School of Environmental Technology
International Conference Proceedings

ISBN: 978-978-54580-8-4
Received: 29 May 2024; Accepted: 14 October 2024; Available online: 29 November 2024
**Volume 2 proceedings**

# Potential Impact of Smart Building Elements on Commercial Property Investments in Lagos State, Nigeria

*Joy E. Omoare*[a], Unekwu J. Adama[b], Namnso B. Udoekanem[c], Rukaiyat A. Ogunbajo[d]*

Department of Estate Management, Federal University of Technology, Minna, Niger State.
joy-ebashi.omoare@binghamuni.edu.ng

**Abstract**
The impact of smart building elements on commercial property investment in recent years including the landscape of real estate investment has undergone significant transformation across the globe, particularly in emerging economies such as Nigeria. This study explores the potential effect of Smart Building Elements (SBEs) on commercial property investment in Nigeria, as the global narrative of real estate investment has been progressively influenced by the Fourth Industrial Revolution Technologies (Industry 4.0), particularly through the integration of (SBEs). In developed regions like the United States, evidence in literature suggests that investors are securing higher premiums in rents and transaction prices by incorporating technologies such as the smart building elements which include sensors, smart meters, smart security cameras, smart thermostats and smart lighting systems into commercial properties. SBEs address the complex demands of commercial spaces which include enhanced comfort, improved accessibility, heightened security, and efficient energy management. The study methodology is based on a review of published articles in peer-reviewed journals and conferences, accessed from online search engines including Google scholar, ResearchGate and Scispace. Results show SBEs facilitate predictive maintenance, enhance space utilization, achieve significant returns on investment, increase tenant satisfaction and retention. Notably, stakeholders (investors, facility managers and tenants) in the real estate sector are aware and accept SBEs. Nevertheless, predominant literature did not capture the tangible economic impact and the operational benefits SBEs can deliver in Lagos state, Nigeria. This research gap underscores a critical need for in-depth empirical study on how SBEs specifically affect commercial property investment outcomes in Lagos state, Nigeria.

**Keywords:** Smart Building Elements, Real Estate Investment, Commercial Property, Returns, Technology

## 1. Introduction

In recent years, the landscape of real estate investment has undergone significant transformation across the globe. Especially in commercial real estate sub-sector, prime property locations, strategic capital enhancements, and the engagement of skilled professionals are pivotal to optimizing performance and generating substantial returns (Feng and Hardin, 2023). Commercial real estate investment, fundamentally, involves acquiring interests in properties with the aim of generating profits through rental income or capital gains.

The global narrative of real estate investment has been progressively influenced by technological advancements, especially through the integration of Smart Building Elements (SBEs). In developed regions like the United States, evidence suggests that investors are securing higher premiums in rents and transaction prices by incorporating smart building elements such as sensors, smart meters, smart security cameras, smart thermostats and smart lighting systems into commercial properties (Bando-Hano, 2018). These smart building elements are energised by smart technologies including the Internet of things, Artificial Intelligence and Machine Learning, Building Automation, Building Management System, Artificial Reality, Virtual Reality and Aerial Drones. SBEs are revolutionizing the design, construction, and management of building infrastructures, significantly altering traditional real estate practices (Oluwatofumi and Hahn, 2021).

Smart building elements address the complex demands of commercial spaces which include enhanced comfort, improved accessibility, heightened security, and efficient energy management. Emerging literature points to the effectiveness of smart technologies in meeting these needs, offering compelling solutions that are increasingly recognized globally (Kumar *et al*., 2021). In the Asia Pacific region, for instance, the surge in smart building implementations has been attributed to their substantial benefits to stakeholders, enhancing both operational efficiencies and user experiences (Wong *et al.*, 2005).

## 2. Literature Review

In year 2023, the estimated value of the global commercial real estate market was approximately 37 trillion U.S. dollars, up from almost 35 trillion U.S. dollars the previous year. The North America region had the largest market size, valued at over 12 trillion U.S. dollars, slightly higher than Asia-Pacific and Europe, Middle East, and Africa (EMEA) (Statista Research Department, 2024). The dynamic trend in the real estate market activities has a strong impact on economic growth and a nation's wealth creation.

According to Abdulhakim *et al.* (2018), smart buildings could denote automated buildings; intelligent buildings and; buildings embedded with smart technologies. It is a term used to describe structures that include technologies such as digital infrastructure, energy efficiency measures, intelligent building management systems, wireless technologies, remote monitoring, information and communications networks, adaptive energy systems, networked appliances, data gathering devices, assistive technologies and automated systems. Furthermore, Smart building is the interplay of building automation systems, integration systems, and telecommunication systems geared towards the building's efficiency, functionality, optimisation, comfort, and economic stability (Indrawati and Amani, 2017). Figure 2.1 shows a building connected with smart elements.


*Figure 2.1 Smart building (Source: Experts in Smart Buildings)*

There exists interconnectivity among smart building elements. Therefore, it has become paramount to distinguish each element individually according to the unique layer of functionality. Smart building elements include: sensors, smart meters, smart security cameras, smart thermostats and smart lighting systems.

### 2.1 Sensors

Sensors are devices that detect and measure physical or environmental parameters and convert them into electrical signals. These signals are then analyzed to provide valuable insights into building systems. Various types of sensors are commonly used in smart buildings, including temperature sensors, humidity sensors, occupancy sensors, and light sensors. These can detect changes in temperature, humidity, light, and occupancy, allowing for real-time adjustments to building systems and informed decision-making for building operations (Wu *et al.*, 2023).

Smart sensors optimize Heating, Ventilation, and Air Conditioning (HVAC) systems, reducing energy consumption and operational costs (Aliyeva, 2023). By continuously collecting data on energy consumption, sensors provide valuable insights into energy usage patterns, allowing building managers to identify inefficiencies and implement energy-saving strategies. For example, sensors can adjust lighting levels based on occupancy, optimize HVAC systems based on temperature and humidity data, and manage power consumption during off-peak hours.

By monitoring air quality and temperature, these sensors improve indoor environments, positively impacting occupant health and productivity (Wu *et al*., 2023). Temperature control can be optimized based on real-time data collected by temperature sensors, ensuring a comfortable environment for occupants. Air quality monitoring sensors can detect pollutants and trigger ventilation systems accordingly, providing a healthy indoor environment. Additionally, occupancy sensors are used for security purposes, tracking the presence of occupants and triggering alarm systems in case of emergencies.
One among the key advantages of sensors is the ability to collect and analyze data, enabling data-driven decision-making and predictive maintenance in smart buildings. By continuously monitoring building systems, sensors can detect early signs of equipment malfunction or failure. This data is then analyzed to predict maintenance needs, preventing costly breakdowns and optimizing equipment performance, which invariably save cost and increase equipment lifespan.

## 2.2 Smart Meters

Smart meters are advanced digital devices that monitor and record electricity consumption in real-time, significantly enhancing energy management and consumer engagement (Batalla-Bejerano *et al*., 2020). They facilitate two-way communication between consumers and utility companies, allowing for accurate billing and efficient energy usage adjustments during peak demand periods (Pitì *et al.*, 2017).
In recent time, energy consumption and efficiency have become of critical concerns; smart meters have emerged as an innovative solution for managing small businesses and commercial energy metering more effectively (Sovacool, *et al.,* 2021). Unlike analog (traditional) metering, which requires manual readings by meter readers, smart metering provides accurate and up-to-date consumption data that enables both utilities and consumers to monitor and manage energy usage more effectively. Further, Smart meters provide immediate insights into energy consumption, enabling users to track usage patterns and costs (Batalla-Bejerano *et al*., 2020). Figure 2.2 shows a smart electric meter:

*Figure 2.2: Smart electric meter (smsmetering.co.uk)*

Smart meters deployment is crucial for a sustainable energy future in commercial properties, empowering consumers to make informed decisions about energy conservation (Batalla-Bejerano *et al*., 2020; Sovacool, *et al.,* 2021). More so, considering the fact that energy consumption and efficiency have become critical concerns, smart meters have emerged as an innovative solution for managing small businesses and commercial energy metering more effectively.
Smart meters represent a significant evolution from traditional mechanical meters, incorporating electronic technology for improved accuracy and stability (Chakraborty *et al.,* 2021). Because smart meters transmit real-time consumption data, utility companies can charge customers based on their actual usage rather than relying on estimates or manual meter readings. Further, smart meter data can help utility companies better understand and manage grid demand. By analyzing consumption patterns, utilities can identify peak demand periods and implement demand response programs (such as offering incentives for customers to reduce energy usage during peak times).

## 2.3 Smart Security Cameras

A smart security camera is a self-contained, standalone vision system that combines an image sensor, processing capabilities, and connectivity within the housing of the device. Smart security cameras utilize machine learning algorithms to detect intrusions and analyse behaviour, enhancing security by sending alerts to users (Yue *et al*., 2021). These cameras not only capture and store video footage but also have advanced features like motion detection, facial recognition and two-way communication. Connected to Wi-Fi network activates the ability to send the videos to smartphones or save them in cloud storage for conveniences.

Automated video analytics can identify deviant conduct, significantly reducing the frequency of burglaries (Pouyan *et al.*, 2023). This is as a result of being an internet-connected device that captures and stores video footage in cloud storage and local storage (especially microSD cards). Allowing users to remotely access the footage through a smartphone application (or web browser) and send real-time alerts when motion or sound is detected for monitoring purposes. Figure 2.3 shows a smart security camera:

*Figure 2.3 Smart Security Camera (source: techserious.com)*

Smart security cameras can be a worthwhile investment for the enhanced security, convenience and features they offer compared to traditional cameras. By providing remote access and real-time monitoring, smart security cameras give you peace of mind and flexibility in monitoring your property. While the initial cost can be higher than regular cameras, the benefits may outweigh the expense in various setting.

## 2.4 Smart Thermostats

A smart thermostat connects to a Wi-Fi using the internet and other features to optimize Heating, Ventilating, Air Conditioning (HVAC) systems' performance, automatically**.** (Guo and Rasmussen, 2023). Features like real-time monitoring and adaptive control allow for tailored temperature adjustments based on user preferences and environmental conditions (Li *et al.*, 2019). More so, some smart thermostats can be programmed to come-on when an occupant is a certain distance from the work space so the environment becomes properly heated or cooled once you walk in the door. User satisfaction surveys indicate improved comfort levels due to the convenience of remote control and personalized settings (Miu *et al.*, 2019), as shown in Figure 2.4.


Figure 2.4 *Smart Thermostat (*source: *edsairconditioing.com)*

## 2.5 Smart Lighting Systems

A smart lighting system is a lighting technology connected to the internet (Gowda *et al.*, 2021). These smart lights can make decisions, follow schedules and can be controlled remotely using a mobile application or voice-activated personal assistants. Smart lighting systems represent a significant advancement in illumination technology, integrating sensors and digital controls to enhance user experience and energy efficiency. These systems allow for customizable settings, such as maximum illumination levels and operational timings, tailored to user preferences and environmental conditions.

Smart lighting systems are designed to optimize energy usage, thereby minimizing wastage and reducing overall consumption (Chew *et al.,* 2017). This can be achieved through the utilization of energy-efficient lighting sources, such as LED lighting, compact fluorescent lamps (CFLs), and the implementation of advanced control mechanisms that enable the system to adapt to various factors in real-time. Furthermore, users can set parameters like light intensity and duration, preventing glare and darkness while improving convenience.

Smart lighting systems are typically integrated with a network, allowing for remote control and monitoring via a central hub or a connected device such as a smartphone. This connectivity also enables seamless integration with other smart light devices and systems, further enhancing the functionality and convenience of the lighting system. Additionally, advanced systems utilize position and brightness sensors to detect occupancy and external light levels, optimizing energy use by adjusting brightness accordingly (Zou *et al.,* 2018). Figure 2.5 shows a representation of a smart lighting system:


*Figure 2.5 Smart lighting system (source: magikligjhts.com)*

# 3. Critical Factors Influencing SBEs Adoption

According to Olushola (2019) factors affecting SBE adoption include; the intention to adopt and ten independent factors, which are technology readiness, compatibility, complexity, executive management support, firm size, regulatory support, security concerns, cost savings, compatibility and relative advantage. The study of Sfakianaki (2019) on the other hand classified Critical Success Factors into five categories for the adoption and implementation of sustainable smart building concepts which includes environmental; economic; social; design and technique; policy and regulation factors.

Nevertheless, Owusu-Manu *et al.* (2022) stated the success factors influencing the decision to adopt Smart Building Technologies as Instrumentation and Control, Connectivity, Interoperability, Data Management and Analytics, Privacy and Security, IT Professional Support, Top Management Support, Viable Funding Strategy, Stakeholders' Computer Self-Efficacy, Stakeholders' Engagement and Participation and Participation and Collaboration. While Weerawardhana *et al.* (2024) distinctively identified the most essential elements impacting smart building adoption to be competency to utilize new technology, preference for smart building features, and user satisfaction. For the purpose of this study, the following factors influencing the adoption of Smart Building Elements were considered:

### 3.1 Environmental Factor

According to Amani and Rezasoroush (2021), one of the main reasons of environmental pollution is fuel consumption in commercial and residential buildings. Therefore, Khan *et al*. (2023) opined; the optimal control of building environmental variables such as temperature, humidity and light, have significant impacts on indoor environmental quality and building energy efficiency. And such control is usually depending on a variety of sensors to connect the built environment with lighting and heating, ventilation, and air-conditioning (HVAC) systems. Hence, it is important to reduce energy consumption in the built environment.

Additionally, Khan *et al*. (2023) further explained that the energy consumption in the built environment is directly connected to the occupant behaviour in the building. Therefore, knowing the fine-grained occupancy information in the building environment is an important parameter for efficient energy use. To understand the occupant behaviour pattern in the built environment, different kinds of sensors have been used (Xiong *et al*., 2015). The sensor information helps to analyze the occupant behaviour and presence patterns, and thermal and visual preferences, which facilitate the building automation system to create a better control of energy usage and indoor environment quality.

Guan *et al.* (2020) stated that human comfort is linked to occupants' health and work performance, which greatly depend on the indoor environment. Therefore, maintaining the optimal comfort zone and good thermal environment condition in buildings is critical to the built environment. Furthermore, the lighting condition in office buildings also contribute immensely to the occupant's productivity in accordance to the human physiology; daylight is more suitable for the better productivity of the occupant compared with artificial lights.

### 3.2 Technological Factor

Al Dakheel (2020) explained that in Smart Buildings, several technologies must be present in order to facilitate the application of smart features and considered the main key technologies related to the functions of Smart Buildings to include; control system, advanced HVAC and lighting system, renewable energy system, sensors and actuators, smart meters, and energy storage: **Energy Storage system** is identified as the technology that has the ability to capture energy (in batteries of several capacities) and release it subsequently for consumption; **HVAC systems** Smart Building HVAC systems adjust and adapt intuitively to the users' profile, preferences and needs, using real-time weather forecast and grid data; **Smart Lighting** is integrated with the BEMS system to allow information exchange, optimization, built-in occupancy sensors and logic systems to automatically adjust their luminance preference; **Sensors and actuators** are technological interfaces connected to features, functions, and technologies within smart buildings such as DSM, storage systems, real-time monitoring, and BEMS; **Smart Meter** is a technological interface connected to the BEMS that promotes communication between the smart grid and the smart buildings.

### 3.3 Economic Factors

Janhunen *et al.* (2020) discussed from a real estate market perspective the existence of multiple reasons to invest in smart technologies, including energy efficiency and lower operating costs with a predictable decrease in maintenance costs. In addition, to ascertain the impact of smartness on property value through savings in operating expenses and additional income (specifically in the context of energy storage systems and new cash flows from the reserve power markets), with a property case study, found that even a progressive smart building system investment was economically profitable, and the investment generated over 10% return-on-investment along with over EUR 10 million increase in property value. This value-influencing mechanism of a similar investment that enhances sustainability and decreases the operating expenses of properties was confirmed by surveyors in a study by Leskinen *et al.* (2020). Smart buildings have a positive impact on occupant comfort and well-being (Khan *et al*.,

2023) with features such as customized lighting, temperature control, and air quality monitoring, which invariably increase productivity of employees.

Paramount, implementing smart building technologies involves upfront costs that include; installation of sensors, control systems, and data analytics platforms. The study of Ejidike and Mewomo (2023) revealed the first most reported barriers undermining the adoption of smart building elements as the high cost of initial application, nevertheless, long-term financial implications must also be considered; reduced energy expenses and maintenance costs. By implementing energy efficiency measures such as occupancy sensors and smart thermostats technologies, there exists assurance of optimal energy consumption and reducing utility bills.

### 3.4 Social Factor

According to Khan *et al*. (2023) Social and behavioural factors play a significant role in indoor air quality, as they can influence safety, location choices, wellness programs, mental well-being, and human interaction. Building location decisions can consider factors such as proximity to pollution sources, access to green spaces and availability of clean outdoor air. Invariably, a healthy indoor environment facilitates positive human interaction, collaboration, and productivity, fostering a sense of community and satisfaction among occupants (Hafez *et al*., 2023).

It is essential to innovate new locally available systems that integrate cultural elements into the social dimension of sustainability (Sadrizadeh *et al*., 2022). Measuring and comparing indoor environmental quality against benchmark standards, alongside applying novel analytical techniques like option-based conjoint experiments, are essential steps. Models integrating renewable energy, optimized energy consumption, lighting optimization, construction waste management, storm-water quality control, heat-island effect on roofs, and outdoor and indoor air quality are valuable for reducing social impacts (Deng and Wu, 2014).

According to Ismail *et al.* (2023), the smart building concept in the real estate industry is essential for creating a sustainable building, contributing to building structures that meet people's social standards. Indrawati and Amani (2017) revealed that adopting the smart building concept in the Indonesian real estate industry plays an essential role in propelling the overall growth rate of urbanization compared to other non-conforming countries in South-Eastern Asia. According to Shurrab *et al.* (2019), social factors are essential in implementing social value that provides building and human shelter.

## 4. Effects of SBEs on Commercial real estate Investments

In the year 2021, the World Economic Forum convened a multi-stakeholder Taskforce on Digital Transformation to dissect some of the barriers preventing more widespread adoption of smart building solutions within the commercial real estate. One key finding was that technologies are often adopted without proper clarity on the business drivers and the metrics to measure return on investment. Incorporating smart building elements into real estate projects requires an initial investment, but the long-term benefits in terms of cost savings, efficiency, tenant satisfaction, and data-driven decision-making can significantly enhance Return on Investment (ROI) and make properties more competitive in the market (Froufe *et al.*, 2020). Smart building integration offers a number of key ways for real estate developers to maximize their ROI on building projects:

### 4.1 Energy efficiency and cost savings

Smart building elements improve energy efficiency and maximise energy savings over time of the building (Ismail *et al*., 2023). In the study conducted by Froufe *et al.* (2020), smart building elements ensure energy consumed within the building is controlled and monitored in real-time to improve the performance of the building and the environment friendly. Wang *et al.* (2020) evaluated occupants' comfort level using the adaptive model for six different control strategies, the result showed that the occupancy information-based control algorithm can save between 11% and 34% of energy without significantly risking the occupant's comfort level. Hence smart building elements have the potential for energy saving by reducing the unnecessary operation of the energy system in a building.

The integration of smart building elements into real estate projects offer a substantial advantage in terms of energy efficiency and cost savings. Smart buildings employ an array of sensors and automated systems that work in harmony to optimize energy consumption. For instance, advanced HVAC systems can adjust temperature settings based on real-time occupancy data, ensuring the rooms are heated or cooled only when needed. Similarly, intelligent lighting controls ensure that lights are turned off in unoccupied areas, mitigating energy wastage. Over time, the cumulative savings on energy bills contribute significantly to long-term return on investment (ROI) for real estate developers, making smart buildings a financially prudent choice.

### 4.2 Predictive maintenance

According to Minoli *et al.* (2017), among the areas building technologies would make considerable impacts is management. The role of a facility manager is often characterized as reactive, dealing with issues as they arise rather than proactively preventing them, which could be time consuming. However, the advent of smart building elements provides a potential revolution turning the facility management process into a proactive one. Smart buildings with their interconnected environments provide a holistic view of real-time operations across a facility. Through the use of sensors, data is continuously fed into a centralized control platform, providing a wealth of information that allows facilities managers to make informed decisions and focus their efforts on future planning. Furthermore, effective property management ensures that the value of buildings are enhanced and returns maximized, therefore property managers lookout for channels of enhancing the productivity of building assets by embracing modern technologies (Ogolla and Kieti, 2022).

Smart building elements use predictive analytics for resource consumption, operation safety, reduce the embodied and operational energy requirement and reduced operation cost (Baduge *et al.,* 2022). More so, the predictive planning made possible by smart buildings offers several significant advantages which includes unification of control of different types of technological equipment; remote control of technologies without physical presence on the device; the possibility of centralized interventions in the system in the event of a situation in the building or the needs of its users; storing information about actions taken by individual users; reducing the time and cost of monitoring the functionality of building technology.

One among the foreseeable benefits of the application of smart building elements is the ability to facilitate predictive maintenance. Sensors are used to collect the data from the building structure (such as elevators, HVAC systems, and plumbing), faults can be identified and suggestions of methods for rectification (Vaishnavi *et al.,* 2021). By collecting data on the performance of these systems, developers gain invaluable insights into the state of the structure and operational efficiency. This data-driven approach enables developers to schedule maintenance and repairs proactively, addressing potential issues before they escalate into costly breakdowns. By reducing the frequency of unexpected repairs and minimizing downtime, developers can allocate resources more efficiently and extend the lifespan of critical equipment. Consequently, the foresight offered by predictive maintenance is a pivotal factor in smart building ability to deliver sustained financial benefits to real estate developers in the long run.

### 4.3 Occupancy and space utilization

The concept of smart buildings is perceived to be the future of the real estate industry, in spite of the growing need for "smartization" it is still glaring that the performance of a building ultimately depends on its ability to satisfy the needs of those who use them (Hassanain *et al.,* 2024). This relates to the HVAC system because it is responsible for airflow and temperature; to the light system, because it regulates the positioning and intensity of the lighting points; to the telecommunications system, especially regarding the sources of information, entertainment, and internet access; to the vertical transportation system, by reducing efforts and increasing accessibility; and to the hydraulic system, mainly due to the degree of privacy of the facilities, type and convenience of the equipment, and the availability (Froufe *et al*., 2020).

Smart building elements have revolutionized the way real estate developers approach occupancy and space utilization. The systems continuously collect data on how spaces within a building are used, providing valuable information on tenant behaviour and preferences invariably; developers can strategically design layouts that maximize efficiency, optimizing the use of available space. This insight can lead to the creation of flexible co-working spaces or meeting rooms that align with tenant needs, ultimately attracting higher-paying tenants who value such amenities. Further, by tailoring the building layout and amenities to tenant preferences, developers can reduce vacancy rates and boost rental income resulting to bolstering the return on investment (ROI) for the property.

### 4.4 Enhanced security and safety

According to Apanavičienė and Shahrabani (2023), Smart buildings are gradually delving into the IoT applications which includes; physical security solutions, such as video surveillance, fire detection, disaster event communication, and smart security lights. Froufe *et al.* (2020) opined the health factor relates to the HVAC system, majoring on the quality of air, which invariably reduce the chances of contamination and maintain adequate temperature. Security and safety in smart buildings are paramount. Humans require complete safety and good health not minding the type of facility which could be a residential building or commercial building (Al-Betawi *et al*., 2020).

Access control systems and surveillance cameras are integral components of smart buildings, providing robust security measures. To *et al.* (2018) opined that the major factor to the desire to adopt smart building elements and increased effectiveness is the 'human element'; to achieve and satisfy occupants' comfort, safety, security, green environment, and community building. Tenants value a safe environment, and these features contribute significantly to their overall satisfaction. Inclusive in the smart security elements are mobile app-controlled access, smart locks, CCTV cameras and automated package delivery systems. These amenities improve the overall tenant experience and increase the likelihood of tenant referrals and positive word-of-mouth recommendations. Hence, satisfied tenants are more likely to renew their leases; reducing turnover and vacancy rates which in turn positively affect return on investment.

The application of smart building elements are becoming invaluable sources for data, equipping real estate developers to make informed decisions. As technology advances, smart buildings are poised to play an even more pivotal role in shaping the landscape of real estate. This evolution is driven by a clear understanding of the ability of smart buildings to deliver tangible returns on investment (ROI) and enhance overall asset value. The demand for smart buildings is likely to surge as tenants and investors recognize their financial benefits and improved quality of life.

## 5. Potential Economic Impact of Smart Building Elements

Lagos state has been widely accepted as the economic hub of Nigeria, of particular significance is the absolute size of the economy. According to National Bureau of Statistics (2023), capital inflow into Lagos state as at the fourth quarter of 2023 constituted 65.38% of the total capital influx into Nigeria while Abuja (34.07%) and Rivers state (0.55%) followed. Lagos state also houses 70% of the country's total industrial investment and 65% of its commercial activities. This invariably means there exists in Lagos state, number of commercial properties higher than any other state within Nigeria to carry out these economic activities hence, the choice of the study area.

The study of Ngoc *et al.* (2023) investigated the factors that motivate investments in commercial real estate; findings show that cost drivers (payback period and anticipated financial returns) were the top two drivers. Nevertheless, according to the study of Rönkä (2019), smart building elements can enhance commercial real estate returns by increasing productivity, fostering innovation, and creating new income streams through demand response solutions, transforming buildings into active contributors to business success. Additionally, commercial properties can also produce gains streaming from rent and occupancy premiums, more attractive debt terms, higher occupancy rates, reduction in insurance costs, among others.

Smart building elements have the potential to advance the operation and maintenance processes (Marocco and Garofolo, 2021). Functionally, occupancy sensors utilize the ability to identify areas of high usage; enabling facilities managers to schedule preventive maintenance and avoid disruptive breakdowns. Similarly, current sensors can detect potential issues within machinery and supply cables, allowing for early intervention before a costly and time-consuming failure occurs. Invariably, proactive maintenance facilitated by data-driven insights, can extend the life of building elements resulting in cost savings and less environmental waste. And a well-maintained environment free from frequent breakdowns and disruptions, can significantly boost productivity and enhance occupant satisfaction.

The study of Bando-Hano (2018) opined, the adoption of smart building elements, offer a premium in rents (37%) and transaction prices (44%) in commercial real estate, while disintegrated solutions show smaller or no incremental value in the same neighbourhood and over the same time period of 2013 to 2017. According to Janhunen (2023) the economic benefits of smart building elements integration can be evaluated by using the property investment and property valuation perspectives. However, in Nigeria, the parameters to determining the economic impact of SBEs in commercial real estate in Lagos state have not been explored. Nevertheless, studies of Oyewole *et al.* (2019) and Alohan *et al.* (2023) considered the awareness and acceptance of the smart building concept, while the studies of Ejidike (2022) and Adebisi and Wahab (2023) focused on the adoption level of smart buildings, drawing data from construction professionals invariably gearing the studies toward the construction industry.

## 6. Findings

The study on Smart Building Elements (SBEs) and their influence on commercial property investment in Nigeria reveals several key findings:

**Predictive Maintenance Benefits**: Smart building technologies facilitate predictive maintenance through the use of sensors that monitor building systems like HVAC and elevators. This proactive approach helps identify faults early, reducing unexpected repairs and operational costs, ultimately extending the lifespan of critical equipment.

**Enhanced Space Utilization**: Continuous data collection on how spaces are used allows developers to optimize layouts based on tenant behavior and preferences. This leads to the creation of flexible spaces that can attract higher-paying tenants, enhancing overall property value.

**Economic Viability**: Investments in smart technologies are driven by the potential for lower operating costs and energy efficiency. Studies indicate that properties with smart systems can achieve significant returns on investment, with some cases reporting over 10% ROI and substantial increases in property value.

**Tenant Satisfaction and Retention**: The integration of smart security features, such as mobile app-controlled access and surveillance systems, significantly enhances tenant satisfaction. A secure and comfortable environment encourages lease renewals, reducing turnover and vacancy rates, which positively impacts return on investment.
**Awareness and Adoption Trends**: There is a growing awareness and gradual implementation of SBEs in Lagos, Nigeria, indicating a promising trend in the adoption of smart technologies in commercial properties. However, the overall adoption rate in Africa remains slow compared to developed regions.
**Research Gaps**: Despite the awareness of SBEs among stakeholders, there is a lack of empirical studies capturing the tangible economic impacts of these technologies. This highlights the need for comprehensive research to understand how SBEs affect investment outcomes in the commercial real estate market.
**Future Implications**: The demand for smart buildings is expected to increase as both tenants and investors recognize the financial benefits and improved quality of life that these technologies offer. This evolution is crucial for shaping the future landscape of real estate investment.
These findings underscore the transformative potential of smart building elements in enhancing operational efficiency, tenant satisfaction, and overall property value in the commercial real estate sector.

## 7. Conclusion

Despite the evident advancements, the adoption of smart building elements in Africa has been comparatively slow, this is evident in countries like South Africa (Kotzé, 2019), Kenya (Ogolla and Kieti, 2022), and Nigeria (Alohan *et al*., 2023; Ejidike, 2022; Oyewole *et al*., 2019). The study of Opawole *et al*. (2023) indicates a promising trend in Lagos, Nigeria, where there is an increased awareness and gradual implementation of smart building elements in commercial properties. These adaptations are primarily motivated by the potential for significant reductions in operational and energy costs, maximization of profits, and enhanced efficiency of building service appliances (Adebisi and Wahab, 2023). Smart integration may represent a pivotal breakthrough in Nigerian commercial real estate sector, signalling a paradigm shift towards more sustainable and economically viable practice.
The implications of these changes are profound, suggesting a critical need for comprehensive research to understand the specific impacts of smart building elements on the commercial real estate market in Nigeria. Holistic investigations should be made into the factors that influence the adoption of SBEs and the satisfaction level of stakeholders of commercial properties as to the effects of the SBEs on productivity, cost savings, energy efficiency, security and maintenance in the study area. Further, the returns on investments of commercial properties with and without SBEs integration should be assessed and compared to determine the dynamics of the investment returns in Lagos state, Nigeria.

## Reference


Abdulhakim, S., Abdulhakim, M., Abdelgader Eissa, H., 2018, Implementation of Smart Building (A Complete End to End Solution for Smart Building System), In International Conference on Green Energy & Environmental Engineering, Proceedings of Engineering and Technology 38(15).

Adebisi, O. D., & Wahab, A. B., 2023, Factors Influencing Adoption of Building Management System in Commercial Buildings in Lagos State, Nigeria, African Journal of Housing and Sustainable Development, 4(1), 49-59.

Al Dakheel, J., Del Pero, C., Aste, N., Leonforte, F., 2020, Smart buildings features and key performance indicators: A review, Sustainable Cities and Society, 61

Al-Betawi, Y. N., Al Nassar, F. H., Al Husban, A. A., Al Husban, S., 2020, Transformations in the built form as a reflection of social change, the case of apartment buildings in Amman. Open House International, 45(1/2), 143-171.

Aliyeva, A., 2023, Securing the Digital Diplomacy Frontier: A Global Perspective in the Cyber Era with a Focus on Azerbaijan, AGORA Int'l J. Jurid. Sci., 17(118).

Alohan, E. O., Oyetunji, A. K., Amaechi, C. V., Dike, E. C., Chima, P., 2023, An Agreement Analysis on the Perception of Property Stakeholders for the Acceptability of Smart Buildings in the Nigerian Built Environment, Buildings, 13(7).

Amani, N., & Rezasoroush, A., 2021, Building energy management using building information modeling: Evaluation of building components and construction materials <philpapers.org> accessed 15.07.2024.

Apanavičienė, R., & Shahrabani, M. M. N., 2023, Key factors affecting smart building integration into smart city: technological aspects, Smart Cities, 6(4).

Baduge, S. K., Thilakarathna, S., Perera, J. S., Arashpour, M., Sharafi, P., Teodosio, B., Mendis, P., 2022, Artificial intelligence and smart vision for building and construction 4.0: Machine and deep learning methods and applications, Automation in Construction, 141.

Bando-Hano, A. K, 2018, The incremental value of smart buildings upon effective rents and transaction prices (Doctoral dissertation, Massachusetts Institute of Technology).

Batalla-Bejerano, J., Trujillo-Baute, E., Villa-Arrieta, M., 2020, Smart meters and consumer behaviour: Insights from the empirical literature, Energy Policy, 144.

Chakraborty, S., Das, S., Sidhu, T., Siva, A. K, 2021, Smart meters for enhancing protection and monitoring functions in emerging distribution systems, International Journal of Electrical Power & Energy Systems, 127.

Chew, I., Karunatilaka, D., Tan, C. P., Kalavally, V., 2017, Smart lighting: The way forward? Reviewing the past to shape the future, Energy and Buildings, 149, 180-191.

Deng, Y., & Wu, J., 2014, Economic Returns to Residential Green Building Investment: The Developers' Perspective Reg. Sci. Urban Econ. 47, 35–44,

Ejidike, C. C., 2022, An assessment of the adoption of smart building concept in the Nigerian construction industry (Doctoral dissertation).

Ejidike, C. C., & Mewomo, M. C., 2023, Benefits of adopting smart building technologies in building construction of developing countries: Review of literature, SN Applied Sciences, 5(2), 52.

Feng, Z., & Hardin III, W. G., 2023, Investment and Capital Improvements in Commercial Real Estate: The Case of REITs, The Journal of Real Estate Finance and Economics, 1-32.

Froufe, M. M., Chinelli, C. K., Guedes, A. L. A., Haddad, A. N., Hammad, A. W., Soares, C. A. P., 2020, Smart buildings: Systems and drivers, Buildings, 10(9), 153.

Gowda, V. D., Annepu, A., Ramesha, M., Kumar, K. P., Singh, P., 2021, IoT enabled smart lighting system for smart cities, In Journal of Physics: Conference Series 2089, 1(012037).

Guan, H., Hu, S., Lu, M., He, M., Zhang, X., Liu, G., 2020, Analysis of human electroencephalogram features in different indoor environments, Building and Environment, 186.

Guo, F., & Rasmussen, B., 2023, Performance benchmarking of residential air conditioning systems using smart thermostat data, Applied Thermal Engineering, 225, 120195.

Hafez, F.S., Sa'di, B., Safa-Gamal, M., Taufiq-Yap, Y.H., Alrifaey, M., Seyedmahmoudian, M., Stojcevski, A., Horan, B., Mekhilef, S., 2023, Energy Efficiency in Sustainable Buildings: A Systematic Review with Taxonomy, Challenges, Motivations, Methodological Aspects, Recommendations, and Pathways for Future Research, Energy Strateg. Rev., 45.

Hassanain, M. A., Sanni-Anibire, M. O., Mahmoud, A. S., 2024, An assessment of users' satisfaction with a smart building on university campus through post-occupancy evaluation, Journal of Engineering, Design and Technology, 22(4), 1119-1135.

Indrawati R.Y., & Amani H., 2017, Indicators to measure a smart building: an Indonesian perspective, Int J Comput Theory Eng 9(6):406–411.

Ismail, K. A., Lino, F. A., Henríquez, J. R., Teggar, M., Laouer, A., Arici, M., Rodríguez, D., 2023, Enhancement techniques for the reduction of heating and cooling loads in buildings: a review. Journal of Energy and Power Technology, 5(4), 1-44.

Janhunen E., Leskinen N., Junnila S., 2020, The Economic Viability of a Progressive Smart Building System with Power Storage. *Sustainability*, 12(15)

Janhunen, E., 2023, Is smart profitable for real estate?-Evaluating the viability of smart energy management system investments for real estate owners, <scholar.google.com> accessed 28.07.2024.

Khan, M. M. H., Bashir, M. T., Sikandar, M. A., Alrowais, R., Syed, S., Zahid, N., Zawar, A., 2023, Green Buildings and Indoor Air Quality: A Health and Technological Review, <scholargoogle.com> accessed 19.08.2024.

Kotzé, P., 2019, South Africa's journey to development via science, technology and innovation, Water Wheel, 18(5), 46-49.

Kumar, A., Sharma, S., Goyal, N., Singh, A., Cheng, X., Singh, P., 2021, Secure and energy-efficient smart building architecture with emerging technology IoT, Computer Communications, 176, 207-217.

Leskinen, N., Vimpari, J., Junnila, S., 2020, Using real estate market fundamentals to determine the correct discount rate for decentralised energy investments, Sustain. Cities Soc. 53.

Li, W., Zhang, J., Zhao, T., 2019, Indoor thermal environment optimal control for thermal comfort and energy saving based on online monitoring of thermal sensation, Energy and Buildings, 197, 57-67.

Marocco, M., & Garofolo, I., 2021, Integrating disruptive technologies with facilities management: A literature review and future research directions, Automation in Construction, 131.

Minoli, D., Sohraby, K., Occhiogrosso, B., 2017, IoT considerations, requirements, and architectures for smart buildings—Energy optimization and next-generation building management systems, IEEE Internet of Things Journal, 4(1), 269-283.

Miu, L. M., Mazur, C. M., van Dam, K. H., Lambert, R. S., Hawkes, A., Shah, N., 2019, Going smart, staying confused: Perceptions and use of smart thermostats in British homes, Energy Research & Social Science, 57.

National Bureau of Statistics, 2023 <www.nigeriastat.gov.ng> accessed 02.8.2024

Ngoc, N. M., Tien, N. H., Hieu, V. M., 2023, The relevance of factors affecting real estate investment decisions for post pandemic time, International journal of business and globalisation.

Ogolla, W., & Kieti, R., 2022, Application of Building Management System (BMS) in Commercial Property Management in Kenya, Understanding African Real Estate Markets, 188.

Olushola, O. B., 2019, Factors affecting IoT adoption, IOSR J. Comput. Eng. (IOSR-JCE), 21, 19-24.

Oluwatofumi, A. D., & Hahn, J., 2021, An Appraisal of the Adoption of Innovative Technologies for Sustainable Real Estate Practice in Edo State, Nigeria, In The 20th Annual AFRES Conference (p 18).

Opawole, A., Olojede, B., Oshin, F., Yusuf, A., 2023, Assessment of the level of awareness of intelligent buildings in Lagos State, Nigeria, Acta Structilia, 29(2), 116-149.

Owusu-Manu, D. G., Ghansah, F. A., Ayarkwa, J., Edwards, D. J., Hosseini, R., 2022, Factors influencing the decision to adopt Smart Building Technology (SBT) in developing countries, African Journal of Science, Technology, Innovation and Development, 14(3), 790-800.

Oyewole, M. O., Araloyin, F. M., Oyewole, P. T., 2019, Residents' awareness and aspiration for smart building features: The case of Okota, Lagos, Nigeria, Nigerian Journal of Environmental Sciences and Technology, 3(1), 30-40.

Pitì, A., Verticale, G., Rottondi, C., Capone, A., Lo Schiavo, L., 2017, The role of smart meters in enabling real-time energy services for households: The Italian case, Energies, 10(2), 199.

Pouyan, S., Charmi, M., Azarpeyvand, A., Hassanpoor, H., 2023, Propounding first artificial intelligence approach for predicting robbery behavior potential in an indoor security camera, IEEE Access, 11, 60471-60489.

Rönkä, E., 2019, Rethinking smart buildings: Real estate as an active contributor to business success, Corporate Real Estate Journal, 9(2), 111-120.

Sadrizadeh, S., Yao, R.; Yuan, F., Awbi, H., Bahnfleth, W., Bi, Y., Cao, G., Croitoru, C., de Dear, R., Haghighat, F., 2022, Indoor Air Quality and Health in Schools: A Critical Review for Developing the Roadmap for the Future School Environment, J. Build. Eng.

Sfakianaki, E., 2019, Critical success factors for sustainable construction: A literature review. Management of Environmental Quality: An International Journal, 30(1), 176-196.

Shurrab, J., Hussain, M., Khan, M., 2019, Green and sustainable practices in the construction industry: A confirmatory factor analysis approach. Engineering, Construction and Architectural Management, 26(6), 1063-1086.

Sovacool, B. K., Hook, A., Sareen, S., Geels, F. W., 2021, Global sustainability, innovation and governance dynamics of national smart electricity meter transitions, Global Environmental Change, 68.

Statista Research Department, 2024, <www.statista.com> accessed 02.8.2024

To, W. M., Lai, L. S., Lam, K. H., Chung, A. W., 2018, Perceived importance of smart and sustainable building features from the users' perspective, Smart Cities, 1(1), 163-175.

Vaishnavi, M. G., Vedanth A., Sanjay, S., Vimal, A., Neethu, U., 2021, Structural Monitoring using Smart Materials and Internet of Things (IoT), International Journal of Engineering Research & Technology (IJERT), 9(1), 49-51.

Wang, C., Pattawi, K., Lee, H., 2020, Energy saving impact of occupancy-driven thermostat for residential buildings, Energy and Buildings, 211.

Weerawardhana, S., Weerakoon, T. G., Wimalasena, S., Moganaraj, N., 2024, Factors Influencing the Adoption of Smart Building and Service Preferences in Sri Lanka, Baltic Journal of Real Estate Economics and Construction Management, 12(1), 18-35.

Wong, J. K., Li, H., Wang, S. W., 2005, Intelligent building research: a review, Automation in Construction, 14(1), 143-159.

Wu, L., Chen, Y., Shen, K., Guo, X., Gao, H., Li, S., Long, B., 2023, Graph neural networks for natural language processing: A survey, Foundations and Trends® in Machine Learning, 16(2), 119-328.

Xiong, X., Zheng, K., Xu, R., Xiang, W., Chatzimisios, P., 2015, Low power wide area machine-to-machine networks: Key techniques and prototype, IEEE Communications Magazine, 53(9), 64-71.

Yue, Y., Li, S., Legg, P., Li, F., 2021, Deep Learning-Based Security Behaviour Analysis in IoT Environments: A Survey, Security and communication Networks (1).

Zou, H., Zhou, Y., Jiang, H., Chien, S. C., Xie, L., Spanos, C. J., 2018, WinLight: A WiFi-based occupancy-driven lighting control system for smart building, Energy and Buildings, 158, 924-938.