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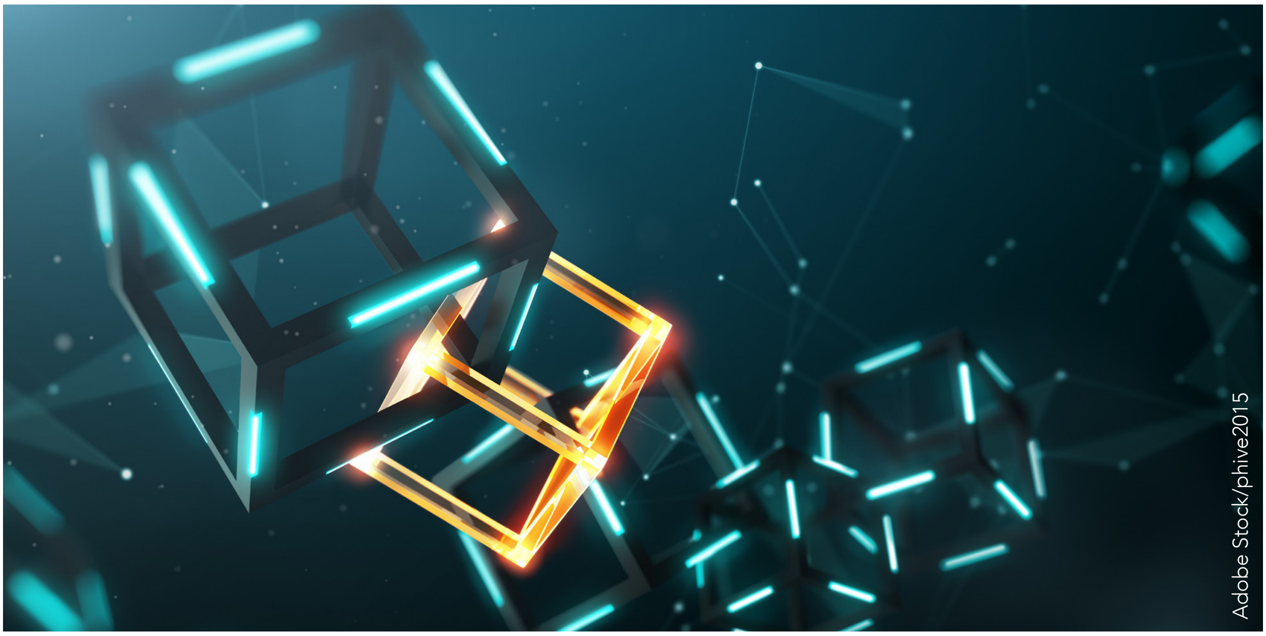
Blockchain and Smart technologies in asset, property, and facility management



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Property Research Trust

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Foreword

Technological advances are disrupting businesses and whole sectors at a seemingly ever-increasing pace. It is clear that smart building technologies, investment in data collection and storage, use of robotics and smart contracts using blockchain are all impacting critical aspects of the built environment.

Using case studies informed by market participants, this important research examines in detail the benefits and challenges facing the property sector as it adopts new technologies. This report's recommendations will help inform built environment professionals as they tackle the introduction of transformatory technologies in buildings where communities live and work.

I am delighted that the Property Research Trust has been able to provide a home for this research and I am grateful to the distinguished team of academics who undertook it and who have written this report.

Alan Dalgleish
Chair, Property Research Trust

Executive summary

Purpose and scope

This study examined the benefits and challenges offered by the uptake of 'smart' building technologies, such as blockchain and artificial intelligence (AI), on asset, property, and facilities management activities in commercial buildings in Australia. Property has been one of the slower and more resistant industries to integrate smart technologies: however, technological disruption is now having a significant impact on the built environment. This is particularly evidenced by the growth in popularity of smart buildings, with global corporations now striving to be located in such flagship buildings.

Existing technologies, such as Building Management Systems (BMS), continue to be important and can be expanded to allow for further data to be collected and building efficiencies to be enhanced. The advancement of Building Information Modelling (BIM) that stores building drawings in 3D and operating information at the construction stage, can be run in conjunction with established BMS to provide a more efficient picture of the building infrastructure and operation. Software packages such as Aconex, which can collect and store the drawings and communications in the construction stage, can also be used for the management of communications relating to the ongoing operation of the building.

With a combination of these technologies, the building information and lifecycle costings will allow property and facility management to be accurately recorded and a long-term asset management plan to be developed.

Investment in data collection and storage has become an important component of efficient property asset and facility management. Effective data capture allows for better management and therefore a more informed decision-making process. Operating costs can be reduced by being able to accurately predict the requirements for cleaning and maintenance, which are major components of any building operating budget. Data collection is not constrained to predictions for operating expenses – it can also be used to increase income generation. This can be achieved through more accurate targeting of advertising sales, maximising car parking rental, along with optimising the tenancy mix.

It is important for the raw data to be collected in a format appropriate for mining and stored with minimal loss. Data can also be used to enhance a tenant's business and turnover, where information is collected to understand customer purchasing behaviour. Data capture is a highly valuable asset in its own right and should be controlled by building owners to allow for mining and subsequently, more informed decision-making.

The use of robotics in cleaning and waste management, in conjunction with effective and meaningful collection of data, can reduce operating expenses by more accurately predicating cleaning requirements, and reducing waste handling and disposal costs.

Centralised services provide efficiencies by allowing benchmarking of expenses and asset lifecycles to ensure costs are minimised through proactive management. Remote management of buildings and services is an important tool that can be used during national emergencies and have proved to be even more important during the Covid-19 pandemic and the limits to social personal interactions and movements that were imposed.

Meanwhile, the management of buildings in remote locations can be improved by a variety of technologies, such as BMS and CCTV systems, that enable managers to be located offsite. Centralised services can also provide the added benefit of allowing the amalgamation of service contracts and minimising the requirements for maintenance.

Smart contracts and the use of blockchain technologies in property management are still in their infancy. However, there appears to be a willingness to learn more about the potential these technologies can add to transacting, record keeping and building providence, and how an integrated technological approach can enhance efficiencies and save costs.

Methods

Through the analysis of case studies and interviews with leading asset and property professionals, this study attempts to identify the implications of using smart technologies in commercial buildings in respect to asset, property and facility management practices and strategies.

Three buildings were investigated as case studies: The EDGE (Amsterdam, Netherlands); International Towers (Sydney, Australia); and Olderfleet (Melbourne, Australia). These are three very different commercial developments. The EDGE was purpose built as a state-of-the-art smart building. The International Towers were built as three sustainable commercial office buildings as part of a 22-hectare development site in Sydney's Barangaroo area. Olderfleet is a contemporary 38-storey office tower located behind a heritage-listed building in Melbourne and completed in 2020.

These case studies outline smart building technology best practice and examine how such technologies can be encouraged in commercial buildings in Australia, while considering barriers and challenges. This information was then applied to formulate interview questions for the second phase of the study, which comprised three one-to-one in-depth interviews with high-level property professionals.

Interviewees were selected from a wide range of property companies that develop, invest in, manage and occupy smart commercial buildings. Participants were employed by an Australian Real Estate Investment Trust

(REIT), a global commercial and residential property consultancy and management company, and an international infrastructure and property development company. Each interview lasted over an hour and the questions were designed to gain an in-depth understanding of perceptions and experiences related to the use of smart building technologies in asset, property and facility management-related operations and decision-making.

Results

The core messages emerging from the interviews can be summarised under four headings: smart building technologies; financial benefits; risks and challenges; and lessons learnt.

Smart building technologies

The appetite for smart building technologies is driven first and foremost by owner-occupiers of buildings. Furthermore, for smart building technologies to be adopted, executive teams and boards need to be supportive of them and innovation in their assets. Some property firms have invested in dedicated teams with skillsets that go beyond asset, property, and facility management, who work on developing integrated, centralised and automated systems. This allows professionals with specialist knowledge to develop new ideas and technologies for large commercial developments.

The areas impacted by smart building technologies include: car parking; building security; cleaning; waste management; supply of utilities; heating, ventilation, and air conditioning (HVAC) services; and centralised control rooms.

Financial benefits

Centralised BMS and comprehensive data collection brings improvements in maintenance planning and long-term asset management, which helps to reduce unnecessary duplication of costs. Property companies can also collate the data for data mining. The collection and analysis of large datasets can, for example, inform retailers about customer habits, influencing retail location and advertising decisions.

Data capture can also result in better decision-making, more efficient adjustments of maintenance and cleaning times, and improvements in tenant mix. Smart building technologies for tagging and bar coding of assets, and data storage, allow better control over location, maintenance and lifecycle of assets. There are also new opportunities, such as the storage and sale of electricity off the grid via blockchain, and automated waste collection.

Risks and challenges

Prior to adopting smart building technologies, building owners and property managers must ascertain how such technologies can provide efficiencies and financial benefits for their assets. Any uptake of these technologies is dependent on the owner's appetite for innovation as well as the level of knowledge of the individuals managing the asset. The existing literature and the results of this study suggest that there is a slow uptake of smart building technologies such as blockchain, and little knowledge of what opportunities are on offer.

Data capture is a useful and lucrative practice. The main issue is who owns and controls the data, particularly when a third party is collecting and storing it. And there continues to be limits to what knowledge data can provide. For example, pedestrian traffic measured in common areas of retail centres does not explain why people are not visiting the site. There is also scope to ensure data accuracy, which can also be important for decision-making, and occupational health and safety and maintenance concerns.

Lessons learnt

- There is less innovation and use of smart building technologies when buildings are managed by property leasing companies.
- Great value exists in the data captured and how it is controlled. It is highly useful information about the building, facilities management, management of tenancies and can assist in determining net operating incomes. This is raw data which can be used as an asset to sell on, or for data mining purposes.
- Data capture requires excellent infrastructure, such as high-speed wi-fi.
- Retail centres are more advanced than other developments in the capture of data via people movement, TCS laser and thermal counting systems.
- Capability for remote management is important during national emergencies, and where geographical location makes it beneficial.
- Data collected can influence redesign and relocation of amenities, and cleaning schedules.
- Centralised BMS and comprehensive data collection provide for improved efficiencies for planning maintenance, long-term asset management planning, and avoid duplication of costs.
- Smart building technologies can enhance sustainability by offering social, economic and environmental benefits.
- There is a need to understand objectives of owners and managers for operation of buildings before smart technologies can be introduced. The financial benefits of each technology need to be ascertained prior to adoption.
- Corporate building managers are primarily focused on day-to-day management activities and not actively investigating smart building technologies. This can be contrasted with buildings managed by owner-occupiers or REITs, who are more proactive in investigating and implementing smart building technologies to make the building more efficient and to lower operating costs. These developments, on balance, are more inclined to implement smart building technologies.

The core messages from the case studies are:

The uptake of smart building technologies and continued interest in these are more likely if the owner (or REIT) is directly involved and has their own in-house property management team. Smart technologies applied to building functions and furniture components, such as lighting, sanitary facilities, coffee machines, printers, waste collections, and occupancy sensors can help plan for demand in terms of energy use, space utilisation and resource management. Comfort and wellbeing (WELL certification) are also important and impact on employee productivity. Privacy continues to be a concern of employee users who opt out of tracking devices and apps to book rooms etc.

The case studies suggest that data ownership is uncertain at building completion. This is a concern for owners and occupiers, as there is real value in data which can assist with asset and facility management. Current smart buildings are intent on energy saving, especially with lighting and amenities. The case study literature suggests smart technologies are more commonplace in Europe and North America. In Australia there has been a pick-up in WELL certification for the built environment.

Conclusions

The study highlights some important findings for the introduction of smart building technologies into commercial buildings. Some of these findings will need to be reconsidered in light of the Covid-19 pandemic and the recent Australian bushfires.

From the study, we conclude that BMS, CCTV and other traditional technologies continue to be core functions, which can be upgraded and adapted through smart building technologies, especially as they relate to remote management.

Data capture allows for better management and decision-making, as well as more efficient adjustment of maintenance and cleaning times, security controls, maximisation of advertising, and the improvement in tenant mix optimisation. This also offers opportunities to reconsider the importance of sound data collection, which can feed into remote management practices, particularly as the ability to have remote management has been so important during national emergencies, as was evidenced during the recent bushfires.

As data capture is highly valuable, it should be controlled by owners to allow for mining and subsequent decision-making for retail location, advertising, car park operations, security, maintenance, and cleaning. Furthermore, the findings show that smart building technologies allow for improved efficiencies in waste management and energy usage.

Introducing smart building technologies and upgrading existing ones allow for efficiency gains by amalgamating service contracts, centralising services, using robotics for cleaning and waste management, and extensive accurate data collection. To achieve such outcomes, quality teams need to be created for the implementation of smart building technologies in building management, with a mix of staff skills to capitalise on specialist knowledge.

While there are opportunities for advanced technology uptake, there is still significant scope to consider the use of smart contracts and blockchain technologies in new areas such as the on-selling of electricity off the grid, and record keeping. Such change, however, was not at the forefront of thinking for most of the managers interviewed.

Recommendations

From the literature, case studies and in-depth interviews with specialists in property and asset management, we have put forward some recommendations on the implementation of smart building technologies into commercial buildings.

First, there is a case for more careful planning for existing buildings before embarking on a technological upgrade. To avoid significant disruption, managers should wait until tenancies end before undertaking upgrades. This is an opportunity to enhance older BMS systems, as well as to carefully introduce technologies which are more efficient. However, the purpose of such updating must be carefully planned, as there are now numerous technologies available on the market, from augmented reality products to AI systems. A more integrated approach, for example encompassing BIM/BMS/AI/AR, should be contemplated.

Built environment professionals should gain skills and knowledge on big data analytics and smart building technologies such as blockchain, AI and AR for asset, property, and facility management. This will require property companies to invest in education, ongoing training and upskilling of staff.

Awareness of sensitive privacy and ethical considerations must be raised before implementation of any advanced technology. As part of the company’s corporate social responsibility, there may be a need to engage an ethics officer to ensure data is collected ethically and privacy regulations are respected, particularly with further data mining.

Smart building technologies offer fresh and exciting opportunities for remote management to be recast with consideration of the impact of Covid-19 and the Australian bushfires. Australia’s experience of both emergencies offers an opportunity for it to become a world leader in remote building management.

After the closure of many commercial buildings due to Covid-19, there is scope for AI/AR and other technologies to facilitate the return to offices within the context of social distancing and facilities management.

Lastly, it is important for building owners to ensure future contracts allow for them to own and control data collection, so that this raw data can be used for data mining or other purposes as required.

Chapter 1 Introduction

In recent times, technology disruption has had significant impacts on every aspect of the built environment. Smart sensors, smart materials and smart meters are seen as the latest and most innovative technologies available to create high-performing buildings (Buckman et al, 2014). In addition, smart buildings are increasingly using various technologies such as different forms of artificial intelligence (AI) – machine learning, natural language processing (NLP), robotic process automation (RPA) (Pearce, 2018) – predictive and social media analytics, big data analytics, news and events sentiment analysis, and text mining (Sivaramakrishnan, 2017).

These technologies provide opportunities for building owners and operators to manage buildings with greater cost, time, and energy efficiency while utilising workspaces in a way that best fits the company culture and goals. As a result, the asset and property management industry is one of the sectors most exposed to disruption, where smart building technologies are expected to have significant and lasting impact on their operations.

AI as a tool for problem solving is not new (Greenleaf et al, 2018), but working in harmony with technologies such as the Internet of Things (IoT) and blockchain, it can ensure buildings run more effectively, providing greater sustainable and economically efficient outcomes. AI has been defined as “the theory and development of computer systems able to perform tasks that normally require human intelligence” (Schatsky, 2014) and takes numerous forms such as Robotic Process Automation (RPA), which formulates reasoning through pattern recognition of large quantities of data. Furthermore, there is ‘autonomics’, where systems can complete routine tasks by interfacing with existing applications to process transactions and responses faster than a human (Schatsky, 2014).

With the help of these technologies, all information about buildings can be compiled into various data rooms and can then act as the building ‘passport’ (Veuger, 2018). As a result, any interested party would be able to extract information, such as tenant information, property valuations, history and maintenance plans of the building and its operational cash flows from various data rooms. Furthermore, with the use of BIM, information about the design and materials used in buildings, responsibilities for installation technology and refurbishment requirements of buildings (Veuger, 2018) can be recorded and transferred.

Such technologies help asset and property managers to better analyse various sources of data and recognise patterns within the large volumes of data. They also provide a means to optimise space utilisation, outsourcing of service delivery, design of low-energy buildings, implementation of reliability-centred operation and maintenance processes, and deployment of innovative technology into the operations (Atkin and Bildsten, 2017). These technologies offer enormous potential for asset and property managers to create more effective property and asset management strategies and reduce portfolio and property-specific risks which would eventually lead to high returns on investments over the long run.

However, most asset and property management firms are yet to explore the extensive potentials of AI and other smart building technologies, and the use of such technologies in these sectors is still at its infancy (Borg, 2018). Many buildings are still using dated technology platforms and high levels of customised manual activities which have a significant impact on their operational costs, building efficiencies and environmental concerns. It is suggested that the asset and building management industries employ large numbers of employees due to the inefficiencies caused by the systems and processes that are currently being used (Deloitte, 2017).

As a result, in recent years the asset and property management industries have looked at ways to employ various smart building technologies and voluminous data to support their decision making and operational functions.

1.1 Aim and objectives

The aim of this study is to examine how companies are making use of smart building technologies in their asset, property, and facility management activities in commercial buildings in Australia. It examines the benefits offered by those technologies, and the barriers and challenges of implementing smart technologies into commercial buildings. It also explores buildings of excellence to identify their best practices and what implementation lessons can be learnt for commercial buildings in Australia. By utilising case study analysis and interviews with asset and property managers, this study seeks to identify the implications of the use of smart building technologies in commercial buildings on their short-, medium- and long-term asset, property and facility management practices and strategies. The aim of the research is broken down into following objectives:

1. Undertake an extensive review of smart building technologies used in asset, property, and facilities management in contemporary commercial buildings.

2. Examine the financial and non-financial implications of such technologies on asset, property and facility management activities.

3. Identify smart building technologies employed in best practice buildings and examine how such technologies can be encouraged in commercial buildings in Australia.

4. Examine the barriers and challenges of implementing smart technologies used in best practice in the Australian context.

5. Provide recommendations on how to address such barriers and challenges.

Chapter 2 gives an overview of the study and reviews the existing literature. The methodology is then presented followed by a summary of the results. The concluding section highlights the key findings of the study and comments on the implications of these findings for professional practice. Overall, the research findings make recommendations for Australia, as to best practice in asset, property and facility management, taking into account its particular circumstances and regulatory regimes, to ensure such practices can be implemented realistically in the commercial building stock.

Chapter 2
Literature review

To understand the context of the research challenges and to provide a conceptual basis for the study, this chapter reviews key literature relating to smart building technologies used in asset, property and facility management industries and their implications. The specific objectives of this chapter are:

- to review existing knowledge relevant to the study
- to identify critical concepts that informed the current research
- to demonstrate the gaps in current understandings and identify directions for this study

2.1 Background

As more people have settled into cities, there has been greater pressure on urban infrastructure. City developers are using smart strategies to assist with greater pressure on public transit, and other essential infrastructure and services, to create a smart urban ecosystem (Singh et al, 2020). In turn, there are more opportunities for buildings to operate with greater efficiencies and capacities to promote greater sustainable outcomes for owners, occupiers, investors and other built environment stakeholders.

Testing has commenced in the built environment, with experimental operation of disruptive technologies, such as big data analytics, AI, the Internet of Things (IoT), robotics, drones, and wearable technologies, aiming to achieve better yields for decision-making and operational activities (Ullah et al, 2018). While it is still too early to make generalisations regarding the effectiveness of the use of these smart building technologies within management and building operation, it is important to understand how they are being used, by which markets, and what the achievements and challenges are in this field.

2.2 AI, big data and blockchain in asset and portfolio management

Existing literature has identified that the asset management industry is increasingly employing various smart building technologies in its operations. The integration of smart technologies enhances the quality of large volumes of data on assets in portfolios, supports consistent investment workflows and enables asset managers to make more informed investment decisions. As shown in Table 1, Novick et al (2014) have discussed how smart building technologies in buildings support asset managers in the decision-making process primarily by providing up-to-date and critical data on portfolios.

Table 1: Role of advanced technology within asset management

Asset management activity	What smart building technologies assist
Portfolio management	Provide real-time view of positions, exposures and risks Support "what if" analysis of scenarios Check recommended activities relative to client-defined portfolio compliance guidelines
Data control and operations	Receive and load data from third parties including securities, benchmarks, ratings, prices Capture organisation-specific data such as internal ratings and sectors Confirm operations with counterparties Take in information on corporate actions from data providers and process these changes
Portfolio administration	Reconcile cash balances against the records Calculate portfolio net asset values and performance Produce performance attribution analysis to allow portfolio managers to understand the decisions driving portfolio returns
Risk management, compliance and oversight	Oversee portfolio-level and firm-level risks and exposures Ensure portfolio risks and returns are in line with organisation's objectives Monitor and manage compliance exceptions throughout the investment process

As AI can behave in the same way as the human brain, including thought processes and the ability to progress (Rossini, 2000), Borg (2018) argues that the use of AI in asset management could quickly deliver several efficiency gains. This comprises AI-supported access to complex data, AI contribution to the creation of proprietary sentiment analysis, AI alerts sent directly to portfolio managers about property-specific and market risks, and AI-assisted investment decisions. Moreover, AI-based systems allow for intelligent matching and predictive analysis on property marketing websites (Ullah et al 2018).

AI can quickly deduce patterns from data, find correlations and highlight actionable insights. It can do so faster, better and with much more data than even the best team of mathematicians could dream of. However, the performance of so-called 'quant traders' has yet to prove that an algorithm can be designed that can always understand something as complex as the global economy and the machinations and volatility of property markets, and the complexities with asset management. That said, as AI transitions from value addition to an essential part of an investment management toolkit, the path towards AI automation is inevitable. Once the data is together, another big benefit of AI is that it can automate the analysis process so investment managers can keep their focus towards critical operations. Rather than replacing workers, it can help take some of the 'heavy' data lifting off their hands, so they can better focus their time on things that require higher cognitive capabilities.

In terms of ESG (environmental, social, governance), individually and collectively the situation is complex. AI could assist by rapidly putting together patterns from data, finding new connections and correlations, and identifying gaps. This more efficiently ensure projects comply with ESG principles to ensure more equitable outcomes that support climate change adaptation. However, AI at this stage cannot solve all complex ESG issues and for all cities and precincts. This will still require some good, old-fashioned human intelligence as part of the process.

Rossini (2000) found AI expert systems can assist in phrasing and structuring property documents (e.g. leases), budgeting for construction projects, elaborating reports and optimising communication between different stakeholders (e.g. clients, property and facility management) for efficient problem solving. Sivaramakrishnan (2017), meanwhile, identified the following main areas in asset management where AI and machine learning technologies can be used effectively (see Table 2).

Table 2: Use of AI and machine learning in asset management

Main asset management area	Tasks
Portfolio management and optimisation	Portfolio construction and optimisation Development of investment and risk strategies Predictive forecasting of long-term price movements
Social media usage and analysis	Market sentiment analyses, pattern charts for portfolios Crowdsourcing ideas to bring analysts, investment managers, and asset managers together to share opinions and monitor trends
Event monitoring and timeline analysis	Use of cutting-edge technologies to consolidate unstructured data and provide actionable insights by collating data from various portfolios The methodologies adopted include NLP, machine learning, and network analysis using sophisticated data visualisation tools
Customer interaction and services	These services include statements of accounts and funds transfer in core banking, portfolio selection, risk return analysis and portfolio dashboard in the asset management space

Source: Sivaramakrishnan, 2017

Pollock (2019) suggests that AI and blockchain technologies will help asset managers to develop more evolving strategies and generate better long-term returns than pre-packed strategies that are based on back-tested data or historical returns of investment options. Also, the management fee, which is a significant part of operating costs of buildings, can be reduced significantly through the application of these technologies (Pollock, 2019).

Big data analytics also offer advantages in evaluation and speeding up processes (Ullah et al, 2018). With the aid of big data, property investors are empowered to predict supply and demand levels and determine price indices. Portfolio management services can benefit from big data when analysing diversified investment opportunities (Du et al, 2014). The provision of vast amounts of data enables customers to be more confident in their decision-making, which would eventually speed up transaction processes (Ullah et al, 2018).

AI and big data are being increasingly used to estimate the lifecycle costs of properties, which is a significant function in asset and wealth management. By comparing building lifecycle costs using several cost estimation methods, Alqahtani and Whyte (2016) identified that Artificial Neural Network (ANN) models, supported by AI and big data, were able to estimate the total running costs of their building samples with an average accuracy of 99%. Günaydın and Doğan (2004) also examined cost estimation for residential buildings using ANNs and concluded that these models can reduce the uncertainties in estimating costs associated with the structural system of a building.

Kim et al (2013) compared the performance of three methods – regression, support vector machines and ANNs – in estimating building construction costs and concluded that ANN models gave more accurate prediction results than the other two. Shehab and Farooq (2013) also identified that ANN models estimated the repair and replacement costs in their project sample and identified that such models save time, improve the accuracy of the estimates and prevent problems that are usually associated with inaccurate estimates.

ANNs would also assist users in comparing alternative projects and the proceed/do not proceed decision-making process. Metaxiotis and Psarras (2004) identified several benefits of neural networks (NNs) and genetic algorithms (GAs) in asset and wealth management, including more accurate decision-making, time gains, flexibility, improved quality of products and minimisation of human inconsistencies.

The accuracy and reliability of property value estimates is an issue of great importance to property stakeholders and asset and wealth managers (Abidoye and Chan, 2017). The digitalisation of records has now been made a priority by most asset and wealth managers. Detailed financial, legal, tax and valuation aspects in buildings have become more systematic and accurate due to the advancements in newly developing building informational models (BIM) and AI technologies.

The ANN method is being used for prediction, pattern recognition, classification, process control, non-linear mapping and data analysis (Cechin et al, 2000; Paliwal and Kumar, 2009), which thus makes it suitable for property valuation and value prediction (Elhag, 2002). ANN models have been successfully applied in different property markets around the world and have produced more accurate and reliable value estimates with greater speed than previous experiences (Ge & Runeson, 2004).

Furthermore, these technologies can simplify various tasks in the property industry. For example, they enable the development of smart contracts as well as the facilitation of financing and crowdfunding. The increased availability of qualitatively better property data results in a more transparent and trustworthy market where fraud is potentially less likely. Although more transparent and voluminous building data could overcome the problem of non-standardised property information, thus accelerating property transaction, the progress is hindered through the unwillingness of actors in the property industry to share data (Saull et al, 2020).

2.3 Smart building technology in property and facility management

With digital technologies becoming a part of daily life, workplaces have also been progressing technologically, encouraging the development of smart buildings (Lecomte, 2019). Buckman et al (2014, pp98-99) define smart buildings as “buildings which integrate and account for intelligence, enterprise, control, and materials and construction as an entire building system, with adaptability, not reactivity, at the core, in order to meet the drivers for building progression: energy and efficiency, longevity, and comfort and satisfaction”.

Thus, the core of smart building consists of sustainability, innovative technology and user-centredness (Ullah et al, 2018), resulting in the optimisation of occupier comfort, productivity and satisfaction with the lowest possible energy consumption (Buckman et al, 2014). Smart building technologies in buildings help in day-to-day management activities, such as tenant management, payment management and tools for landlords and tenants to communicate with facility management activities to ensure the efficiency and long-term sustainability of buildings (Baum, 2017).

The existing literature has also identified significant operational improvements created by AI, big data and machine learning technologies in several building specific areas. These include: energy efficiency/reduction and other environmental imperatives (Ameyaw and Chan, 2014; Siu and Xiao, 2016); indoor environment improvements (Pitarma et al, 2016); workplace/worker productivity (Ekstrand and Damman 2016); performance measurement and management (Ling and Wong 2016; Douglas 2016); sustainable buildings (Georges et al, 2015); intelligent buildings (Arditi, Mangano & De Marco, 2015); maintainability and durability of buildings (Enshassi and El Shorafa, 2015); procurement decisions (Perera et al. 2016); and advanced information and communication technologies such as digital tools, including building information modelling (Gheisari and Irizarry, 2016).

Building Management Systems (BMS), which consist of systems that are installed individually, controlling only separate tasks (e.g. lighting or elevators), are established systems. As these systems require the facility manager to aggregate these data, more advanced, partially integrated BMS that connect several automated activities (e.g. energy management systems) have emerged. Although these are sufficient in supporting sustainability instruments, such as green building certification, smart technology uses fully integrated, IoT-enabled BMS to control the entire building technology, without manual interaction.

The technologies consist of an underlying communication infrastructure that interconnects monitoring devices such as sensors, cameras, RFIDs (radio frequency identifications), meters or any kind of everyday appliances (e.g. doors, windows or lights), a cloud infrastructure, a data-mining analytical algorithm as well as user surfaces (Jia et al, 2019). The collaboration of these layers results in automated point decisions, allowing for informed, strategic, and fast decision-making, as well as synchronised actions by owners or property managers (Kejriwal & Mahajan, 2016).

The advantage of an integrated BMS lies in the interoperability between different systems, such as windows and the air conditioning system, even if they are manufactured by different companies (Jia et al, 2019). In contrast to conventional sensors, IoT-enabled sensors are comparatively cheaper, while providing more in-depth information (Veuger, 2018).

The advancement of IoT technology influences the facility management of properties to a great extent, especially due to its global accessibility, instant responsiveness, wireless communications, applicability for indoor and outdoor areas and remote tracking possibilities (Yang et al, 2013). This includes the ability of IoT devices to comprehend and respond to the needs of the building occupants and the property as a whole without requiring local attendance of a facility manager (Wortmann & Flüchter 2015). For example, IoT systems can control heating, air conditioning and lighting, enable property managers and owners to proactively schedule repairs and maintenance, optimally allocate desks and rooms, enhance security systems, digitise logistics management, and improve waste management, as well as enabling interaction with retail customers (Donovan et al, 2018). Lightbulbs equipped with IoT technology, for example, do not only provide light, but can also register the presence of people and send information to the owner's devices. Thus, these lights can fulfil the aim of a security system with minimal costs (Wortmann & Flüchter, 2015).

Moreover, integrated systems collect a range of data that is helpful in performing facility and property management functions. For example, IoT systems can contribute to the understanding of utilisation patterns and provide knowledge with regards to the maintenance and refurbishment level which can feed into lifecycle management and decision-making processes (Brous et al, 2019). In addition, they can assess a building's operational efficiency, assist in budgeting and benchmarking as well as in the creation of financial reports (Ghasson, 2006).

The vast amount of data generated is not only useful at the building level, but also on a portfolio or urban scale for descriptive, prescriptive as well as forecasting purposes (Kejriwal & Mahajan, 2016). In the retail sector, smart technology could be applied to register online sales, leading to the development of a more accurate turnover rent model (Smith & Savage, 2016).

As part of an IoT enabled BMS, sensors are mostly employed as monitoring devices in commercial property. Wireless sensor networks (WSN) are especially common in collecting data regarding indoor environmental quality (e.g. light, temperature), occupant behaviour and motion, as well as energy usage. Sensors therefore play a significant role in maintenance and repair, informing human operators about the state of deterioration, faulty equipment and the need for replacement (Jia et al, 2019). Moreover, weather sensors can signal severe weather events and contribute to preparedness and resilience (Kejriwal & Mahajan 2016). Sensor-enabled bins, meanwhile, can communicate how full they are to enable efficient collection and minimise overflow (Adler, 2015). And in retail properties, sensors can help the vendor to identify consumer types, footpaths and their buying behaviour (Kejriwal & Mahajan, 2016).

In addition, physical technology in facility and property management includes robots and drones. While robots can assist in collecting and recycling waste, performing inspections and fulfilling maintenance and cleaning duties (Ullah et al, 2018), drones or unmanned aerial vehicles (UAVs) are useful in taking aerial photographs of properties and their surroundings in marketing activities (Newell, 2017). Drones can also assist in mapping and surveying, making the process cheaper, quicker and safer (McNeil & Snow, 2016).

Moreover, wearable technology, such as smartphones, augmented reality (AR) goggles, smart helmet visors, global positioning system (GPS)-fitted safety vests, and smart watches can aid data collection in buildings (JLL, 2017). With wearable devices, occupants, facility managers and builders are linked to the property and can interact with the smart building technology, for example to adjust heating or cooling, or obtain immediate information with regards to maintenance and safety issues that can also be passed on to the tenants and/or owners. Through the increased interaction with the building, the occupants' sense of affection for the building might increase (Ullah et al, 2018). In retail properties, smartphone apps enable customer interaction, guiding them through the shop, while pointing at special promotions and assisting them in finding car parks (Kejriwal & Mahajan, 2016).

2.4 Financial and non-financial implications of smart building technologies

King (2017) detailed eight main benefits that can be provided by smart building technologies in buildings to asset, property, and facility managers. These are:

1. Insightfulness – Real-time data is reported and used to inform decisions on

building operations. Portfolio managers can see their operations across the globe and compare performance, giving them actionable insight on how to drive efficiencies and improvements.

2. Sustainability – Facility managers are able to easily monitor and control the performance of the buildings against their sustainability strategies.
3. Flexibility – Managers are better able to accommodate agile, dynamic models of work, such as activity-based working, by allowing spaces to be easily reconfigured and adapted to technological advances.
4. Experiential – Office users have greater control over their environment, allowing them to tailor comfort levels to their personal preference.
5. Health – Smart technologies contribute to a healthy environment and provide technology that can facilitate and measure wellbeing, helping to reduce costs of absenteeism.
6. Productivity – More efficient and better use of space and environments that enable companies to get more out of their staff is facilitated.
7. Collaboration – Encouragement of interactions, knowledge sharing and improve business performance.
8. Effectiveness – Support is offered in meeting the needs of stakeholders and transforming the company property into an enabler of business growth.

Due to the vast impact of smart building technologies on the property industry, it is expected that property values are influenced. Baum (2017) emphasises that AI and other smart building technologies used in the industry will push the property market towards more flexible and liquid conditions, like the markets of other investment grade assets such as shares and bonds. In particular, smart buildings with efficient use of spaces will continue to attract capital and drive innovations which will result in higher property values and lower investment risks.

Energy efficiency and its potential impact on property values has received significant attention in the literature. The ability of smart technologies to monitor and to react to occupants' behaviour in real-time is expected to decrease energy consumption extensively through efficient energy distribution and conservation (Akkaya et al, 2015; Habibi, 2020; Kejriwal & Mahajan, 2016; Nappi & de Campos Ribeiro, 2020; Valks et al, 2020; Yu et al, 2015). Examples of these energy savings include the automated adjustment of the HVAC based on the number of people present in each building area (Akkaya et al, 2015) and the alignment of the indoor lighting system with the light intensity outdoors (Jia et al, 2019). These reductions are expected to be reflected as energy cost savings by most senior leaders in the property industry. Indeed, many large corporations that apply smart energy management systems reported a decrease of 10% to 30% in energy costs (Smith & Savage, 2016).

These findings were also confirmed by Pan et al (2016), who evaluated energy management systems in buildings. It was found that a static and centralised building control system does not allow for an energy efficient building operation even if the building is certified as a green building. In contrast, an automated and networked IoT-enabled system applying computing technologies was able to achieve energy proportionality on a user, building and organisation scale and thus avoided wasted energy. These results were achieved through the use of smart grids (a two-way communication system transferring information and energy) as well as smart meters, which allow for the measurement of various parameters, the signalling of diagnostic information and communication among one another (Depuru et al, 2011).

While many studies concentrate on energy savings, the financial implications of better space utilisation through advanced technology might be of even more importance. Although hot desking has existed since the 1990s, assigned desks were often found to be unsuitable and inappropriate, leaving employees unhappy (Cooper et al, 2017). However, smart systems can assist in the strategic allocation of temporary desks by generating big data about occupant behaviours (Smith & Savage, 2016). This includes information about the use of space, occupier flow, user detection and occupancy level (Valks et al, 2020). These systems are able to assign desks based on group projects, proximity to team members, noise levels, the duration of stay, necessary equipment, occupant history and preference (Cooper et al, 2017). As the more efficient allocation of workplaces, or "intelligent hot desking", requires less rental area, substantial gains in rental costs are possible (Cooper et al, 2017).

In addition to the impact of smart technology on hot desking, the generated data also assists in forecasting space demand carrying value implications. Based on the company's outlook and historic data about occupant behaviour, the usage patterns of different room types and areas can be analysed and used for strategic decisions. For example, specific meeting rooms might be preferred or intentionally avoided by users. Understanding the preferences regarding size, lighting and equipment gives insights on how future meeting rooms should be designed.

Also, data about the use of workspaces is essential to develop forecasting models and predict space requirements. If recurring patterns (e.g. seasonal or weekly cycles) become visible, decisions regarding coworking (sharing a rental unit by multiple tenants), the reduction of the rental area or subleasing means additional space under consideration for the most appropriate duration can be made (Sharma, 2017).

These advantages gained particular importance during the Covid-19 pandemic. With the pandemic emphasising indoor environmental air quality and changing the definitions of personal space and physical distance, smart technologies can assist in controlling HVAC systems, monitoring the building's maintenance status without the need for physical inspections, optimising cleaning services and balancing health requirements and financial challenges (JLL, 2020).

Besides the financial implications, many studies emphasise the importance of smart technology in increasing occupier comfort (Habibi, 2020; Kejriwal & Mahajan, 2016; Nappi & de Campos Ribeiro, 2020; Valks et al, 2020). With the aid of IoT technology, information about temperature, air quality and occupancy can be combined to provide a healthier indoor air quality (Kejriwal & Mahajan, 2016). The key strength of smart technology lies in its ability to not only present data, but also to determine the perfect climatic settings for each employee by empirically analysing their likings and historic information (Jia et al, 2019). In contrast to older technologies, IoT is able to find a balanced setting by reconciliating the often opposing needs of energy efficiency and user comfort (Jia et al, 2019).

The positive impacts of smart technologies on health and wellbeing were also found to be related to employees' productivity levels. Ghasson (2006) found that the ability of smart sensors to customise lighting, operate sun blinds and to control heating, cooling and natural ventilation while providing individual control, ensures an optimal, safe and comfortable work environment according to the needs of each employee. Individual temperature control, meanwhile, has been shown to impact productivity in a positive way (Loftness et al, 2003). And individually configurable workspaces, smart booking systems for meeting rooms, and intelligent, activity-based seating configurations, were found to be important drivers for productivity (Sharma, 2017).

As face-to-face interactions and physical movement of staff members have been proven to positively correlate with productivity levels and job satisfaction, the analysis of information obtained through smart offices can help improve office design to impact this (Nappi & de Campos Ribeiro, 2020). With salaries being a significant operating expenditure for most companies, even a minimal change in productivity levels can result in large cost savings through reduced staffing requirements (Sharma, 2017). Cooper et al (2017) conducted a simulation in a London office building, which confirmed that productivity gains outweighed the costs of implementing the required technology.

The collection of large amounts of data through smart devices also offers financial opportunities through sharing with external stakeholders. For example, urban planners might have an interest in this information due to its impact on city systems, such as public transport and road infrastructure. Taxi companies will also have an interest in the data provided by smart devices, for example allowing them to react when employees leave at unanticipated times (Cooper et al, 2017). In addition, data collected in retail stores and shopping centres regarding consumer purchase behaviour, customer movement, sound, energy and lighting is of value to advertisers, tenants, other retailers as well as institutional investors (Kejriwal & Mahajan, 2016; Smith & Savage, 2016).

As smart buildings are expected to achieve greater efficiencies, which are said to reduce energy and maintenance costs by up to 30% in large property complexes (e.g. industrial premises, office parks or shopping centres) (Kejriwal & Mahajan, 2016), an increase in rent would become justifiable (Smith & Savage, 2016). However, a technology upgrade also comes with increased costs for the acquisition and ongoing costs of hardware, software and responsible staff (Jia et al, 2019). Analysing projects from academia and industry, Jia et al (2019) found that the benefits through time and energy savings of smart technologies, offering appropriate quality for the purpose, are in most cases able to offset the initial expenses.

While it is agreed that smart technologies are significant component of building heterogeneity (Lecomte 2019), the effect of smart technologies on property values is unclear. Kejriwal and Mahajan (2016) suggest that the financial advantages might not necessarily result in an increase in property value, but that these technologies might become the norm, leading to properties that are not 'smart' being traded at a discount. With the increasing importance of this 'smartness', technological obsolescence now outweighs physical and economic building obsolescence (Lecomte, 2019), leading to accelerated depreciation (Ghasson, 2006).

With adaptability, disruptive technologies, sustainability and distinctiveness becoming key attributes of financially viable property (Veuger 2018), the old mantra 'location, location, location' might become 'location, information, analytics' (Kejriwal & Mahajan, 2016; Lecomte, 2019). Thus, the evaluation of buildings needs to be altered (Kejriwal & Mahajan, 2016) with property modelling being required to include digital positionality (Lecomte, 2019). For example, Lecomte (2019) recommends the inclusion of the property's capability to implement and keep up to date with technology and industry standards in the development of building scores.

In addition, the importance of flexibility and versatility of the physical components was emphasised, as well as the capability of interaction between occupier and building. Moreover, smart building scoring should target the development of price indices at the property level with the prospect of integration into higher scales, such as neighbourhood, city and county indices.

2.5 Barriers and challenges associated with smart building technologies

Despite the positive implications of applying smart technologies, its applicability in commercial buildings appears limited, with the existing literature identifying several barriers. The major challenges include:

- the interoperability of devices and databases (Akkaya et al, 2015; Bashir & Gill, 2017);
- the need for professional data analysts for correct interpretation and leverage of the data collected (Akkaya et al, 2015; Brous et al, 2019);

- data governance issues (Bashir & Gill, 2017; Brous et al, 2019);
- data protection and privacy (Bashir & Gill, 2017; Donovan et al, 2018);
- security of systems against malicious attacks (Bashir & Gill, 2017; Donovan et al, 2018);
- risk allocation and liability between users and technology providers; and
- the amendment of service charge provisions in leases due to the increased expectancy of the landlord to provide network systems (Donovan et al, 2018).

The hurdle highlighted the most is guaranteeing appropriate forms of cybersecurity and data protection. On the one hand, smart technology itself is very vulnerable due to the vast number of interconnected devices and complex systems involved in every single aspect, including the networking structure, software and hardware being prone to security faults (Jia et al, 2019; Kejriwal & Mahajan, 2016). On the other hand, the security requirements of the collected data are high due to the extensive amount of sensitive and personal information, which can result in financial and reputational damages if hacked (Kejriwal & Mahajan, 2016).

If the privacy concerns of employees outweigh the perceived benefits, the implementation of smart technologies might be rejected (Nappi & de Campos Ribeiro, 2020). As safety cameras and GPS record every movement and activity, occupants can feel uncomfortable with the constant surveillance that is being shared with others, and the invasion into their private life (Jia et al, 2019). Nappi and de Campos Ribeiro (2020) found that although employees perceived access to information about team members as beneficial, they rejected the availability of their own data that could be interpreted negatively by others. These privacy concerns are even more relevant when occupiers have limited and non-transparent control over the type and form of data, as well as its recipients.

Even seemingly harmless information might carry significant implications for the individuals' private lives. For example, the data produced from wearable devices with accelerometers can carry health implications, for example indicating the existence of Parkinson's disease. As this data is valuable not only for employers, but also for insurance companies to calculate premiums and pharmaceutical firms for marketing drugs, the importance of data protection should not be underestimated (Neff 2016).

To mitigate these challenges, Nappi and de Campos Ribeiro (2020) discovered that staff members require knowledge of the advantages and disadvantages associated with smart technology, anonymous data collection and analysis, the right of access to their own data and clarification of data ownership. For IoT technology to become accepted in commercial property, the reasons for implementation, the time of use and how to control the collected data must be communicated to the staff (Nappi & de Campos Ribeiro, 2020).

2.6 Summary of knowledge gaps and development of research questions

Analysis of the existing literature identifies several smart building technologies available in commercial buildings and their implications. However, most of the literature examining such technologies provides critical reflection on them without any discussion with relevant market participants who have experience of such technologies. Furthermore, many studies are confined to the European and the US markets. Limited research has been conducted in Australia to examine the level of smart building technologies used in its commercial stock and the impact of such technologies.

The aim of this study is therefore to empirically examine the smart building technologies used in commercial buildings in Australia and their financial and non-financial implications. The research problem is examined from asset, property and facility management perspectives.

Chapter 3
Research Methodology

This chapter outlines and justifies the research approach used to answer the research question.

The objectives of this chapter are to:

1. discuss the research methodology adopted
2. outline the analysis process for the best practice case studies
3. describe the interviewing process
4. explain how gathered data were analysed and interpreted

3.1 Qualitative research methodology

The qualitative research approach was selected as the most appropriate research methodology due to the explorative nature of the research (Silverman, 2013). Qualitative data is contextual as the analysis involves developing insights based on a deep understanding of a particular context (Cassell et al, 2018) and such data provides “rich descriptions that are vivid, nested in a real-life context” (Amaratunga et al, 2002, p22). A qualitative approach is well suited for locating the meanings people place on the events, processes, structures of their lives and their perceptions, assumptions, prejudgements and presumptions. Qualitative research methods are particularly important when prior insights about the phenomenon under scrutiny are modest (Ghauri and Gronhaug, 2005; Mariampolski, 2001), which is the case in this study.

The research followed a multi-staged process that involved case study analyses followed by a series of in-depth interviews (See Figure 1). It offered the opportunity to generate in-depth understanding of the nature and characteristics of smart building technologies used in commercial buildings, and asset, property and facility managers’ perceptions, behaviours and experiences.

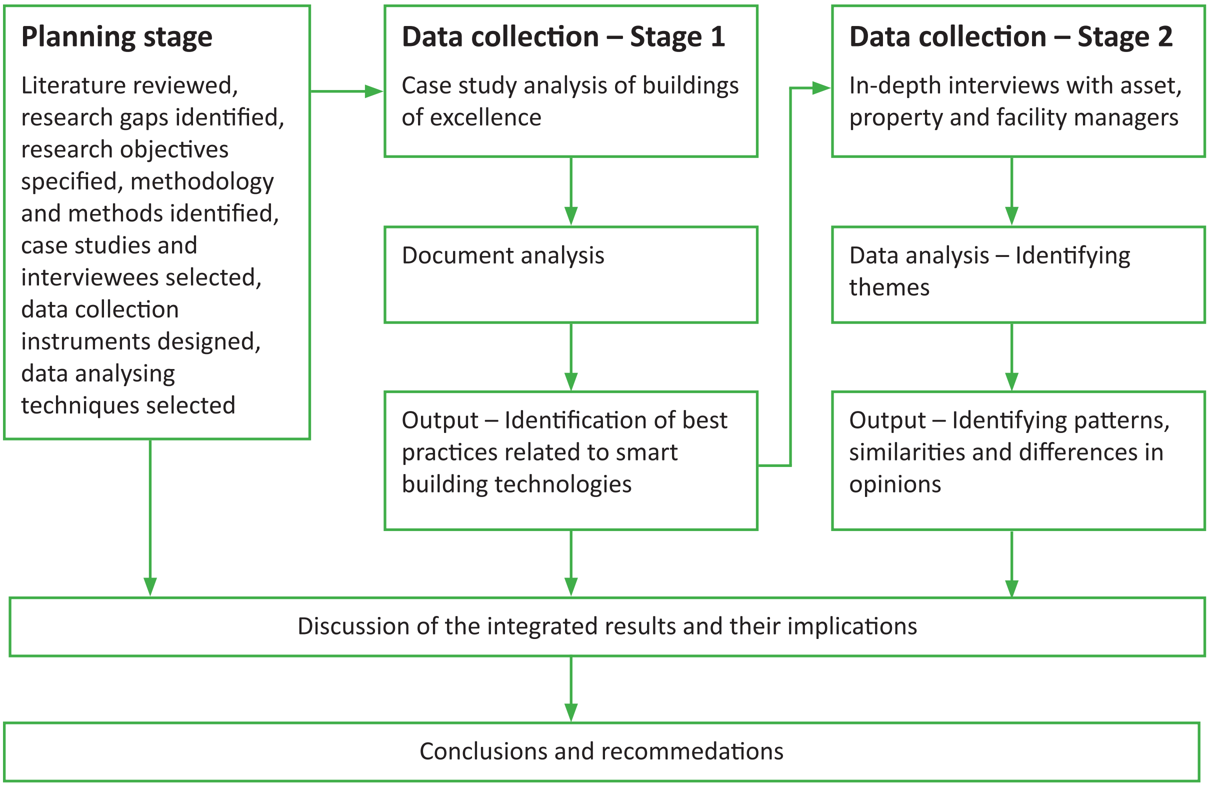

Figure 1: Multi-staged qualitative research design

In the first stage of data collection, through document analysis three buildings representing best practice were examined to understand how they were making use of smart and efficient technologies. The findings were then further examined in the next stage of data collection, where one-to-one, semi-structured, in-depth interviews were conducted with asset, property, and facility managers of large-scale property companies in Australia. The interviews aimed to examine modern technologies used in asset, property, and facility management practices in commercial buildings in Australia, their financial and non-financial implications, barriers, and challenges of implementing smart technologies into buildings and provide recommendations on how to eliminate such barriers and challenges.

Interview information was analysed using thematic analysis, and conclusions and recommendations were then drawn by integrating the findings from the two stages.

3.2 Case study analysis

The three case study buildings examined in this research are the EDGE building in the Netherlands, the Olderfleet building in Melbourne, Australia, and International Towers in Sydney, Australia (See Table 3).

Table 3: Case study buildings

Building name	Building size	Nature of occupancy	Construction	Technology focus
The EDGE, Amsterdam, Netherlands 	40,000 sq m	Premium grade office Main tenant: Deloitte	Developer: OVG Real Estate Construction completed: 2015	Extensive use of sustainability and digital technology to create innovative and congenial workplace
The Olderfleet building, Melbourne, Australia 	58,000 sq m	Premium grade office Main tenant: Deloitte	Developer: Mirvac Construction completed: 2020	Extensive use of digital technology and sustainability while integrating with its heritage setting
International Towers, Barangaroo, Sydney, Australia 	283,900 sq m in three towers	Premium grade office, retail, residential, hotel Main tenants: PWC, Westpac, Gilbert+ Tobin, KPMG	Developer: Lendlease Group Construction completed: 2016	One of the world's most contemporary and sustainable workplaces

All three buildings have used smart building techniques extensively in design and innovative technologies to improve sustainability, workforce interaction and end-user experience. All have been identified as some of the smartest and most environmentally sustainable buildings in the world. The EDGE has received the world's highest BREEAM rating awarded to an office building, while International Towers was awarded Best Innovation Program within the Property, Construction and Transport Industry across Australia and New Zealand in the 2019 AFR BOSS Most Innovative Companies annual awards.

Due to the integration of state-of-the-art technology, sustainability features and amenities, the Olderfleet building in Melbourne is also considered as one of the Australia's highest-performing smart buildings.

A document analysis was conducted to collect secondary data in relation to the nature and operation of these buildings and associated technologies used in their asset, property and facility management operations. Various industry reports, market reports, academic reports and websites related to the companies that developed, own and operate these buildings were thoroughly analysed. The objective was to identify the benefits and limitations of these technologies and what implementation lessons there were to be learnt for commercial building stock in Australia.

3.3 Interviews with asset and property managers

In the second stage of data collection, one-to-one, semi-structured, in-depth interviews were conducted with asset, property and facility managers of selected large-scale property companies to obtain an in-depth understanding of smart technologies used in commercial assets in their portfolios and their experience with them. Since participants were able to contribute additional contextual information which enriched the findings of the case study analysis, in-depth interviews were considered as the most appropriate data collection method.

Individual in-depth interviews are particularly appropriate when the interviews are with professional people or with people on the subject of their jobs (Tull and Hawkins, 1993), which is the case in this study. Semi-structured forms of interviews were used as they offer a versatile way of collecting data, allowing the interviewer to probe to clear up vague responses, or to ask for elaboration of incomplete answers (Welman and Kruger, 2001).

Furthermore, they allowed participants to answer the questions more freely and ensured a consistent coverage of the topics between the interviews. Therefore, the responses could be compared between participants and links between case study analysis and interview findings could be identified.

Interview participants

Key informants were selected based on their relevant expertise, experience and the ability to provide the information that was sought. The non-probability sampling method of judgement sampling was therefore used to identify participants most appropriate for this research. Judgement sampling involves the choice of subjects who are in the best position to provide the information required (Cavana et al, 2001). Therefore, the selection of the samples was not made on the basis that they were representative, but rather because they could offer the contributions sought (Churchill and Iacobucci, 2002). As shown in Table 4, all three interviewees held high levels of responsibility for key asset, property and facility related investment and management decision-making for their portfolios.

Table 4: Profiles of interview participants

Interviewee	Job Title	Nature of organisation	Type of commercial properties developed/ owned/managed/occupied
1	Chief Strategy Officer	Australian Real Estate Investment Trust	Owns mainly premium grade retail and office properties
2	Director, Asset Management Services	Global commercial and residential property consultancy company	Manages mainly complex commercial and residential assets
3	Senior Development and Investment Manager	International infrastructure and property development company	Develops infrastructure and complex property assets including commercial properties.

As shown in Table 4, interview participants were selected from a range of property companies who develop, invest in, manage, and occupy smart and technology efficient commercial buildings. As a result, the findings represented the perceptions and experiences with smart buildings from the perspectives of professionals in commercial property development, investment, management and occupation. The participants were industry experts who were content matter experts within their respective fields and regularly engaged in providing professional advice on digital technologies used in commercial assets in their portfolios.

The number of participants was determined by saturation, when the themes emerged became repetitive and no new information relevant to the study was revealed or the new information that emerged was negligible (Kumar, 2005; Strauss and Corbin, 1998).

Interview questions

Interview questions were designed to elicit an in-depth understanding of interviewees' perceptions and experiences of using smart building technologies in their asset, property and facility management-related operations and decision-making. The interview protocol was constructed to serve as general interview guideline and was mainly based on the findings of literature review and case study analysis.

They consisted of pre-determined open-ended questions beginning with information gathering, and developing into more specific questions as the interview proceeded, depending on the responses participants gave to prior questions.

The summary of the key issues and sub issues discussed in the interviews is presented in Table 5.

Table 5: Key issues and sub issues discussed in the interviews

Smart building technologies used in asset management functions	Data capture on the building usage and performance
	Data interpretation
	Cost and revenue forecasting
	Asset performance analyses
	Space utilisation
	Risk analysis (specific risks and market risks)
	Maintaining sustainability standards
	Streamlined reporting
	Identification of return maximisation activities in the short to long term
	Regulatory compliance
	Life cycle cost analysis for the property
	Other
Smart building technologies used in property and facility management functions	Benchmark setting (for revenue expectations, costs – Operating expenses, Capital expenses)
	Building operation activities
	Building maintenance activities
	Tenant management
	Lease and contract management
	Management of building services
	Security
	Health and safety
	Monitoring and reporting
	Other
Advantages of the use of smart building technologies	Return on the investment
	Operational efficiency of the building
	Cost efficiency
	Time efficiency
	Meeting tenant and other user expectations
	Meeting sustainability standards
	Expected economic lifetime of the building
	Other
Risks associated with the use of smart building technologies in asset, property and facility management	Financial specific risks
	Non-financial specific risks
Any barriers or challenges of introducing smart building technologies into asset, prop-erty and facility management activities in commercial buildings in Australia	Building specific
	Technology specific
	Organisation specific
	Resource specific
	People specific
	Other
Recommendations to eliminate such barriers and challenges	Short term solutions
	Medium term solutions
	Long term solutions

Interviews lasted between 45 and 90 minutes and were conducted either at their workplace or online. The interviews began with a short introduction of the research and the purpose of the interview. Interviewees were then given an opportunity to seek clarification on any queries or concerns they had regarding the research or the interview. All the interviews were performed by the researchers and were audio recorded, with the permission of the participants, for transcription afterwards.

Following general guidelines, the interviews began with broad questions and proceeded gradually to more specific ones. The participants' responses to the questions determined how the interviews developed and each one differed from the next in sequence, wording and pace, although distinct patterns common to all interviews emerged. Clarification and expansion of points identified as critical were sought. Field notes were also made for each interview, reflecting the researcher's impressions.

3.4 Qualitative data analysis process

The research findings were analysed using thematic analysis, which aimed to identify patterns or themes within the qualitative data collected (Creswell, 2009). Once completed, each interview was transcribed, with notes from the researchers. Before the analysis began, the researchers read all transcripts and developed a coding system based on the research questions, interview guidelines, existing literature and the findings of the case study analysis. Accordingly, major themes and sub-themes were developed, supported with key phrases and quotes from the participants.

The data analysis procedure was then implemented in three stages. First, each interview was read and analysed to identify unique patterns and key themes. This allowed detailed insight into the individual interviewees' perceptions and experiences with smart technologies used in the buildings in their portfolios. Second, the interviews were analysed across cases, which enabled conclusions to be drawn on the research questions. This step permitted the identification of patterns, similarities and differences in terms of interviewees' perceptions, behaviours and experiences related to their portfolios. Third, the interview findings were compared with the findings from case study analysis to determine overall findings and conclusions.

The next section presents the findings from the case study analysis and in-depth interviews.

Chapter 4
Results

This chapter provides an analysis of the case studies followed by a discussion on the interview findings. The interviews provided a good breadth of information that enabled findings to be identified which have been reinforced with the case study analysis.

4.1 Case study analysis

Although the literature review has shown that a variety of technologies exist and possibilities for integration seem endless, commercial building owners and managers are hesitant in adopting smart technologies. The three case studies are presented here. In addition to the implications on building operation and facility management, the advantages, and barriers, in applying smart technologies are outlined.

The EDGE - Amsterdam

The EDGE was completed in 2014, dubbed "the most sustainable, smartest office building in the entire world" (EDGE 2020b) (See image 1).

Image 1: The Edge building, Amsterdam, Netherlands (Image: Flickr.com/DennisM2)

The building is equipped with an extensive, ethernet-based IoT system, controlling building functions and components such as lighting, HVAC, security, coffee machines, lockers, gym equipment and meeting rooms

(Bakker, 2020; Davies 2019). In total, 28,000 sensors collect information about the building operations and its interactions with employees. The LED lighting system consists of 6,000 luminaires equipped with IP addresses and smart sensors, allowing the indoor environmental air quality as well as occupant movement to be monitored (Davies, 2019). Moreover, the automated ceiling system allows employees to individually adjust the temperature and lighting levels at their workplaces (Bakker, 2020). Staff are connected to the building via a smartphone app, through which access to the property and its amenities is provided. Team members can be located, car parks allocated, desks and lockers assigned (Davies, 2019), rooms booked, individual workplace preferences managed, and relevant information, such as train schedules, can be shared (Metz, 2016).

In addition, the building features robots that can detect security issues and verify alarms when no one is in the property (Davies, 2019) (See image 2). To track the data collected, the EDGE features two separate dashboards: one for the tenants and employees, displaying office occupancy levels; and one for facility and property managers, controlling the building management system (Jalia et al, 2018).

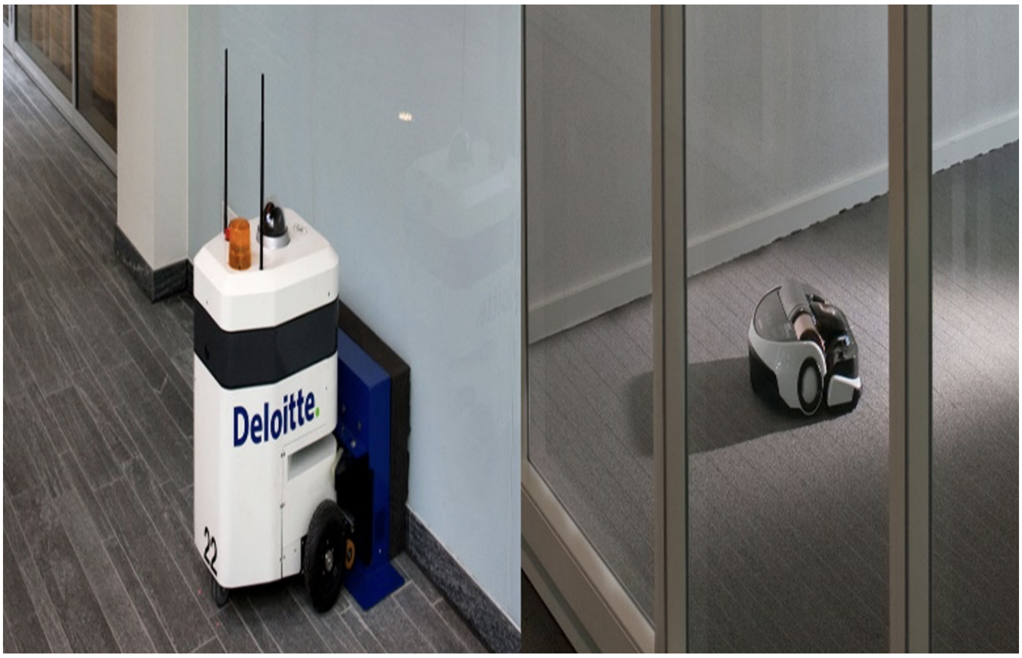

Image 2: Robots with camera-equipped automaton (Randall (2015))

The advantages of these smart technologies are numerous. For example, information collected through the smart lighting system improves facility management, such as energy management, maintenance, and security services (Davies, 2019); information on the use intensity of sanitary facilities helps optimise cleaning processes; and information on the filling degree of coffee machines and printers enables early replenishment (Metz, 2016).

Through the building systems being able to sense patterns of occupation and insights into the work schedule of staff members, areas can intentionally be closed to circulation to reduce cleaning and energy consumption (Bakker, 2020). Meanwhile, waste is minimised through information about occupancy, while weather and traffic data is used to forecast demand in the cafeteria to reduce food waste (Davies, 2019). And through the application of smart technologies, the reduction in energy use is expected to achieve savings of €100,000 per year (Verhaar, 2018).

In addition to building operations, benefits with regards to space utilisation were identified. These include the opportunity for the anchor tenant Deloitte to share its rental space with five other tenants, allowing for flexibility in the amount of area needed, as well as potential synergy effects (Bakker, 2020). Using smart workstations, the EDGE can accommodate 2,800 employees with only 1,100 workplaces (Metz, 2016), leading to anticipated savings of €1.5m in utilisation costs per year (Verhaar, 2018).

At the same time, user comfort and wellbeing are increased through the choice of location and individual settings for the workplaces (Bakker, 2020), positively impacting on employee productivity (Mocerino, 2016). Overall, Deloitte reported an increase in happiness, 60% less absence and a rise in interest from graduates and professionals for job openings (Bakker, 2020). Although the property is Deloitte's priciest office per square metre, it is the cheapest when calculated based on the number of employees (Bakker, 2020).

However, the biggest hurdle in benefitting from these advantages is the users. Instead of booking meeting rooms through the app, many staff members search for available rooms in person (Bakker, 2020). Also, many employees opt out of the tracking function due to concerns about privacy and data protection, which reduces the effectiveness of many building features (Jalia et al, 2018). These consequences show that employees will override or not use digital systems at all if they do not comply with human needs. Also, data ownership presented a problem, with no contractual agreement at building completion (Bakker, 2020).

International Towers, Barangaroo, Sydney, Australia

The International Towers, part of the 22-hectare redevelopment site in Barangaroo in Sydney, Australia (See image 3), are three commercial tower buildings (Freestone, Davison & Hu, 2019) completed in 2016 (Gillen, Jeffery & Hermans, 2019).

Image 3: International Towers, Barangaroo, Sydney, Australia (Image: Wikimedia Commons/Bahnfrend)

The complex is equipped with open building system integration (OBSI), based on iviva software that communicates through an integrated communications network (ICN) (Operational Intelligence, 2020; TetraTech 2018). The software enables the connection of various systems from different vendors, such as HVAC, lighting, CCTV, hydraulics, access controls, meters, and elevators, across the three towers (Operational Intelligence, 2020). In total, more than a million real-time I/O points allow the building management team to monitor building systems, observe CCTV recordings, administer alarms, manage property access, and control comfort levels (Peterson, 2018).

The technology carries significant benefits for different stakeholders. For example, property and facility managers can collect and analyse data across various building modules, synchronise maintenance activities, increase operational efficiency, optimise management processes, accelerate the detection and solving of problems, and enhance the building system's performance. Other stakeholders, such as tenants, engineers and service providers, benefit from the OBSI and are addressed through customised user interfaces and operational dashboards. This allows tenants to retrieve, view and check the information instantly (such as temperature, lighting, security, energy usage, waste management and occupancy), and tenants are enabled to manage specific services, such as air conditioning and property access outside working hours, as well as comfort controls (Peterson, 2018).

In addition to managerial advantages, the technological advances of the building complex also result in reduced energy use. Energy savings in lighting were achieved using intelligent, LED technology that allows for individual zoning on a micro level (TetraTech, 2018) and vertical shading panels, which are automatically aligned with the direction of the sunlight to provide shading, thus reducing cooling needs.

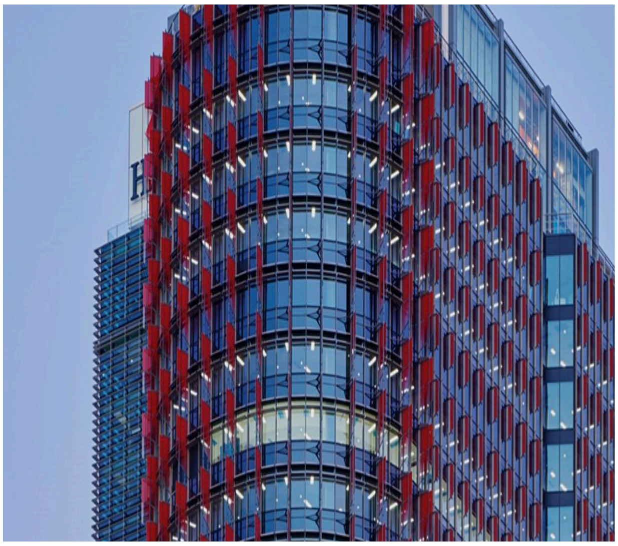

Image 4: Vertical shading panels aligned to reduce sun glare (NSW Government, 2017)

However, the design focus was not solely on energy efficiency, but foremost on occupiers' health and wellbeing, which resulted in the world's first WELL Core & Shell Certification at Platinum level (Gillen et al, 2019). Interviews with employees conducted by O'Connor and Studholme (2019) found that they appreciated the positive aspects of autonomy through the ability to individually schedule and plan the location of their work activities. In addition, they reported increased performance levels and enhanced information flows

Olderfleet building, Melbourne, Australia

Olderfleet consists of a contemporary 38-storey office tower completed in 2020 and located next to a heritage-listed building (Mirvac Group, 2020a) (See image 5).

The building is equipped with a fibre-optic infrastructure that can be connected to offsite data centres as well as risers suited to accommodating technological advances. Moreover, the building features an extensive data infrastructure, consisting of smart building sensors and an operating platform to control temperature, lighting, and CO2 levels of individual workspaces. Energy and water usage, renewable energy production and waste management are constantly monitored to ensure efficient operations.

Image 5: The Olderfleet Building, Melbourne, Australia (Image: Wikimedia Commons/Sardaka)

In addition, the entire building features a wireless overlay and a vast number of telecommunication carriers to guarantee mobility and workplace flexibility (Mirvac Group, 2020c). The property is also equipped with Bluetooth digital access and automated systems for lockers, car parks and bike storage (Mirvac Group, 2020b).

The advantages of these features lie in the individual control users have over their workplaces, and increased health and wellbeing, leading to better productivity and cost savings through lower energy and water consumption (Lenaghan 2020). In accordance with employee expectations and the trend to harmonise work and life, the building offers more automated, flexible, mobile, and cooperative ways of working to improve operating processes (Mirvac, 2019).

Case study conclusions

The case studies show that IoT sensors have been applied in commercial buildings to achieve energy savings and increase employee productivity. While the emphasis of the technology applied in the EDGE lies on the overall building sustainability, the focus of the Australian examples is to improve comfort and wellbeing to achieve the highest WELL certification.

However, the full technological potential remains untapped if occupants are not completely engaged. Thus, the effectiveness and profitability of smart technologies are highly dependent on the configuration of desk-sharing concepts and employees' willingness or ability to engage. With the anchor tenant of the EDGE being the same company as that of Olderfleet in Melbourne, it seems consultancies that are characterised by a high desk-sharing ratio are very open to technological advances, and able to benefit substantially from smart systems. An indication of the success of EDGE and the importance of technology in real estate, the building's technology has been replicated as a model in new developments across Europe and North America (EDGE, 2020a). With smart technology still rare in commercial buildings in Australia, it remains to be seen how it will develop in time.

4.2 Interview findings

An interview was held with an international corporate real estate company specialising in commercial property management and consultancy (interviewee 2). The company acts for private individual owners, which may be 'mum and dad' private investors through to companies that manage single or multiple properties. Information was also obtained from the perspective of a real estate investment trust (REIT) (interviewee 1), who are the asset owners and carry out property and asset management functions. These interviews were reinforced by a design and engineering consultant (interviewee 3) who provided information on new initiatives being driven by the owners or future occupants of the asset rather than by property managers.

Key findings that emerged from the interviews are grouped in four themes:

- Smart building technologies
- Financial and non-financial benefits
- Risks and challenges
- Lessons learnt

Smart building technologies

The introduction of smart building technologies has been predominantly driven by the owner of the building or the occupier, rather than by the property or facility manager.

All interviewees indicated that there has been a slow start to the introduction of smart building technologies. This is a result predominantly of a lack of knowledge, rather than a reluctance to find out what smart building technologies are available and therefore the advantages to introducing new initiatives.

The goals of building owners and their appetite to introduce smart building technologies were a major factor regarding which market participants are actively pursuing this advancement. Interviewee 1 emphasised "the importance to have an executive team and board that are supportive of smart building technologies and innovation as there are costs incurred that may take a reasonable amount of payback time". According to this interviewee, their company took a very focused approach by employing a property specialist to lead a team to investigate developing systems that are integrated, centralised, and automated. The team included specialists from different backgrounds, not just property or facility management, including electrical, security, cleaning services, and IT.

Interviewee 1 emphasised that considerable financial investment has been purposefully made by the company to investigate and implement new technology initiatives over the next five years. These forward-looking initiatives include new technology to consolidate the control room for more efficient management of car parking and building security, along with a centralised control room to more efficiently manage multiple retail centres using remote management. The objective will be to "optimise and reduce energy costs, along with reducing labour and management costs by not having to physically visit the sites and also to maximise the time for trade or maintenance staff on site, which will have the ultimate effect of reducing operating costs" (interviewee 1).

New technology has been much slower to advance with companies managing properties on behalf of owners. They see their role as "being one of managing the leases and operation of the building, with the owners, through consultants, initiating changes that may be required" (interviewee 2). In many cases, their income from clients is driven by rents, therefore the focus is on securing tenancies, rather than on introducing new technology to improve the building's efficiency.

Key issues discussed in the literature and by interview participants include the methods for data capture, and the question of who owns and therefore controls the use of the data. This concerns data related to facility management, along with data required to manage tenancies and maximise the net rental income. As data collection and storage is becoming critical in building management, an additional factor identified by all interviewees is the importance of having adequate systems in place, such as high-speed wifi. The wifi system is the backbone that enables data capture across retail centres along with efficiencies in commercial buildings.

Retail centres appear to be more advanced in data capture, with the use of movement-detection software, along with thermal and laser counting systems. If visitors have their phones switched on and wifi connected when they enter the centre, their movements can be tracked by location, time, and date. From this information, the systems can then track high customer, high dwell locations to focus advertising.

An additional benefit from tracking customer movements is to gain an understanding of how long they are staying in one spot, and where they go to after leaving each shop. This can be further analysed to determine how many shops a customer visits before they make a purchase. The "tenancy mix of retail centres can then be optimised and a more efficient layout of tenancies established to maximise the shopping experience" (interviewee 1).

They added there are cost benefits in being able to "track customers and their dwell time as managers are able to adjust rosters of service personnel to enable more efficient cleaning services to those areas that have higher demand and also provide a more accurate timing of those services to meet that demand".

One of the issues in data collection experienced by interviewees is data not being fully captured by the system, which then requires managers to extrapolate that data based on other user information. This is an area interviewee 1 expects will be improved upon with advances in data collection and storage.

Interviewee 1 also noted that customer data can only be collected (so far) on who is visiting the mall rather than who is not visiting and additionally, why they are not visiting.

Although the researchers are aware of centres and retail or commercial space that place a higher rental value on the most visited (by pedestrians or vehicles) locations, the interviewees did not adjust rents according to traffic count. Interviewee 1 sees this as potentially counterproductive in that tenants may then try and negotiate rents down where there is less traffic flow, or when circumstances change.

There is a financial risk if incorrect management assumptions result in the tenancy mix not being optimal. The collection of accurate data will move the basis of tenancy mix away from being mainly based on a market feel, with a small amount of data to back it up, to being predominantly data-driven. As interviewee 1 suggested "most retail centres experience around 40% of tenant churn within five years, which has a high cost to business and the tenant. The more information that is available to the tenant and to owners, the better tenant mix that can be achieved, which also means that the tenants can operate more efficiently around customer requirements."

Data from building management systems (BMS) and the predicted performance of the assets is collected electronically from a central location. Historically, this has been within the building itself. However, in recent times this has moved offsite, where several buildings can be monitored at the same time in a more convenient location. This allows the offsite management of retail centres and office buildings, which can include temperature control, access control and security. This is particularly useful when the asset/property or facilities manager is overseeing buildings in remote locations, or if there has been an event that means the building cannot be safely accessed. Through a centralised system, the building manager can, for example, monitor tradespeople through CCTV systems, give access as required, or to have direct conversations with onsite personnel.

Photographs can also be collected to form a visual history of assets, which can provide better knowledge for maintenance across the asset lifecycle. Technology has been introduced to provide tagging and barcoding of equipment so that any work that is carried out on the building can be scanned and costed. Records can be kept for maintenance time frames, costs and lifecycle of the asset, which then forms the basis of a long-term strategic asset management plan.

Another significant cost factor in the management of a building is represented by running and maintaining heating, ventilation, and air conditioning (HVAC) systems. Interviewee 1 has installed vibration sensors in HVAC units to monitor vibration levels that will indicate when servicing is required before the equipment breaks down. This has resulted in operational cost savings with maintenance being carried out prior to any breakdown, and less inconvenience for the occupants. Such efficiency can help retain tenants when it comes to lease renewals. It also inputs into the improved data collection for the building, which can track the lifecycle of an asset, which in turn reduces risk of an unscheduled outages or costs.

Health and safety in buildings requires having a robust reporting system to record accidents. By having an efficient reporting system, incidents or potential risk areas can be investigated by the property manager, in a timely manner. An example is the use of an electronic wand system for tracking cleaning staff. The wand is used to check in to designated areas and confirm by the cleaner that the cleaning has been completed in accordance with the agreed schedule.

One improvement that can be made is to redesign amenities to ensure water in bathrooms is contained to minimise the risk of accidents from slipping. Tracking technology can also be used to log the number of people that are using the bathroom amenities. In conjunction with the tracking of usage, a system has been introduced by Interviewee 1 that enables a better understanding of how often toilets and urinals have to be cleaned, based on usage and odour rather than a time frame. The cleaning schedule can then be varied according to the number of users and odour levels, which then saves operating expenses.

Smart electricity meters in Australia are mandatory for all residential homes and are now common in commercial buildings. They allow electricity suppliers to digitally access consumption data, without having to physically visit the building. The benefit of the smart meter in a commercial premises is that power usage can be separated out between tenancies accurately without making estimates. Interviewee 1 advised on a trial they are undertaking with a company using blockchain to record the energy use.

This system allows for automation of energy sales to tenants, without the property manager having to read meters, allocate power, invoice tenants and then have the holding cost until payments are made. As the tenant/

user consumes the energy, they are billed for that usage through the power ledger. This means the building manager is not incurring holding costs while waiting for tenants to pay their bills, as these are charged directly through the third-party automated system. Energy use is a major component of operating expenses within any large commercial building, so any saving here is advantageous.

Power factor correction devices on the meters ensure the effectiveness of the voltage being delivered and provide a more constant flow of output. Interviewee 1 suggested that "14% savings have been obtained in power usage as a result of the power factor correction device and the efficiency of the meters". This is in contrast to interviewee 2 who advised that energy providers still come and read the electricity meters even though smart meters are being used. The property manager "tracks usage of utilities to match what the power providers bill so that there are no surprises at the time of charging and for budgeting operating expenses" (interviewee 2).

Car parking is another area where smart building technologies can reduce operating costs. Management of parking areas is often outsourced to specialist companies. With the increased importance on data collection and ownership of that data, the management contract has now become more than simply operating the car park area. Where the management of car parking has historical contracts, which allows for operators to collect and control car park data, the building owner or manager may face a situation of having to pay to buy that data back from the car park operator. Interviewee 1 noted that it is important for property managers to think about how future contracts can encompass the ownership and collection format of the data.

Automated rubbish bins that compress the waste are a new technology for waste management. This technology can reduce the number of times a bin is emptied and reduce the time required to transport the waste and the cost of disposal. Before this innovation was introduced, "the bins were changed 55 times a week, which reduced to six when the robotic bin was introduced, which compressed the boxes" (interviewee 1).

Retail centres and commercial buildings have also introduced individual bins to separate out general, recycling, and organic waste. By becoming "more efficient in waste management, 83% of waste was then moved away from landfill to recyclable or organics waste" (interviewee 1). The use of robotics in cleaning and waste management raises the question of where else robotics can be used to reduce costs. This is an area in which all interviewees expressed interest.

Financial and non-financial benefits

The benefits of a centralised BMS and comprehensive data collection are found in efficiencies in relation to facilities management. They can be achieved by being able to plan maintenance, have a long-term asset management plan, and also grouping maintenance jobs together to avoid duplication of costs. Benchmarking of data is commonly carried out against the previous year's energy consumption and reviewing of operational expenditure.

Property Council of Australia benchmark data is also used to check whether buildings are performing within typical ranges (interviewee 1 and 2). Proactive use of the BMS to determine better consumption or replacement of plant assets is carried out. In addition, "consultants and maintenance personnel use benchmarking for checking that everything is running in accordance with requirements" (interviewee 2).

When dealing with service providers, who are generally paid on an hourly basis or on a contract to maintain/service the building, "it can be difficult to get them to be proactive in instigating efficiencies that will reduce their time required" (interviewee 1). Therefore, it is left to building managers to be proactive in this area and drive operational expenditures down.

A significant cost has always been the cleaning of the building. Avidbots are automated cleaning machines used at night to clean retail centres and commercial common areas. As interviewee 1 explained "they are now being used extensively to clean floors in centres and create savings on labour costs. Initially there was a lot of resistance as companies that provide the physical labour pushed back on them and did not want to use them, with the expectation being that it would reduce the labour costs". Avidbots are able to map the building to efficiently carry out cleaning and at a time when there will be a lower volumes of pedestrians.

Financial savings are obtained through management being able to reduce the operating costs of the common areas. In accordance with the Australian Property Council 2019 benchmarking data, building operating expenses (opex) have increased by around 5% per year, which can mainly be attributed to increased labour costs. By consolidating suppliers and using procurement efficiencies through smart technologies, this cost can be minimised. Interviewee 1 noted that through efficiencies and implementing automation technology, their company has been able to achieve zero increase in opex per year. This is a positive outcome as labour and material costs have been increasing over the same five-year period.

Building efficiencies can also be gained through sustainability initiatives. When sustainability features such as solar panels and recycling water were encouraged by the Australian government, electricity and waste disposal were relatively cheap compared with current prices. Interviewee 1 discussed how costs in these two areas have increased substantially in recent years, which has led to their focus in reducing these costs. An integrated energy strategy is required, which involves operating the building more efficiently, for example monitoring temperatures, opening buildings later and closing earlier to save energy, plus more efficient services such as lifts, HVAC, and escalators.

Solar energy has been strongly promoted through subsidies in Australian commercial property operations in the past 20 years. In most commercial buildings in Australia, solar systems have been installed as cost-reducing measures, rather than to provide a financial return.

One initiative that can be used to achieve cost savings is to charge the solar storage battery during off-peak times (lower cost of energy) and then energy is consumed at peak times. This reduces energy consumption from the grid, where it is purchased at a higher cost. Balancing solar energy, buying off the grid and spot pricing (energy is purchased at the price set at that point in time) is an important skill for property managers.

This was emphasised by interviewee 1: "Reduction in energy costs has become a focus of the management of the facilities. This has led to a management requirement that, at the time of introducing new systems that impact assets, a plan is required to show the cost benefit, including how the ongoing maintenance is going to be managed and cost savings made." This initiative means that all staff are focusing on how cost savings can be made with new proposals, without reducing the service or quality of the operation.

What is blockchain and how does it fit in with smart technology?

Blockchain is "a distributed, append-only ledger of provably signed, sequentially linked, and cryptographically secured transactions that is replicated across a network of computer nodes, with ongoing updates determined by software-driven consensus" (Davidson et al, 2018).

Blockchain is the architecture that enables users to transfer value digitally (Sinclair et al, 2022).

Businesses and governments are increasingly realising the need for the use of digital channels to interact with their stakeholders. While micro-level decision-making with respect to technology adoption is occurring within organisations, at a macro level a much more fundamental transformation is occurring. Technologies such as blockchain are transforming the mechanisms of economic organisation, coordination and governance.

Blockchain technology is both trade infrastructure and an institutional infrastructure. As a trade infrastructure it facilitates the transfer of information to accompany 'things' as they move along real estate related supply chains from producer to final consumer. Blockchain is a technology that innovates on governance (Berg et al, 2020). Innovation in institutional technologies implies new models of economic interaction that compete with current market practices to drive down costs. In the real estate context, blockchain is creating new ways of verifying and transferring property rights and creating platforms for the emergence of new real estate-related asset types and related secondary markets.

Recently, developments in blockchain-based technology means evolving mechanisms through which information, value and property rights can be exchanged digitally. The terminology associated with the emerging cryptoeconomy is complex. Smart contracts, oracles, non-fungible tokens (NFTs) and decentralised autonomous organisations (DAOs) represent the underlying infrastructure, or blockchain 'toolkit', which as they develop enable the digitisation of real-world assets and facilitate the emergence and evolution of new real estate-linked crypto-based economies (Sinclair et al, 2022).

Smart contracts and blockchain

It is still common practice to use a template contract to form the basis for all negotiations with tenants. Contracts are digitalised only as a scanned copy because both parties are required to physically sign the contract. Concerns were raised by interviewee 2 around whether the correct person is the one signing the document if it is a 'smart contract', as it is a legal document. Interviewee 2 suggested that "comfort is needed that the correct person is the one executing the contract, currently there is confidence as the tenant or owner is sitting in the room while signing and they are familiar to the property manager due to negotiations that have taken place".

In addition, there is a requirement to "check that all the correct people have executed/signed the contract when you are dealing with companies, corporations or trusts, which adds a higher level of complexity to ensuring the correct people have signed the document" (interviewee 2).

The adoption of blockchain in property management has been slow. None of the interviewees are currently using blockchain technology for the physical management (storing the building assets or lifecycle information) of the building or for the management of leases or tenants. Confirming this, interviewee 3 suggested that they "haven't seen anything where blockchain is being used related to buildings or been asked to provide the technology in order to use it".

The concerns raised by all the interviewees are about ensuring data is kept secure and understanding who can access it. Blockchain technology is being used by service providers such as Powerledger, for the storage of their database and related power information, but not currently by asset or facility managers.

4.3 What lessons can be learnt?

One of the lessons from this research is how managers of commercial office space can learn from smart building technologies that have been introduced into retail space to streamline waste management, cleaning and security.

Retail can also learn from the commercial sector regarding sustainability initiatives. Measures such as solar energy production, LED lighting and recycling water, have become commonplace in commercial buildings over the last 10 years, primarily driven by building rating systems such as Green Star and NABERS. Government agencies in Australia require any new building they plan to occupy to have a minimum NABERS building rating before they will even negotiate on a lease. This has had the effect of increasing demand for space in buildings that have Green Star and NABERS ratings.

Future developments of smart building technologies should focus on the objectives of owners and managers of buildings. Financial and non-financial benefits of each technology need to be assessed prior to adoption to achieve efficiencies.

Chapter 5
Conclusions and recommendations

This study examines the benefits and challenges offered by the uptake of smart building technologies such as blockchain and AI, on asset, property, and facility management activities in commercial buildings in Australia. Property has been one of the slower and more resistant industries to integrate smart building technologies, but technological disruption is now having a significant impact on the built environment. This is particularly evidenced by the growth in popularity of smart buildings, with global corporations striving to be located in such flagship buildings. In this chapter we present our conclusions and recommendations from the study.

Existing technologies such as BMS continue to be important and can be expanded to allow for further data to be collected and building efficiencies to be enhanced. Building information management (BIM), which stores 3D drawings and operating information, can be run in conjunction with established BMS to provide a more efficient picture of the building infrastructure and operation. Software packages that can collect and store drawings and communications can also be used for the management of communications relating to the ongoing operation of the building. With a combination of these technologies, building information and lifecycle costings will allow property and facilities management to be more accurately recorded and a long-term asset management plan to be constructed.

Investment in data collection and storage has become an important component of efficient asset and facility management. Effective data capture allows for better management and therefore creates more informed decision-making processes. Operating costs can be reduced by being able to accurately predict the requirements for cleaning and maintenance, which are major components of any building operating budget.

Data use is not limited to predictions for operating expenses, however, but can also be used to increase income. This can be achieved through more accurate targeting of advertising sales and maximising car parking rental, along with optimising the tenancy mix. Data can also be used to enhance the tenant's business and turnover, by collecting information that can help them better understand customer purchasing behaviour. Data is a valuable asset in its own right and should be controlled by owners, to allow for mining and subsequently more informed decision-making. It is also important for data to be collected in a format appropriate for the smart technology requirements.

The use of robotics in cleaning and waste management, in conjunction with effective and meaningful collection of data, can reduce operating expenses by more accurately predicating cleaning requirements and reducing waste handling and disposal costs.

Centralised services provide efficiencies, which can then be benchmarked against industry standard expenses and asset lifecycles, to ensure the costs are minimised through proactive management. Remote management of buildings and services is an important tool that can also be used during national emergencies. The management of buildings from remote locations can be improved by having technologies installed such as BMS and CCTV. Centralised services can also allow the amalgamation of service contracts and minimise the need for maintenance to be carried out ad hoc.

Smart contracts and the use of blockchain in property management are still in their infancy. However, there appears to be a willingness to learn more about the potential these technologies can add to transacting, record keeping, building providence, and an integrated technological approach.

Financial and non-financial implications

Efficiencies can be gained by amalgamating service contracts, centralising services, the use of robotics for cleaning and waste management, and extensive accurate data collection. To implement smart building technologies, there needs to be a progressive and forward-thinking team equipped with a variety of skills, including property management, security, information technology, energy efficiency, cleaning, along with other skillsets, dependant on the nature of the building requirements. The owner, or executive team that make the decisions to implement smart building technologies, needs to be committed to taking the initiative and risk of investing substantial funding and resources into the building. This must be a full-circle commitment as it takes time for investment in smart building technologies to deliver benefits, particularly in relation to energy savings, and show return on the investment.

Barriers and challenges

There continues to be barriers and challenges to investing in smart building technologies in existing buildings. It is much easier to include such technologies from the start of purpose-built smart buildings. A significant barrier to introducing smart technologies into the management of existing buildings seems to be in the level of knowledge of the person or company managing the asset. Findings from the study suggest that where a building is commissioned or managed as owner-occupied or REIT, they are more proactive in investigating and implementing smart building technologies to make the building more efficient with lower operating expenses, compared to a small private owner. They also appear to have a desire for a higher level of technology within the building compared to corporate property management companies, which are primarily focused on day-to-day management activities.

In the interviews, it was suggested that there is a high level of caution around changing systems that might disrupt the building and therefore tenant comfort or business operations. There is also a need to look at including smart building technologies to coincide with when new tenants take over leases, rather than during their lease term, which could cause them disruption.

A further barrier to the introduction of technology is that in many cases the income of property management companies is driven by rental income and therefore the focus is on securing tenancies, rather than on introducing new technology for building efficiency.

Recommendations

From the analysis of literature, case studies and in-depth interviews with specialist property managers and consultants, we can make some recommendations on the implementation of smart building technologies in commercial buildings. First, as it is less challenging to design and build a smart building from the start, there are lessons for more careful planning for existing buildings before embarking on a technological upgrade. To avoid significant disruption, managers should wait until tenancies end, before undertaking upgrades.

This is an opportunity to improve BMS already in place, as well as to introduce smart building technologies. However, the purpose of such updates must be carefully understood, as there are now numerous technologies available on the market, from Blockchain to AI systems, but some of these may promise more than the services they can offer. A more integrated approach, such as BIM/BMS/AI/AR, working for a purpose, should be contemplated.

Built environment professionals must continue to be encouraged to gain skills and knowledge on big data analytics and smart building technologies such as Blockchain, AI and AR for asset, property and facility management. This will require property companies to invest properly in education, ongoing training and upskilling of staff.

More awareness of sensitive privacy and ethical considerations must be addressed before implementation of any smart building technologies. As part of a company's corporate social responsibility it may need to engage an ethics officer to work with the data team to ensure data is collected ethically and privacy is paramount, particularly with any further data mining.

WELL certification is now an accepted component of Australian commercial developments. More, however, must be done to educate owners and developers on smart building technologies including AI and AR, as well as how these can be integrated into new builds and existing buildings to support the United Nations Sustainable Development Goals (SDGs).

Smart building technologies offer fresh and exciting opportunities for remote management to be recast as a science of its own, considering Covid-19 and the 2019-20 Australian bushfires. Australia's experiences of both are an opportunity for it to become a world leader in remote building management.

Considering the shuttering of many commercial buildings due to Covid-19, there is scope for AI/AR and other smart building technologies in the new office environment of social distancing and facilities management.

Lastly, it is important for building owners to ensure future contracts allow for them to own and control data collection, so this raw data can be used for data mining or other purposes as required.

The study highlighted numerous opportunities and challenges for the introduction and use of smart building technologies in buildings. As we recover from the pandemic, smart building technologies are the new normal, offering opportunities to enhance efficiencies and implement new social distancing protocols, while at the same time collecting and using data in an ethical manner which is respectful of privacy and aligns with good corporate social responsibility.

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