in certain cases. A separate review study conducted in the US market by [32] corroborated the existence of a green premium when compared to non-certified counterparts. The study also indicated that the rental premium varied from 0% to 23%, based on their review of 71 published research articles.

In conclusion, evidence suggests that green certification in the US market contributes positively to rent, with a potential increase of around 10% for certified buildings compared to non-certified ones, although there are few instances of adverse effects. Nonetheless, variations in this premium may occur across different markets due to political and economic factors, and even within a single market based on its overall performance over time.

B. *Studies conducted in the European continent*

The topic has also been extensively studied in Europe, with the second-highest number of studies conducted on this subject. Similarly, to the US market, the results of these studies have been mixed. Among the studies reviewed, 81% showed a favourable association between rental rates and green status. In contrast to the United States, where LEED and Energy Star are the primary certifications, in Europe, BREEAM and DGNB are the more commonly used certifications. The upcoming subsection will analyze and interpret the findings of research conducted in European countries.

[48] conducted a significant study that demonstrated green-labelled (BREEAM) buildings in the London office market earned 21% higher rental rates and 26% greater sales transactions compared to non-green-certified buildings. This investigation also discovered that for each additional observed green-certified building, the derived rental rate per square meter increased by 1.6%, potentially due to gentrification. However, clustering green buildings caused a 1.4% lower achievable rental rate for each additional green building, indicating that saturation may lead to lower premiums. Similar results were observed by [49] in the Netherlands office market, with rental premiums limited to 6.5% for designated energy-efficient buildings. According to the research findings, the rental rates for buildings with green ratings experienced a decline during the economic recession of 2008-2009. In particular, the research revealed that a mere one-point rise in the energy index resulted in a 5% decrease in the rental rate. However, as the economic conditions improved, there was an upward trend in rental prices for energy-efficient buildings, whereas rental prices for inefficient buildings continued to experience a decline. Consistent with the previous findings, [50] further supported the positive association between green rating and higher rental prices in the office market of Poland. The research suggested that BREEAM rating is the most prevalent certification in Poland's office market, with tenants showing a willingness to pay the highest premium (14%) for certified buildings compared to non-certified ones. Furthermore, the research revealed that tenants demonstrated a willingness to pay an additional 11.4% for the buildings with LEED ratings and 8.6% for DGNB-certified structures. According to [50], tenants in Poland were willing to pay an average premium of around 12.4% for space in buildings with any certification, which aligns with findings from similar research conducted in other European countries in Central and Eastern regions. Expanding on the previous findings, [51] carried out a study that utilized life cycle cost analysis (LCC) to investigate cost-benefit analysis in the office market of Poland. The study affirmed that the additional investment required for obtaining green certification can be recovered within 7 to 12 years, depending on the discount rate utilized (4% or 9%, respectively).

[52] conducted a noteworthy study that demonstrated the favourable impact of BREEAM certification on average rent and prices in London neighbourhoods between 2000 and 2009. The study found that BREEAM-certified buildings commanded a premium of 19.7% for leases and 14.7% for sales transactions compared to non-certified buildings in the same neighbourhood. Additionally, another researcher analyzed data from 19,675 office buildings in Finland, France, and Germany over the period of 2010 to 2015, and found that certified buildings commanded a 19% green premium compared to non-certified buildings, consistent with the results observed in the London office market. A study of 55 development projects in Milan, Italy found that properties certified with LEED Gold and Platinum ratings commanded significant price premiums of 7% and 11%, respectively, in Porta Nuova and the Central Business District [53]. These findings highlight that higher green ratings result in premium prices compared to lower ratings. Additionally, the study emphasized the advantages of achieving green ratings, including a reported fourfold higher market absorption rate in green-certified buildings compared to non-certified buildings. To put it differently, the study reported that the certified properties achieved an 80% leasing rate within six months, while non-certified buildings only managed a 21% leasing rate.

Given the multiple green ratings available in Europe, it is worthwhile to analyse which certification provides the most benefits to developers and what its rating is. Fulfilling the above gap, [54] investigated the effects of BREEAM rating on different UK marketplaces between 2006 and 2010. The study discovered that rental premiums vary depending on the market and time, but they tend to rise with higher BREEAM certification levels. This discovery reinforces the

rationale for property developers to invest in higher certification ratings, as the investment becomes more worthwhile as the rating improves.

However, it's important for developers to not assume that green certification alone will simply result in higher rental rates. The quality of the building, as reflected by its grade, is another crucial and independent factor to take into account. Hence, [55] investigated the effectiveness of green certification by excluding the grade of the building by analysing data from 160 European office buildings. According to the research, properties with top-tier certifications such as LEED-gold or platinum, BREEAM, and DGNB were found to command higher rents and market values, with increases of 23% and 43% respectively. These findings align with similar studies conducted in Europe.

Although the empirical data indicate a correlation between green certification and a higher rental premium, it has been noted that other variables may be responsible for the increased rental rate. Therefore, more well-designed market research is necessary to tackle this matter. A study conducted by [56] aimed to assess the level of importance given to sustainability by tenants in the UK office market between 2006 and 2008. Surprisingly, only a single participant in the study mentioned sustainability, specifically the preference for a BREEAM-rated building, as a factor in their office space selection process. Instead, the primary drivers for relocation were business growth (36%), seeking new locations (30%), and office consolidation (24%). Additionally, the study found that operating costs, including energy expenses, had a limited impact on building selection, which contradicts findings from prior research conducted in Europe.

To sum up, robust research conducted in Europe reinforces the positive link between rent and green certification. Furthermore, the findings indicate that the average premium surpasses comparable US benchmarks by a slight margin.

C. Studies carried out elsewhere around the world

Several studies were conducted globally, beyond the USA and Europe, and some of them are elaborated on below.

[57] conducted a qualitative study which revealed that green buildings tend to have higher rental rates compared to conventional structures, varying between RM 0.50 to RM 2.25 per square foot. Furthermore, the study found that green office structures have greater growth of rental rates that fluctuate between RM 0.50 to RM 1.00 per square foot each year, as well as a 5% higher property value. Similarly, [58] discovered in a study of 59 office buildings in the Shanghai office market that green buildings fetch a 12.8% premium rent above standard office buildings. Furthermore, [58] discovered that the costs of upgrading a conventional design to LEED may be recouped in a year, which contrasts sharply with the findings reported by [51] in the European market.

Similar to the above, there are several research have established the desirable association between green rating and office building rent. Examples of such studies include research conducted in the Central Business District of Kuala Lumpur [59], a study conducted in Sao Paulo [60], as well as a study conducted in Johannesburg, South Africa [61], among others. [61] conducted an analysis of data from 30 Green Star rated buildings and 30 non-certified buildings, revealing a premium rent of 4.5%.

[62] discovered that office premises certified by HKBEAM, BEAM Plus, and LEED had a rental value that was roughly 10.9% higher than non-certified office premises in Hong Kong markets. They also observed that the projected green development cost premium for prime (grade A) office buildings was estimated to be around 7% of the total cost, with an anticipated payback period of two years. According to a recent study conducted by [63], the reported rental premium for LEED-certified offices in China as a whole is 19.5%. In the specific samples from Shanghai and Beijing, the reported rental premiums are 25.5% and 20.8% respectively. [59] conducted a study in the CBD of Kuala Lumpur's Golden Triangle which also indicated that building rental performance can be improved through green certification. Furthermore, in a case study conducted in Sao Paulo, the largest urban area in Latin America, it was demonstrated that office buildings with green certification (LEED-certified) commanded higher rents than their counterparts in developed countries [60]. The study findings also showed that there was no premium observed for office buildings that did not obtain green certification upon completion, in comparison to non-green office buildings. This conclusion was drawn based on data analysis spanning from 2010 to 2014.

Contrary to the findings of Costa et al., green-certified buildings have been found to perform better in many markets, not only in new constructions but also in existing conventional buildings that have been retrofitted to become green. The economic impact of retrofitting buildings to green standards was examined by [64], who found that most

renovations in their selected sample were carried out between 2005 and 2009 and certified between 2008 and 2011. [63]. compared the rent and occupancy rates before and after retrofitting with a control sample, and they demonstrated that both rents and occupancy rates grew similarly to the control sample. A similar finding was reported by [65], who studied the value benefits of energy efficiency retrofits on commercial office buildings in Toronto, Canada, and concluded that retrofitting buildings could lead to an increase in effective rents.

In the literature, some studies examine the connection between green certification and rental rates, while others investigate the willingness of tenants to rent. For instance, [66] conducted a study in South Korea which revealed that tenants showed a higher potential willingness to rent in buildings with green certification. However, the study found that an increase in the level of green certification did not always lead to a greater readiness to rent. [67] reported that after being informed of the green features, most tenants in the Indian office market expressed a willingness to pay a higher rent in the future for green buildings. On the other hand, [38] discovered that class-A buildings commanded a 14.6% rental premium compared to grade C structures, while Energy Star or LEED-certified buildings only received a 2.2% rental premium. This result is consistent with the research conducted by [55] in Europe.

Several studies have shown a positive relationship between green certification and rental rates, but there are some studies that have found no association. For instance, a survey conducted in Malaysia revealed that green buildings were rated the least important feature from the perspective of tenants, likely due to the lack of pressure on authorities to mandate green features and the nascent stage of green building implementation in the country (Adnan et al., 2013). This finding is similar to that of [67]. [68] also found no significant energy efficiency premium or discount for energy-inefficient buildings in Sydney's CBD, despite reduced factor costs, social responsibility, and legal obligations as incentives for tenants to pay a green premium. [69] and [70] similarly found no compelling evidence of a green premium in Toronto's commercial property market. It is possible that the use of gross rent, which obscures the impact of energy efficiency, may have contributed to these findings.

As mentioned earlier, the evidence on the existence of a green premium is mixed, with some studies supporting it and others contradicting it. However, if the green premium is a myth, why do developers still invest in eco-friendly buildings? [71] attempted to answer this question by conducting a survey in Malaysia to explore the driving forces behind such investments. The study found that financial incentives, such as cost savings over the building's life cycle and external financial incentives, such as green tax incentives, were the key motivators for developers to invest in green building development. In contrast, internal incentives, such as environmental responsibility and sustainability, were less important. The findings suggest that further research is needed to support the claim that developers can command a premium rent on green office investments.

Table 5 showcases the rental premiums observed in the United States for green-certified buildings when compared to non-certified buildings.

Table 5. Summary of Findings In The USA

Rental premium per square area over non-certified similar buildings and highlights of other findings	Reference
Landscaping with good aesthetic and good building shades enhances rental rate each by 7%. But, a good visual screen by landscape will reduce rental by 7.5 %	[72]
LEED-certified buildings earn a premium of 10%, and Energy Star buildings earn a premium of 5.76%.	[73]
Green buildings earn a premium of 15.2% to 17.3%, Energy Star buildings earn a premium of 7.3% to 8.9%,	[37]

Rental premium per square area over non-certified similar buildings and highlights of other findings	Reference
LEED-certified buildings earn a premium of 5.2% and Energy Star buildings earn a premium of 3.3%	[33]
Green office properties enjoy rental rate premiums over comparable non-green buildings	[40]
LEED, Energy Star labelled buildings earn a premium of 3% to 5%, and dual-certified buildings earn a premium of 9% An occupancy premium not confirmed to LEED-certified buildings but to Energy Star.	[34]
Energy Star or LEED-certified buildings earn a 5% green rental premium and a 8.9% occupancy advantage	[46]
Energy Star, LEED-certified buildings earn a premium of 2.5% and 2.9% respectively (Fixed effects model). The difference in differences (DID) model confirmed the rent premium for Energy Star but do not suggest for LEED	[35]
Results exhibit significant rental premium after retrofitting conventional buildings into green building	[64]
Green buildings earnt a 4.1% higher rent premium in 2007 and reduced to 1.2% by 2009. Effective rent was fallen 7.5% from 2007 to 2009	[36]
The most important green building attribute as per tenants is public transportation (within 5 minutes)	[74]
Energy Star, LEED-certified buildings earn premiums of 16.4% and 10.6% respectively	[41]
The mandatory requirement to obtain LEED certification for new buildings significantly positively affects market penetration.	[75]
Smaller buildings earn green premiums whereas larger buildings showed limited evidence for green premium	[45]
LEED-certified buildings earn a premium of 10.2% in Canada and 3.7% in the USA whereas Energy Star earn a premium of 2.7% in the USA	[76]
LEED-certified buildings earn a premium of 18.2%, whereas ENERGY STAR labelled buildings earn 3.9%	[44]

Rental premium per square area over non-certified similar buildings and highlights of other findings	Reference
Energy Star or LEED-certified buildings earn a premium of 2.2%, and Class A commands a 14.6% rental premium against grade C buildings	[38]
High daylight (55% to 75% sDA300/50%) earns 5%, Very high daylight (55% to 75% sDA300/50%) earns 6.1% premium	[43]
LEED-certified buildings with certification and platinum levels are statistically insignificant to Average Weighted Rent and LEED silver and gold levels are statistically significant to Average Weighted Rent	[77]
Healthy buildings earn a premium of 4.4% to 7.7% more than non-certified buildings	[78]

Table 6 presents the rental premiums identified in Europe for green-certified buildings in comparison to non-certified buildings.

Table 6. Summary of Findings In The Europe

Rental premium per square area over non-certified similar buildings and highlights of other findings	Reference
Clustering of green buildings leads to lower the achieved rental rate by 1.4% for every additional green building increase	[48]
Designated efficient buildings earn a rental premium of 6.5%- and one-point increase in the energy index results in a 5% reduction in the rental rate.	[49]
Buildings with any certificate earn a premium of 12,4 %, LEED-certified buildings earn 11.4 %, whereas BREEAM and DGNB earn a premium of 14% and 8.6% respectively	[50]
BREEAM-certified buildings earn a 19.7 % rental premium and a 14.7 % premium for sales transactions	[52]
BREEM-certified buildings earn a premium of 23% to 26%. The Premium increases with higher versions of BREEM	[53]
Buildings certified with LEED Gold or platinum, BREEM, DGNB earn a premium of 23%. The market value of those buildings increased by 43%	[54]

Rental premium per square area over non-certified similar buildings and highlights of other findings	Reference
No evidence was found of a willingness to pay more for green buildings	[28]
Green buildings show higher life cycle costs compared to non-green buildings.	[51]
Buildings with LEED Gold and Platinum show a significant premium with 7% and 11% price differentials.	[53]
Green buildings earn a rental premium of 19%.	[79]

In Table 7, the rental premiums for green-certified buildings are presented, highlighting a comparison with non-certified buildings across various regions worldwide.

Table 7. Summary of Findings In Other Parts of The World

Findings – Rental premium per square area over non-certified similar buildings	Reference
Green buildings – Reported higher rental rates of around RM 0.50 to RM 2.25 per square foot and Higher rental growth rates of around RM 0.50 to RM 1.00 per square foot	[57]
Energy-efficient/green buildings scored the lowest in terms of importance by tenants in selecting a new office to occupy	[80]
No significant presence of energy efficiency premium. No strong evidence of discounts for energy-inefficient buildings	[68]
LEED-certified buildings earn a premium of 12.8%.	[58]
Building rental performance can be improved by green certification.	[59]
Water & energy efficiency, site & locality, construction materials, indoor air quality, landscape & design are the 6 key features identified by occupants.	[81]
The correlation between the LEED certification and rental premium is Not statistically significant.	[69]

Findings – Rental premium per square area over non-certified similar buildings	Reference
There is no conclusive evidence that green premium exists in commercial property.	[70]
Effective rent will increase by retrofitting buildings	[65]
LEED labelled office properties in Sao Paulo yield a higher green premium than their peers from developed countries	[60]
Tenants show a higher Willingness to Pay (WTP) for Green-certified buildings. An increase in the grade of certification did not necessarily leads to higher WTP	[66]
Buildings certified with HKBEAM, BEAM Plus, or LEED earn a rental premium of 10.9%.	[62]
WTP premium for green office space is positively related to prior knowledge of green certification.	[67]
LEED-certified buildings earn a premium of 19.5% in China while for Shanghai and Beijing are 25.5% and 20.8%, respectively.	[63]

VI. CONCLUSION & RECOMMENDATIONS

Investing in green accreditation requires developers to allocate funds to various construction and operational aspects, including IoT. This means that the total investment for a green-certified building is higher than that of a non-certified one. Therefore, it is crucial to assess the return on such additional investment. One immediate benefit that building owners receive is higher rent.

To examine the impact of green certification on office rent, relevant literature was reviewed in this study. The key finding is that buildings with green certifications generally earn higher rent than non-certified ones. Research conducted across different regions of the globe, including the US, Europe, and other areas, from 2003 to 2021, has substantiated an 85% green premium in the US, 81% in Europe, and 75% in other regions.

Studies have shown that the effect of green certification on rent can be enhanced if the building is marketed as green-certified [42]. However, the green premium may vary across different markets [46] and change over time, depending on the economic stability of the market. Furthermore, it has been found that higher levels of green certification are associated with increased rental rates in comparison to lower levels, as demonstrated by research conducted by [54].

However, some studies have produced contradictory findings since they only considered the existence of green certification and rental rates without accounting for the occupancy rate. The findings of [36] also support the recommendation to assess rent in relation to the occupancy rate (i.e., relative rent = rent x occupancy rate). In line with the aforementioned, a review study conducted by [47] affirmed that research papers examining value indicators primarily prioritize rent, price, and occupancy rate. Thus, this study suggests that in future studies, relative rent be considered as an endogenous variable. Furthermore, this study suggests that additional research should also focus on energy and sustainability to gain a deeper understanding of the relationship between green features, energy efficiency, rent, and property value.

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