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The drivers, success factors, and inhibitors of the internet of things (IoT) in office buildings

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A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business

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ABSTRACT

IoT adoption in office buildings was accelerating as a result of growing demands placed on real estate providers to improve the quality of their spaces, amongst other factors. Deployments of IoT projects were experiencing high failure rates, which posed a challenge to organisations in the form of wasted resources. Understanding success factors, inhibitors and drivers increased the likelihood of project success. This research aimed to explore the drivers, inhibitors, and success factors of IoT solution deployments in office buildings to provide those deploying solutions with information that could be incorporated into their deployments to increase the likelihood of success. The study used an adapted version of the building blocks of digital transformation theorised by Westerman to relate drivers to IoT deployments and the Technology, Organisation, Environment (TOE) framework to relate success factors and inhibitors to project outcomes. A qualitative approach was adopted, and semi-structured interviews were conducted with ten individuals with experience deploying IoT solutions in office buildings. The interviews were analysed using thematic analysis. The analysis revealed several drivers, success factors, inhibitors, and stakeholders for IoT deployments in office buildings. They also revealed that drivers were relevant to specific stakeholders, that the IoT market was still maturing, and that there were varying degrees of success experienced in deployments by participants. Those deploying IoT solutions in office buildings e buildings can use the findings to align deployments to drivers, improve delivery practices, and design more effectively to improve project outcomes.

KEYWORDS

Internet of things, solution drivers, solution inhibitors, success factors, office buildings.

DECLARATION

I, __Zahir Suleman Mamoojee___, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Zahir Mamoojee Signature: 

Signed at …Houghton, Johannesburg……

On the ……28th…….. day of ……February…… 2023…..

DEDICATION

To my wife Aadila, for your love and patience throughout this process.

ACKNOWLEDGEMENTS

To my creator without whom nothing is possible, and through whom everything is achieved. All praise to him for giving me the ability to complete this exercise.

To my wife, Aadila, for always supporting me, motivating me, and believing in me. For selflessly sacrificing our time together. This would not have been possible without you.

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LIST OF ACRONYMS

Acronym	Definition
4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
B2B	Business to Business
BI	Business Intelligence
BIM	Building Information Modelling
BMS	Building Management System
CAGR	Compound Annual Growth Rate
CEO	Chief Executive Officer
CFO	Chief Financial Officer
COO	Chief Operating Officer
CRE	Commercial Real-Estate
CSF	Critical Success Factor
DT	Digital Transformation
EMEA	Europe, Middle East, Africa
EPC	Energy Performance Certificate

ERP	Enterprise Resource Planning
ESG	Environmental, Social, and Governance
FM	Facilities Management
GSM	Global System for Mobiles
HR	Humans Resources
HVAC	Heating Ventilation and Air Conditioning
ICT	Information and Communication Technologies
IoT	Internet of Things
IP	Internet Protocol
IT	Information Technology
LAN	Local Area Network
LEED	Leadership in Energy and Environmental Design
OEM	Original Equipment Manufacturer
OT	Operational Technology
RFID	Radio-Frequency Identification
ROI	Return on Investment
SANEDI	South African National Energy Development Institute

SCADA	Supervisory Control and Data Acquisition
SLA	Service Level Agreement
TOGAF	The Open Group Architecture Framework
EU	European Union
UK	United Kingdom
US	United States
VUCA	Volatile, Uncertain, Complex, Ambiguous
WEF	World Economic Forum

CHAPTER 1. INTRODUCTION

1.1 Statement of Purpose

This qualitative study explores the drivers, inhibitors, and success factors when applying Internet of Things (IoT) solutions in the office building environment.

1.2 Background of the Study

The Internet of Things (IoT) can be defined as “a paradigm where everyday objects can be equipped with identifying, sensing, networking and processing capabilities that will allow them to communicate with one another and with other devices and services over the internet to achieve some objective” (Whitmore et al., 2015, p. 1). IoT is seen as a key enabler of the fourth industrial revolution and is a major growth vertical in technology. This has largely been driven by a convergence of technological development, including cheap sensors, improved network connectivity, and long-lasting batteries that has made IoT solutions available to the mainstream market (Deloitte Touch Tohmatsu India LLP & Confederation of Indian Industry, 2020). The global IoT market is expected to grow at a compound annual growth rate (CAGR) of 25.4% (Fortune Business Insights, 2021), growing from a market size of $381 billion in 2021 to an estimated $1,85 trillion in 2028 (Fortune Business Insights, 2021). A McKinsey & Company (2021) report estimates that the IoT will unlock between $5.5 and $12.6 trillion in economic value by 2030.

The majority of IoT value is expected to come from business-to-business (B2B) applications of IoT in the following settings: factories, human healthcare, worksites, cities, retail environments, outside (autonomous vehicles, operations management in defence, ship navigation), home (chore automation, energy management), vehicles, and offices (McKinsey & Company, 2021). IoT solutions are expected to drive increased operational efficiencies, disruptive business models, and sustainability in communities, amongst other benefits (Deloitte Touch Tohmatsu India LLP & Confederation of Indian Industry, 2020).

Smart buildings, of which the offices mentioned above form a part, use IoT-enabled sensors to improve building monitoring, management, functioning, maintenance, efficiency, and user experience (Emergen Research, 2021; Jia et al., 2019). The global smart buildings market is expected to reach a size of at least $141 Billion by 2028 (Emergen Research, 2021; MarketsandMarkets, 2022; TechNavio, 2022) at an expected CAGR of above 9% for the period to 2028 (Emergen Research, 2021; Fortune Business Insights, 2022; MarketsandMarkets, 2022; TechNavio, 2022). This growth has been largely driven by increasing stringency in regulations, focus on energy usage and sustainability, and budgets for investment in smart building technology (Emergen Research, 2021).

Buildings can be split into residential and commercial buildings (Lawal & Rafsanjani, 2021). Commercial buildings can be categorised into 14 types (United States Energy Information Administration, 2018). A study of buildings in the United States (US) illustrates that warehousing, storage, and office buildings account for most commercial buildings, accounting for 17% and 16% of all commercial buildings respectively (United States Energy Information Administration, 2018). A similar study by the European Union found that 30% of all non-residential building floor area was occupied by offices (European Commission, 2013). These studies show that office buildings make up a significant proportion of commercial buildings.

The Covid-19 pandemic resulted in a large increase in the number of people working from home (Milasi et al., 2021). This trend started to reverse in 2022. Global real-estate management and investment firm JLL (2021) has reported that office space leasing volumes have increased for the first time since the pandemic and increased office re-entry rates globally. This return to office is not expected to mirror pre-pandemic practices. According to a CBRE (2021) interview of large companies with over 10 000 employees, the “next” or “new” normal way of working will be based on a hybrid work model, splitting work between offices and remote locations.

Along with adapting to this new hybrid model, there is increased pressure on stakeholders that provide and manage office spaces to include measures that

improve the quality of their spaces (JLL, 2021). These increased demands, which include a greater focus on health and wellbeing, sustainability (in the context of environmental, social, and governance (ESG)), occupant satisfaction, space utilisation, risk reduction, and cost reduction, have prompted an increased focus on digital solutions in offices (World Economic Forum, 2021). IoT solutions, current and future, promise to deliver value in each of the areas mentioned above and will be an essential technology to deliver the office spaces of tomorrow. Therefore, IoT technology and its applications are a critical item on the roadmap of most organisations with an office building footprint.

It should be noted from the introduction above that much of the available literature on IoT and IoT in office spaces was published by corporates rather than in journals and peer-reviewed papers. Therefore, the background paints a strong industry instead of an academic view.

1.3 Research Problem

According to recent reports, between 30% and 50% of IoT projects fail before they can be implemented at scale (Beecham Research, 2020; Microsoft & Hypothesis Group, 2021), while past reports have put this figure at 74% (Cisco, 2017). These failures can be attributed to multiple factors including but not limited to a lack of required skilled resources on projects, integration of solutions into existing systems, poor executive buy-in, unclear business value, and others (Beecham Research, 2020; Capgemini Research Institute, 2017; McKinsey & Company, 2021; Microsoft & Hypothesis Group, 2021).

An understanding of success factors and inhibitors of projects is one way that can enable those implementing them to set projects on the right course of action and improve the likelihood of their success (Belassi & Tukel, 1996; Pinto & Mantel, 1990). Furthermore, benefits criteria/drivers provide the reasoning and organisational goals for deploying initiatives, identifying them, and aligning delivery to them is critical to the success of projects (Melton et al., 2011).

As investment in IoT solutions for office spaces increases, the high failure rate of these solutions poses the potential for the wastage of significant company

resources on failed IoT projects. Organisations implementing IoT solutions for their office spaces need to be well-informed to make the correct decisions that will decrease the chances of project failure.

This research investigates the drivers, inhibitors, and success factors when applying IoT solutions in office buildings. It is hoped that by better understanding these drivers, inhibitors, and success factors and incorporating them into their deployment processes, those developing and implementing IoT projects in their office spaces can improve the success rate of their deployments.

1.4 Research Questions

Research Questions:

1. What are the drivers for the deployments of IoT solutions in office buildings?
2. What are the inhibiting factors to deploying IoT solutions in office buildings?
3. What are the success factors of the office building IoT solution deployments?

1.5 Rationale

IoT has been identified as one of the key enabling technologies of digital transformation (Armstrong & Lee, 2021) and is becoming more prevalent in businesses across sectors. This research intends to contribute to research in the field of digital business by expanding on the body of knowledge available on IoT solution implementation as a component of broader digital transformation within business.

Interest in this topic was formed through the researcher's experience in developing and deploying office space solutions in IoT. Through involvement in IoT projects in the office space setting, it was observed that many of these projects fail to show value to the clients that procure them—resulting in wasted resources from both a client and provider perspective. This phenomenon has

been observed in the field and is reinforced by the literature, as highlighted in section 1.3.

It is hoped that through this research, a contribution can be made to understanding the drivers, inhibitors, and success factors of IoT solutions in office building settings, building on the growing body of research in IoT. Furthermore, it is hoped that decision-makers and other stakeholders involved in the design, procurement, and delivery of office space IoT solutions can use the outcomes of this research in a practical setting to improve the success rates of their IoT initiatives by aligning project outcomes to the correct drivers and success factors and avoiding the inhibitors to successful deployment of solutions.

1.6 Delimitations of the Study

i) The primary focus of this study is on IoT solutions within the broader sphere of digital business. It excludes other aspects of digital business such as robotic process automation, additive manufacturing, augmented reality, and other focus areas of digital business.
ii) This study is limited to office spaces within the broader range of smart buildings, and IoT solution settings.
iii) The study is limited to pre-existing office spaces, not those in the planning and construction phase.
iv) This study uses a qualitative approach as it seeks to understand the drivers and inhibitors of IoT solutions deployed in office spaces through the experiences of research participants. Quantitative means are therefore excluded from use in this study.
v) This study is cross-sectional as it involves understanding drivers and inhibitors of IoT solutions deployed in office spaces from a population at a specific point in time.
vi) The participants of this study are limited to the management level and above in organisations that deliver and adopt IoT solutions.

1.7 Definition of Terms

Table 1.1 contains terms and their definitions relevant to this research report.

Table 1.1: Terms and Definitions

Term	Definition
Critical Success Factors	“Things that must go right” to improve the likelihood of success of IoT deployments in office buildings (Bullen & Rockart, 1981).
Drivers	A driver is a preliminary and/or expectation about future benefits that positively triggers and influences the adoption of something (Liere-Netheler et al., 2018).
Enhancers	Factors that increase the likelihood of project success (Williams & Ramaprasad, 1996)
Inhibitors	Factors that prevent the successful deployment of IoT solutions in office buildings (Cambridge University Press, n.d.).
Internet of Things	…the network of physical objects—devices, instruments, vehicles, buildings and other items embedded with electronics, circuits, software, sensors and network connectivity that enables these objects to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems…(Gokhale et al., 2018, p. 2)… this integration allows physical, and digital entities to interact in novel ways allowing value to be created in terms of cost efficiencies and/or

	perceived utility, and captured through the emergence of new isolation effects, on an individual, organisational and society level (Goumagias et al., 2021, p. 15).
Internet of Things Solution	The definition of an Internet of things solution used in this paper is derived from Cisco's 7-layer reference model for IoT (Cisco, 2014). An IoT solution is a solution comprising of: physical devices or sensors that act as a technological interface to interact with, or gain information about a physical entity (Bauer et al., 2013); connectivity to connect the devices within a network or across networks and transmit data; edge computing for data analysis and transformation; data storage tools, data abstraction for aggregation and access, data processing applications; and people or systems that consume solution outputs.
Office Buildings	A building or premises or part thereof whose principal use is for an office or for office purposes and where the primary activity is knowledge work (Law Insider, n.d.; McKinsey & Company, 2021).
Smart Building	A smart building can be defined as one that combines space and technology, using ICTs to adapt its operations and physical form in response to gathered data (Lecomte, 2019; Wong et al., 2018).

1.8 Assumptions

- It is assumed that IoT solutions for office spaces have the potential to create value for companies.
- Views from participants of this study would provide enough insight to draw conclusions about the drivers, inhibitors, and success factors of IoT solutions deployed in office building environments.
- Participants recruited for the study were from organisations that deliver and adopt IoT solutions in office environments and had sufficient knowledge of the IoT in the office building environment to contribute meaningfully.

1.9 Chapter Outline

Chapter 1 – Addresses the background of the research, clarifies the problem statement, and research questions. It then seeks to define aspects of the research through delimitations, definitions, and assumptions.

Chapter 2 – Is the literature review and theoretical framework. It provides insights from the literature on the three research questions, resulting in propositions for each. A theoretical and conceptual framework are then given to provide a theoretical lens for the research and linkage of concepts.

Chapter 3 – Delves into the research methodology outlining in detail the approach, design, methods, population, research instruments, and data collection procedures. It then outlines the quality assurance techniques, and ethical considerations. Finally, a plan to conduct the research is presented.

Chapter 4 – Presents the findings of the study. Findings are present in themes relevant to specific propositions. Questions, propositions, and themes are linked, and a conclusion is made on the research findings.

Chapter 5 – Discusses the research findings in relation to the propositions made. Discussions and conclusions are made on each proposition in relation to the research.

Chapter 6 – Provides conclusions to the research focused on the findings in the context of the research questions, and conceptual framework. It includes recommendations to stakeholders based on the research, and study limitations. It is concluded with suggestions for future research.

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1. Introduction

The literature review aims to provide insight into current knowledge and thinking in the field of IoT applied to office buildings. The study will explore the body of knowledge associated with critical themes stemming from the research topic and critically review them as a baseline for answering the research questions.

The review begins with an introduction to the topic of digital transformation, IoT, the role of IoT in digital transformation, and its applicability in the office buildings context. This is followed by a deeper exploration of the main drivers for deploying IoT solutions, factors inhibiting IoT solution deployment, and characteristics of successful IoT projects in office buildings. Finally, the theoretical and conceptual models underpinning the research are presented.

2.2. Background Discussion

Digital transformation (DT) can be defined as:

> The sum total of all organisational change efforts in response to technological disruption, that results in a marked change in the form and nature of the organisation, especially so that the organisation's ability to thrive in the digital age is improved. (Armstrong & Lee, 2021, p. 756)

Digital transformation has become critical to organisations as they look to survive in an increasingly volatile, uncertain, complex, and ambiguous (VUCA) world as it enables organisations to improve their competitive positioning by applying digital technologies (Armstrong & Lee, 2021; Souza et al., 2020). Effective implementation of digital transformation often results in internal process optimisation, novel methods of delivering products and services, enhanced

customer experience, and the disruption of entire industries by introducing new business models based on digitised products (Souza et al., 2020; Vugec, 2018).

The broad scope of benefits that digital transformation can result in indicates that it does not only include the use of new technologies but also encompasses changes in business strategy, models, processes, structures, and culture (Vugec, 2018). Digital technology plays a critical role, however with several key technologies, sometimes referred to as fourth industrial revolution (4IR) technologies (Armstrong & Lee, 2021), driving digital transformation (Ebert & Duarte, 2018). These technologies include robotic process automation, additive manufacturing, cloud computing, blockchain, Open APIs and microservices, virtual reality, cyber security, neurotech, big data, artificial intelligence (AI), and IoT (which will be focused on further) (Armstrong & Lee, 2021; Ebert & Duarte, 2018).

The term “Internet of Things” was coined by Kevin Ashton of the Massachusetts Institute of technology in a presentation done to Procter and Gamble in 1999 and was used as the title of the presentation describing a radio-frequency identification (RFID) based supply chain solution (Ashton, 2009). Despite the growth in popularity of the IoT, there is currently no universally accepted definition of the term, with many definitions used depending on the situation and perspective taken (Gokhale et al., 2018; Rose et al., 2015; Sorri et al., 2022). Early definitions of the term focused on IoT's technical aspects, neglecting non-technical elements such as business value (Sorri et al., 2022). The definition of IoT in this paper combines definitions from two separate sources to provide a comprehensive definition spanning both the technological and non-technological aspects. The internet of things can be defined as

> …the network of physical objects—devices, instruments, vehicles, buildings and other items embedded with electronics, circuits, software, sensors and network connectivity that enables these objects to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating

> opportunities for more direct integration of the physical world into computer-based systems…(Gokhale et al., 2018, p. 2; Goumagias et al., 2021)… this integration allows physical, and digital entities to interact in novel ways allowing value to be created in terms of cost efficiencies and/or perceived utility, and captured through the emergence of new isolation effects, on an individual, organisational and society level. (Goumagias et al., 2021, p. 15).

This paper also refers to “IoT solution " a broad term that encompasses solutions in many forms and does not have a standard definition. To define an IoT solution an analysis was done of IoT solution architectures proposed by different sources. A definition was formulated by examining commonalities between six different architectures. The most common architectural components of an IoT solution identified in the literature were sensors/hardware devices, network connectivity, some form of software platform/application layer, and data analytics (Cisco, 2017; Gokhale et al., 2018; Gupta & Quamara, 2020; Hossein Motlagh et al., 2020; Raiwani, 2013; Voas, 2016). When considering the components mentioned, the most comprehensive architectural framework is provided by Cisco (2017), which goes beyond the technology and includes the solution output consumer. The definition of an Internet of things solution used in this paper derived from Cisco’s 7-layer reference model for IoT (Cisco, 2014) is:

> A solution comprising of: physical devices or sensors that act as a technological interface to interact with, or gain information about a physical entity (Bauer et al., 2013); connectivity to connect the devices within a network, or across networks and transmit data; edge computing for data analysis and transformation; data storage tools; data abstraction for aggregation and access; data processing applications; and people or systems that consume solution outputs.

Souza et al. (2020) argue that because IoT enables the connection of physical and virtual processes, it plays a critical role in the “digital transformation of

business models, organisations, and processes" (Souza et al., 2020, p. 3). Armstrong and Lee (2021) reinforce this view by pointing out that digital solutions are deployed for 4 main reasons: (1) process improvement, (2) product enhancements or new product development, (3) new business model creation, (4) or to serve a social imperative, and that IoT solutions enable some or all these goals as required. Examples of how each are achieved through IoT are listed below (Armstrong & Lee, 2021):

- Process improvement – predictive maintenance through connected assets
- Product development – smart doorbells
- New business model – subscription based predictive maintenance.
- Social imperative – monitoring of air and water quality in communities.

IoT technologies and solutions are key to digital transformation initiatives. However, these initiatives are broad, and this research focuses on IoT technologies as applied to digitally transforming the office building environment.

The commercial real-estate (which office buildings is a subset of) and facilities management (FM) sectors are transforming due to the adoption of new information and communication technology (ICT) solutions (Atta & Talamo, 2020). This digital transformation results in changes in how buildings are managed and manifesting in new models, processes and services in the FM space (Atta & Talamo, 2020; Kim, 2018; Wong et al., 2018). The emerging trend of Proptech defined as "massive implementation of emerging technologies within the real estate sector" (Siniak et al., 2020, p. 2; Wong et al., 2018)has been characterised by implementation of technologies such as building information modelling (BIM), artificial intelligence, fintech, IoT and many others (Wong et al., 2018). As Proptech deployments increase, IoT is becoming a foundational digital transformation technology within the FM space. This is due to the capability of IoT technology to merge physical and digital worlds which enables building users, components and services to be connected (Atta & Talamo, 2020). This often near-real-time connection of different systems results in increased availability of information and interoperability that empowers various stakeholders within the building environment to benefit off cost reductions, improved service, and building performance (Atta & Talamo, 2020).Some common applications of IoT solutions

in buildings include: Energy management, water management, environmental control, smart lighting systems, and space occupancy analytics (Dryjanski et al., 2020). The value creation potential of IoT solutions for buildings has been widely recognised (Atta & Talamo, 2020) and IoT is set to become more entrenched in buildings as the industry matures.

2.3. Drivers for deployments of IoT solutions in office buildings

This section covers the research into the drivers of deployments of IoT solutions in office spaces. The goal is to explore what studies have determined the main drivers are. The identified drivers were used to inform the research questions during the interview phase and will either be reinforced, disputed or built on by the study's outcomes. For this research, the definition of the term “driver” was adapted from Liere-Netheler et al. (2018) - a driver is a preliminary and/or expectation about future benefits that positively triggers and influences the adoption of something.

When researching the drivers for IoT deployment in office buildings, it was evident that there was not an abundance of research addressing the office buildings niche specifically. Research in this section, therefore, covers findings in academic papers but also includes some from seminal works. The research also points out that IoT solutions deployed in office building settings can be categorised under the broader banner of “smart buildings” or “Proptech” (EDU, 2021; Horch et al., 2017). The research was broadened to include drivers of the adoption of smart building and Proptech solutions in general.

The term Proptech was defined in the previous section. However, no definition has yet been provided for “smart buildings” which are an important concept in any conversation regarding the adoption of technology in buildings. Using definitions from Wong et al. (2018) and Lecomte (2019) as interpreted by Engvall and Larsson (2021), a smart building can be defined as one that combines space and technology, using ICTs to adapt its operations and physical form in response to gathered data. Some smart buildings' technologies include building automation

systems, monitoring and analysis technologies, energy management systems, facilities management systems, and many others (Dryjanski et al., 2020).

Drivers for the adoption of smart building technology and some instances IoT technology in office buildings were studied from various literature sources. The drivers from each source and the focus of the source range from real-estate to buildings in general, to office buildings along with the technology focus of each source, including smart building technology, Proptech, IoT, smart office systems, and real estate technology were summarised in Table 2.1.

The drivers were then analysed to determine the most common across the literature. The result was 17 unique drivers identified across the sources; this number includes some drivers found in Table 2.1 that were merged to form a single category as follows:

- Building management was combined with process optimisation/functional efficiency (including operation and maintenance) as optimisation, and efficient operations included building management activities.
- Citizen wellbeing was merged with health and wellbeing.

It should also be noted that energy efficiency and management could be placed under the sustainability category but was mentioned on its own so frequently that it warranted its own category. **Error! Reference source not found.** shows how many of the nine sources each driver appeared in.

Table 2.1: Drivers of Adoption of Technology in Different Real-Estate Settings (Author's Own Work, 2022)

Reference	Focus Building Type	Tech. Focus	Drivers for Adoption
(Dryjanski et al., 2020)	Buildings in general	Smart building tech.	• Sustainability • Citizen wellbeing • Cost reduction • Energy efficiency • Building management • Waste control • High internet connectivity
(Larios et al., 2013)	Buildings in general and office buildings specifically	Smart building tech.	General: • Energy efficiency • Cost optimisation • Comfort gain • Productivity increase • Security enhancements • Safety enhancements Office building Specific: • Time optimisation • Process optimisation • Employee satisfaction
(EDU, 2021)	Buildings in general	Proptech	• Management/control • Health and wellbeing • Cost efficiency • Functional efficiency • Sustainability
(McKinsey & Company, 2021)	Office buildings	IoT solutions	• Employee productivity • Insurance costs • Energy management • Security • Human productivity • Occupant wellbeing

(World Economic Forum, 2021)	Commercial real estate	Real estate technology	• Health and wellbeing • Sustainability • Occupant satisfaction • Space utilisation • Brand recognition and loyalty • Risk reduction • Cost reduction • Increased efficiency • Data aggregation
(Buckman et al., 2014)	Buildings in general	Smart building tech.	• Longevity • Energy and efficiency • Comfort and satisfaction
(Sinopoli, 2016)	Buildings in general	Smart building tech.	Financial performance: • Income • Expenses/costs • Occupancy • Rental rates • Security and life safety • Efficient operation and maintenance • Occupant productivity and satisfaction • Water distribution • Ability to offer digital services
(Salosin et al., 2020)	Office buildings	Smart office systems	Reducing operating costs in: • maintenance • water supply • heat and electricity • Safety • Energy Efficiency
(Jia et al., 2019)	Buildings in general	Smart building tech.	• Location-based services • Energy efficiency • Proactive building and equipment maintenance • Indoor occupant comfort

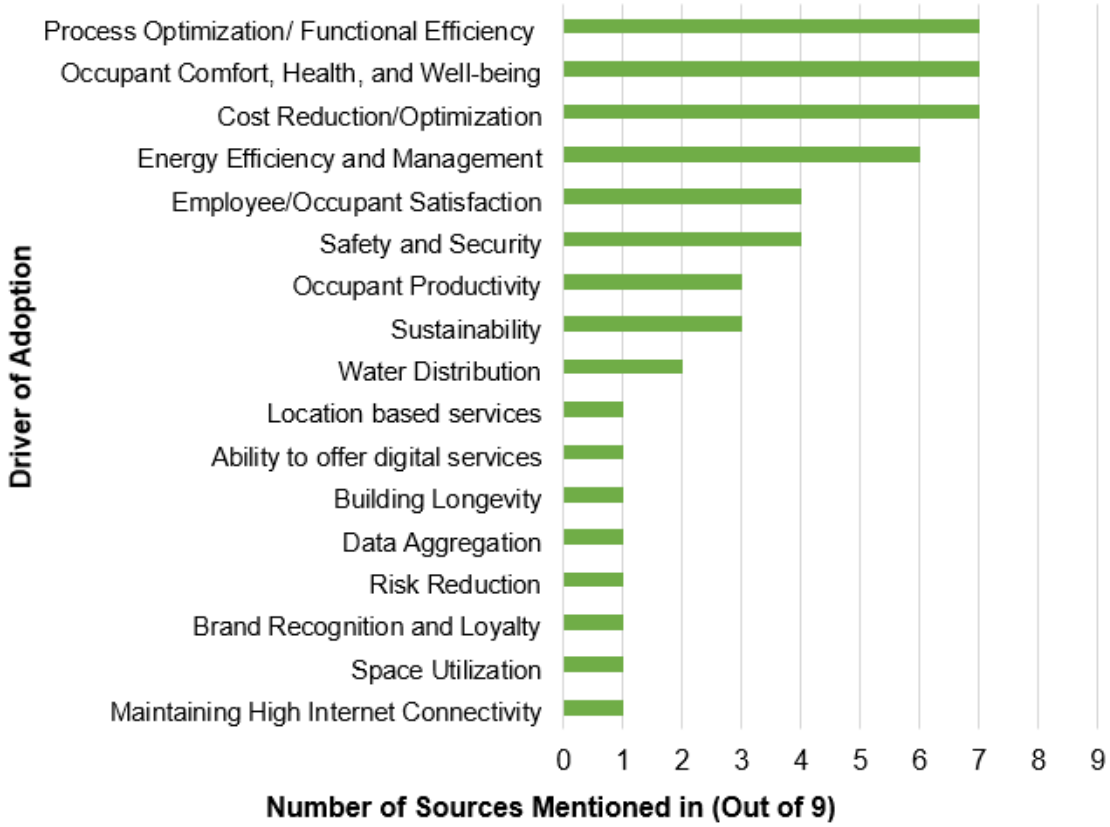


Figure 2.1: Number of Sources each Driver was Mentioned in – based on data from Table 2.1 (Author's Own Work, 2022)

It can be seen from Figure 2.1 that eight of the drivers appeared in 3 or more of the sources included (Buckman et al., 2014; Dryjanski et al., 2020; EDU, 2021; Horch et al., 2017; Jia et al., 2019; McKinsey & Company, 2021; Salosin et al., 2020; Sinopoli, 2016; World Economic Forum, 2021). Of the top eight most frequently occurring drivers, the top 7 were mentioned in one or more of the articles in Table 2.1 that focused specifically on office buildings (McKinsey & Company, 2021; Salosin et al., 2020). Sustainability was not mentioned specifically in those texts, but the assumption can be made that with many corporates globally committing to sustainability goals, sustainability is likely to feature as a strong driver for adopting IoT technology in office buildings. The 9 factors mentioned 2 or less times may have been specific to the situations assessed in the relevant studies but are worth consideration as the topic is researched further(Buckman et al., 2014; Dryjanski et al., 2020; EDU, 2021; Horch et al., 2017; Jia et al., 2019; McKinsey & Company, 2021; Salosin et al., 2020; Sinopoli, 2016; World Economic Forum, 2021). The need for further

validation of all drivers mentioned in **Error! Reference source not found.** was reinforced in World Economic Forum (2021) which stated of the drivers they had identified: “Proper understanding and validation of these drivers can enable better communication across the real estate value chain and ensure delivery on stakeholder expectations” (p. 4). This provides further validation for this research and the like to ensure the success of digital transformation initiatives in the commercial real estate space.

Furthermore, when analysing the literature, it is evident that drivers for deploying smart building solutions are different for different stakeholders in the real-estate environment. These stakeholders include building tenants (Dryjanski et al., 2020; EDU, 2021), the local community (EDU, 2021), investors (EDU, 2021), occupants, and building operators (McKinsey & Company, 2021). The perspectives of these stakeholders should be considered to form a comprehensive understanding of the drivers of deploying IoT solutions in buildings.

2.3.1. Proposition 1

There are several drivers of IoT solution deployments in office buildings. These drivers can be expected to be different for different stakeholders: building tenants, the local community, investors, occupants, and building operators.

2.4. Inhibiting factors to deploying IoT solutions in office buildings

The second major focus area of the literature review were inhibiting factors which create difficulty in IoT solution deployments in office spaces and hence in the realisation of value from these solutions. The term inhibit can be defined as “to prevent something from developing in the way or at the rate that is possible” (Cambridge University Press, n.d.). Inhibitors in the context of this research and adapting the definition of inhibit provided are factors that prevent the successful deployment of IoT solutions in office buildings. inhibitors and challenges are used interchangeably in this section. The identified inhibiting factors will be used to

inform the research questions during the interview phase and will either be reinforced, disputed or built on by the study's outcomes.

Research on factors that challenge IoT deployment is not a popular domain. It has shown the lowest growth in terms of a number of papers published when considering six areas of IoT deployment including: technology, applications, security, communication, architecture, and challenges (Aman et al., 2020). Resulting in a limited number of published research papers addressing the area of IoT solutions in office buildings. Office building IoT solutions can be classified as a subset of general IoT solutions for buildings, cities, and IoT solutions. The literature search was therefore expanded to include literature on challenges to deploying IoT solutions in general, for smart cities, and for smart buildings. Assuming that some of the inhibiting factors uncovered would be common across the spectrum. Seminal works from reputable organisations were also considered due to the increase in publications available to the market as the IoT industry grows.

A clear theme that emerged is that factors inhibiting IoT deployments can be divided into business and technical factors. Most of the research papers found on IoT deployment challenges focused on technical challenges (Carcary et al., 2018; Čolaković & Hadžialić, 2018; Dryjanski et al., 2020; Goad & Gal, 2017; Lawal & Rafsanjani, 2021; Mehmood et al., 2017; Nicolescu et al., 2018; Papadopoulou et al., 2017; Shahinmoghadam & Motamedi, 2019) with just under half of them incorporating business related challenges (Chui et al., 2019; Dryjanski et al., 2020; Nicolescu et al., 2018; Prasher, 2018). Seminal sources focus on technical and business challenges due to the strong industry exposure of the authors (Beecham Research, 2020; Capgemini Research Institute, 2017; Cisco, 2017; Microsoft & Hypothesis Group, 2021) . A total of 16 unique business challenges, and 7 unique technical challenges were cited in the literature reviewed. Top among business challenges were lack of internal skills, poor funding of initiatives, project costs, and no clear business case defined.

IoT projects are complex, involving a range of novel technologies and many stakeholders (Raghu, 2018). They require a range of management and specialist technical skills that are in short supply which makes finding the right skills to

deploy IoT solutions a challenge across organisations (Beecham Research, 2020; Chui et al., 2019; Cisco, 2017; Dryjanski et al., 2020; Microsoft & Hypothesis Group, 2021; Nicolescu et al., 2018).

Funding IoT projects can prove challenging as the initial layout of capital to procure sensors at scale is high. This often results in small-scale projects being implemented one at a time (Dryjanski et al., 2020). Funding pressures are worsened by cost of implementation, which can be unpredictable for complex IoT solutions and factors such as operations and maintenance, connectivity, and application are often unaccounted for and increase costs over the project duration (Dryjanski et al., 2020).

According to Prasher (2018), IoT projects are more likely to fail without a strong business case and clear benefits up front. ROI is a critical part of any IoT business case. Businesses struggle to quantify ROI during project initiation as there is often no clear understanding or vision of the business objectives and implementation strategy, and how the two will result in a return on investment (Beecham Research, 2020; Prasher, 2018). A further contributor to this is IoT implemented for the sake of it to give the perception of business being technologically savvy and forward thinking (Beecham Research, 2020).

Prasher (2018) considered the challenges faced in deploying IoT from a project management lens and identified the following issues:

- Lack of universal IoT jargon when deploying IoT projects introduce complexity in managing projects (Madakam, 2015, as cited by Prasher,2018).
- Challenges in building teams stemming from the relative novelty of IoT and related technology. Teams must constantly train and upskill to survive, and often skills are sourced from different cultural backgrounds. Both of these factors lead to conflict and challenges when deploying IoT solutions.
- Poor linkage of IoT project goals and organisational strategy.
- Unclear scope definitions.
- Unrealistic and unattainable project goals.

- Unclear roles and responsibilities resulting in delivery issues.

In addition to the challenges identified by Prasher (2018), further issue in managing IoT project deployment were identified including:

- Lengthy times to project completion (Beecham Research, 2020; Cisco, 2017).
- The lack of alignment between business units results from differing mindsets and resistance to change (Beecham Research, 2020).
- Lack of senior management involvement hampering project success (Beecham Research, 2020).

Further to the most commonly cited issues and those related to the management of IoT projects, a few other notable issues were found. Poor alignment of incentives between building owners and tenants was an issue that was hampering IoT implementation at scale in office building environment. This is the result of building owners funding IoT initiatives which primarily benefit tenants in many instances (McKinsey & Company, 2021). Issues with vendor claims have also been cited as a challenge wherein businesses are given unrealistic expectations of IoT solutions by vendors who cannot deliver on their claims (Beecham Research, 2020). Volatility of markets, suppliers and technologies has proven to be an issue as the rapid developments in technology such as decommissioning of 2G and 3G networks, political issues linked to sanctions, and global events have all impacted on IoT project and technology deployments in general (Beecham Research, 2020).The complete list of business challenges found are listed in Table 2.2 along with the sources for each.

Table 2.2: Business Challenges When Deploying IoT Solutions (Author's Own Work, 2022)

Business Challenges	Source/s
Lack of internal skills	(Beecham Research, 2020; Chui et al., 2019; Cisco, 2017; Dryjanski et al., 2020; Microsoft & Hypothesis Group, 2021; Nicolescu et al., 2018)
Funding challenges	(Beecham Research, 2020; Dryjanski et al., 2020; Microsoft & Hypothesis Group, 2021)

Cost/Keeping projects in the budget	(Beecham Research, 2020; Cisco, 2017; Nicolescu et al., 2018)
No clear business case/Objectives/No clear measures of ROI	(Beecham Research, 2020; Capgemini Research Institute, 2017; Nicolescu et al., 2018; Prasher, 2018)
Time to completion/Keeping Projects on Schedule	(Beecham Research, 2020; Cisco, 2017)
Team building and integration (add Cisco)	(Beecham Research, 2020; Prasher, 2018)
Lack of universal IoT jargon	(Prasher, 2018)
No clear link with organisational strategy	
No clearly defined project scope	
Unclear delivery roles and responsibilities	
Unrealistic project goals	
Poor incentive alignment between building owners and tenants	(McKinsey & Company, 2021)
Lack of senior management involvement	(Beecham Research, 2020)
Lack of alignment between business units	
Vendor Issues	
The volatility of markets, suppliers and technologies	

The most commonly cited technological issues were security and privacy concerns, communication infrastructure/network performance/connectivity, interoperability/verticalized platforms/lack of standard architecture, data management challenges, privacy concerns, diversity of things/heterogeneity, scalability of solutions (Beecham Research, 2020; Capgemini Research Institute, 2017; Carcary et al., 2018; Čolaković & Hadžialić, 2018; Goad & Gal, 2017; Lawal & Rafsanjani, 2021; Mehmood et al., 2017; Microsoft & Hypothesis Group, 2021; Nicolescu et al., 2018; Shahinmoghadam & Motamedi, 2019; Wong et al., 2018).

Security was a major concern in IoT as connected systems required protection in the form of security measures. The fact that IoT devices are often remote, battery powered, and are simple means that they often do not have the ability to run high grade security features (Beecham Research, 2020). In addition to the devices the various system layers used in IoT solutions such as platforms, connectivity, and connections between multiple systems are vulnerable to security breaches (Beecham Research, 2020; Raghu, 2018). This increases organisations' vulnerability to cyber-attacks and increases an organisation's attack surface (Beecham Research, 2020; Raghu, 2018). The security threat to IoT systems

also poses a privacy concern as IoT systems may contain personal and non-personal data which can become exposed during security breaches (Lawal & Rafsanjani, 2021). If system users cannot be sure that the IoT system they is trusted it will generally not be accepted (Mehmood et al., 2017).

IoT systems must have reliable network connectivity that is able to support scale deployments and is well monitored for performance. As IoT solutions scale the number of devices and locations increases, and the variability can adversely impact connectivity in network infrastructure (Capgemini Research Institute, 2017). Poor network performance has the ability to render IoT solutions useless as they rely on networks for updates and data transmission (Beecham Research, 2020). Connectivity is a challenge in buildings particularly as sensing devices are located in various parts of buildings which might not have adequate network coverage (Lawal & Rafsanjani, 2021). An additional challenge is that there has not been a standard set of connectivity protocols adopted in the industry resulting in uncertainty on which connectivity protocols to invest in (Capgemini Research Institute, 2017).

Interoperability in IoT refers to “the ability of devices and systems to interoperate regardless of deployed hardware or software” (Čolaković & Hadžialić, 2018, p. 27). The current IoT solution landscape consists of different standards from different providers across the technology stack including devices, network connectivity, cloud architectures, security standards, communication protocols, and applications (Aman et al., 2020). The most common types of IoT solutions are specific to the application and siloed in nature with separate standards applied, leading to heterogeneity of technology in the field (Čolaković & Hadžialić, 2018; Dryjanski et al., 2020). This lack of standardised architecture leads to major interoperability issues (Čolaković & Hadžialić, 2018; Lawal & Rafsanjani, 2021), resulting in complexity and high costs of system integration (Dryjanski et al., 2020), uncertainty about future standards that stifle decision making (Capgemini Research Institute, 2017), difficulty in deploying cross-system IoT solutions at scale (McKinsey & Company, 2021), and complexities in device/system maintenance (Aman et al., 2020).

IoT enables the real-time collection of data from devices and systems, increasing the amount and types of data being gathered by organizations (Beecham Research, 2020). This data must be stored securely, processed and analysed to add value to organizations and require skills and resources from organizations to do so. The issues in managing this data include a lack of skills to do so in many organizations (Capgemini Research Institute, 2017), complexity caused by irregular and uncertain datasets (Nabizadeh et al., 2019), absence of tools to handle the data, ensuring privacy and security, and central storage and retrieval (Mehmood et al., 2017).

Scalability refers to the ability to integrate new devices and applications to an existing IoT deployment without compromising its performance (Aman et al., 2020; Čolaković & Hadžialić, 2018). The challenge for the organization is adopting an architecture that will enable large volumes of heterogeneous devices to be added to the system in future (Pereira & Aguiar, 2014). Solutions not designed with scalability in mind generally need to undergo costly redesigns when scaled (Beecham Research, 2020).

Availability and reliability are important in IoT systems as they provide monitoring and control capabilities of systems in different environments, which in some cases are critical systems (Goad & Gal, 2017) . Keeping systems available has become a challenge in the deployment of IoT and stems from many factors including intermittent availability of communication technologies such as networks, the lack of interoperability of systems as mentioned previously (Aman et al., 2020), and the need for devices that can collect and store data independently of networks (Čolaković & Hadžialić, 2018)

IoT devices are often located in areas where there is a lack of reliable power supply (Shukla et al., 2015). In these cases alternatives such as battery power, or harvesting power from the environment of the sensors are needed to keep devices operational (Aman et al., 2020). Although advancements have been made in low power sensor technologies that use batteries and low power communication technologies, these are still in their infancy and often costly to implement or unsuitable for the application at hand (Lawal & Rafsanjani, 2021). Additionally, they add maintenance overheads as batteries must be changed over

time. Finding devices with the right capabilities, at the right price point and power consumption characteristics is a major issue in IoT deployments (Čolaković & Hadžialić, 2018).

The complete list of technical challenges is listed in Table 2.3 and the sources for each.

Table 2.3: Technical Challenges When Deploying IoT Solutions (Author's Own Work,2022)

Technical Challenges	Source
Security and Privacy Concerns	(Beecham Research, 2020; Capgemini Research Institute, 2017; Carcary et al., 2018; Čolaković & Hadžialić, 2018; Goad & Gal, 2017; Lawal & Rafsanjani, 2021; Mehmood et al., 2017; Microsoft & Hypothesis Group, 2021; Nicolescu et al., 2018; Shahinmoghadam & Motamedi, 2019; Wong et al., 2018)
Communication Infrastructure/Network Performance/Connectivity	(Beecham Research, 2020; Capgemini Research Institute, 2017; Čolaković & Hadžialić, 2018; Dryjanski et al., 2020; Lawal & Rafsanjani, 2021; McKinsey & Company, 2021; Mehmood et al., 2017)
Interoperability/Heterogeneity Verticalized Platforms/Lack of Standard Architecture	(Aman et al., 2020; Capgemini Research Institute, 2017; Čolaković & Hadžialić, 2018; Dryjanski et al., 2020; Lawal & Rafsanjani, 2021; McKinsey & Company, 2021; Mehmood et al., 2017; Papadopoulou et al., 2017)
Data management challenges	(Beecham Research, 2020; Capgemini Research Institute, 2017; Carcary et al., 2018; Chui et al., 2019; Cisco, 2017; Čolaković & Hadžialić, 2018; Lawal & Rafsanjani, 2021; Mehmood et al., 2017)
Scalability of solutions	(Beecham Research, 2020; Carcary et al., 2018; Čolaković & Hadžialić, 2018; Nicolescu et al., 2018)
Solution Availability and Reliability	(Aman et al., 2020; Carcary et al., 2018; Čolaković & Hadžialić, 2018; Lawal & Rafsanjani, 2021; Nicolescu et al., 2018)
Energy/Power	(Aman et al., 2020; Goad & Gal, 2017; Mehmood et al., 2017)

The assessment of the literature included both seminal and academic sources. An observation from the review was that all seven technical challenges to deploying IoT solutions were mentioned either in both seminal works and academic literature, or only academic sources. There is a high likelihood that this study will reinforce these factors due to the credibility that has been provided by the academic sources.

Of the business challenges found, nine were from both academic and business literature or just academic literature. These were lack of internal skills, funding challenges, cost, clear business case, universal IoT jargon, clear link with organisational strategy, clearly defined project scope, unclear delivery roles and responsibilities, and unrealistic project goals (Beecham Research, 2020; Chui et al., 2019; Cisco, 2017; Dryjanski et al., 2020; Microsoft & Hypothesis Group, 2021; Nicolescu et al., 2018; Prasher, 2018). The remaining seven occurred purely in seminal works (Beecham Research, 2020; McKinsey & Company, 2021) and might therefore be biased to the business goals of the organisation that published them. This might also explain the higher number of business factors found due to inconsistencies across seminal works.

Furthermore, only one business challenge – Poor incentive alignment between building owners and tenants, and three technical challenges - security and privacy concerns, communication infrastructure/network performance/connectivity, interoperability/heterogeneity of verticalized platforms/lack of standard Architecture were mentioned specifically in the context of IoT solutions deployed in buildings.

2.4.1. Proposition 2

Inhibiting factors to deploying IoT solutions in office buildings can be categorised into business and technical factors. These factors are expected to include one or more of the business and technical factors found in the literature and summarised in Table 2.2 and Table 2.3 respectfully.

2.5. Success factors for office building IoT solution deployments

Most of the literature about success factors was centred on the concept of critical success factors (CSFs) in disciplines such as information technology (IT) and information systems. Bullen and Rockart (1981) in their early work define CSFs as “the few key areas where "things must go right" for the business to flourish and for the manager's goals to be attained” (p. 7). This definition is adopted in various forms in literature exploring success factors. This paper does not consider the criticality of success factors and narrows them from a broad business and managerial context to a specific context namely, the deployment of office building IoT solutions. This research will therefore refer to “success factors”, and adapting the definition of Bullen and Rockart (1981), defines success factors as: “things that must go right” to improve the likelihood of success of IoT deployments in office buildings.

Upon surveying the literature none addressing the characteristics of successful IoT deployments in buildings were found. The search was broadened to include IoT solutions in general. Four main sources were used to determine the factors of successful IoT deployments. A summary of 25 factors that were mentioned in the literature can is provided in Table 2.4.

Table 2.4: Success Factors of IoT Solution Deployments (Author's Own Work, 2022)

#	Success Factor	Factor Detail	Reference/s
1	Design centred on the end-user	The solution provides a positive user experience providing a high degree of usability.	(Sayar & Er, 2018; Silverio et al., 2019; Trzaskoma, 2020)
2	Alignment with company strategy	Grounding IoT deployments in business strategy, and alignment with long-term strategic goals.	(Raghu, 2018; Trzaskoma, 2020)
3	Business Transformation	Clear understanding of the technology. Capabilities to radically transform business process to harness IoT solutions' value-creating power.	
4	Cyber security and privacy	Multiple approaches to cyber security should be taken, and ongoing staff training on cyber security is done. This should be combined with a clear understanding of privacy regulations.	
5	Data Management	Having an in depth understanding of data flows and storage, and how the data will be translated to deliver value. Assuring data trustworthiness and using appropriate BI tools.	
6	People/Updated talent management strategies	Investment in people through creation of dedicated IoT teams, upskilling, continuous learning to benefit from failures, and bringing in external expertise to consult on matters. Executive training on business and technical aspects is a critical part of this so that correct decisions can be made when crafting solutions. Creating new roles for individuals that with technology, people, and business skills to collaborate across information technology (IT), operational technology (OT), and business functions.	(Kranz, 2017; Raghu, 2018)
7	Developing a partner ecosystem	Companies must partner with the correct ecosystem partners to solve business problems together and capture the full value of IoT solutions.	(Kranz, 2017; Sayar & Er, 2018)
8	Solution interoperability	Systems designed to easily integrate with current and new solutions.	(Silverio et al., 2019; Trzaskoma, 2020)
9	Top management buy-in	Getting early buy-in from top leadership and demonstrating the value that can be derived from the solution.	
10	Focus on business challenges	Project must be driven by a clear purpose and problem statement	(Kranz, 2017; Trzaskoma, 2020)
11	Risk awareness	Keen understanding of the various risk involved in deployment are considered from different perspectives, including those inherent in the technology.	(Raghu, 2018)
12	Business and IT alignment	The goals and scope of the project must be agreed on between business and IT stakeholders.	(Trzaskoma, 2020)

13	Business runs the initiative	Business stakeholders are more likely to pursue IoT deployments for the correct reasons that deliver business value.	
14	Alignment between IT and OT	Both teams generally have different goals and must be aligned to the project goal.	
15	Clear key performance indicators	Clear key performance indicators and timelines to monitor progress of initiatives.	
16	Scalability	A solution that is built to scale up front.	
17	Technology awareness	Successful deployments occurred at companies with employees that were more aware of technological developments.	(Silverio et al., 2019)
18	Company size	Larger companies have budgets to assign to IoT and more relevant use cases, increasing likelihood of success.	
19	Cost of implementation	Projects based on an accurate cost-benefit analysis.	
20	A well- articulated system design strategy	All stakeholders are briefed early on in the design process to avoid task ambiguity and establish a clear understanding of the requirements of all parties during implementation.	(Sayar & Er, 2018)
21	Redefining the roles and responsibilities of frontline personnel	System providers must train internal technical staff to support customers, or partner with the right partners to do so.	
22	Training and recruiting service aware staff	Providers of IoT solutions must train frontline staff to clearly articulate system value to clients.	
23	Guiding customers on system use	Solutions providers must provide guidance on how to use the system to achieve their desired outcome and to motivate them to continue using it.	
24	Aligning customer focus across the business	system developers must place customer centricity at the heart of all efforts and create alignment across teams on customer behaviour to inform system design.	
25	Methods and techniques for systems thinking and creativity	system designers should use visual resources and design tools to create clarity on staff responsibilities. These should be combined with narrative-based techniques to inform user interaction and experience of solutions.	

Factors 1 to 10 in Table 2.4 were featured in 2 or more of the reviewed works. 1 to 16 in Table 2.4 were from papers that discussed success factors of IoT solution deployments in general (Kranz, 2017; Raghu, 2018; Sayar & Er, 2018; Silverio et al., 2019; Trzaskoma, 2020), and might be generalisable to multiple contexts. Factors 17 to 19 taken from Silverio et al. (2019) were based on a sample of IoT deployments in the construction industry in a specific geography and may mean that the factors are less generalisable. Finally, factors 20 to 25 in Table 2.4 were taken from Sayar and Er (2018) who provided a unique perspective which was focused on organisations designing and deploying the IoT solutions as opposed to the solution deployment in general.

2.5.1. Proposition 3

There exist specific success factors of IoT deployments in office buildings. These success factors are expected to include one or more of the factors found in the literature and summarised in Table 2.4.

2.6. ANALYTICAL FRAMEWORK

2.6.1. Theoretical Framework

The theory related to this research can be broken down into two core themes: Drivers of deployment, critical success factors (CSFs).

Drivers of deployment

According to Westerman et al. (2011) the building blocks of digital transformation are centred on three main areas within the organisation – Customer experience, operational process, and business models; with digital capabilities supporting them; this framework is shown in Figure 2.2 . The view of Armstrong and Lee (2021) is that there are four main reasons for deployment of digital solutions – process improvement, new product development, business model creation, and solving a social imperative. Berman (2012) states that strategic routes for digital transformation are centred on customer value propositions and transforming operating models or combining the approaches simultaneously.

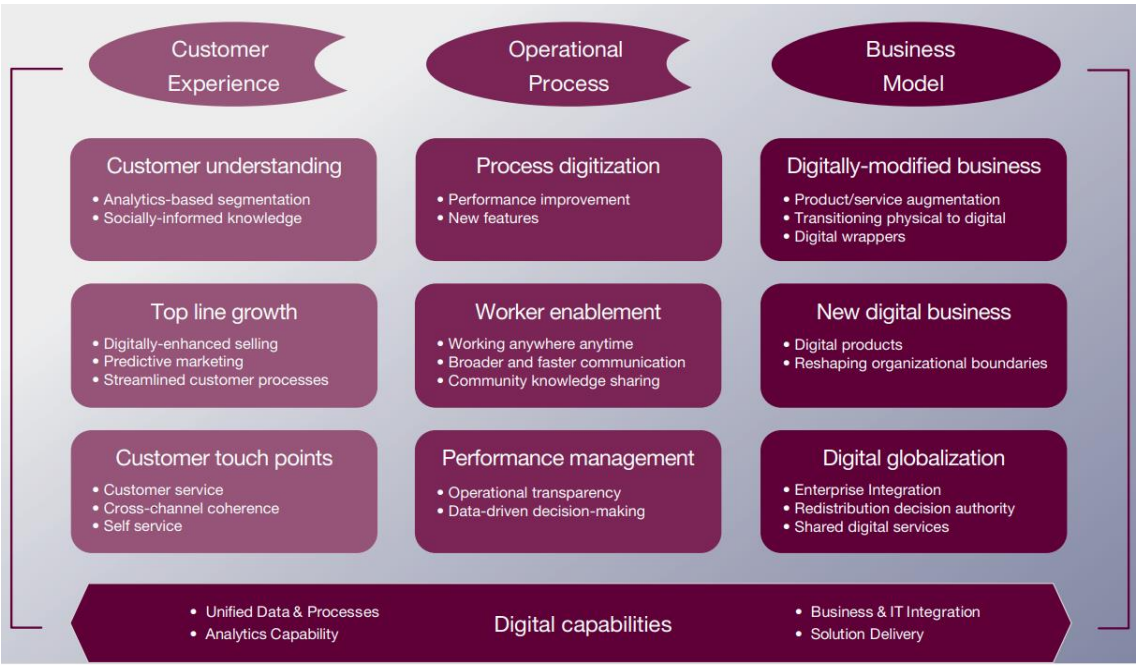


Figure 2.2: Building Blocks of Digital Transformation (Westerman et al., 2011)

According to Morakanyane et al. (2017), value creation is the core outcome of digital transformation initiatives and includes factors such as operational efficiencies, and costs savings to name a few. Therefore, all drivers (as defined in this research) of digital transformation must be linked to value creation. Examples of value creation mentioned in Morakanyane et al. (2017) can be likened to the deployment drivers mentioned in section 2.3. of the literature. These drivers can be grouped under the key organizational areas of digital transformation (Morakanyane et al., 2017).

In this research, the theoretical view held by Westerman et al. (2011) is accepted as it encompasses customers, operations, and business models. However, it lacks the critical element of 'social imperatives' included by Armstrong and Lee (2021), which has become increasingly important to organizations; an example is ESG among the factors influencing investment performance (Zumente & Bistrova, 2021). This research, therefore, adopts the view that digital transformation initiatives fall under four main areas in the business:

- Customer Experience
- Operational Processes

- Business models
- Social imperatives

The drivers identified can be categorized under each of those areas when considering IoT deployments in office buildings as a digital transformation initiative.

Critical Success Factors

Most of the literature encountered about success factors were centred on the concept of critical success factors (CSFs) in disciplines such as information technology (IT) and information systems (IS). Bullen and Rockart (1981) in their early work, define CSFs as “the few key areas where "things must go right" for the business to flourish and for the manager's goals to be attained” (p. 7). This definition is adopted in various forms in literature exploring success factors. This study narrows CSFs from a broad business and managerial context to a specific context namely, the deployment of office-building IoT solutions. The definition of Bullen and Rockart (1981) is adapted to suit this context, and critical success factors are defined as: The few key areas that must go right to improve the likelihood of success of IoT deployments in office buildings.

Williams and Ramaprasad (1996) in their paper aimed at defining a taxonomy for critical success defined attributes for characterizing CSFs as Enhancing or inhibiting, standing or instigating, and director or indirect. Their study shed light on the nature of CSFs in that they can either be factors that increase (enhancing) or decrease (inhibiting) the likelihood of project success, meaning that they can be characterized as enhancing or inhibiting factors (Texas Instruments, 1988; Williams & Ramaprasad, 1996). According to literature, a keen understanding of success factors can enable organizations to plan for project success by leveraging the specific variables that affect success (Bullen & Rockart, 1981; Vogelsang et al., 2018; Williams & Ramaprasad, 1996). It is important that both enhancing and inhibiting factors are considered during implementation, as focus on one might cause negligence of the other, leading to issues (Chow & Cao, 2008; Williams & Ramaprasad, 1996).

Williams and Ramaprasad (1996) provide three ways to characterize CSFs based on causality as either those linked to success by an understood causal mechanism, those necessary and sufficient for success, those necessary for success, and those associated with success. The intent of this research is not to establish exact causal links between CSFs and project success, nor factors that on their own are likely to result in the success of projects. The intent is to understand those factors that affect project success through the experience of study participants. It is expected that participant responses will associate factors with project success and through that provide reason to believe a causal relationship exists. Conforming to the definition of criticality based on association from Williams and Ramaprasad (1996).

Based on the findings of the literature, this study will define critical success factors as per the adapted definition from (Bullen & Rockart, 1981); factors will be grouped as either enhancing or inhibiting, and will be assumed to have causality based on association (Williams & Ramaprasad, 1996). It should be noted that enhancing factors and success factors are used interchangeably in the rest of this paper.

Categorizing CSFs

Three types of studies were encountered when researching frameworks on critical success factors: those that grouped factors into categories (Adzmi & Hassan, 2018; Chow & Cao, 2008; Shenhar et al., 2002; Taherdoost & Keshavarzsaleh, 2015; Vogelsang et al., 2018), those that uncovered individual factors and grouped them into phases (Pinto & Mantel, 1990), and those that grouped factors into categories and studied or formulated interactions between the groups (Belassi & Tukel, 1996; DeLone & McLean, 2003).

This study aimed not to determine the interactions between critical success factors but to uncover what the factors themselves might be through a qualitative study. Grouping of success factors into categories was the most commonly used approach in the literature. Several reasons for this were provided including that individual success factors differ according to project type and so generalizing individual factors can be problematic (Pinto & Mantel, 1990; Shenhar et al., 2002),

factors evolve based on development such as technological advancement (Belassi & Tukel, 1996), and lastly categories allow easier determination of relationships at a level that was more practical for researchers and practitioners to use (Belassi & Tukel, 1996). Based on this an approach from literature that categorized success factors was opted for.

Three of the studies considered (Adzmi & Hassan, 2018; Chow & Cao, 2008; Taherdoost & Keshavarzsaleh, 2015) categorized success factors for projects but were focused specifically on project management in IT, which narrowed the focus too much for this study. Vogelsang et al. (2018) sought to uncover success factors for digital transformation projects using the IS success model developed by DeLone and McLean (2003) as a starting point. Their findings were that the DeLonge and McLean model was technically focused and was therefore not generalizable to a digital transformation context (Vogelsang et al., 2018), and that the Technology, Organization, Environment (TOE) framework developed by Tornatzky et al. (1990) was more appropriate to categorizing digital transformation success factors. Their reasoning for this was that it combined the technical perspective of Delone and McLean with an organizational and environmental perspective, which was more appropriate to digital transformations that generally extend beyond technology (Vogelsang et al., 2018).

The TOE framework defines three contexts that influence how an organisation adopts and implements technology (Tornatzky et al., 1990). These contexts are the environment, organization, and technology and can be used to categories success factors (Tornatzky et al., 1990). The TOE framework is adopted to categories CSFs in this research owing to its applicability to digital transformation initiatives. The logic employed is that IoT is a key digital transformation technology, forming a subset of digital transformation projects. By this logic the theories can be extended to apply to IoT.

2.6.2. Conceptual Framework

A graphical representation of the conceptual framework is presented in Figure 2.3 and the elements are explained according to the letter labels in Figure 2.3.

A - Drivers provide the motivation and ultimate value-based reason behind the start of an IoT office space deployment and can be categorized as customer experience, operational processes, business models, or social imperatives.

B – Critical success factors influence the deployment of the project and are either enhancers or inhibitors.

C - The deployment is grounded in the drivers and influenced by Inhibitors and enhancers which play a role in determining its final outcome.

D - Inhibitors, have a negative impact on the deployment and can be categorized as organisational, environmental, or technical.

E - Enhancers, if present in the deployment, have a positive effect impact on the deployment and can be categorized as organisational, environmental, or technical.

F - Ultimately the drivers, enhancers, and inhibitors have an impact on the outcome of the deployment.

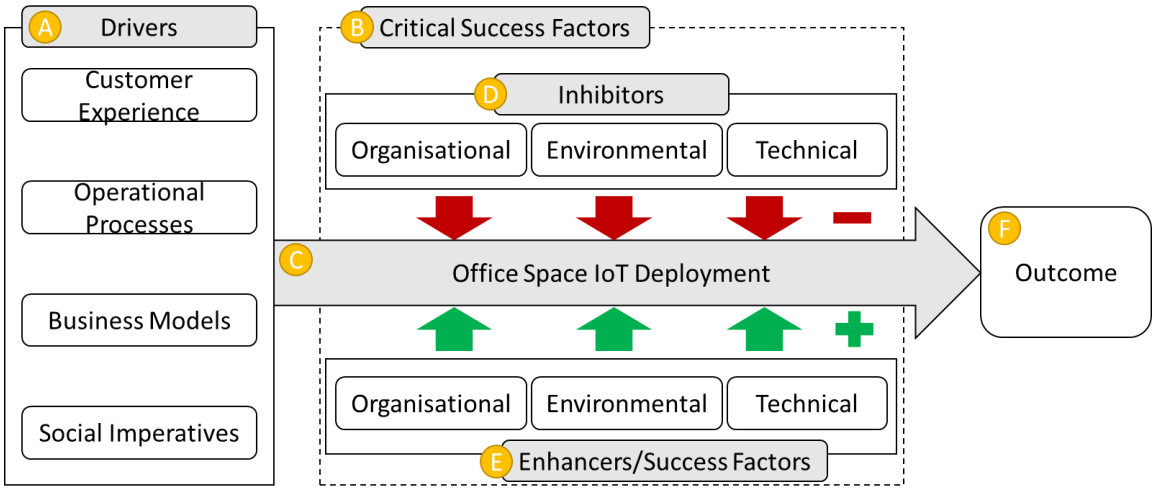


Figure 2.3: Conceptual Framework

2.7. Conclusion of Literature Review

The review indicated that IoT is a key technology in digital transformation and can play a role in delivering process improvements, enhanced customer experience, new business models, and alignment with social imperatives. IoT has become a core digital transformation technology in the field of proptech. It offers a variety of use cases that bring value to various stakeholders, including cost reductions and better service. For all its promise, however, the literature pointed to a high failure rate of IoT projects of between 30% and 70% depending on reference sources. This prompted a further review of IoT solutions' drivers, inhibitors, and success factors in office buildings.

No existing generally accepted definition of IoT was present in the literature, resulting in the formulation of a definition. An exploration of the drivers of IoT solutions in office buildings revealed that little research had been done on IoT in the office building setting, and so the broader field of smart buildings and proptech, were explored. This revealed a variety of drivers that could be grouped under the broader organizational areas of customer experience, operational processes, business models, or social imperatives. It also revealed that drivers are different depending on the stakeholder involved. In addition, the World Economic Forum (2021) study on technology in corporate real-estate reinforced the need for the validation of drivers.

Inhibitors were defined as factors that prevent the successful deployment of IoT solutions in office buildings. Again, limited research was found on inhibitors or challenges to deploying IoT solutions with a study from Aman et al. (2020) showing that challenges had the lowest research paper publish rate amongst several IoT deployment factors under study. Findings also indicated that inhibitors can be categorized into technical and business challenges and that most of the current research focuses on technical challenges. A total of 23 unique challenges were found. Literature also indicated that these factors could be incorporated into deployments to improve the chance of project success.

Lastly, success factors were researched and framed using the definition of commonly researched ‘critical success factors’ and adapting the definition for this

research, which does not include a study of criticality. Once more, specific research on IoT success factors for deployments in smart buildings was not common. The survey included factors for broader IoT deployments and found 25 factors cited across the literature. Furthermore, research indicates that these can be categorized into 3 distinct groups and incorporated into planning to improve project success. Three main propositions stemmed from the literature review and are repeated below.

2.7.1. Proposition 1

There are several drivers of IoT solution deployments in office buildings. These drivers can be expected to be different for different stakeholders: building tenants, the local community, investors, occupants, and building operators.

2.7.2. Proposition 2

Inhibiting factors to deploying IoT solutions in office buildings can be categorized into business and technical factors. These factors are expected to include one or more of the business and technical factors found in the literature and summarized in Table 2.2 and Table 2.3 respectfully.

2.7.3. Proposition 3

There exist specific success factors of IoT deployments in office buildings. These success factors are expected to include one or more of the factors found in the literature and summarized in Table 2.4. They stem from 3 main areas: organizational, environmental, and technical.

CHAPTER 3. RESEARCH METHODOLOGY

The methodology that was used to address the propositions from section 2 and ultimately answer the research questions posed in section 1 are described in this chapter. The chapter begins with a description of the approach taken and the design of the research. This is followed by the data collection method, the population and sample to be studied, description of the research instrument, and how data will be collected. Finally, the study's limitations, quality, and ethical considerations are covered.

3.1 Research Approach

Qualitative research is an approach that seeks to understand phenomena in their natural setting through the meaning attributed to the phenomena by participants who have experienced them (Creswell & Creswell, 2017; Hammarberg et al., 2016). Data in qualitative approaches is generally gathered using tools such as text analysis, in-depth, or semi-structured interviews and provides rich context and detail of a phenomenon from the perspective of the participant (Creswell & Creswell, 2017). The data gained through qualitative research is non-numeric and therefore not subject to typical numerical analysis techniques such as counting and measurement (Hammarberg et al., 2016). Qualitative research approaches are best used when researchers aim to use inductive reasoning to draw conclusions about phenomena, and where individual experience and complexity are important and high respectively (Creswell & Creswell, 2017).

Implementations of IoT solutions are variable depending on the specific deployment. Therefore, individuals involved in the process will have different experiences and perspectives on the implementations, their drivers, inhibitors, and success factors. This research aims to understand the drivers, inhibitors, and success factors of IoT deployments in smart office buildings through the experience of individuals involved in those deployments. A qualitative research approach facilitates this as it enables questions to be answered based on

experience through the participant's standpoint (Hammarberg et al., 2016), and was selected as the approach for this research.

Qualitative research is based on some key assumptions. A set of these assumptions based on the works of Creswell and Creswell (2017) are listed below and discussed in terms of their appropriateness for this research:

- Research is based on inductive reasoning – This research will take an inductive approach as it seeks to build theories from observations.
- Multiple perspectives are included – Perspectives of multiple participants will be used to solve the research problem.
- Distance between the researcher and participants is minimized – This research will use interviews of participants in their natural setting and gather data from actual conversations with the participants.
- Researcher as the instrument – In this study, the researcher will be the key instruments to gather and interpret participants' information.
- Context-bound – The context and setting of the participants in this study is important to the information being gathered.
- Uses text analysis – This study will use non-numeric data from interview transcripts and other text sources to inform research outcomes.
- The goal is to uncover patterns or theories to explain a phenomenon – This research seeks to uncover the drivers and inhibitors of IoT solutions in office buildings through the experience of those that have participated in those deployments.

3.2 Research Design

This research does not fit into the specific categories of phenomenology, grounded theory, ethnography, narrative inquiry, or qualitative case studies. It does, however have all the qualities of qualitative research in that it seeks to understand the meaning participants make of their experiences in office building IoT projects, the researcher is the research instrument, it is inductive, and will result in a descriptive outcome as described in section 3.1 (Merriam, 2002).

Generic qualitative research enables the researcher to conduct qualitative research without adhering to the characteristics and methods of the five methodologies mentioned above (Merriam & Tisdell, 2015) or any specific research methodology (Jahja et al., 2021). Its focus is on discovering and understanding “a phenomenon, a process, the perspectives and world views of the people involved, or a combination of these” (Merriam, 2002, p. 6). A generic qualitative method inductively draws patterns and themes from data gathered through interviews, observations in the field and documents and presents it in a descriptive account (Merriam, 2002).

This research aimed to gather detail on the drivers and inhibitors of IoT solution deployments in office buildings. The generic qualitative design enabled this as it focused on the participants' perspectives and enabled insights to be gathered from different stakeholders involved in deploying the solutions.

One of the key methods used in generic qualitative research is interviews (Merriam, 2002). A semi-structured interview method to gather information from participants was used as the primary means for data collection in this study. Through the collection of this data from multiple participants and its analysis, themes emerged that enabled the answering of the research questions.

Like any research method, a generic qualitative approach has advantages and disadvantages. The advantages in the context of this research are:

- The approach provided rich data for answering the research questions through semi-structured surveys and open-ended questions.
- The ability to make revisions as themes and patterns emerged, and review these with participants (Miles et al., 2014, as cited by Hickman, 2015).

Some disadvantages were:

- Interviews resulted in mass data being collected which posed a challenge to analyse in terms of time and complexity of the analysis required.
- The researcher was the instrument in this type of research, and biases from previous experience could have crept into the information analysis.

- Finding sufficient participants to participate in the research was challenging as the research focused on office building solutions as a niche within IoT.

3.3 Data Collection Methods

In some studies, structured surveys with close-ended questions are used to gather data from large samples of research participants, offering a breadth of opinions (Adams, 2015). Other studies use very open-ended questions in focus groups engaging less people and adopting an extremely fluid approach to questioning (Adams, 2015). This allows for a greater depth of data collection. Semi-structured interviews fall in the middle of these two approaches using elements from both approaches, they employ a mix of closed and open-ended questions that allow for follow-up questions, often uncovering more insight into topics (Adams, 2015).

This research was conducted using one-on-one, semi-structured interviews with individual research participants as the primary means of data collection. Interviews were conducted interactively in a live setting or via online conferencing to enable follow-up questions to be asked. Recordings (with the consent of participants) were made of the interviews so that data could be reviewed and accurately transcribed after the interviews took place.

The use of semi-structured interviews was seen as appropriate for this research as:

- It is an often-used and widely accepted method of data collection in generic qualitative research (Creswell & Creswell, 2017; Jahja et al., 2021). This lends it credibility as a method for this phenomenological research design.
- This research seeks individual participants' perspectives on the drivers and inhibitors of IoT deployments. These perspectives can be extracted through open-ended, probing questions about the topic. This will enable the researcher to guide the interview and get the right and rich information from the participants (Jahja et al., 2021).

- This research focuses on drivers but also focuses on inhibitors, which have a negative connotation to them. Participants might feel more comfortable discussing inhibiting factors by using a one-on-one approach instead of a focus group setting.

3.4 Population and sample

3.4.1 *Population*

The population for this research was defined as all individuals with experience in deploying IoT solutions. The target population was individuals with experience in deploying IoT solutions in office buildings.

The reason for selecting this target population was because the target population was likely to contain individuals that could provide insights into the research questions through their first-hand experience in the field of IoT and in the specific context of IoT deployments in office buildings.

3.4.2 *Sample and Sampling Method*

The sample of interest selected for this research were individuals with 2 years or more experience deploying IoT solutions in office buildings in either a decision making, delivery, or solution development capacity. The reason for 2 or more years of experience being stipulated was so that the individuals in the study would have sufficient depth of knowledge to provide meaningful, experience-based input towards answering the research question. Decision makers, delivery role players, and solution developers were included in the sample to provide a breadth of perspectives that would enable a richer variety of experiences when answering the research questions.

The selected sampling methods for this research were non-probabilistic due to the qualitative nature of the research (Jahja et al., 2021). This research used a combination of two sampling methods: purposive sampling and snowballing.

Purposive sampling enables the researcher to select participants based on his or her/judgement of the participant's ability to provide useful information in answering the research question (Jahja et al., 2021), and the relevance of participants to the objectives of the study (Merriam & Tisdell, 2015). Snowballing is a technique for accessing participants from the research sample through references from existing research participants in the study (Streeton et al., 2004). The technique enables the researcher to credibly approach new participants through an introduction or endorsement from an existing participant (Denscombe, 1997, as cited by Streeton et al., 2004). Researchers must generally know the network they wish to study to use snowballing effectively (Faugier & Sargeant, 1997).

These methods were selected for three main reasons:

- The researcher's background in the IoT industry provided exposure to and facilitated relationships with individuals of the outlined sample. This provided the researcher with a starting pool of participants leveraged using snowballing to identify and recruit new participants from the networks of the starting pool.
- The IoT industry, particularly associated with IoT for office space, was small making it difficult to find participants from the sample. Purposive sampling allowed the researcher to find and pick participants based on their relevance to the study. Snowballing extended the researcher's ability to find participants from the sample.
- People within the research sample are generally part of large or small business and have a network of peers in the industry. One example might be an individual from the sample who knows many peers through conferences or other means. Snowballing enabled the researcher to leverage of this network to reach more potential participants from the sample.

The number of participants sufficient in qualitative research varies according to the source. Creswell and Creswell (2017) recommend the following for different qualitative methods based on numerous study reviews:

- Narrative – 1 to 2 participants
- Phenomenology - 3 to 10 participants
- Grounded Theory – 20 to 30 participants
- Ethnography – A single culture-sharing group

This approach used the concept of saturation wherein the number of participants is determined based on the researcher's determination that few new insights are being gathered from interviews (Lincoln & Guba, 1985). It was hoped that five participants from the researcher's existing network could be interviewed and that each of them would be able to refer at least one new participant from the sample as per the snowballing approach mentioned above. The aim was therefore to conduct at least 10 interviews. The rationale is that the study most closely resembles a phenomenological one and guidance is taken from Creswell and Creswell (2017).

The intent was to drive participation in the research by initially leveraging off sound relationships that the researcher had with individuals from the sample. Further participation was encouraged as a product of the snowballing method through referrals from the initial participants who provided credibility to the request for an interview from the research. Figure 3.1 is a summary of the research population and sample.

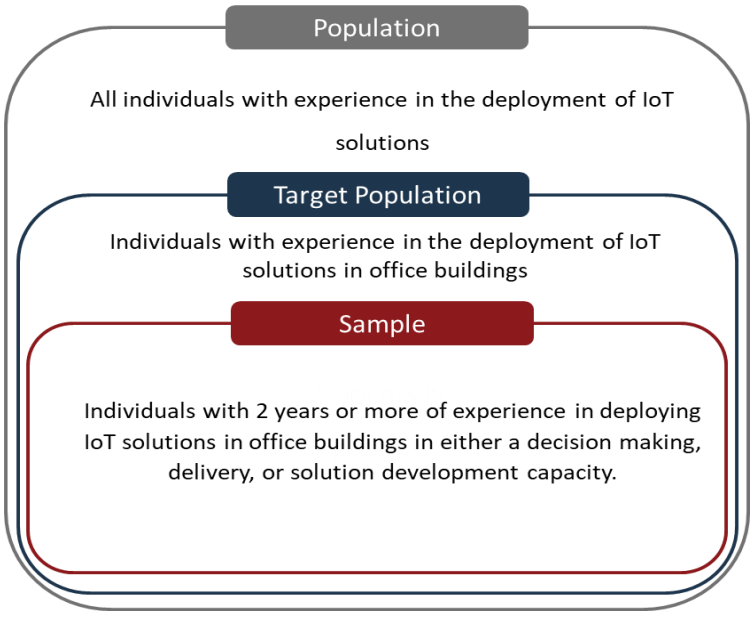


Figure 3.1: Summary of Research Population and Sample

3.5 The Research Instrument

Data collection was done through semi-structured interviews as described in section 3.3. using an interview guide as an instrument. The interview guide was an essential step to ensure that the content of the interviews covers the required subject matter in the allotted time (Adams, 2015). The structured interview guide drafted for this research was informed by Adams (2015) and can be found in Appendix C.

The guide was structured in 7 sections: introduction, ice breakers, theme 1 - drivers of IoT deployment in office buildings, theme 2 - successful deployments, theme 3 - inhibitors to deployment, extra information, and ending. The introduction sets the tone for the interview and explains the purpose and reinforces confidentiality. The ice breakers allowed the participant to ease into the interview subject matter. The theme sections covered the major research questions and propositions. Positive themes such as drivers and success factors were intentionally placed before the negative theme of inhibitors, as starting with a negative theme could have skewed all responses in a negative light (Adams, 2015). The extra information section aimed to pick up any pertinent themes that the participant might have in mind that had not already been addressed. Finally, the ending prompted the participant to refer new potential participants.

3.6 Procedure for Data Collection

Data in this research was collected through semi-structured interviews with participants. The data collection procedure was divided into three sections pre-interview, interview, and post-interview, and guidance were taken from recommended practices from Adams (2015); Jahja et al. (2021) and Creswell and Creswell (2017).

Pre-interview:

- Candidate participants were identified from the researcher's personal network.

- These candidates were contacted by email and their participation was requested two weeks before the interview commencement.
- As part of the email, a brief introduction to the research topic, scope, and estimated interview length (45 to 60 mins) was provided in the form of a participant information sheet. The sheet can be found in Appendix A.
- If interviewees agreed to participate, they were provided with a consent form, interview guide, and written confirmation of their willingness to participate in the study. A suitable time and place for the interview was requested from the participant in the email. The consent form and interview guide can be found in Appendix B and C respectively.
- In person or online interviews were arranged using Microsoft Teams video conferencing with each participant. Invitations were sent to the interviewees, confirming the interview arrangements.

Interview:

- On commencement of the interview, the researcher introduced himself, verbally reconfirmed consent for the interview, and requested permission to record.
- For in person interviews the recording was done using the researcher's mobile phone, interviews on Microsoft Teams were recorded using the built-in recording feature on the application. Recording was started when permission was been received from the participant.
- The researcher interviewed in a relaxed manner and took written notes through the process.
- At the end of the interview the researcher re-affirmed confidentiality with the participant.
- Because this research used snowballing the researcher requested the participant to provide an email introduction to a contact with similar sample characteristics.
- The researcher also requested permission to follow-up with the participant for additional information if needed and thanked them for participating.

Post-interview:

- All interview recordings were downloaded onto the researcher's laptop and transcribed using transcription software. The transcriptions and recordings were stored in a folder on the researcher's laptop which was password protected. Research notes were digitized and captured in the same location.
- Once referral emails were received from participants for new potential participants. The process started from the beginning with mail contact being made to the potential participants.

3.7 Data Analysis Strategies and Interpretation

Content and thematic analysis are the two main techniques used in qualitative analysis (Jahja et al., 2021). This research used thematic analysis as it is suited for analysing data purely qualitatively, whilst content analysis uses both qualitative and quantitative analysis. Manual coding and data analysis can be laborious and time consuming during thematic analysis and Creswell and Creswell (2017) recommend using software tools to aid in the analysis. The researcher conducted the analysis using Atlas.ti software. All research transcripts and other data were uploaded to the software for analysis.

The method that was used was take from based on works from Braun & Clarke (2006) and consisted of 6 phases:

- Familiarization with the data: The data was transcribed from the research interview recordings. After the initial transcription, the data was read, and notes were made of some of the findings. The transcripts were uploaded to Atlas.ti software for coding.
- Generating Codes: Data transcripts were read again, and initial codes were generated in Atlas.ti. A hybrid approach to coding was adopted consisting of a theoretical approach which used insights from the literature to generate codes and an inductive approach where codes emerged purely from the data (Braun & Clarke, 2006). Coding was done using a descriptive approach which considered only the participants' feedback and not the researcher's input (Saldaña, 2014).

- Finding Themes in the Data and Thematic Review: Codes were grouped into theme folders in Atlas based on specific messages and similarities in the coded data. A semantic approach to theme identification was applied (Braun & Clarke, 2006). The initial themes were reviewed and a document organizing themes and sub-themes was created to ensure that themes were distinct and coherent.
- Assigning Theme Names and Definitions: Themes were refined and given final names to be used in the report.
- Writing the report: The data was presented in the report through the findings section using carefully selected interview extracts to convey the findings effectively. The findings were used in the discussion and conclusion of the research.

3.8 Quality Assurance

3.8.1 *Credibility*

Credibility in research refers to the extent that the research findings represent the participants feedback and accurate interpretation of their views. Prolonged engagement, persistent observation and member checking are three ways to enhance the credibility of qualitative research (Korstjens & Moser, 2018). In the study, the following methods were taken to ensure credibility:

- Prolonged engagement - The interviews allowed for lengthy engagements with the participants, the interview guide contained targeted questions that stemmed from the literature, and the semi-structured interview format allowed for follow-up and deeper, probing questions.
- Persistent observation – the researcher thoroughly examined the data through multiple reads to ascertain the true essence of the interview responses. Multiple coding and recoding iterations of the data were done to refine themes.

3.8.2 *Dependability*

Dependability lies in the consistency of the research findings if the research is replicated in a similar context (Lincoln & Guba, 1985). Dependability was accounted for in this research approach through the documentation of the research method, effectively providing an audit trail (Korstjens & Moser, 2018). Sections 3.1. to 3.7. detail the approach, design, data collection methods, population and sample information, an instrument used, data collection, and analysis procedures. Subsequent researchers can use these approach details to assess whether the study complies with research best practices, audit the approach and to replicate the study if necessary. Due to the qualitative nature of the research, small sample size, and anonymity of the participants some variation in results should be expected if the participants differed from the original study.

3.9 Ethical Considerations

- The research report was submitted to Turnitin, and a plagiarism declaration was signed to prove the report's originality.
- Confidentiality was maintained by:
  - Keeping participant identities undisclosed to anyone besides the researcher.
  - Ensuring that all data in reports is not attributable to respondents or their organizations.
  - Ensuring that any confidential information is not published in the final report.
- Identities of participants and organizations were assigned pseudonyms to maintain anonymity.
- Participants were provided with an information sheet and a consent form to ensure informed consent. The information sheet explained the study details, and the consent form ensured that signed consent was received.
- Data was protected by storing interview recordings, notes and transcripts in a central location on the researcher’s computer that was password protected using credentials known only to the researcher.

CHAPTER 4. PRESENTATION OF FINDINGS

4.1 Introduction

This chapter presents the results of the data gathered through semi-structured interviews. The chapter begins with a profile of the research participants. The findings of the research are then provided. They are structured by relevant research propositions and then themes and follow a flow of insights backed by quotes from interviews. To end-off the chapter, a summary is provided linking the research questions, propositions and themes, and a paragraphed summary of the findings.

4.2 Profile of Participants

When carrying out the study the target of ten participants was met, and the data from the ten was used in the analysis.

Purposive sampling using the researcher's judgment to select participants was used in selecting the participants of this study (Jahja et al., 2021). The targeted sample for this research was individuals with two years or more of experience in deploying IoT solutions in office buildings in either a decision-making, delivery, or solution development capacity. The interviewed sample met these criteria and participant information is summarized in Table 4.1.

The planned number of 10 interviews were executed. All participants held senior positions in their organizations. They each had two or more but less than six years of experience at IoT projects in office buildings. Seven had experiences in decision making, delivery, and three had purely decision-making experience. Six participants were from IoT companies, three from telecommunications companies, and one from a building management system provider.

Table 4.1: Research Participant Information

Participant	Position	Company Type	Years of IoT Experience	Role Type
1	Managing Executive	Telco. Company	3	Decision Making
2	Global Head of Architecture	IoT Company	5	Decision Making, Delivery, Development
3	Chief Operating Officer	IoT Company	5	Decision Making, Delivery, Development
4	General Manager	IoT Company	3	Decision Making, Delivery, Development
5	Head of IoT	IoT Company	2	Decision Making, Delivery, Development
6	Product Owner for IoT suite of products	IoT Company	5	Decision Making, Delivery, Development
7	Managing Director	IoT Company	2	Decision Making
8	IoT and Smart Building Demand Generation Lead	Building Management System (BMS) Company	2	Decision Making
9	Technical Services Principle	Telco. Company	3	Decision Making, Delivery, Development
10	Group Property Strategy Manager - Digital Innovation Portfolio	Telco. Company	4	Decision Making, Delivery, Development

4.3 Themes from the Study

This study aimed to understand the drivers, inhibitors, and success factors of IoT solution deployments in office buildings. It investigated the factors influencing the adoption and outcome of IoT in office buildings. The study addressed the three research questions below:

- What are the drivers for the deployments of IoT solutions in office buildings?
- What are the inhibiting factors to deploying IoT solutions in office buildings?
- What are the success factors of the office building IoT solution deployments?

A thematic analysis of the data was done using a hybrid of an inductive and theoretical approach (Braun & Clarke, 2006). The theoretical approach borrowed from the literature in the formulation of the themes whiles the inductive approach resulted in some themes that emerged through the analysis. Furthermore, the research used a semantic theme approach (Braun & Clarke, 2006) and descriptive coding techniques (Saldaña, 2014), which ignored the researcher's input into the interview as it was irrelevant.

The analysis resulted in the emergence of the themes listed below:

- The Nature of the IoT for Office Spaces Industry
- Drivers of IoT Deployments in Office Buildings
- Stakeholders of IoT Projects for Office Buildings
- Project Success Rate
- Inhibitors to Deploying IoT in Office Buildings
- Success Factors for Deployment of IoT in Office Buildings

Findings are presented in themes and grouped under the propositions they are relevant to in the following sections. The Project success rate theme is placed at the beginning of the findings under proposition 2 as it is relevant to the findings on success factors and inhibitors under propositions 2 and 3.

4.3.1 *Findings Relevant to Proposition 1*

a. *The Nature of the IoT for Office Spaces Industry*

One of the key themes that emerged from the interviews was concerning the nature of the IoT for office spaces industry. The theme is useful in contextualizing the environment in which the participants experienced IoT projects and their drivers. Two sub-themes emerged to explain the nature of the industry at the time of the research:

1. IoT is a repackaging of traditional concepts.
2. Initiatives are in their early stages of adoption and the market is not yet mature.

IoT is a Repackaging of Traditional Concepts

Participants indicated that the internet of things was a buzzword that created hype in the market, indicating that it was not a new thing but rather the latest iteration/evolution of building management, and supervisory control and data acquisition (SCADA) systems used in previous buildings and operational environments. Participants 2 and 3 provided the following opinions in this regard:

> "It's not new, it's just enabled by newer technology…we should distil it to its base components and just say it's problem solving with technology that is enabled through the internet." – **Participant 2**

> "I would be pretty hard on the IoT pitch in that all that I'm doing is taking a BMS that works on a different protocol, BACnet, and I'm converting it to Internet Protocol (IP)." – **Participant 3**

Initiatives are in their early stages of adoption and the market is not yet mature

Participants expressed views on the maturity of the IoT market for Office Building Solutions. The first notable point was that IoT in Office Buildings was still in its early stages of adoption and that the market was still maturing. With Participants 3, 4, and 9 noting that:

> “I think we are still in the very early stages of mass IoT adoption, and I think the figures state that as well” – **Participant 3**

> “Even in the conceptualization portion it goes well and then when it comes to the execution phase, it falls flat. I think it is because these type of things are like sort of in the infancy, if you want to call it that…” – **Participant 9**

> “I think the big challenge right now is just getting clients to understand the value of it right now, for us to actually get our businesses to grow and to achieve what we know can be done. I think it's just that maturity curve in the whole market. Look and, I mean a typical thing where a client goes through a bit of a trough of disillusionment saying, ‘yeah we've seen a lot of this interesting stuff, but we haven't had a lot of success from it’. So just I think getting through that curve where we get to the mature phase of things is going be an interesting journey for a lot of organization in this space.” – **Participant 4**

A further reinforcement of this point was that the interview participants that indicated how long they had been involved in IoT projects had involvement ranging from between two and six years with Participants 2, 9, and 10 noting:

> “I've done everything from pre-sales to solution architecture, to project management, and just now general technical delivery, and worked in IoT Company 1 for four years” – **Participant 2**

> “That’s how this all came about so let’s say that happens around about 2016 that all started kicking off. We started experimenting with occupancy counters, desk booking and stuff like that.” – **Participant 10**

Interview results also point to IoT for Office Buildings still being specialized and unique, with no dominant market player that has set the standard for solutions in the industry. According to participants IoT solutions for office buildings were still regarded as a nice to have for companies, and largely adopted by companies that were innovative in nature. Participants 3, 4, and 8 alluded to this in their interviews:

"Look a lot of IoT solutions are not must have solutions for clients and I think that's a very interesting point that I've come across 'Listen that's cool stuff but I mean we don't really need that'. You absolutely need to have a firewall, and then everyone needs a laptop, but you don't necessarily need occupancy sensors. Your business can run without those. That's why these things that I've just mentioned now are so much more important versus a must have a solution." – **Participant 4**

"Smart buildings and IoT being, let's face it, at the early stages of its life. Certainly not there. There's still quite a broad spectrum of frontline players. Nobody's really taken the lead. If you think about some of the other big industries in buildings, there's certain big players that sort of set the standards. I think IoT and smart buildings is still finding its way to that point" – **Participant 8**

"I think it's quite a unique, very specialised play. I think it's, you know, once you've got a customer that's engaged that's using and really looking at the business value the growth kind of occurs, but I think it's quite a niche." – **Participant 3**

b. *Drivers of IoT Deployments in Office Buildings*

Participants were asked what the drivers of deployments for IoT in office buildings were, in line with the research objectives. The feedback received from the interviews can be broken down into 9 sub-themes that emerged as listed below:

- The new normal post COVID-19;
- Data driven decision-making and strategies;
- Office Space Optimisation;
- Operational Efficiency;
- Utility Management and Sustainability;
- Building Occupant Experience;
- Asset management;
- Regulatory Compliance;
- Shortage of competent technical resources to manage operations.

The New Normal Post COVID-19

The COVID-19 Pandemic led to new thinking about work and the viability of hybrid models. At the time of this study things were still normalising after the pandemic with uncertainty as to what the "new-normal" would look like. This left stakeholders of office buildings with decisions on how to best use offices for the new-normal and landlords looking to wow tenants into retaining space in an environment where less space was expected to be used by tenants. IoT was seen as a technology that would enable decisions to be made for optimal practices in terms of office space in the new normal, facilitating new hybrid, occupant friendly, and efficient ways of working. These findings are highlighted in the quotes below.

> "I'd say the current trend that certainly around optimisation. So, we've had this whole hangover from COVID right. Are working from home or not? Do they have to come in for two days, three days a week? Which days? You've still got this very much, uh, a flux of unknown within corporate real estate. So, you know, once kind of COVID is truly behind us or it's the new norm, and that we've learned to live with it. Then you will still have a period of understanding the different mixes of strategy in terms of the hybrid working model, what works and what doesn't. So, you're still going have a couple months of needing to settle and getting used to the way things currently are." – **Participant 3**

> "Why spin technology in offices when offices are empty, people are still kind of working from home? We still got a lot of shifts occurring in the next two years with this balance between work from home and not, and consolidation of real estate before I'm actually going to figure out what I'm going to put in there. I think yeah, that's maybe a little a little grey cloud of unexpected, unplanned circumstances." – **Participant 3**

> "I think what we currently experiencing in our industry and specifically referring to smart buildings is an evolution. Building owners are actually starting to understand the requirement to retain tenants because they're not as forthcoming. Maybe that is impacted by the COVID pandemic and the reluctance for bigger corporates to occupy large commercial spaces.

So there's more value in the landlord looking after his tenants and making the lettable space attractive. " – **Participant 7**

"The other one is obviously getting stats on where in your environment spaces are being consumed and how that works. The view there is what should our environment look like? Because post COVID there's a completely different work culture and it's not a one desk per individual at Sanlam, eight to five every guy must sit there otherwise he doesn't earn his salary. So, the environment needs to look completely different, and a lot of clients are now reimagining their workspaces, but they just don't know whether those are effective new designs, and you need to measure that. So, what you're spaces should look like as well because there's quite a bit of investment that goes into that." – **Participant 4**

Data Driven Decision Making and Strategies

Participants identified data-driven decision-making and strategies as a driver for the adoption of IoT in office buildings. According to the participants, IoT would become more prominent as a factor for informing office space strategy and decision-making from multiple angles including budgeting, space allocation, and leasing decision amongst others. The extracts from participants below illustrate the importance they attached to IoT as a decision-making tool.

"I'm saying to you 'I have 120,000 square meters. If I take 25% of 120 square meters in three years, I need to get to 80 000 square meters.' I'm just giving you a specific thing. And IoT will play a role and so will the whole rationalisation project. But IoT would have driven that decision. At the moment IoT is just monitoring the decision that gets driven if it makes sense." – **Participant 1**

"Having that predictive ability to say what you actually need to do based on the information that we've got for you Mr client is X. So real business decisions that can be made now, then the predictive ability goes a little bit further as well. Now you build trends as well out of the information you get and you have got to be able to say to clients listen if you continue down the same track and the same trends that you have currently, 18 months

from now, you're going to have to get a new building or increase your floor space or whatever it might be. So that there's business planning that also now can be put in place from a client's perspective and that adds real value." – **Participant 4**

"Initial emphasis was on understanding the building estate and how to identify surplus space and use that to drive strategy about either moving organisations from different buildings that are not necessarily appropriate for the work style that Telecommunications Company 2 wanted to adopt of open plan, flexible space." – **Participant 10**

" Of course, we are still living in, I'd say 90% of businesses, 95% of businesses still have their existing real estate portfolios, they've got lease commitments, they might own the buildings, right. So you still have a period where you probably still got another year before data becomes a the next supporting factor or requirement to drive what's the next. What's the strategy now for the next three to five years so. I think we're kind of in that phase of the market typically." – **Participant 3**

" As I said, there's always a pressure on operational expenditures. I think from a financial perspective there's always pressure on you to reduce it or have zero rated sort of OpEx expenditure. So, if you can have that intelligence sitting behind there that basically can sort of predict and assist in predicting your OpEx expenditure for the next three to five years. So, if you've got a clear picture of what's going on in the current condition of your systems, when do you think it will reach your end of life and when the replacements are due and all of those type of things, you can sort of start straight lining your budgets and that makes the financial people happy." – **Participant 9**

Office Space Optimisation

Participants experienced space optimisation as a driver of IoT adoption in office buildings. In the participants' experience, IoT solutions were used to reduce or expand space based on actual sensor data, plan space layouts according to behavioural data, and predict requirements for future space needs based on

occupancy data. The benefits would be space optimised from a cost, occupant experience and productivity perspective. Participants 9 and 10 mentioned the use of IoT to plan spaces around behaviour:

> "So, I think if you can use the IoT aspect to design an office, according to what you see from a behavioural aspect. So, if you can use the IoT to look at occupancy, people behaviour, where do they sort of go on a daily basis. You can then actually start determining to say what these guys actually need more collaboration spaces other than boardrooms. And then we can do some changes to facilitate that, which of course leads to productivity." – **Participant 9**

> "Our view was very much along the lines of we want to reduce the amount of space to the right amount but plan ahead to actually sort of do that in advance. By cutting down the amount of space and fitting out, you fit out less space in a new building for example, and that's a cost saving in itself. It's all about acquiring the right and smallest amount of space and then monitoring how people use the space. Uh, and we were using flexible working and desk booking as a way of making sure that people allocated to a building were at a higher ratio than the desks we provided back in the days when people were expecting to come in and have a desk. With new builds and reduction of space and old builds it was all about getting bigger space, more modern space, and closing down all the space and fitting out less space." – **Participant 10**

Participant 4 mentioned the potential of IoT for space planning decisions when making decisions to reduce or expand.

> "That could be in the form of a client having a full building and are now planning to build a new building and can actually delay the new building by two or three or four years if they use the current space just more effectively. It's all around the financial and Rand and cents saving and/or benefit in terms of being more effective with the space that you actually need. The clients just don't know what they don't know. If you've never measured it. You've got a sense of maybe we've got enough space, which

you just don't know. If you measure it, it is crystal clear to clients. Guys, I mean we can at least get away with 20% less space or we've got a capacity of 20% to grow into before we need to expand, and that is super valuable so that is an easy benefit to calculate, and client's really see that as a justifiable kind of view on the return on investment. So that's the one." – **Participant 4**

Operational Efficiency

Eight out of ten participants mentioned operational efficiencies that can be gained from IoT as a driver for adoption in office buildings. According to participants, IoT can provide operational efficiencies in many ways. These included visualising operations, operating equipment more intelligently and enhancing current systems, tailoring operations to occupancy levels, and reducing truck-rolls.

Participants mentioned that IoT was a tool that enabled landlords and stakeholders within office building operations to get visibility of data on their operations in real-time and from a single system. Arming users with data to make operational decisions based on IoT data more easily. This aspect was discussed by Participants 7 and 8 as quoted below:

> "So, my one driver was the visualisation aspect and often it is an immediate requirement that the landlord would state that he doesn't know what's going on in his building. All that speaks to him getting a dashboard or a platform to start seeing what's going on in this building." – **Participant 7**

> "Historically like I say, it was the key drivers were to ensure that an asset or a building with assets had the ability to view things in one single pane of glass." – **Participant 8**

An aspect of how operational efficiency acts as a driver to IoT in office buildings mentioned by participants was the ability of IoT solutions to operate equipment more intelligently and enhance existing systems by making device data available to them. These systems are then able to act on real-time, often more accurate data feeds in executing process. This was reflected on by participants 5 and 8.

"Optimisation means a couple of things. Firstly, there's a cost reduction. Now how do you do a cost reduction? You become smart in monitoring those areas. You say to the equipment. You cannot run if it's raining outside. Why is the air conditioning on? You know? So, you're taking environmental factors into consideration. You also save one person anticipating, do you need to switch on the air conditioning system? Is it really necessary? Can that person not switch on a fan? Or maybe open a window? So, you're making smart decisions…You need to be smart, and how do you become smart? you take the same infrastructure that you've got now, optimise it, save energy you run at certain critical times, and I think that's what we are doing now." – **Participant 5**

"Yes, of course you've got your ERP, enterprise resource planning functionality, which is more HR, Integrated workplace management solutions. These types of platforms that can be bolted onto the top once the data is being pulled up and into a data lake or a data warehouse. The data storage means that you can enable all these sophisticated cloud platforms to do lots and lots of great things. You find that there's an endless, I don't even think we've seen the end of it. There's more insights that have been created with that people will want to use the data for." – **Participant 8**

Tailoring operations to building occupancy was mentioned as a driver for the adoption of IoT in office buildings. As per participants, IoT applications such as occupancy counting solutions provided building operators with data that enabled them to pro-actively change how they run a building based on the actual occupancy level.

"Having shared office space and reduced occupancy, if less people are using a building, then there's a grey area where that sort of... You have the ability to control and understand how many people are using the building, how they're using it. Then that can sort of transition over to the optimisation of building. Should you be running a building to how it is designed for its full capacity when only half the people are using it?" – **Participant 8**

Lastly, participants experienced the remote monitoring capabilities offered by IoT as a tool for more accurately diagnosing issues remotely and reducing the number of site visits needed to attend to issues.

> "When we try and think about what a smart building is or the Internet of Things, it's ensuring that you have everything connected and ensuring that the outcomes are really more efficient running building and a building where somebody's, of course it's man hours at the end of the day, so ensuring that a building can be managed from one single point without having to, as the Americans say, initiate more truck rolls. You want to reduce those truck rolls as much as possible and have greater visibility of your building. So certainly, from a building management perspective, I think that seems to be a big focus – **Participant 8**

Utility Management and Sustainability

Utility management and sustainability were grouped as drivers due to the close links between them found in interview feedback. Utility management includes using IoT to manage the consumption of utilities including water and electricity for various reasons, whilst sustainability includes managing the consumption of utilities to meet various sustainability targets. From a utilities management perspective energy management featured very strongly as a driver for IoT adoption with IoT seen as a technology to understand the consumption of energy and drive that consumption down through actionable insights. Participants in the quotes below mentioned utility management as a driver for IoT adoption.

> "Well, in South Africa electricity usage and water usage. But across the world, it's probably the same, right? It's utilities we want to use as little utilities as possible to run our building." – **Participant 2**

> "Now the focus is very much on measurement of consumption. With a view to understanding what the relative efficiencies are of our various buildings in terms of size, versus use, versus energy consumption and just at a very basic level by being able to measure the energy consumption, we can then experiment with various things and watch the effect of that in near real time

or at end of day levels. So, a shift in focus there to prioritize energy consumption monitoring." – **Participant 10**

"Yeah. I think at the moment, what is about to add most value to clients. Is understanding the energy usage profile that is quite an interesting thing. You could even apply it to your sort of domestic application. Do you know as an individual what your household consumes and when? So, it would be of most interest to the landlord to understand what his building is consuming and when. A lot of data can be extracted in that regard and a lot of remedial action can be implemented once that data is available. So, one case, an example is a building we looked at. Where we found that the energy profile illustrated that at a minimum, whether it's day or night, unoccupied or fully occupied, the building was drawing at an amperage of about 500 to 600 amps. Which illustrated that significant plant was running 24/7 without scheduling, without monitoring, without controlling. Again, understanding the energy usage profile a lot for remedial action to be taken to switch off that plant and make sure that the building sleeps or hibernates as close to zero energy usage as possible" – **Participant 7**

Tied to utilities management as a driver of adoption is sustainability. Organisations were using IoT technologies to measure, reduce, and report on consumption to improve their sustainability practices.

"But I also think something of late or of the modern world is obviously your carbon footprint did, like everybody wants to reduce or show that they're reducing carbon footprint, for tax rebates, and to get the little green star next to their name to make sure that they're building is effective as possible." – **Participant 2**

"So, for me definitely the most important one is energy and the energy reduction focus and then I think your bigger, your more advanced landlords and property developers and owners. They want to be more responsible and say what is what? What are our carbon emissions, you know, what are we doing? Are we using energy sensibly?" – **Participant 5**

In addition to making buildings more sustainable participants mentioned the need for organisations to achieve sustainability certifications as a driver of IoT adoption. IoT was seen as an enabler to implement and achieve sustainability certifications. Participants 5 and 7 made mention of this in their interviews.

> "You know in South Africa we've got the Green Star Building (certification); you've got certain carbon emissions. I think where we will see uniform and more successful implementation if we can get a certain standard within those organisations and we're busy with the Green Star building association at the moment. I'll give you an example. A client opens a new building, and they get a 5-star rating. What does it mean? Does it mean it's a historic design that's taken place because they get a 5-star rating? Yes, it is. It means that this building was designed (a certain way) and therefore they get it. If the design parameters or the operational parameters of that building changes now, will they still get 5-star ratings? No, they won't. What are the mechanisms going forward to ensure that IoT will be a benchmark going forward in the survival of these commercial buildings? I think that's important. But we need to we need to rethink that model. We are busy talking to people like the Green Star on carbon emissions, South African National Energy Development Institute (SANEDI), those type of people. To understand that's the minimum specification of a potential protection or IoT system and that I think that will make it easier going forward." – **Participant 5**

> "I think over and above the actual return on investment, there are intangible factors that need to be considered. It speaks to sustainability agreements that the larger corporates are starting to enter into and that speaks to the carbon footprint and the carbon credits that they are accumulating in time. Then something that is called an Energy Performance Certificate (EPC). I don't know if you're familiar with that, an energy performance certificate that these landowners or building owners need to start applying for and there's a measurable that needs to be provided, and how is that measurable provided? Well through a smart

reporting tool or at least an IoT solution that can bring these metrics forward and start measuring key indices?" – **Participant 7**

Building Occupant Experience

Improving the occupant experience of those using office buildings was mentioned by multiple participants as a driver for IoT solutions adoption. IoT solutions were cited as being able to create the best environment for users of the building which included making it more comfortable, healthy, accommodating, and productive.

Participant 2 highlighted the potential of IoT to create more comfortable spaces through applications such as temperature control, and lighting conditions.

> "I think we, if we start from the ground up, it's the users of the building. If you want to set up a building effectively for the people who need to be in it and it needs to be as comfortable and that's really what drives a lot of these things like aircon, air quality, light all of those things." – **Participant 2**

> "The other side of smart buildings is having the most comfortable or the most ergonomic environment to work in to drive productivity. You've got the right temperature. Yeah. But in my mind that gets a little bit like. 'It's very scientific about people's feelings and things', but it is a factor, right? If you're working constantly in a dark environment with poor air con. You're not going to be as productive as when it's there's lots of light and there's lots of cool air." – **Participant 2**

Participants 4 and 10 focused on IoT solutions enabling environments that cater to the needs of occupants and promote productivity.

> "Those are the two big drivers for us that we discussed with clients and ultimately the effective workspace environment and the conditions that are conducive to productivity there, the benefit is not only a savings one, but also a gained one in terms of people just being in a good space that it's easy for them. They got the right type of work environments and spaces that they need. There's always meeting rooms available. It is nice and

> cool or nice and warm. Whatever conditions you want, it's just a great place to work and it makes a massive difference in terms of just the whole experience with people and how productive they are that one is very difficult to calculate." – **Participant 4**

> "The longer-term vision is we want to be able to create these digital twins want to use buildings to make people more productive and feel better. Monitoring beyond the environmental side. Managing the CO2 and making sure there's plenty of fresh air, making sure that maybe if you've got a chair with people sitting for too long where it gives them a bit of a…you know send them a message to a phone or whatever, saying you think you ought to go for a walk now and stretch your legs." – **Participant 10**

Participant 4 highlighted the increased drive for IoT solutions to make spaces safer and healthier for occupants.

> "Then the other one for us is the health one for us, the environmental side of it. So very interestingly in South Africa, less of a topic. I think for two reasons. One is we probably have, cleaner air in South Africa than most other parts of the world. So, so I mean we're not as polluted as in Europe and other parts of the world, and also, we got third world problems to worry about. So having enough CO2 is less of a of a priority to us than the Europeans. There it is, a very, very important thing for them. Being able to tell the employees that they got a safe space and also, I think they're being pushed by legislation and the various governments to comply to certain regulations around that. So, they much more focused on knowing and understanding what conditions are like and being able to report that both internally as well as publicly presenting that and so forth" – **Participant 4**

Asset Management

A driver for IoT solution adoption that was discussed by six of the respondents was asset management through deployment of IoT solutions to monitor assets and integration of IoT solutions with enterprise systems. The drivers forming part of asset management fell under three categories: improved maintenance, availability and reliability, and increased lifespan.

Participants said that clients were better able to proactively maintain assets and conduct preventative maintenance using IoT in the present and going into the future.

> "I think the proactive maintenance bit or the proactive nature in dealing with problems becomes a key feature because you could almost identify what's going to happen before the end user does." – **Participant 1**

> "We use IoT to enable ourselves to provide a better service to our client to ensure that generator or whatever assets which is critical to the clients will always be available when it's needed and we also look at a managed service where it's not just collecting data, but it's also looking at the maintenance of the assets as well, making sure that all of its preventive maintenance have been done, inspection tasks have been completed, annually." – **Participant 6**

Participants also mentioned that communication enabled by IoT allowed maintenance teams to improve the availability and reliability of assets in their environment which has the consequence of increased operational uptime.

> "The how we use IoT products is we don't resell IoT per se. We've got our enterprise asset management software and we use IoT to enable in a more efficient and more performance asset management practices and what that means is we've got asset management projects with clients, and we help our clients to strategize in terms of the maintenance practices, but then also ultimately to help them improve the availability and reliability of the assets. You can do that better with collecting data continuously or periodically from assets and give the assets a voice and then use that data in real time to trigger any events to reduce risk and improve performance, et cetera." – **Participant 6**

Participants indicated that IoT technology improved the operation and lifespan of assets by, amongst other measures, operating assets only when they needed to be operated.

"…And then obviously the subsequent attribute for a very successful deployment is if you could say to people, I'll make sure that your critical infrastructure runs and operates when necessary. So, you'll be very surprised if we go into a building and we'll do a bit of a feasibility and we do a check, we find that the pumps are left 24/7 they've just run, the chillers are off, but the infrastructure just runs. So not only is that costing you money, but you actually in fact your plant is at half its lifespan, and you've got to replace that equipment at an earlier rate." – **Participant 5**

"So, then you get into an optimised sort of approach, but then also using the data to understand how some equipment in the building is being used. Maintenance wise, should things be run at 25% of its capacity to ensure that it's got a longer life." – **Participant 8**

Regulatory Compliance

Participants mentioned regulatory compliance as a driver for IoT adoption and emphasised the role that IoT has to play from either a standpoint of showcasing compliance or of office buildings becoming compliant with regulations. Notable regulatory drivers mentioned for office buildings were concerning the internal environment to ensure occupant well-being, energy performance reporting for sustainability, and the presence of systems to that enable efficient operation of buildings. Participants 4, 7, and 8 provided their input on regulatory compliance in the quotations that follow:

"Then the other one for us is the health one, the environmental side of it. So very interestingly in South Africa, less of a topic. I think for two reasons. One is we probably have cleaner air in South Africa than most other parts of the world. I mean we're not as polluted as in Europe and other parts of the world, and also, we got third world problems to worry about. So having enough CO2 is less of a of a priority to us than the Europeans. There it is a very, very important thing for them. Being able to tell the employees that they got a safe space and I think they're being pushed by legislation and the various governments to comply to certain regulations around that. So, they much more focused on knowing and understanding what conditions

are like and being able to report that both internally as well as publicly presenting that and so forth" – **Participant 4**

"Then something that is called an EPC (Energy Performance Certificate). I don't know if you're familiar with that, an energy performance certificate that these landowners or building owners need to start applying for and there's a measurable that needs to be provided, and how is that measurable provided? Well through a smart reporting tool or at least an IoT solution that can bring these metrics forward and start measuring key indices?" – **Participant 7**

"We look at legislation that's been passed in I believe France at the moment but similar to South Africa, I think too…now South Africa and maybe France are at two opposite ends of the spectrum on this. If you take France, for instance, 90% of their occupied buildings have any form of BMS or automated solution into it. Now there's legislation which has recently been passed that says that at least there needs to be some sort of simplified building management system or building automation system monitoring something in there. So, this digitalization, getting data out, understanding what's happening in buildings is now becoming a standardised legislation. In South Africa, I believe there is some sort of plan to have this implemented as well. You'll start to see this being standardised across more countries. So yeah, gone with the carrot. I think the carrot and the stick argument, I'd say it's probably there's going to be the next phase. If you're building, isn't at a level like your energy performance certificate." – **Participant 8**

Shortage of Competent Technical Resources to Manage Operations

The interviews revealed a shortage of technical skills as a driver for IoT adoption in office spaces. The shortage has resulted in an environment where IoT systems are able to provide data that is pre-analysed and available to consume remotely in a simplified manner allowing more abundant lower skilled workers to manage operations and equipment. This was elaborated on by participant 9 during the interviews.

"I think, looking these days at your technical resources available to you, I'm talking about competencies of technical resources. The pool has become very small. So, where you previously relied on a technical resource to basically go out and do an assessment of condition of equipment and infrastructure and things like that and reporting on the current condition availability. That seems to be becoming a big problem for us, so the reliance on a physical resource. We had to move that away, to get to smart, small devices and intelligence that you can basically then remotely monitor all of your equipment and have early warning of certain conditions on that equipment to make sure that when the time comes, and these backup systems needs to be available then it actually is available. I think one of the biggest drivers is the is the availability of proper competent technical resources and the pool is really draining." – **Participant 8**

c. *Stakeholders of IoT Projects for Office Buildings*

This section covers feedback from participants on the various stakeholders involved in office building IoT projects that emerged as a theme from the interviews. Participant feedback covered a wide range of stakeholders within organizations that are involved in IoT projects in office buildings. The stakeholders covered include C-suite executives, human resources, facilities managers, building owners, building users, IT teams, ESG teams, and finance departments.

Executive Level Stakeholders

From a C-suite perspective the CEO and CFO of companies were mentioned multiple times as being key stakeholders. The CEO was mentioned as being important in many instances as the outcomes of the systems implemented are of interest to the CEO examples of which are sustainability or cost reports that might be outputs of an IoT solution. The second most consistently mentioned executive was the CFO who was seen as key to signing off business cases and approving budgets for IoT projects and had a directed interest in the running costs of the buildings that IoT solutions could potentially reduce. Participants mentioned that endorsement from C-level executives generally eased buy-in from the project

level. The quotes from Participants 4 and 8 illustrate the view of participants on C-level stakeholders.

> "Then you have obviously the CFO and the CEO. Those guys are really the most important guys actually to having these conversations because they've got an overall interest both from a people as well as a cost and a strategic perspective." – **Participant 4**

> "Of course, yes, we do. We focus on a lot of these people as well as people who are in control of the money. This what's how much things cost within the building. So, the financial directors and CFOs and so on… We found once we've engaged with somebody at a C-suite level they would ultimately introduce you down to somebody who's on sort of an operational level, and then the decisions could be made a lot quicker from that perspective because we felt like the somebody in C suites is looking at things in a in a much broader level, but ultimately the key decision to get a project off the ground or if a deployment off the ground happens at a project management level." **– Participant 8**

Human Resources (HR)

Participants spoke about HR being a stakeholder firstly because facilities management resides under HR in many organizations. Secondly because HR are interested in the well-being and productivity of staff, and the experience that people have of buildings. Office space was also becoming a differentiator in the job market at the time that the interviews took place. The prominence of HR as a stakeholder is outlined in the quotes below.

> "The other role player is the is the HR person because this is all about people, people experience and ties very much into that conversation. They've got a really keen interest; the HR people get pulled into these conversations with us." **– Participant 4**

> "… long time property has reported into HR, which actually makes a lot of sense because you've got personnel strategy that can be directly linked to

the work environment where employees and staff policies come into play. So, it works very well." **– Participant 10**

"Prior to COVID as I was saying earlier HR was also becoming much more of an active stakeholder in that staff well-being and having a great place to work etcetera was something that was being used to stop people leaving the organization and so reducing churn and also enabling recruitment of the next generations, that are coming in to use for workplace." **– Participant 10**

Facilities Managers

Facilities managers are generally in charge of making a building run smoothly and IoT systems have a direct impact on the facilities manager. The importance of the facilities manager as a stakeholder was highlighted by participant 4:

"And because it could be in a way, the facilities manager, because he's interested in the overall facility both in terms of the facility cost as well as making sure conditions are right and so forth. He doesn't always care about the people and their experience. He also doesn't always care about the cost as long as he ticks the boxes in terms of the facilities management side and the reporting that he needs to do around that. I guess it depends on organization to organisation and person to person. Whether the facilities manager really cares and has got the ownership of this. But I mean he's one of the role players"**– Participant 4**

Building Users

The users of the building were mentioned by participants as critical stakeholders that often get forgotten about when implementing IoT solutions. Participants highlighted that IoT solutions must be aligned to make the experience of building users good.

"It, it really does vary across multiple different stakeholders within the business, but I'd probably say the most important evolution is also in the employee themselves and the users of the space and understanding how the utilization of space works for them individually as well as when they

are collaborating as a team, and whether the space serves what they're trying to do." **– Participant 3**

Building Owners

Participants mentioned the building owner or landlord as a stakeholder in deployments of IoT. As the owner of the facility the landlord was seen as having an interest in solutions that would improve the facility, its management, and attractiveness to tenants.

> "I always like to see an IoT solution as a tool. It's. It's essentially a tool. We are equipping the building owner with that present them with the essential metrics and useful stuff if you'd like that. That'll make his environment better. You'll have more leverage to win tenants. He's got more oversight of his assets and he can look after them better. So, it's an essential tool and we if we start bringing that message across to building owners, then then we'll start getting traction faster and faster." **– Participant 7**

The IT Department

IT was seen as a stakeholder by participants albeit with a different set of interests to the previously mentioned stakeholders. Their role was seen as critical to the operation and enablement of office space IoT solutions.

> "Exactly, look and then the IT guys invariably gets involved, but they actually don't care about this stuff really it's not their world... The only reason why they get pulled in is because they need to veto it from a security perspective, and they are the guys that need to keep it up and running. If there's integration to be done, they are the guys that get given the responsibility. But I mean they don't really care about saving money from a facilities perspective, creating great working environments, so they don't have the same interest as the as the HR and the facilities people and nor do they have the overall strategic interest that as CFO or COO." **– Participant 4**

Sustainability Teams

The final set of stakeholders described by participants were sustainability teams in corporates that had a role to play in implementing and reporting on sustainability. IoT solutions in office buildings driven by sustainability provided outputs relevant to sustainability teams.

> "Here's a third stakeholder coming in, again pre-COVID was becoming a more obvious driver and that was the corporate sustainability drivers that companies became much more aware of the corporate benefits and quite frankly the stock market requirements to report on sustainability goals and achievements." **– Participant 10**

> "So, I think that is one of the big stakeholders is the financial guys and then of course sustainability your ESG guys those guys and this is now basically stakeholders in the results that that is obtained." **– Participant 9**

A description of each of the drivers found is summarised in Table 4.2

Table 4.2: Description of Each Driver Found in the Study

Driver	Description
The new normal post COVID-19	Applying IoT technology to equip office spaces in the new-normal after the COVID-19 Pandemic to facilitate hybrid, occupant friendly, efficient ways of working.
Data driven decision-making and strategies	Using data to inform decisions and strategies including budgeting, space allocation, and leasing decisions amongst others.
Office Space Optimisation	Reducing cost and improving occupant experience, and productivity using sensor data.
Operational Efficiency	Using IoT data to enable efficiencies within the operating environment in office buildings.
Utility Management and Sustainability	Using IoT to decrease utility consumption and improve sustainability practices in office buildings.
Building Occupant Experience	Creating the best environment for building users including considerations for comfort, health, accommodation, and productivity.
Asset management	Using IoT to improve maintenance, availability, reliability, and lifespan of assets.

Regulatory Compliance	Using IoT to showcase or achieve compliance with regulations such as energy performance, efficiency, and occupant well-being compliances.
Shortage of competent technical resources to manage operations	Reducing the need for scarce, highly skilled technical resources to manage operations.

d. *Drivers to Relevant to Stakeholders*

An analysis between the drivers mentioned by participants and the stakeholders they were relevant to was done to understand which drivers were of interest to which stakeholder. Table 4.3 is a summary of the findings.

Table 4.3: Drivers Relevant to Different Stakeholders as per Participant Interviews

		Stakeholders						
		Executive Level	Human Resources (HR)	Facilities Managers	Building Users	Building Owners	The IT Department	Sustainability Teams
Drivers	The new normal post COVID-19		✓			✓		
	Data driven decision-making and strategies	✓	✓					
	Office Space Optimisation	✓						
	Operational Efficiency	✓		✓				
	Utility Management and Sustainability	✓						✓
	Building Occupant Experience	✓	✓		✓	✓		
	Asset management			✓				
	Regulatory Compliance	✓						✓
	Shortage of competent technical resources to manage operations			✓				

4.3.2 *Findings Relevant to Proposition 2*

a. *Project Success Rate*

This section was included before the results of the inhibitors and success factors were presented. The reason was that it provides a basis to contextualise the experience of participants of deployment successes and failures.

Participants provided feedback on their experience of project success when deploying IoT in office buildings. Five out of the 10 participants provided a clear indication of the success that they had experienced with projects. The responses can be separated into two, those who felt that IoT initiatives were largely successful and those that felt they were largely unsuccessful.

Three of the five participants mentioned that their experiences of IoT deployments were successful. This is shown in the extracts below taken from participants.

> "Oh yeah, look, I mean, if you're asking about success, I would say all of them were successful. I think every project that I have embarked on, and it's got nothing to do with partners. I mean I've used partners from app. development to an international partner for the seat booking system, to a local partner for the building management solutions. I think they all have had their successes and they've all been successful in their own right." – **Participant 1**

> "So, in my experience I think what we aim to achieve and what we've achieved is pretty successful in most of our projects. So, I would go as far as saying 90% of our project and obviously it's ongoing, but yeah" – **Participant 7**

> "I think our ones have been fairly successful because we've kept them simple." – **Participant 5**

Two of the six participants experienced much lower level of success and felt that the initiatives they were involved in were largely unsuccessful. Furthermore, participant 2 expressed that this was a problem in digital transformation projects in general.

Participant 6 when addressing the percentage of successful IoT projects in their experience said: "Yeah, I think 10% might be a bit too aggressive and now that I think about it and it's probably in the order of 25%”

Participant 2 when ask if IoT projects in smart buildings were largely successful said: “Definitely not. But I say that with like a bunch of caveats, I don't think it's IoT solutions, I just think solution implementation as a whole in terms of in the technology world is not successful.”

b. *Inhibitors to Deploying IoT in Office Buildings*

This section covers the theme of inhibitors to successful deployment of IoT in office buildings as a theme from the study. The section is divided into 11 sub-themes corresponding to the inhibitors.

Difficulty Selling the Business Case for Large Deployments

Half of the participants felt that one of the inhibitors of deploying IoT solutions in office buildings was making the business case for large deployments and selling it internally. The consequence of this being that scaling from proof of concept to large rollout was difficult in their experience.

> "The inability to do the sell internally I've mentioned as well. Articulating the business value ultimately that can be derived, and also up front having a discussion to clarify clearly what the return on investment could potentially be here because clients turn around very quickly and say but this going to cost me a lot of money. Do you understand the value that you are going to get here? Have you calculated that? Just the inability for that to be done properly up front" – **Participant 4**

Several reasons were highlighted by participants as to why the business case is difficult to make and sell internally. The first of those was that it is difficult to visualise the value often from the project until it is actually deployed. This was raised by participant 8.

> "What's holding it back is I think the sometimes the misunderstanding what needs to be budgeted from a cost perspective. That doesn't always have

to be a lot of money, but it can cost a lot to do these things, so sometimes I think it will be disregarded completely because as usual it's hard to recognize what your return on investment can be on something like this from the offset until it's actually implemented. So, all these things like optimisation to save money on energy, or ensuring that you can have better maintenance on running your building, or sometimes things that are spoken about and can be demonstrated in theory but there's still a reluctance to do something like this because it's hard to visualise" – **Participant 8**

The second reason provided as per the quote from participant 9 below was that the non-monetary benefits that IoT solutions in office buildings have the potential to provide are not always considered when making the business case.

"If you want to do a major something and let's look at the campus for instance, you say, OK, right, we might move in here and we're going to just go in there and change a whole lot of things. Well let's call it a submetering project on water that just goes stillborn because your return on investment is going to be between 15 and 20 years. So, I think when these business cases are done, they don't really take into account the environmental benefits, the brand benefits, all of those type of things that can be sort of monetized, there is well, I haven't come across a matrix where they actually, monetize the benefits in that regard. But I mean that will contribute to sort of making that business case. " – **Participant 9**

Thirdly participant 9 also felt that business cases did not take into account the potential future benefits of the solutions as they had potential to evolve over time and generate more value.

"So, another thing is that people don't…I don't think they understand the full benefit of what IoT could provide? OK, we would previously talk about the data like, and connecting datasets with each other. Once you start connecting these datasets and then you start realising, oh, I've got now a whole totally different insight into this thing. It's a live environment that needs to continuously evolve. It cannot be ok I want to see my generators

and I want to hear the alarms and that's where it stops. OK, so do I want to see the efficiency of my generator set? If I see the efficiency and the efficiency changes over time, I've got predictable maintenance. You know what I'm saying? So, it keeps on evolving… So, it needs to keep on evolving and it's going to make us work smarter, be more productive, predict failures all those types of things, and I think people have not realised that, and normally that doesn't form part of your original business case. So over time your return on your investment actually becomes much bigger than you previously anticipated." – **Participant 9**

Apart from making the business case according to participants challenges included translating the value to decision makers internally. The decision makers are often non-technical and so another challenge mentioned was the ability to move between the technical and business conversation.

"I just found that unless clients have got an innovative strategic approach in general. It is a very hard sell sometimes because what happens is that the stakeholders internally need to actually go and translate the cool IoT stuff that they like and think brings value, translating that into business value in terms of the internal discussion. Like a client for example said to me, yes, this fantastic stuff but I'm going to have to take this to the beanies (accountants) to get them to approve money to be spent on this. So, the whole benefit or ROI discussion internally, I think there's a big inability for some of the stakeholders to translate that to the decision makers and the exec. So frustratingly, in a lot of organisations they (accountants) are the gatekeepers as well." – **Participant 4**

"Yeah, so in a typical building environment, there's a technical person called the facilities manager. Now what makes it complex in larger buildings, they are normally outsourced. So, they go to a company called CBRE Accelerate, they manage a building. So, a good example would be a massive building like our client head offices. It's a multi-story building the or cost is about R3,5 million/month. The potential of saving via IoT system is about R580,000 but there's a different facilities manager and a company that manages the asset. To convince them is a technical conversation and

then it needs to go up into the boardroom where the financial decision is made by the CFO and CEO." – **Participant 5**

Seeing IoT Projects as Linear and not Evolutionary

A finding on inhibitors of IoT project success in office buildings noted by participants was the treatment of the initiatives as linear, finite projects as opposed to iterative, evolutionary initiatives. Participant 1 noted that deployment teams did not appreciate that projects need to be seen as more iterative, and that teams should be assigned to constantly evolve solutions.

> "For as long as you have a system, you would have a team, even if it's a smaller team than the core, to be able to constantly evolve and adapt the actual solution itself…So I would say you know from a failure perspective I don't think it's a failure, you know of the actual project itself. I would say it's a failure or lack of understanding from both sides as to what their journey looks like. And instead of plotting a start and end to a project, it should be plotted as a life cycle that constantly goes around… Yes, I think we're sometimes I feel we lack is that it's to what I said before is between the meeting of minds. Whether that's the delivery team in terms of the solution or the customer team asking for the solution. There's sometimes a very finite end and I think with IoT systems, personally, I think it's a journey that you embark on with a partner rather than a solution for right now. I think that understanding must be there up front." – **Participant 1**

Participant 9 expanded on this emphasizing the need for constantly evolving solutions based on new information available from the data that is extracted from the solutions over time.

> "So, another thing is that people don't…I don't think they understand the full benefit of what IoT could provide? OK, we would previously talk about the data like and connecting datasets with each other. Once you start connecting these datasets and then you start realising, oh, I've got now a whole total different insight into this thing. It's a live environment that needs to continuously evolve. It cannot be 'ok I want to see my generators and I want to hear the alarms' and that's where it stops. OK, so do I want to see

the efficiency of my generator set? If I see the efficiency and the efficiency changes over time, I've got predictable maintenance. You know what I'm saying? So, it keeps on evolving…" – **Participant 9**

Maturity of IoT Solution Providers

Participants experienced the maturity of IoT solution providers to be an inhibitor to successful deployments. The sentiment was that these providers are generally new, smaller companies that do not have the maturity to engage the market well, try to do everything internally, do not have the capacity to deliver, and try to sell technology instead of business value to clients. This was mentioned by participants 4 and 10.

"There's some basic things, obviously that need to be in place. If young IoT companies are not necessarily mature in terms of how they engage the market and provide solution consulting…And then I guess then the other thing is an immature approach from IoT suppliers in that they are trying to sell tech instead of overall business value and solutions, and also the inability to follow through on making sure that the client ultimately gets that value… At the same time, partners don't want to go and develop every single sensor or piece of the solution, so I think it's a very important thing to get right. Unless you get all the bits right together, ultimately, you're not going to be able to deliver the value to the client. I think that's something that needs to mature still. I think a lot of fairly young companies in this space and not necessarily very mature in terms of how all of those aspects are dealt with." – **Participant 4**

"You could well be running with small companies and that's an advantage right as in some respects, but they're keen to work with you and help that and also can be disadvantages. In that we don't have resource and can't sustain some of the requests that are made of them so projects that go well I would say where you have a single supplier driving it. So, it's up to the supplier to source the various materials and stuff like that, but that also means that you lose a certain amount of control, so that's not great. So, when one of our previous partners in the digital building space was running

the deployment of the third floor in our building the cost was way higher than as it actually turned out." – **Participant 10**

Not Knowing What to Do with the Data

In the experience of participants, a lack of experience and knowledge on what to do with the data that is derived from IoT solutions in office buildings is another inhibitor of success. Participants mentioned that due to the novel nature of these solutions and the wealth of data that they provide the true potential of what can be derived from the data to add value to clients had not yet been discovered. This is brought across in the quotes from participants 2 and 9.

" I just think overall the interoperability of data is not understood enough yet. That's probably If I could distil it to one point. Like deriving value from data is not understood yet, like building a dashboard is not deriving value, and once you've figured out which key levers to pull to derive the right value from information, then we can start talking about controlling buildings like completely seasonally. Integrating weather etc., integrating throughput of people." – **Participant 2**

"Yeah, specifically related to buildings and so on, I think IoT, or the 4th industrial revolutions got quite a bit quite a way to go in terms of what we do, figuring out what we do with the data, right? And the interoperability thereof, because there's so many things in a building that one can measure, right, but effectively stitching together a use case that drives value for a customer. I don't think we're there yet. I think we've got conceptual ideas of what those use cases should be, but I don't think anybody, and specifically us, I don't think we've actually sat down and started linking the data and figuring out like, just like put it data team with an architect team on it to see is this actually proving useful or not. Like to disprove and prove use cases. I think we're just not there yet. I think it's something that we should do if it is to be a successful product… I think there's some exceptional power that can be derived from that." – **Participant 2**

"But when it comes to creating sort of algorithms. If you start connecting data points across systems to create new data points or new insights into things. That's where things sort of fall flat." – **Participant 10**

Lack of Post Implementation Support

Support was seen as important to IoT deployments, and the absence of support was a common source of failure in their experience. If projects did not go through a proper support process they tended to fail according to participants, furthermore some clients were seen as not having the capabilities to support IoT solutions yet which made it even more important for them to be supported post implementation. Participant 7 felt that support was the most important factor as per the quote below. The quotes from participants 2 and 6 emphasise its importance further.

"Support. Yeah, I think nail on the head there, support, it is absolutely crucial. We can all understand the breath. We can all conceptualize it, and you know buy ourselves time to figure it out before we deploy it. That's not where the risk was. The risk of failure lies once it has been deployed, hardly supporting it. And if you don't, that immediately leads to failure. So, hands down, the most important aspect is how do you support it" – **Participant 7**

"Then you hit the nail on the head. We can deliver something, and we can go live, and we can do everything right. It's like if it doesn't go through a proper support cycle or if it doesn't go into a support team, it breaks, it fails." – **Participant 2**

"Yeah. What else? Like I said previously, you would actually plan the project in the hope that the client will overtake it and they will run with. But it's not the case and it's not what happens in reality. Eventually it becomes your baby to support and manage throughout in some cases throughout its life cycle." – **Participant 6**

Poor Solution Design

Participants mentioned poor solution design as an inhibitor to successful deployment. Two specific factors were of design were cited as being prevalent: a

lack of alignment between designs and client requirements, and poor device selection that did not appreciate the industrial nature of office building deployments.

> "The other one is poor design you might understand the problem really well and be like we are spending too much money on electricity. We need to reduce electricity. That's a fairly simple problem statement and solution. How do we do that? We go and implement the cheapest technology possible to do it. So obviously it's going to fail. The thing is that IoT is, and unfortunately that's where everyone needs to draw like these parallel connections between IoT devices and your old school BMS, SCADA type components cause it's like you can install cheap light switches and cheap light sensors and cheap things which will solve your problem momentarily, but they all break because they're not made for large commercial buildings that run 24/7, right? So, the devices are just not there. They're tinkerers or for people in their houses and that's where your technology selection or your device selection becomes crucial. I think a lot of IoT solutions in general just fail due to poor device selection because even though IoT is moving away from the heavy components your quality still sits in, not necessarily expensive components, but more robust devices equal more price equal longevity."– **Participant 2**

> "Yeah. In fact, when I think about the conceptual design phase. You should spend lots of time on the design phase before you implement because what we do find that once you start implementing how the client understood the solution and how we understood the solution is two different things. And then you deliver something that's not 100% aligned with what the client needs. Yeah, I think that stage of the project is also important to consider. your client should be on the same track and should be on the same page in terms of that solution." – **Participant 6**

Furthermore, from a device selection perspective participants mentioned that not fully considering the maintenance that goes with the deployment of the solutions as described by participant 9.

"Then in some instances we have issues where devices are battery powered and that contributes to maintenance. Now you've got 2000 battery powered devices on the campus like we have at a location that now needs to be maintained. So, I think that's from a hardware perspective." – **Participant 9**

Poor Change Management and Reluctance to Change

Participants viewed poor change management and a reluctance to change as inhibitors to successful deployments. The aspects of change management that were highlighted by participants were poor briefing of stakeholders on the solution and how to use it, adoption, and adaptation of process for the new technology.

"The people that also use the building, that will be affected by the technology, which is a big factor to consider because what we found in terms of , we're probably going to get you the success and but we found that when you implement an IoT solution but the processes haven't been looked at and the people haven't been briefed in terms of will be affected by this. Then the solution actually fails. Yeah, so one of the very critical stakeholders are the people that will use the solution." – **Participant 6**

"Case in point for a client we go and deploy 7000 sites. There is a business case. It's not what we thought, but there is a business case which is only great for the dude right at the top cutting on the bottom line, everybody else hates it. Operations, hates it. The users hate it. Is that a failure on the way the change management happens, probably because it's still valuable if they know how to use it." – **Participant 2**

Further to the change management participants felt that reluctance to change from parties within the client's operations was also an inhibitor to success.

"Reluctance to change, I mean, people get into that thing, and they don't want to change anything, 'but it's been working for 20 years. Why do we want to change it now?' it's that whole kickback that you get when you start having discussions about, we want to do this, and we want to do that… " – **Participant 9**

Closed Legacy Systems

Participants mentioned closed legacy systems as an inhibitor to deployments that they had experienced. According to them projects failed when incumbent solution providers in an environment did not allow integration into the systems on-site as they perceived IoT as a threat, and a lack open integration standards into current systems was not present.

> "You know, every single player needs to perform in order for the team to win. If one of those little key components is not there you can't deliver it and I found it out now. So, in this instance there was a control specialist that was threatened by the IoT space, and he said listen: 'I'm not going to open my equipment to let it talk to your system', then it falls flat. So, I think in my opinion the idea of a system that talks on the edge, gets all these pieces of the information, and combines all of it then and gives it on a single pane of glass. It's not always that simple. There's a lot of moving parts in in this mechanism, yeah." – **Participant 5**

> "People, and a third-party that needs to open a building management system for you. They see you as a threat and they stop their services. So, they disallow you access to information. So, you can't access the building information. That I must say is the biggest stumbling block. The third-party specialists that say well we don't know what you're doing we don't like what you're doing we're not going to help you." – **Participant 9**

> "Again, I don't want to sound like I'm repeating myself, but I think if… we look at where projects and strategies have not fulfilled the original desires is that there wasn't this full connectivity, Or the solution that's been deployed is very much boxed in by a particular vendor, for instance and open integration standards for a building of not been considered" – **Participant 8**

Lack of Clear Solution Ownership

Participants mentioned that a lack of ownership for the IoT solutions at clients was a reason for failure. They felt in particular that the solutions had no real home,

and nobody was in charge of developing an approach to their development and maintenance.

> "Yes. So now that's it. That's a very interesting question because this thing lies a little bit in no man's land. For a lot of organisations… The other thing is we've touched on is split ownership as well. I mean this thing doesn't lie slap bang in anyone's any specific one area of responsibility in terms of role players and organisation and is kind of owned. So, I think that breaks up the ownership a little bit in the potential execution thereof and decision making" – **Participant 8**

> "We find that there's no, there's no real strategic approach to the concept of implementation. Which might be one reason why it leads to failure so quickly. So, what I'm trying to say is that if we approach a shopping mall, for example. There's no one individual responsible for mapping out an architecture and almost creating a vision of what an IT solution should look like in one to 10 years' time, and that quickly leads to failure because there were several attempts made to get this off the ground but without sort of a draft architecture or a draft plan, never mind it being a smart plan, it just being dark plan, it immediately leads to failure. So again, in, in any organisation probably more so than ever before, there should be a Chief Technical Officer or whatever you want to call it, Chief Digital Officer that should be put into a position to start, educating himself with what is required to make these decisions and what are the steps to be followed." – **Participant 7**

Lack of Strategic Intent

Participants mentioned a lack of clear strategy and strategic intent when deploying solutions as an inhibitor of success. This was mentioned in the context of strategic approaches to the delivery of the entire solution.

> "Yeah, we've touched on it and quite a number of those already, but I think first firstly absence of a strategic intent, whether with the whole thing from the client side." – **Participant 4**

"We find that there's no, there's no real strategic approach to the concept of implementation. Which might be one reason why it leads to failure so quickly." – **Participant 7**

Lack of IT Support for IoT Initiatives

Participants highlighted a lack of support from IT teams as an inhibitor to IoT deployment success in office buildings. Participants felt that there was a lack of alignment between the project delivery teams and IT teams which led to a lack of care and cooperation from IT teams. Participant 4 highlighted this as well as participant 9 with great emphasis.

"Exactly, look and then the IT guys invariably gets involved, but they actually don't care about this stuff really it's not their world and then really care about it. The only reason why they get pulled in is because they need to veto it from a security perspective and they the guys that need to keep it up and running. If there's integration to be done, they the guys that get given the responsibility. But I mean they don't really care about saving money from a facilities perspective, creating great working environments, so they don't have the same interest as the as the HR and the facilities people and nor do they have the overall strategic interest that as CFO or COO." – **Participant 4**

"The IT guys are so reluctant they don't see that they have got a role to play. So, within the organisation the IT people needs to… They need to be enabler for whatever is required from our side. I mean, we've had this discussion like for three years now with the IT guys. So, they're saying ok from a cyber security perspective we not going to allow you on the network. So, ok but what about a subnet now? But if you want a subnet you need to buy the switches you need to do this. So, they don't see the role that they actually play in these things going forward. That is one of the big things that is a problem. I don't think within organisation the expectation is for you to move forward and adopting this but then at other levels you're not getting the support that you require and that is within a big organisation like us where they don't see themselves as being enabled to you because

that's not their core business. Which is not true, and I think that is the whole thing. A lack of alignment between IT and what the guys involved in the IoT projects are trying to do. So, they typically see themselves as a separate and not part of the IoT initiatives. I think you will find that in all of the organisations, and I think it's a major inhibitor there but say you would go and pitch to somebody else. I mean, they're going have the same security issues that we have and we're going to probably have the same thing from an IT perspective and all those types of things. So, I think that's a major, major one." – **Participant 9**

The Inhibitors are summarized in Table 4.4 , categorised as business or technical.

Table 4.4: Summary of Sub-Themes and Categories of Inhibitors

Sub-Theme/Inhibitor	Category	Description
Difficulty Selling the Business Case for Large Deployments	Business	Difficulty making the business case for large deployments and selling it internally.
Seeing IoT Projects as Linear, and not evolutionary	Business	Treatment of IoT initiatives as linear, finite projects as opposed to iterative, evolutionary initiatives.
Maturity of IoT Solution Providers	Business	Providers are generally new, smaller companies that do not have the maturity to engage the market well, try to do everything internally, do not have the capacity to deliver, and try to sell technology instead of business value to clients.
Not Knowing What to Do with the Data	Technical	Lack of experience and knowledge on what to do with the data that is derived from IoT solutions in office buildings.
Lack of Post Implementation Support	Technical	Projects that didn’t go through a proper support process post implementation tended to fail.
Poor Solution Design	Technical	Poor design in terms of aligning designs to requirements, and device selection.
Poor Change Management and Reluctance to Change	Business	Poor change management in terms of briefing stakeholders on systems use, process changes, and reluctance to change from clients.

Closed Legacy Systems	Technical	Incumbent providers not allowing integration into systems and lack of open integration standards.
Lack of Clear Solution Ownership	Business	No home for solutions in the organisation so that they could be developed and maintained.
Lack of Strategic Intent	Business	Lack of clear strategy for deploying IoT solutions.
Lack of IT Support for Initiatives	Business	IT teams misaligned and with projects and non-cooperative in supporting deployments.

4.3.3 *Findings Relevant to Proposition 3*

a. *Success Factors for Deployment of IoT in Office Buildings*

This section covers the factors mentioned by research participants as being important to improve the likelihood of project success for IoT deployments in office buildings. The section is divided into 17 sub-themes corresponding to the factors.

Clear Business Value

Participants spoke about business value being an important success factor for deployments. The first aspect of business value for successful projects mentioned was that before deploying solutions there should be a tangible business benefit to the client as per the participant feedback below.

> "It really should be implemented because there's a tangible benefit from a business perspective at the end of the whole thing. So if you got that kind of mindset from a client and go on the journey with them, with that as the basis for the discussion, then generally it's really productive and a beneficial project."- **Participant 4**

> "So, one thing is to say, 'listen you need less space'. But I mean, what does it mean? I mean, you want to go to your CEO, your COO your CFO and say listen, this is the current scenario, this is what we suggest needs

to be done and the actual business benefit is X million Rand per month or per annum. So, turning that into a tangible business benefit as well. These last two things, I think that's the difficult part." - **Participant 4**

Participants also emphasised that in their experience the business value should be translated into a clear and simple business case that can be easily understood by non-technical people such as CFOs that are decision makers within organisations, This was noted in the responses of participants 7 and 5:

"… You'd like to believe that the stakeholders that you want to sell this to would be the operational bodies, the facility managers and or the like. But in actual fact like anything else, it all boils down to finance. So, the business case is what makes it or breaks it. The discussions fast get channelled into the direction of the CEO, the CFO and a business case needs to be created around it. So, the discussions really focus on what the tool in terms of the IoT platform and technology can provide to make a strong business case that proves to be viable to the landlord or developer." - **Participant 7**

"We make sure that we address that business case. You need to understand, or you need to be able to explain to a CFO that he understands what is it that you're selling and what are you saving?... You need to make sure if you can explain things to them in a simple way. I'll give you a typical example. We had a conversation with a big international player called company x, they are UK based company and they operate a large portfolio in the UK as well as Europe. We did a presentation for them. This a first world country that's got a phenomenally big business… He said, what you've done for your clients is a complete overkill. My clients will never understand it. It's almost too much, you need to tone it down. They won't understand it and that to me was a nice example of don't impress people with too much information. Unfortunately, the conversation with them is going on. It's just those people at a certain executive level just wants to see numbers they don't want to see the nice people walking in the building. Make the business case that you can save money easy

understandable and that's your return on investment. Make it simple. Don't overcomplicate it." - **Participant 5**

According to participant experiences, beyond just ensuring business benefit, the value that solutions create must be clearly articulated and easy to understand at all levels of users. This clarity of value underpinning the project was key to success as stated by participant 1.

> "But if you ask me holistically, you know, I can't give you a very definitive answer as far as that's concerned. But I can tell you how the platform looks. I can tell you how it works. I can tell you it's interoperability between systems. I can tell you; you know, it probably would have saved a couple of hours of an automated intervention into Archibus. So, he's like 'ya ok, but quantify that?' Because for me, what he said is I would like to have the same storyline that you have in order to sell the same thing, because I don't want to have to go Participant 1 every time, I need to sell the IoT platform. I think that for me is what the key take away is to the point I'm saying - the simplicity, the value and the simplicity of understanding and the value it offers should be so intuitive that anybody within the ranks can do it" - **Participant 1**

Clear Business Objectives and Actionable Outcomes

Participants felt that in their experience having clear business objectives from the outset was another success factor for IoT projects in office buildings. Projects where clients were very clear on what they were looking to get out of projects, and what they wanted to measure were typically more successful in their initiatives.

> "Those are the other clients when they start out the project and they've got a clear view of what it is that they actually want to measure, why they want to do that, what information they ultimately want to look at and what business decisions they want to make based on that. Those are the clients that more often than not get the right business benefits and the outcomes." - **Participant 4**

" So yes, visibility and all of those type of things are great, but what do you do with that information? How do you actually take all of this smart stuff and start adding value to your investment? So, I think for it to be successful you have to have a return on investment because it's not cheap to actually start rolling out IoT across the board. So, I think it needs to be clear in the beginning right to what do we need to achieve?" - **Participant 9**

"There's a very clear and crisp view jointly with the client as to what do we want to achieve here and how are we going to go about doing that. Then you also work on what do we turn this data into for you, Mr client? What is it that you want to see? Those have been the successful projects for us. And I would say an 80% hit rate on those." - **Participant 4**

Furthermore, projects that were based on actionable outcomes that were planned to be derived from the projects before implementation were seen to be more successful. Participant 3 emphasised this point.

"I think where the value kicks in is when we're able to take this historic value or data and make sense of it in order to take action. Whether that's Human intervention and action, or whether it's a process of an if, then statement. If this temperature drops to that, what does it do? So, I think the success of IoT projects occurs when there's actually an actionable business outcome that can be achieved not just a shiny screen displaying historical stuff. I think that's really where the success is. " - **Participant 3**

"But again, it's got to be on. What is the business looking for? What's the outcome? What is the value that can be derived from whatever system? That's the key I think to having a successful project. It is more around delivering the business outcome within a certain amount of time." - **Participant 3**

Adopting a Strategic Approach to Projects

According to participants, projects that were initiated with a clear strategic intent and roadmap in mind were more successful. The strategy is the foundation on

which the project/initiatives deliver against and evolve towards over time. Participants 4, 8, and 7 highlighted the importance of a strategic approach.

> "Then also from the client side, just having that clarity of strategy up front, when you start out these projects. I think those are in my view the key things that really makes a difference in terms of it being a business benefit at the final analysis of versus it just being cool." - **Participant 4**

> "It all comes down to ensuring that you've got a great strategy from the start and what we've noticed is there's a desire to jump to two or three before going to stage 0" - **Participant 8**

> "We find that there's no real strategic approach to the concept of implementation. Which might be one reason why it leads to failure so quickly. So, what I'm trying to say is that if we approach a shopping mall, for example. There's no one individual responsible for mapping out an architecture and almost creating a vision of what an IoT solution should look like in one to 10 years' time and that quickly leads to failure because there were several attempts made to get this off the ground but without sort of a draft architecture or a draft plan, never mind it being a smart plan, it just being dark plan, it immediately leads to failure. So again, in, in any organisation probably more so than ever before, there should be a Chief Technical Officer or whatever you want to call it, Chief Digital Officer that should be put into a position to start educating himself with what is required to make these decisions and what are the steps to be followed." - **Participant 7**

Having a Clear Understanding of Needs

Participants viewed having a clear understanding of customer needs and requirements as a contributor to the success of IoT projects. They emphasised that client needs, and requirements must be well understood, and even road mapped before any design and deployment of projects occurs. Furthermore, they mentioned that architecture and design activities must be clearly aligned to the needs. Understanding of the needs also enabled the prioritization of easy wins during the deployment of projects according to participant 7.

> "First and foremost, understanding the requirement of the client. Again, the IoT topic is overwhelming. You need to understand the low hanging fruits and the pain points from the client's perspective, and if you start addressing those as first order priority. It'll just set you up for successful deployment. So, I would say first and foremost understand the requirements and aim to accomplish IoT solutions that addresses those." - **Participant 7**

Participants 6 and 2 emphasised the need to understand the requirements and problem when embarking on an IoT deployment.

> "On the topic of success drivers. First of all, your requirements. Make sure that you understand what your requirements are and that you have a digital transformation road map for your specific use case. So first make sure that you understand what your requirement is and what your problem is" - **Participant 6**

> "But before we get into the design, proper understanding of the requirements of the customer. Again, and I think a lot of people do this and there's extremes like we're on the one extreme as IoT Company 1, we don't do enough customer requirements. We just do design. I think we do design fairly well. But it's like it's like throwing technology at a business doesn't stick. If you look at the enterprise architecture approach, first, understand what the business has, what the business is, what the business can do, so heavy requirements and a fine line, then design right. So proper requirements, understanding a problem with a solution and always the simplest problem has always, the simplest answer, and if you've got that covered with success criteria" - **Participant 2**

Using Subject Matter Experts

Participants pointed out the need for subject matter expertise and consulting capability as a success factor for projects. It was noted that providers needed to use expertise to advise clients that did not necessarily have in house IoT expertise and looked to provides for guidance. Therefore, a key success factor

was for providers to use expertise and consulting capabilities to become trusted partners and advisors instead of mere technology providers.

> "Where we looked at a lot of the stats that we've gathered for him across all of his buildings in the country, and now we're looking at it saying, ok so, what does this mean for him? And having the discussion to say, ok, what decisions do you need to make now? So, there's a completely different discussion to tech and sensors and how the data gets reported and all of that, and you need to have that layer of engagement with your client as well to make project successful. There's a bit of bit of consultative value you need to add there as well. Otherwise, it's just cool tech." - **Participant 4**

> "I think having the ability to as you are in a project worked with the client to make sure that you're moving in a way that actually gives the right outcome. So just I think being close to clients and not having a mindset of just providing a sensor or box drop kind of a mentality. I think really, really being part of delivering the total outcome from A-Z I think for is super, super important and that's where you get a different engagement with a client over time as well where you become part of their business thinking instead of just being a supplier of piece of electronics." - **Participant 4**

The interviews also revealed that participants thought an important factor was that subject matter expertise in the office building domain was important to informing good design.

> "How do we constitute our project team? Who's going to be in that team? Do we have the technical capabilities? Do we have the guys that actually understand if we're saying we're running it out within say let's talk generator monitoring or HVAC or do we actually have a subject matter expert as part of the team that can assist bringing all of the data points together, and then start creating the intelligence that you require out of that system. I think that is that is one major thing that needs to be considered for project to be successful." - **Participant 9**

> "I think where you also tend to have successes where the various subject matter experts that's part of the actual team tend to contribute; I'd almost say holistically to the actual solution itself. Like I said, a lot of customers don't know what the potential might be. They just see what they need for now and therefore I think bringing in things like, you know, expert partners to almost do an overarching brainstorm and then bite size it." - **Participant 1**

Participants also noted that providers needed to use their expertise to advise on the direction that clients should take in adopting IoT solutions and how these could translate into tangible benefits. An example of this was provided by participant 1 in the context of an energy management solution.

> "But if you came in, you said that's what I'm going to do for you. I am going to reduce your energy bill by virtue of efficiency, by virtue of recommending new… I will reduce your energy bill, but I will also green your energy portfolio, and I'll reduce your energy bill by 10%. Because you are kind of almost efficient you know in terms of plugging your bucket but what we can do for you is take you from a dirty contributor to a cleaner contributor and we can do that via 25% shift in terms of how we can change some of your capacity to be able to provide it. Whether you get that from an IPP or you are getting it from me, providing my own solar capacity, or with Wind, or biogas, or whatever doesn't matter. The point is you're putting your neck on the line to be able to do that… that's where the expert bit comes in" - **Participant 1**

Lastly an ingredient for successful deployment of office space IoT solutions was sticking to solutions that providers had strong domain expertise in, as per the extract from participant 7:

> "I think the type of projects that we've taken on directly speak to our expertise and that's the HVAC and the optimisation around that, and we do understand that is the largest consumer of electricity in a built-up space. We could tangibly add value to optimise plants speaking to the HVAC usage profile. So, I think we have and continue to support in that sense

and being able to really expertly advise our clients on what can and should be done." - **Participant 7**

Good User Experience and Usage

Participants noted good user experience and actual usage of solutions as success factors. From a user experience perspective participants mentioned that solutions that were easy and intuitive to use, and provided reliable outputs were successful.

" So yes, I'll first cover the bases, but our vision is always to go to a stage that is, you know, the almost the dream state that anybody else would like to be in, you know where it's so self-sustaining that it becomes something like a simple intuitive app you know. I always say you know the IoT platforms should be for the end user like we talk about the CEO or myself, like and I don't play Minecraft or Candy Crush, but should be as intuitive as being able to click and drag and drop and be able to see things. Because ultimately that's what it is." - **Participant 1**

"If you want to get into things like intelligence and programming and automation, that's a different story altogether. But it should be easy for us to be able to measure those things for me to say actually, just give me one second. I'm going to go on to my app. and I'm going to tell you what the year to date was on XY and Z. Even if it's not accurate, it should be good enough to be able to have confidence within that." - **Participant 1**

Usage of the solution was another factor of success mentioned. If all user profiles use the solution regularly and the data was accurate and on-time it increased the success of the implementation.

"That probably if we could distil successful implementations of anything if all user profiles use it, it's successful." - **Participant 2**

"Because if you going to have a system, give you critical alarms or do your fault finding for you. The data needs to be accurate, and it needs to be on time." - **Participant 9**

Embedding the Solution in the Organisation

Participants mentioned various aspects of embedding the solution into the client organisation as a success factor. The first way of doing this that was elaborated on by participants 5 and 6 was to ensure that the solution is embedded into the clients' processes and culture so that it can be managed and sustained.

> "Then also enabling people to look after that environment is critical. You know obviously from a back-end we can look after it from a maintenance point of view. But I'm saying who's got access to the system. What's going on in the system? It's not this plug and play where you implement it and you leave it, it needs to be supported. It needs to be part of the company culture. Then you've got a recipe for success, and I think really one of our successful ones is we've got it now with a client. It's part of their culture, this energy saving, this building management system, the optimisation is part of their business culture now. In every little reception there, there's a screen going up showing what are the building metrics." – **Participant 5**

> "It's a joint thing. So, what we did usually in the beginning we found that we would deliver a solution and its mainly technology focused. So, here's the technology. Here's how you use a technology. But then how is it integrated into the client's processes and business was probably one of the most important elements to look at. In the beginning we would trust our clients to look at that and how it would actually merge into their business. But then it's the thing that usually falls flat. So, what we now do is we consult, and we advise our clients in terms of how the processes are affected. We encourage integration to existing systems as far as possible and especially in terms of our industry, in terms of our business context, our IoT solutions are integrated from the word go into our asset management software, and because we feel that it has to be integrated, we have to automatically trigger work orders. Otherwise, if you just get a notification from an IoT device, first of all, does the manager of the person receiving that notification, is that manager way of that event? Has it been logged somewhere on a system and is it tracked? Is the work closed off?

> Is there history of all of that data? Are all of the stakeholders informed of the events?" – **Participant 6**

The second important factor of embedding the solution mentioned was communication of relevant information about the solution to clients and stakeholders.

> "So, the risk for me is high in terms of business, and so communication is very important. All stakeholders should be aware of the solution and the client should communicate the solution through to all of people that will be using other tech." – **Participant 6**

Partnering for Success

The participants mentioned partnering with different entities as a success factor for the deployment of IoT solutions in office buildings. What this meant for participants was that entities deploying solutions should not try and deliver on every aspect of the solution by themselves but use a network of appropriate partners to assist in delivery. The reasons for partnerships being important to success were given as follows:

- They enable the right expertise and skill to be brought in to execute on projects effectively as highlighted by participant 1.

  > "I think that the build, buy and partner model needs to be applied appropriately to IoT teams. You know, I think there's a portion that you can build with the skill that you have and the teams that you… pull in. From a stakeholder engagement perspective, I think there's stuff that we must just say it's easier for us to buy that technology either out or to buy it in, in order to service because it's cheaper to actually do that because it's something that's being deployed, something that's been tried and tested, and something that can be aggregated quite easily. And then I think there's a bit that we are lacking because we think we can do it all ourselves, which is the partner bit right and that way when it comes to things like water energy." – **Participant 1**

- They allow companies to focus on their core competencies and deliver on those well. As highlighted by participant 6

"Yeah, I think, uh, what is successful? One thing that's from my experience and what I've learned is that we need to rely on business partners to help us with specific functions and an example is the supply of the technology itself. So, when we are looking for specific hardware for a project. In the beginning, we tended to try to source it ourselves and to go through the learning experience, which is quite costly as opposed to rather relying on your technology partner and asking them to help you source the correct hardware for the specific use case. Which saves a lot of time, saves a lot of headaches, and so that they can rather source, the correct hardware. So that's one big success factor for us as well is having a network of business partners to assist with functions that you aren't, experts in." – **Participant 6**

- Partnering with reputable organisations such as large management consulting firms to assist in building business cases and elevating conversations to higher organisational levels as highlighted by participant 8.

"We do buddy up with some great partners. As I said in in the previous segments, where I just spoke, is we want to try and expand that to people that have a broader reach on a more general level as opposed to some of the more technical partners that we have like the IBMs with their platforms and so on. They speak on one particular level, but then I think then there's a higher conversation that needs to be had which I certainly think the likes of KPMG and Accenture, that these kinds of organisations could give a bit more of a broader platform." – **Participant 8**

Solution Support

Supporting the solution during and after the implementation phase was experienced as a success factor by the participants. This involved getting support teams involved in project delivery from the beginning of projects. It also included making resources available to clients after deployment to ensure smooth running of the solutions.

"Get support involved early… They must be involved there from day one then I think like proper, just like support cadence and like general like run

of the mill business components with customers it's like usability, can there be improvements? Just because the projects done doesn't mean it can't improve right. So, is the customer using it, is it being monitored, are things going down regularly? Are they coming back?" – **Participant 2**

"I think just the operational support afterwards, it makes a massive, massive difference." – **Participant 4**

"Yeah, another contribution is support of the system once you've deployed and you've implemented. How do you support it? That's also an important success factor. What we try to do is first of all is document the solution as far as possible to enable your client to use the solution. Then also not just sell the technology, but also sell a support element to the client to ensure that you are monitoring the health and the performance of your solution, and you can react to events that the technology itself cause. As you know, once you implement the solution, there's always things that happen to your technology. Someone plugs out something and your solution is offline, or someone changes like Wi-Fi passwords so the technology can't connect to it. So yeah, I think it's quite an important factor that you have to consider IoT support" – **Participant 6**

An Internal IoT Champion

The participants mentioned the presence of an internal IoT champion as a factor for successful deployments. The role of the champion in their description was a party that would own the IoT deployment in the company and act as the driving force of the initiative by constantly advocating internally and driving the delivery.

"I think for me the key driver is if you implement it at a client where there is a very approachable and somebody driving a project, somebody that takes ownership of a project and says, listen, I want to implement this IoT system, and I will make it a success. You've got a better chance of doing it." – **Participant 5**

"Certainly, the champion, because you need a sponsor for the solution to obviously go and get budget to spend money on these type of things and

why? What's is the justification? So, I think that's a continuous person that needs to advocate and own that at the end of the day… " – **Participant 3**

The role of the champion as per participant 5 was also to understand the technology and help communicate it to the organisation to obtain buy-in from stakeholders. The champion also acts as the owner of the initiatives internally, revising them and ensuring that they are up to date.

> "That comes from management structure. So, once you get that and let me explain that one. What I mean by a team leader, somebody really embracing it. We dealt with the CFO there that totally didn't understand IoT and didn't want it. And our projects were not going, were not going. Until we found someone, the sweet spot, somebody that says listen, I understand that this a good way to doing, and he fed into the CEO. Now, our projects are just going so you need a champion within the organisation basically we need a champion to drive it." – **Participant 5**

> "So there needs to be a process and resources driving it within the company that has now rolled this out and most of the time we find that does not happen. So, we get an external party to come and install this for us. We've got an outsource company that's basically working with the information gathered from that system, but it's nothing internally going on or internal ownership to say, OK, right guys, let's look at it and let's evolve it. This is working. This not working. How can we enhance the system? That sometimes doesn't happen. Well, most of the times doesn't happen." – **Participant 9**

Executive Sponsorship for Initiatives

Executive sponsorship was mentioned as a key success factor for IoT initiatives. Participant 4 mentioned that their successes had come in situations where they had the right level of executive sponsorship, and participant 8 reinforced this point by adding that c-level engagement and sponsorship ultimately led to solutions being implemented.

"Direct, engagements, like I said, where we've had successful projects is if we have the right strategic kind of scoping, if I can call it that, at the outset, and we've got the right executive sponsorship.″ – **Participant 4**

"We focus on a lot of these people as well as people who are in control of the money. This what's how much things cost within the building. So, the financial directors and CFOs and so on. But we found ourselves always when it came to key decisions of deployment and making key decisions on how to structure an application was people that are more involved in the architectural side of things, the project management side of things are more functional in terms of building the project. We found once we've engaged with somebody a C-suite level they would ultimately introduce you down to somebody who's on sort of an operational level, and then the decisions could be made a lot quicker from that perspective because we felt like the somebody in C suites is looking at things in a in a much broader level, but ultimately the key decision to get a project off the ground or if a deployment off the ground happens it a project management level." – **Participant 8**

Technology Selection

Participant 6 felt that the correct technology selection was a factor in the success of projects. They mentioned that using a technology score card was a good way to select the correct technology some factors included in the score card were technology maturity, cost, maintainability, support availability, and supply management.

"Yeah, we actually have a score card where when we choose technology. We ensure that, first of all, is mature technology and has it been properly tested in the field? Because we did have experience in the beginning where we purchased a technology and they promised a specification and I can use an example battery life of five years to find that it only lost three months in the field, no flexibility in terms of device management. So, it's device management capability wasn't as expected, which hampered our project and what we will have to deliver. Then you're also, like you say, the

cost of the technology also does have an effect and then the maintainability of it as well. How easy is it to replace batteries if you need to? Then also OEM support, which is a big thing for us. If there's something wrong, we need support, technical support from the OEM or the distributor and then also supply management of that. If we buy a technology from a specific company, we want to at least have a three-year of supply and it's an agreement we go into with the supplier and we want a support contract. They should be an SLA in place and yeah otherwise it affects us quite significantly" – **Participant 6**

Project and Solution Documentation

Participants highlighted the importance of good documentation to the success of the IoT projects. From their experience, good documentation of the design and other policies and procedures were fundamental enablers for different project aspects.

"Proper design and documentation are like the biggest thing for successful implementation. Being able to articulate your solution because these solutions might not always be overly complex. That being able to articulate something on paper for anybody else is always powerful because that then speaks to change management. That speaks to training, that speaks to hand over to support, so proper documentation is your first step to success." – **Participant 2**

"Yeah, another contribution is support of the system once you've deployed and you've implemented, how do you support it? That's also an important success factor. What we try to do is first of all is document the solution as far as possible to enable your client to use the solution." – **Participant 6**

Land and Expand Approach

Participants 5 and 7 mentioned that a land and expand approach was best suited to successful projects. This meant first starting off with small easy to deploy initiatives that show good results, and then scaling up to more, and more complex projects.

"My input and suggestion would be to address the essential land into that space, and then expand from there." – **Participant 7**

"I think that the spinoff from that is we've got a multi-tiered approach. You want to get your first most valuable low hanging fruit. You want to go in and say look we're going save you 25% on your energy consumption if we just implement a small little box in (an IoT gateway and control device) do a couple of optimisations. That's already got somebody's attention. Then for us the key drivers after that are the access control the occupant sensing, the presence sensing an and I think that's important. I think for us it's nice as well. It's a land expand model. Once you enter an easy way, easier conversation to the next platform or the next tier of technology that needs to be implemented." – **Participant 5**

Reliable Network Connectivity

Some participants viewed reliable network connectivity as the first step to a successful IoT deployment. This is because connectivity is the critical backbone of IoT, providing internet access. The importance of network was mentioned by participants 8 and 9.

"So, we talk about the stage zero if you've got a digital transformation strategy and you starting it with wanting to understand the insights. You may need to take two or three steps back and go to a stage zero and make sure that you've got a great network in place, a converged network as well as more things connected to it, because doing insights with half of the things or half of the components and devices connected is only going to give you half the story .That, in a nutshell, is I suppose what the key driver is." – **Participant 8**

"The challenge that we have a lot of it is around communication. When we initially started here at Telecommunications Company 1. We wanted to put this on the LAN, on the network and then we started getting pushed back from cybersecurity all of those type of things. And then we started moving across the GSM and then we've got dead spots and the data is not coming through or, things are going down. So that is one of the big challenges is

to actually putting down the communication that we can, making sure that whatever we are receiving is accurate and in real time. Because if you going to have a system give you critical alarms or do your fault finding for you. The data needs to be accurate, and it needs to be on time. – **Participant 9**

Standardised Delivery Specifications

Participants indicated that standard rollout and delivery processes were important for deploying successful solutions, particularly in cases of large rollouts across multiple regions. This was outlined by participant 8 as per the quote below.

"One of the biggest issues that we had is you've got a global company with a lot of real estate in many different countries. But in order to get a standardisation of a design across a large territory, particularly even if it's just across the European territory or a Europe Middle East, and Africa (EMEA) territory, we found that if you're not going back to standardizing your specification and if you don't have the ability to deploy with one single contractor or system integrator, you're going to get inconsistencies. A lot of the lessons that we learned with some of our clients, and it's happened in two cases. One big social media platform and one very big online retailer who have a large-scale portfolio found themselves in a bit of a tricky situation where you've got all the plans in the world, all the specifications, but you don't have a standardised rollouts or delivery process of this. It can come down to learning through your failures I supposed. Eventually we got it right, but the pain points for the first year of doing that were quite costly." – **Participant 8**

Communication with the Client

Communication channels with the client were outlined as being an enabler of successful project deployments by participant 2 who explained that having the right stakeholders from the customer and solution provider communicate with their counterparts was important in successful deployment.

"I think proper communication channels with the client, I think it's like. You can't have a project delivered everything through a Project Manager to another Project Manager. Like there should be streams. There should be structures like the right people need to talk to each other on the right-hand side, and it's actually interesting if you go and unpack what I've just said with how The Open Group Architecture Framework (TOGAF) is set up. Like TOGAF is overly complex if you think about, but when they distil it. It's like put the right stakeholders on one side with the right stakeholders on the other side and let them build bridges at all layers of the organisation before you implement something. And that's pretty much all that you need for an effective technology implementation, right?" – **Participant 8**

The success factors are summarised in Table 4.5 and categorised as organisational, environmental, and technical.

Table 4.5: Summary of Sub-Themes and Categories for Success Factors

Sub-Theme/Success Factor	Category	Description
Clear Business Value	Organisational	A tangible business benefit to the client translated into a clear, simple to understand business case.
Clear Business Objectives and Actionable Outcomes	Organisational	Clear objectives for outcomes and measurements of initiatives.
Adopting a Strategic Approach to Projects	Organisational	Having a clear strategy that initiatives can deliver against and evolve towards over time.
Having a Clear Understanding of Needs	Organisational	Client requirements must be well understood before deployment and designs aligned to them.
Using Subject Matter Experts	Organisational	Includes using subject matter expertise to advise clients, and having strong domain expertise internally to align solutions to.
Good User Experience and Usage	Technical	Easy to use, intuitive solutions that provided reliable outputs, and showed high usage by clients.

Embedding the solution in the organisation	Organisational	Ensuring solutions are embedded into client's processes and culture and communicating solution information to stakeholders.
Partnering for Success	Organisational	Entities deploying solutions should not try and deliver on every aspect of the solution by themselves but use a network of appropriate partners to assist in delivery.
Solution Support	Organisational	Getting support involved from project inception and making resources available to support post implementation.
An Internal IoT Champion	Organisational	A party that would own the IoT deployment in the company and act as the driving force of the initiative by constantly advocating internally and driving the delivery.
Executive Sponsorship for Initiatives	Organisational	Getting the right level of executive support for deployments.
Technology Selection	Technical	Choosing the correct technology by considering maturity cost, maintenance, support availability, and supply.
Project and Solution Documentation	Organisational	Documentation of the design, policies, and procedures.
Land and Expand Approach	Organisational	Starting off with small easy to deploy initiatives that show good results, and then scaling up to more complex projects.
Reliable Network Connectivity	Technical	Setting up a reliable connectivity backbone for the system.
Standardised Delivery Specifications	Organisational	Standardising delivery and rollout processes.
Communication with the Client	Organisational	Having the right stakeholders from the customer and solution provider communicate with their counterparts.

4.4 Linking Themes and Study Propositions

4.4.1 *Proposition 1 Conclusion*

Proposition: There are several drivers of IoT solution deployments in office buildings. These drivers can be expected to be different for different stakeholders: building tenants, the local community, investors, occupants, and building operators.

The top two drivers, according to the frequency of codes, were operational efficiencies that could be gained from the solutions and data-driven decision making. Utilities management, sustainability, and Asset management followed closely as factors driving deployments. Participants mentioned seven stakeholder types, more than the 5 anticipated in the proposition. Furthermore, the stakeholders could be associated to drivers mentioned by the participants, although not uniquely per participant, contrary to the proposition.

4.4.2 *Proposition 2 Conclusion*

Proposition: Inhibiting factors to deploying IoT solutions in office buildings can be categorised into business and technical factors. These factors are expected to include one or more of the business and technical factors found in the literature and summarised in Table 2.2 and Table 2.3 respectfully.

The responses resulted in 11 inhibitors identified, represented as sub-themes in the section 4.3.2. Eight of the inhibitors could be categorised as business, and three as technical factors. This was less than the 16 business and 7 technical factors found in the literature.

Of the inhibitors mentioned, difficulty selling the business case for large deployments was most common amongst participants. Stemming from an inability of stakeholders to visualise benefits, factor in non-monetary benefits, and communicate business cases in a field where many solutions are often very new. A lack of support for the solutions was another commonly mentioned factor. Participants felt that if support teams were not involved from initiation and projects

are handed over to support, as opposed to transitioned, then projects failed. This was commonly felt as clients did not have the in-house IoT skills to support solutions. These factors, along with the poor alignment of designs to requirements, change management practices that failed to embed solutions in organisations, and legacy technology made inaccessible by proprietary standards and uncooperative vendors were other common reasons mentioned by participants.

4.4.3 *Proposition 3 Conclusion*

Proposition: There exist specific success factors of IoT deployments in office buildings. These success factors are expected to include one or more of the factors found in the literature and summarised in Table 2.4.They stem from 3 main areas: organisational, environmental, and technical.

Participant responses resulted in 17 factors/characteristics being mentioned with only 8 of those mentioned corresponding to the 25 found in the literature.

Among the factors the most commonly mentioned among respondents was the need for subject matter expertise when deploying these projects, as they were critical in devising solutions based on strong domain expertise. Clear business values, objectives, and outcomes were also commonly reported as success factors by participants who believed that projects had to be underpinned by business drivers to succeed. Many of the participants also mentioned user experience as being critical to success in an era where intuitive apps had become the norm, and the need for champions to own IoT projects as IoT initiatives generally had no clear home in organisations who were not used to managing IoT as a relatively new aspect of operations.

Success factors could be grouped into technical and organisational factors, but no environmental factors were drawn from participant feedback.

Table 4.6 is provided for ease of understanding the links between the research questions, relevant propositions, themes, and sub-themes resulting from the thematic analysis of the data.

Table 4.6: Summary Linking Research Questions to Propositions and Themes

Research Question	Proposition	Themes and Sub-Themes
What are the drivers for the deployments of IoT solutions in office buildings?	**Proposition 1:** There are several drivers of IoT solution deployments in office buildings. These drivers can be expected to be different for different stakeholders: building tenants, the local community, investors, occupants, and building operators.	**Theme 1: The Nature of the IoT for the Office Spaces Industry** • IoT is a repackaging of traditional concepts • Initiatives are in their early stages of adoption and the market is not yet mature **Theme 2: Drivers of IoT Deployments in Office Buildings** • The new normal post COVID-19 • Data driven decision-making and strategies • Office space optimisation • Operational efficiency • Utility management and sustainability • Building occupant experience • Asset management • Regulatory compliance • Shortage of competent technical resources to manage operations **Theme 3: Stakeholders of IoT Projects for Office Buildings** • Executive level stakeholders • Human resources (hr) • Facilities managers • Building users • Building owners

		• The IT department • Sustainability teams
What are the inhibiting factors to deploying IoT solutions in office buildings?	**Proposition 2:** Inhibiting factors to deploying IoT solutions in office buildings can be categorised into business and technical factors. These factors are expected to include one or more of the business and technical factors found in the literature and summarised in Table 2.2 and Table 2.3 respectfully.	**Theme 4: Project Success Rate** • The perception of the successfulness of deployments of IoT solutions in office buildings as per research participants. **Theme 5: Inhibitors to Deploying IoT in Office Buildings** • Difficulty selling the business case for large deployments • Seeing IoT projects as linear, and not evolutionary • Maturity of IoT solution providers • Not knowing what to do with the data • Lack of post implementation support • Poor solution design • Poor change management and reluctance to change • Closed legacy systems • lack of clear solution ownership • Lack of strategic intent • Lack of IT support for initiatives
What are the success factors of the office building	**Proposition 3:** There exist specific success factors of IoT deployments in office buildings. These	**Theme 6: Success Factors for Deployment of IoT in Office Buildings** • Clear business value

IoT solution deployments?	success factors are expected to include one or more of the factors found in the literature and summarised in Table 2.4.They stem from 3 main areas: organisational, environmental, and technical.	• Clear business objectives and actionable outcomes • Adopting a strategic approach to projects • Having a clear understanding of needs • Using subject matter experts • Good user experience and usage • Embedding the solution in the organisation • Partnering for success • Solution support • An internal IoT champion • Executive sponsorship for initiatives • Technology selection • Project and solution documentation • Land and expand approach • Reliable network connectivity • Standardised delivery specifications • Communication with the client

4.4.4 *Conclusion of Findings*

Drivers, inhibitors, and success factors emerged through the thematic analysis of the data. The results revealed that IoT initiatives were still in their infancy in a maturing market, with participants experiencing mixed success in their deployments.

The data also revealed clear drivers and links between drivers and stakeholders which could provide insight into IoT adoption in office buildings. Clear inhibitors to success were uncovered as well as success factors. Although the factors differed in number and type to those found in the literature.

CHAPTER 5. DISCUSSION OF THE FINDINGS

5.1 Introduction

This chapter discusses the findings of the study in relation to the literature reviewed and propositions made. The section is divided broadly into five subsections. Three subsections discuss the findings by research proposition. One section discusses the findings pertaining to the success of IoT projects in office buildings, and the final section is a conclusion of the discussion.

5.2 Discussion Pertaining to Proposition 1

Proposition: There are several drivers of IoT solution deployments in office buildings. These drivers can be expected to be different for different stakeholders: building tenants, the local community, investors, occupants, and building operators.

5.2.1 *The Nature of the IoT for Office Spaces Industry*

The research findings point to IoT as an evolution of existing technologies that have been repackaged and named. This was consistent with the findings of the literature which described IoT as driven through the convergence of technological development (Deloitte Touch Tohmatsu India LLP & Confederation of Indian Industry, 2020). The implication was that some of the principles and skills used to deploy traditional technology such as SCADAs and BMS's could be translated into the deployment of IoT projects in office buildings. Secondly participants mentioned that IoT technology was often cheaper to deploy to achieve similar outcomes. The drivers of deploying traditional building technology solutions might therefore be similar to those for IoT solutions.

The literature also pointed to Proptech and by virtue IoT as "emerging" (Siniak et al., 2020) and "high-growth" (Emergen Research, 2021). The findings were consistent with this as participants highlighted that the industry was maturing. The

implications of this might have directly affected the participants' feedback as the challenges faced in deployments could have been symptomatic of a maturing industry.

5.2.2 *Drivers of IoT Deployments in Office Buildings*

When comparing the drivers from the study with those in the literature, 10 of the factors could be grouped into five from the study. Seven of the eight drivers that appeared in three or more of the literature sources featured in the study findings. The driver that did not feature was “safety and security” which was unexpected as safety and security was one of the key focuses of building managers (Larios et al., 2013).

Three of the remaining nine factors from the literature that featured in two or less of the sources and were expected to be less likely to feature in the study as a result, did in fact feature. They were “space utilisation”, “water distribution”, and “building longevity” which were equivalent to the findings of “office space optimisation”, “utility management and sustainability”, and “operational efficiency, respectively”. These factors could have been due to an increased focus on space management resulting from the COVID-19 pandemic, managing water distribution as a part of sustainability initiatives, and building longevity encompassing the cost of operations.

The remaining six drivers from the literature that did not feature in the findings were: “maintaining high internet connectivity”, “brand recognition and loyalty”, “risk reduction”, “data aggregation”, “ability to offer digital services”, and “location-based services”. This was expected as they did not feature in more than one of the literature sources, indicating that they may have been less commonly experienced as drivers. Error! Reference source not found. summarises the drivers from the study, their equivalents found in the literature, and the literature sources.

Table 5.1: Drivers from the Study and Their Equivalents in the Reviewed Literature

Driver from Study	Equivalent Driver from Literature	Literature Source
Office Space Optimisation	Space Utilisation, Process Optimisation/ Functional Efficiency (including operation and maintenance)	(EDU, 2021; Horch et al., 2017; Jia et al., 2019; Salosin et al., 2020; Sinopoli, 2016; World Economic Forum, 2021)
Operational Efficiency	Cost Reduction/Optimisation	(Dryjanski et al., 2020; EDU, 2021; Horch et al., 2017; McKinsey & Company, 2021; Salosin et al., 2020; Sinopoli, 2016; World Economic Forum, 2021)
Utility Management and Sustainability	Energy Efficiency and Management, Sustainability, Water Distribution	(Buckman et al., 2014; Dryjanski et al., 2020; EDU, 2021; Horch et al., 2017; Jia et al., 2019; McKinsey & Company, 2021; Salosin et al., 2020; Sinopoli, 2016; World Economic Forum, 2021)
Building Occupant Experience	Occupant Comfort, Health and Well-being, Occupant Productivity, Employee/Occupant Satisfaction	(Buckman et al., 2014; EDU, 2021; Horch et al., 2017; Jia et al., 2019; McKinsey & Company, 2021; Sinopoli, 2016)
Asset management	Building Longevity, Process Optimisation/ Functional Efficiency (including operation and maintenance)	(Buckman et al., 2014; EDU, 2021; Horch et al., 2017; Jia et al., 2019; Salosin et al., 2020; Sinopoli, 2016; World Economic Forum, 2021)
The new normal post COVID-19	N/A	N/A
Data driven decision-making and strategies	N/A	N/A
Regulatory Compliance	N/A	N/A

Shortage of competent technical resources to manage operations	N/A	N/A

Alignment of Drivers Found in the Literature and the Study

Addressing “Office Space Optimisation” as a driver, participants spoke about using IoT solutions to right-size space, plan layouts and other outcomes that enabled the optimised use of office space. These factors were aligned to EDU (2021) which spoke about the need for space to be fit for purpose to operate efficiently and The World Economic Forum (2021) that spoke about planning layouts, designs and features to optimise space utilisation, both in the context of using IoT solutions.

Five out of the 10 participants mentioned operational efficiencies gained through remote monitoring, reduced truck-rolls, and enhanced equipment operation as a driver for IoT adoption in office buildings. This aligned with the cost “reduction/optimisation” as a driver from the literature, where sources cited increasing efficiency as a key driver for the adoption of IoT in buildings through similar examples such as remote visibility (World Economic Forum, 2021).

Participants mentioned “utility management and sustainability” as drivers. The emphasis was on driving down energy consumption and achieving certification using IoT as a tool in office buildings. This coincided with the literature where using IoT in buildings to achieve sustainability certifications such as Leadership in Energy and Environmental Design (LEED)(Larios et al., 2013), reducing energy consumption through IoT interventions (Buckman et al., 2014), water distribution efficiencies through smart metering and leak detection (Sinopoli, 2016), and maximising overall resource consumption efficiency using IoT (Jia et al., 2019) were all mentioned as drivers of implementing the technology. Alignment between the literature and participants, and the high prevalence of the driver being mentioned between the two indicates that it is an important and topical factor.

“Building Occupant Experience” as a driver from the study was equated to “Occupant Comfort, Health and Well-being, Occupant Productivity, Employee/Occupant Satisfaction” as drivers from the literature. According to participants, IoT adoption in office buildings was driven by the ability of IoT solutions to improve occupants' comfort, safety, health, and productivity. Buckman et al. (2014) concurred with this view and found that occupant comfort was one of the drivers of smart building adoption. The World Economic Forum (2021) found that the well-being of occupants was a key reason in adopting technology such as IoT enabled real-time air quality monitoring to make spaces healthier and safer to return to post the pandemic. Finally the findings of Sinopoli (2016) were concurrent with the productivity aspect mentioned by participants where technology such as IoT adopted in smart buildings was usually done to make occupant tasks easier or increase productivity.

The final driver from the research consistent with the literature was “asset management”. Participants highlighted the role of IoT in improving asset lifespans, availability, reliability, and maintenance through IoT technologies for remote and intelligent monitoring. In the literature, Jia et al. (2019) asserted that functional efficiencies through adopting IoT were a driver as IoT enabled real-time data for predictive and preventative maintenance in operations. Furthermore, Sinopoli (2016) reinforced this by naming enhanced and efficient operations as the primary driver for technology deployment in smart buildings.

Drivers Found in the Study but not in the Literature

As per the World Economic Forum (2021), there was a need to validate and understand the drivers of deployments of IoT solutions in real-estate. This study has contributed to the validation of 10 factors found but also proposed 4 more which were not found in the literature considered for this study. These drivers were:

- The new normal post COVID-19;
- Data driven decision-making and strategies;
- Regulatory compliance;
- And Shortage of competent technical resources to manage operations.

“The new normal post-COVID-19” emerging as a driver was probably a result of the timing of this research. The literature review had taken place whilst the world was still dealing with the pandemic, and as such, it did not yet feature in the literature.

“Data driven decision-making and strategies” using IoT in the office building environment was also emerging, according to participants, although it was not a new field. This tied into “regulatory compliance” as IoT solutions provided data that could be used for compliance purposes.

The “shortage of competent technical resources to manage operations” was possibly a symptom of a wider shortage of technical skills (Statista, 2021). These shortages were driven by the adoption of new technologies that required new skills that weren’t immediately available (Brunello & Wruuck, 2019), placing more reliance on smart technologies such as IoT to bridge the skills gap.

5.2.3 *Stakeholders of IoT Projects for Office Buildings*

Five stakeholders of the office building IoT solutions were found in the literature. They included:

- Tenants;
- Local community;
- Investors;
- Occupants;
- and Building Operators.

The research resulted in seven stakeholders being mentioned by participants in interviews. The seven were: Executive Level Stakeholders, Human Resources (HR), Facilities Managers, Building Users, Building Owners, The IT Department, and Sustainability Teams. There was an overlap between three of the stakeholders proposed in the literature and those from the study findings. The stakeholders resulting from the study and their equivalents from the literature are summarised in Table 5.2

Table 5.2: Stakeholders from the Study and Their Equivalents in the Reviewed Literature

Stakeholder from Study	Equivalent Stakeholder from Literature
Executive Level Stakeholders	N/A
Human Resources (HR)	N/A
Facilities Managers	Building Operators
Building Users	Occupants
Building Owners	Investors
The IT Department	N/A
Sustainability Teams	N/A

Stakeholders Found in the Literature but not in the Study

"Tenants" and the "local community" as stakeholders did not feature in the research. It is possible that the local community did not feature in the research as participants were mostly from telecommunication and IoT solution companies who focused on business clients with private offices and were not necessarily open to the community. The absence of tenants as stakeholders in the research findings was surprising as a business generally occupies buildings as the tenant, and the tenant is affected by the technology in the building. A reason for this could have been that IoT solutions deployed by IoT solution providers or BMS solution providers (who were some participants) were done through the engagement of landlords and not tenants, as the solutions often affected the structure or original equipment in the building.

Associating Stakeholders to Drivers

It was found that drivers from the study could be associated to stakeholders; therefore, the proposition that drivers were different for different stakeholders was true to an extent. The main difference found was that some drivers were important to multiple stakeholders. Table 4.3 summarises the interests of stakeholders in different drivers. One-notable finding was that no drivers were associated to the IT department as stakeholders. The reason for this was that the IT department was mainly seen as an enabler of IoT solution deployments rather than a direct stakeholder in the outcomes of the solutions.

Building users were linked to a single driver, “building occupant experience”, which affected them directly as the space users. Building owners were driven by “occupant experience” and “the new normal post COVID-19” as they had an interest in making space great for occupants to attract and retain tenants, and how to optimise their spaces for use post COVID -9.

Sustainability teams were driven by “utility management and sustainability”, and “regulatory compliance”. From a regulatory compliance perspective, the sustainability teams would have been interested in how IoT solutions could enable compliances such as energy performance certificates, as IoT was becoming a critical technology in improving compliance checking (Metallidou et al., 2020) and sustainability compliance was increasing in importance for corporates (Baumgartner & Ebner, 2010).

Human resources were driven by “building occupant experience”; as custodians of people within an organisation and space, it would have been in HRs interest that the space be as pleasant as possible for occupants, and that the space had the required facilities to support staff in carrying out their duties efficiently (Ichsan et al., 2020). “The new normal post COVID-19” was another driver for HR as organisational plans affecting staff would need to be implemented by HR such as remote work policies and practices that were influenced by the pandemic (Iqbal et al., 2021). Technology was seen as an important tool for HR in enabling the new normal (Iqbal et al., 2021).

Facilities managers had the second most drivers associated to them. The first which was unique to them was a “shortage of competent technical resources to manage operations”. This was a critical driver for facilities managers as they were responsible for maintaining, improving, and adapting buildings in the course of their operation (Okoro & Musonda, 2019). “Asset management” and “operational efficiency” were two other drivers relevant to facilities managers. Facilities managers were tasked with the upkeep of physical infrastructure to drive operational uptime (Grimshaw, 2003; Okoro & Musonda, 2019), making “asset management” an important driver. They also had to plan the most efficient use of limited resources while managing facilities (Isa et al., 2016; Myeda, 2014). Lastly “space optimisation” was important to them as they had to ensure that the

space was best used and rightly specified for the number and type of building occupants (Myeda, 2014; Okoro & Musonda, 2019; Steiner, 2005).

The executive level, which referred mainly to the CEO and CFO in this context, had the largest number of drivers associated at five out of the eight identified. Executives were responsible for strategic business decisions in organisations and these decisions were starting to rely more on data as a support factor (Axelrod, 2015; Brynjolfsson et al., 2011). This supported the emergence of “data driven decision-making and strategies” as a driver from the study. These executives, and the CFO in particular, were focused on process optimisation (Spanyi, 2011) and operational excellence (CFO Research Services & Accenture, 2009), driving higher efficiencies in organisations. That was a potential reason “office space optimisation” and “operational efficiency” as drivers were associated to them. As mentioned previously sustainability compliance was becoming increasingly important for corporates (Baumgartner & Ebner, 2010) and according to Walls and Berrone (2017) organisational leaders had a big influence on implementing environmental practices, providing reason for “Utility management and sustainability” as a driver being associated to executives. “Regulatory Compliance” with specific emphasis on energy, sustainability, and occupant wellbeing was found to be a driver for executives. The three areas of energy, sustainability, and occupant wellbeing are features of ESG type compliances. A study conducted on CEOs found that 74% of them stated regulation as a driver of ESG adoption and split it into sustainability reporting, health, safety, and environment (Deloitte, 2021). Another study found 46% of firms interviewed cited regulation as a driver of ESG adoption (Kumar et al., 2020). Furthermore, Singhania and Saini (2022) found that the 28 countries considered in their study had 30 ESG regulations for companies to subscribe to, an example of such regulation was the directorate of the European Union that all companies had to account for human rights, climate, and environmental impacts of their operations (European Commission, 2022). These factors showed the increasing importance of regulatory compliance as a driver for executives.

Of the drivers mentioned “building occupant experience” was relevant to the highest number of stakeholders found in the study, four. Followed by “the new

normal post COVID-19", "data driven decision-making and strategies", "office space optimisation", "operational efficiency", "utility management and sustainability", and "regulatory compliance" which were all drivers for two stakeholders each. "Asset management", and "shortage of competent technical resources to manage operations" were found to be relevant to one stakeholder each. This might mean that a focus on building occupant experience for solutions could be a way of getting buy in from the most stakeholders in the organisation.

5.3 Discussion Pertaining to Proposition 2

Proposition: Inhibiting factors to deploying IoT solutions in office buildings can be categorised into business and technical factors. These factors are expected to include one or more of the business and technical factors found in the literature and summarised in Table 2.2 and Table 2.3 respectfully.

When analysing the results from participants a total of 11 inhibitors were noted. The inhibitors could be categorised into business and technical factors as per the proposition. The inhibitors uncovered in the study consisted of four technical inhibitors, and seven business related inhibitors. This means that more business factors were uncovered, countering the trend found in the literature where academic works mainly addressed technical inhibitors.

It is clear however, that the total number of inhibitors uncovered in the research (11) was less than the total number found in the literature (23). Of the business inhibitors found in the study six corresponded to the business inhibitors found in the literature. Of the nine business inhibitors from the literature that featured in academic works, only four corresponding inhibitors were found in the study. The study found two business inhibitors from the broader list of those exclusive to seminal literature reviewed.

Three technical inhibitors were found in the study, and all corresponded with technical inhibitors in the literature. The absence of more technical factors might have resulted from the research sample that consisted of stakeholders in more business-focused capabilities. The inhibitors from the study and the equivalent

inhibitors found in the literature are summarised in Table 5.3, along with the literature sources each was found in.

Table 5.3: Summary of Inhibitors from the Study and Equivalent Inhibitors from the literature.

Category	Inhibitor as per Study	Equivalent Inhibitor from Literature	Literature Source
Technical	Not knowing what to do with the data	Data management challenges	(Beecham Research, 2020; Capgemini Research Institute, 2017; Carcary et al., 2018; Chui et al., 2019; Cisco, 2017; Čolaković & Hadžialić, 2018; Lawal & Rafsanjani, 2021; Mehmood et al., 2017)
Technical	Poor solution design	Availability and reliability - specifically relating to maintenance and device selection	(Aman et al., 2020; Carcary et al., 2018; Čolaković & Hadžialić, 2018; Lawal & Rafsanjani, 2021; Nicolescu et al., 2018)
Technical	Closed legacy systems	Interoperability/heterogeneity/verticalized platforms/lack of standard architecture	(Aman et al., 2020; Carcary et al., 2018; Čolaković & Hadžialić, 2018; Lawal & Rafsanjani, 2021; Nicolescu et al., 2018)
Business	Difficulty selling the business case for large deployments	No clear business case/objectives/no clear measures of ROI	(Beecham Research, 2020; Capgemini Research Institute, 2017; Nicolescu et

			al., 2018; Prasher, 2018)
Business	Maturity of IoT solution providers	Vendor issues	(Beecham Research, 2020)
Business	Lack of post implementation support	Lack of internal skills	(Beecham Research, 2020; Chui et al., 2019; Cisco, 2017; Dryjanski et al., 2020; Microsoft & Hypothesis Group, 2021; Nicolescu et al., 2018)
Business	Lack of clear solution ownership	Unclear delivery roles and responsibilities	(Prasher, 2018)
Business	Lack of strategic intent	No clear link with organisational strategy	(Prasher, 2018)
Business	Lack of IT support for initiatives	Lack of alignment between business units	(Beecham Research, 2020)
Business	Seeing IoT projects as linear, and not evolutionary	N/A	N/A
Business	Poor change management and reluctance to change	N/A	N/A

Alignment of Inhibitors in the Literature and Study

Although the majority of business inhibitors from the study, four out of six, did align with inhibitors that were found in academic literature, many inhibitors from the literature did not feature in the research results. This included 10 business related, and 4 technical inhibitors. A proposed reason for this could have been that the analysed literature was not specific to IoT deployments in office buildings but encompassed IoT in general, smart building and smart city related sources. This was a result of a lack of literature on the topic. A larger sample size with more varied experience might also have led to more inhibitors aligned to the uncovered literature.

Upon inspection of the inhibitors in Table 5.3 the driver from the study “maturity of IoT solution providers” and that from the literature “vendor issues” seem misaligned. It should be noted that in this context, “vendor issues” were a summary of the broader topic of vendors promising and not being able to deliver on those promises (Beecham Research, 2020). and that was aligned to the sentiment of participants that vendors were immature and unable to deliver on their solutions due to immature practices. The same issue might be noted when comparing the inhibitor from the study “lack of post implementation support” and the “lack of internal skills” found in the literature. The literature refers to finding the right skills to deploy IoT successfully in organisations, the lack of these skills and capabilities were also mentioned by participates creating alignment between the two.

“Data management challenges” as a factor was discussed in broad terms in the literature and included the perspective that organisations lacked the skills to analyse and process the data (Capgemini Research Institute, 2017). This was aligned to the participants' views that solution providers did not yet understand what to do with the data emanating from IoT projects in office buildings.

“Poor solution design” as an inhibitor from the research was aligned to the “availability and reliability” inhibitor from the literature. The literature mentioned the challenges of using devices with batteries that led to maintenance overheads and other costs as a blocker to IoT project success (Lawal & Rafsanjani, 2021). This aligned with the feedback from participants, where poor device selection from a maintenance perspective were one of the reasons for poor design.

Dryjanski et al. (2020), and Čolaković and Hadžialić (2018) made specific mention of the siloed nature of systems with different standards that cause interoperability issues when deploying IoT solutions. These same issues were elaborated on by participants who felt that legacy systems with different integration protocols were a challenge to deploying IoT in office buildings.

“Difficulty selling the business case for large deployments” was another study inhibitor that corresponded to inhibitors from the literature. According to Prasher (2018) IoT projects that were not built on a business case and clear benefits were

likely to fail. This sentiment was echoed by six of the study's 10 participants, indicating that the lack of business case may have been the single most important inhibitor to the success of IoT deployments.

Prasher (2018) in a study on IoT project challenges from a project management perspective found that unclear delivery roles and responsibilities were a factor in causing major delivery issues in IoT projects. This corresponded to the finding that a “lack of clear solution ownership” was an inhibitor to IoT success where participants experienced that solutions were not owned by any particular department, team, or individual in business leading to failure. This was symptomatic of unclear roles and responsibilities. Participants, and the literature through Prasher (2018) mentioned the lack of linkage to strategy as an inhibitor. Participants felt that projects without strategic intent were more likely to fail which pointed to a lack of linkage to a strategy as stated in the literature.

The literature broadly stated a lack of alignment between business units as an inhibitor to successful deployments (Beecham Research, 2020). Participant feedback focused strongly on a specific lack of alignment between IT and business units deploying IoT solutions as an inhibitor. The literature broadly covered that specific research finding (IT support for initiatives) as an inhibitor.

Inhibitors Found in the Study but Not in the Literature

The study resulted in 2 inhibitors which were not found in the literature; these were: “seeing IoT projects as linear and not evolutionary”, and “poor change management and reluctance to change”.

Literature on broader digital transformation initiatives cite change management as an important factor in the success of these initiatives (Kaleva, 2020), and participants' feedback brought it down as an inhibitor experienced in IoT deployments as a subset of broader digital transformation.

The findings revealed that a traditional drop-and-go approach to managing IoT projects was not enough and led to project failures. The nature of IoT solutions as solutions relying on sensor data and multiple live systems and their ability to

produce new data insights meant that they had to be constantly monitored and improved to be successful, according to participants.

5.4 Discussion Pertaining to Proposition 3

Proposition: There exist specific success factors of IoT deployments in office buildings. These success factors are expected to include one or more of the factors found in the literature and summarised in Table 2.4.They stem from 3 main areas: organisational, environmental, and technical.

The research yielded 17 success factors for IoT deployments in office buildings. Of the 17, 14 could be categorised as organisational factors, and 3 as technical factors, with no environmental factors being uncovered. Therefore, two of the three categories from the proposition were covered when categorising the success factors.

Seven of the success factors resulting from the research were aligned to eight of the success factors from the literature, with some of the factors corresponding to two from the study and vice versa. From the 16 factors in the literature that occurred in multiple sources, only six were present in the findings. With one factor occurring in a single source from the literature present in the research findings. A total of 17 factors found in the literature did not occur in the research findings whilst 10 success factors were found in the research and not in the literature. Table 5.4 summarises the success factors found in the study, their corresponding factors from the literature, and the sources that they occurred in.

Table 5.4: Summary of Success Factors from the Study and Equivalent Success Factors from the literature.

Category	Success Factor from Study	Equivalent Success Factor from Literature	Literature Source
Organisational	Adopting a strategic approach to projects	Alignment with company strategy	(Raghu, 2018; Trzaskoma, 2020)

Organisational	Partnering for success	Developing a partner ecosystem	(Kranz, 2017; Sayar & Er, 2018)
Organisational	Executive sponsorship for initiatives	Top management buy-in	(Silverio et al., 2019; Trzaskoma, 2020)
Organisational	Clear business value	Top management buy-in	(Silverio et al., 2019; Trzaskoma, 2020)
Organisational	Having a clear understanding of needs	Focus on business challenges, A well- articulated system design strategy	(Kranz, 2017; Trzaskoma, 2020)
Organisational	Embedding the solution in the organisation	Guiding customers on system use	(Sayar & Er, 2018)
Organisational	Solution support	N/A	N/A
Organisational	Clear business objectives and actionable outcomes	N/A	N/A
Organisational	Using subject matter experts	N/A	N/A
Organisational	An internal IoT champion	N/A	N/A
Organisational	Project and solution documentation	N/A	N/A
Organisational	Land and expand approach	N/A	N/A
Organisational	Standardised delivery specifications	N/A	N/A
Organisational	Communication with the client	N/A	N/A
Technical	Good user experience and usage	Design centred on the end-user, Aligning customer focus across the business	(Sayar & Er, 2018; Silverio, Renukappa, & Suresh, 2019; Trzaskoma, 2020)
Technical	Technology selection	N/A	N/A
Technical	Reliable network connectivity	N/A	N/A

Alignment of Success Factors in the Literature and Study

“Adopting a strategic approach to projects” corresponded to “alignment with company strategy” as the literature highlighted the importance of aligning projects with strategic goals and entrenching solutions in the business strategy (Raghu, 2018; Trzaskoma, 2020). Participants mentioned clear strategic intent and roadmaps as key to project success. Both literature and participants emphasised the importance of a partner ecosystem when deploying IoT to extract the full value of solutions (Kranz, 2017; Sayar & Er, 2018).

“Executive sponsorship for initiatives” and “clear business values” as factors from the study corresponded with the single factor from the literature, which was “top management buy-in”. The reason for this was that top management buy-in included the importance of getting top ranking business officials onboard and the ability to show the value from the solution as key to success (Silverio et al., 2019; Trzaskoma, 2020). This aligned well to the research findings where half the participants mentioned clear business value as a success factor, and executive sponsorship was touted as critical to success.

Four participants mentioned “good user experience and usage” as important to success. The aspect of user experience and usability was captured by the factor “design cantered on the end-user” (Sayar & Er, 2018; Silverio et al., 2019; Trzaskoma, 2020) in the literature, whilst “aligning customer focus across the business” emphasised that customer centricity should be at the heart of projects during the design phase (Sayar & Er, 2018). “Good user experience and usage” as a factor from the study, therefore, encompassed both these aspects.

“Focus on business challenges” and “a well-articulated system design strategy” corresponded to the success factor of “having a clear understanding of needs”. “Focus on business challenges” emphasised the importance of a clear problem statement (Kranz, 2017; Trzaskoma, 2020), and “a well-articulated design strategy” highlighted the importance of requirements being understood upfront during the design process (Sayar & Er, 2018). These two aspects fit into “having a clear understanding of needs” where participants mentioned the need to understand requirements and problem statements for successful deployments.

The last factors that were aligned between the research findings and literature were “embedding the solution in the organisation” and “guiding customers on system use”. Sayar and Er (2018) emphasised the need for solution developers to guide customers to use systems for their desired outcomes and to encourage continuous use. This aligned to the views of participants who experienced communicating the solution to the client and making sure that it was entrenched in the organisation.

Success Factors Found in the Study but not in the Literature

Of the factors found in the study, there were certain factors mentioned by multiple participants and were therefore surprising not to have been mentioned in the literature. These factors listed by frequency of mention were:

- Using subject matter experts;
- Clear business objectives and actionable outcomes;
- An internal IoT champion;
- Solution support.

These were notable factors due to the frequency of mention across a network of participants that were not related.

Other factors that were found in the research but not in the literature were mentioned by one or two participants, included:

- Project and solution documentation;
- Land and expand approach;
- Standardised delivery specifications;
- Communication with the client;
- Technology selection;
- Reliable network connectivity.

These factors may have been isolated to the experience of a few but could still be important considerations for deployment success. Overall, the uncovering of ten factors that were not found in the literature might have been attributable to

the lack of papers on this particular subject matter at the time of this research. They might be useful as a basis for future research in the field.

5.5 Discussion on Project Success and Failure

The discussion on project success and failure is relevant to both the propositions on inhibitors and success factors as it provides insight into the perception of project success from the research participants. The literature indicated a high incidence of IoT project failure, ranging from 30% to 74% of initiatives failing ((Beecham Research, 2020; Cisco, 2017; Microsoft & Hypothesis Group, 2021). The participants were unable to provide a percentage estimate of failure rate but there were clearly participants that felt their projects were mostly successful and those that felt their projects were mostly unsuccessful. 40% of those who indicated success felt that their projects were largely unsuccessful. This provided further confirmation that there was room to improve the success of these projects, and that the lessons learnt from those deploying successfully could aid in those who had experienced less success.

5.6 Study Findings Relative to the Conceptual Framework

When the research findings were considered in the context of the conceptual framework in section 2.6.2, they aligned with the concepts within the framework as shown in Figure 5.1. When comparing Figure 5.1 to the original contextual framework, an addition was made as the framework to include the stakeholders that were uncovered in the research. The stakeholders are marked “A” in Figure 5.1 and connected to drivers that were found relevant to them. Drivers could be grouped under “B” in Figure 5.1 showing the value-based reasons stakeholders had for initiating office building IoT projects. Driver that could be categorised as customer experience, operational process, or social imperative based were present in the findings. This excluded a category, business models, which was part of the original conceptual framework.

The inhibitors found in the study were categorised as business or technical. Whilst the original conceptual framework categorised them as either

organisational, environmental, or technical. In this context “business” and “organisational” were synonymous as categories as both referred to factors relevant to the internal organisation, its processes, and structures. Inhibitors from the study were grouped under “E”, “Inhibitors” in the conceptual model and were categorised under organisational/business and technical as per the original model and expected to have negative impacts on deployments.

Success factors/enhancers were grouped under “F” and “Success Factors” in the conceptual model but were only categorised under organisational and technical, with no environmental factors found per the original conceptual model. As per the original model these were expected to have positive influences on deployments.

The participants interviewed indicated that the inhibitors and success factors had negative and positive effects, respectively, on the outcome of deployments (“G”, in Figure 5.1) which was consistent with the original conceptual framework.

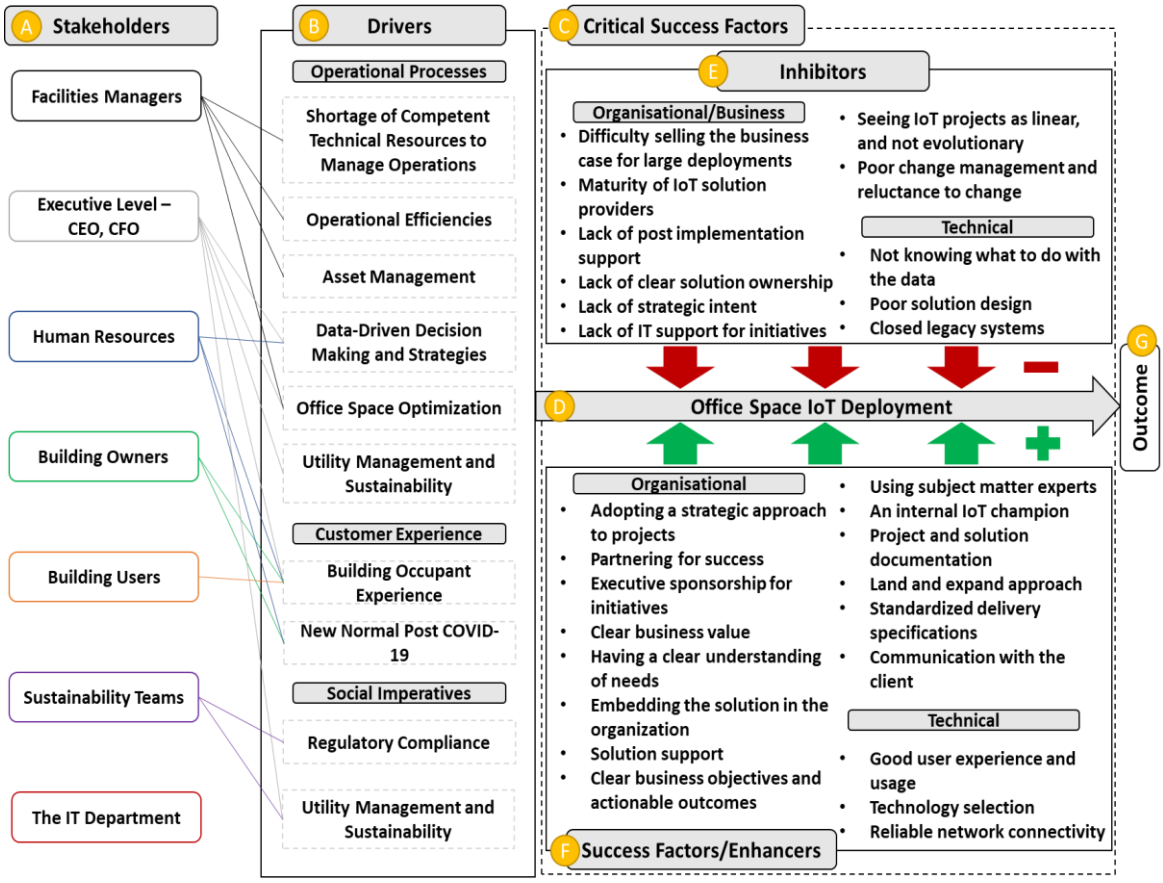


Figure 5.1: Results Shown Overlaid onto the Conceptual Framework

5.7 Conclusion

This section discussed the findings of the research per proposition. It included a note on the nature of the IoT for office buildings industry and the perceptions of the success of IoT projects. Overall, the nature of the industry being immature could have had a significant impact on the perceptions of success and on the challenges facing deployments in the industry. It is expected these will change as technology and industry mature. The perceptions of the success of initiatives varied amongst participants and success rates did not look as low as suggested in some of the literature sources with more participants indicating that they found their initiatives successful rather than not. The findings pointed to their being a need to increase success rates however from those that did not have high incidences of project success.

Proposition 1 regarding drivers and stakeholders fared well in terms of being aligned when compared to the research findings. Overall, nine drivers were found in the study covering most of those from the literature found in multiple sources. These drivers were linked back to specific stakeholders and provided an understanding of what was important to who during IoT solution deployments.

Inhibitors were uncovered and compared to proposition two. Again, the alignment between the findings and propositions was good as inhibitors could be categorised as business and technical. Furthermore, 9 of the 11 factors found in the study aligned with those in the literature.

Success factors showed a lower degree of alignment between the proposition and research findings. The success factors found in the research could only be categorised in two out of three categories proposed, and just 8 of the 25 factors in the literature review aligned with only seven found in the research. The research yielded another 10 factors that were not present in the proposition. There was therefore overall alignment between findings and propositions, but the alignment varied in degree.

When considering the research findings in relation to the conceptual framework, both inhibitors and success factors could be grouped into organisational and

technical categories only without the presence of environmental factors. Furthermore, drivers could be grouped under three of the categories in the original framework, excluding business models as a category. Overall, the findings aligned well with the conceptual framework and the framework was extended to include the stakeholders found in the study.

CHAPTER 6. CONCLUSIONS & RECOMMENDATIONS

6.1 Introduction

This chapter provides conclusions, recommendations, limitations, and suggestions for further research based on the study's outcomes. It first covers the conclusion per the research question and then in relation to the conceptual framework. Recommendations are made on how stakeholders can use the research, then the research limitations are discussed, and suggestions for future research are made.

6.2 Conclusions Regarding Research question 1

Research question 1 was: What are the drivers for deployments of IoT solutions in office buildings?

The research found that IoT for office buildings was in its early stages of adoption, a maturing market, with a client base that felt that the solutions were nice to have when weighed against more critical needs such as networking equipment and the like. This reinforced the need to understand the drivers of IoT solutions in office buildings so they could be clearly understood and communicated.

The direct answer to the research question from the study was that there were nine drivers for the deployment of IoT solutions in office buildings, and they were:

1. Office space optimisation
2. Operational efficiency
3. Utility management and sustainability
4. Building occupant experience
5. Asset management
6. The new normal post COVID-19
7. Data driven decision-making and strategies
8. Regulatory compliance

9. Shortage of competent technical resources to manage operations

The first 5 in the above list were reinforcements of findings from the literature. Although these factors reinforced the literature, seven factors found in it were not found in the study and might have been down to the incorporation of available literature on proptech, and smart buildings, in general, to compensate for low numbers of papers on IoT in office buildings specifically.

Furthermore, stakeholders of the deployment of IoT in office buildings were identified and linked to drivers that were important to them. This was an important development beyond just identifying drivers as understanding their relevance to stakeholders could provide a basis for more effective conversations, and initiatives. The stakeholders and associated drivers found are listed below:

- **Executive Level (CEOs and CFOs)** – Data Driven Decision-making and Strategies, Office Space Optimisation, Operational Efficiency, Utility, Management and Sustainability, Building Occupant Experience.
- **Human Resources** – The New Normal post COVID-19, Data Driven Decision-making and Strategies, Building Occupant Experience.
- **Facilities managers** – Operational Efficiency, Asset Management, Shortage of competent technical resources to manage operations;
- **Building Users** – Building Occupant Experience.
- **Sustainability Teams** – Utility Management and Sustainability, Regulatory Compliance.
- **The IT Department** – None identified, enablers of the project.

Overall, the research validated drivers from the literature and expanded on the literature with new findings that could be used in stakeholder engagement and various other ways when deploying solutions.

6.3 Conclusions Regarding Research question 2

Research question 2 was: What are the inhibiting factors to deploying IoT solutions in office buildings?

The study findings identified 11 inhibitors to deploying IoT solutions in office buildings. These could be separated into business, and technical factors as per the literature and are listed below:

- Business/Organisational Inhibitors:
    1. Difficulty selling the business case for large deployments
    2. Maturity of IoT solution providers
    3. Lack of post-implementation support
    4. Lack of clear solution ownership
    5. Lack of strategic intent
    6. Lack of IT support for initiatives
    7. Seeing IoT projects as linear, and not evolutionary
    8. Poor change management and reluctance to change.
- Technical Inhibitors:
    1. Not knowing what to do with the data
    2. Poor solution design
    3. Closed legacy systems.

Most of the academic literature on inhibitors to IoT deployment were more focused on technical inhibitors and proposed more technical than business inhibitors. The results of this research buck that trend and provide more business inhibitors. There were also much fewer inhibitors found in this study than in the literature, which might have been a result of it including seminal works from different sources provided a wider variety of inhibitors. The research did, however, reinforce six business and three technical inhibitors from the literature.

The research was able to answer the research question and expand on much needed academic sources on inhibitors to deploying IoT in office buildings.

6.4 Conclusions Regarding Research question 3

Research question 3 was: What are the success factors of the office building IoT solution deployments?

Results of the study indicate 17 success factors for office building IoT deployments. These factors could be separated into organisational and technical factors and are listed below:

- Organisational:
    1. Adopting a strategic approach to projects
    2. Partnering for success
    3. Executive sponsorship for initiatives
    4. Clear business value
    5. Having a clear understanding of the needs
    6. Embedding the solution in the organisation
    7. Solution support
    8. Clear business objectives and actionable outcomes
    9. Using subject matter experts
    10. An internal IoT champion
    11. Project and solution documentation
    12. Land and expand approach
    13. Standardised delivery specifications
    14. Communication with the client

- Technical:
    1. Good user experience and usage
    2. Technology selection
    3. Reliable network connectivity

Ten of the factors found were unique to the study, not featuring in any of the literature consulted. Seven were found in the literature. Of the results from the three research questions, success factors were the only ones where more factors were unique to the study than coinciding with those found in the literature. This could have resulted from the research participants' experience of IoT projects in Office buildings as the majority felt their projects were successful and, therefore might have had more success factors than inhibitors to reflect on.

Finally, some success factors were mentioned by multiple participants such as “using subject matter experts”, and “clear business value” for example. This could

not be taken as a reflection of the importance of the success factors as no measure of the criticality of the factors were deployed. The research reinforced some of the success factors found in the literature and resulted in 10 more which could contribute to understanding the success of IoT initiatives for office buildings.

6.5 Recommendations

Based on the findings presented in the study the following is recommended:

- The recommendations address three main role players with involvement in IoT delivery within office building environments.
- Decision makers, who are typically management and above, should use the drivers found in the research as guidance of where IoT technology can add value to the organisation. Thereby avoiding costly situations where solutions are adopted without true grounding in value and fail. The research also pointed out that the industry was maturing and that adopters of IoT solutions in an office building specific contexts had to trade-off IoT with other more “necessary” projects, and their related expenditures. Decision makers should use the drivers found in this research and others to aid in building sound business cases for adopting IoT projects. They should guide their teams through the assignment of clear ownership to initiatives, creating clear strategies for the adoption of IoT solutions, and aligning business units (IT in particular) for deliveries. These were noted as factors that impacted deployment success from the research and were within the realm of decision makers to influence.
- When delivering IoT projects for office buildings, those in a delivery capacity can use the research findings to understand the various stakeholders, drivers, inhibitors, and success factors. This will aid them in avoiding practices that would cause issues in the delivery, aligning with best practices to improve their chances of success, and aligning effectively with the correct stakeholders to achieve buy-in and smooth delivery of initiatives.
- Designers should use the drivers found in the research as input to align design initiatives with them so that they deliver the right value to the right

stakeholders. Designers are often involved in the technical aspect of the solutions, and they incorporate the research findings as guidance to ensure the data is well used, appropriately selected devices, systems are designed with high user experience standards, and network communications are well established. Furthermore, they should not rely on themselves solely for the delivery of the solution but use partners to deliver aspects out of their core competency, but also be aware the partners might not always be able to do what they promise in a maturing industry.

- Lastly, the research findings provide a general view of stakeholders, drivers, inhibitors, and success factors to deploying IoT in office buildings. Therefore anyone wanting to understand the landscape of the projects from the perspective of the four areas mentioned could use the research findings as a source.

6.6 Limitations and Suggestions for Further Research

6.6.1 *Limitations*

The following limitations to the study were noted:

- The researcher was employed in the IoT industry at the time of the study and had experience in office building IoT deployments. These experiences may have lent some bias to the interpretation of study results.
- The participants in the research mainly had the experience of IoT deployments in the South African market with only three out of the 10 participants having experience in European markets.
- In general, the pool of academic literature available on IoT deployment success factors, and inhibitors was quite small, and the pool focused on office buildings even smaller. Expanding the literature to include digital transformation, in general, might aid in getting more information in further studies.

- The research participants were senior members in their organisations with most having business and delivery related and not technical roles. This means that the outcomes might have been skewed towards a more business focused perspective. Future research could include a more balanced mix of experience in participants.
- Interviews were time-consuming, and participants were difficult to find.
- The research considered feedback from a small group of select participants who provided data based on their experience. The results might not be replicable using different participants. This also means that the study did not use a representative sample and results cannot be extrapolated due to the qualitative nature of the research.

6.6.2 *Suggestions for Further Research*

The topics below are suggested for further research:

- This research did not assign criticality to the success factors of IoT projects for office buildings. Further research could provide insight into the criticality of these factors to make them more useful to practitioners.
- This study focuses primarily on IoT projects for office buildings. A wider quantitative study that attempts to identify drivers, success factors, and inhibitors for the industry in general would be useful to a much wider audience.
- Some of the factors identified in the study could be tested using a survey for further reach.
- The findings of the study indicated that the IoT for office buildings industry was still in a maturing phase. Understanding the relationship between the industry's maturity stage and the inhibitors faced could provide insights into how IoT market maturity affects projects.
- When considering the drivers of the projects, the research provided a high-level view of drivers with some detail. It is suggested that the sub-factors of the drivers be understood in detail so that designers of IoT solutions can target very specific, known levers to deliver value through the detailed understanding of drivers.

REFERENCES

Adams, W. (2015). Conducting Semi-Structured Interviews. In *Handbook of Practical Program Evaluation* (pp. 492-505). https://doi.org/10.1002/9781119171386.ch19

Adzmi, R. M., & Hassan, Z. (2018). A theoretical framework of critical success factors on information technology project management during project planning.

Aman, A. H. M., Yadegaridehkordi, E., Attarbashi, Z. S., Hassan, R., & Park, Y. (2020). A Survey on Trend and Classification of Internet of Things Reviews. *IEEE Access*, *8*, 111763-111782. https://doi.org/10.1109/ACCESS.2020.3002932

Armstrong, B., & Lee, G. (2021). *Digital Business (2nd edition)* (2nd ed.). Silk Route Press.

Ashton, K. (2009). That 'Internet of Things' Thing - In the real world, things matter more than ideas. *RFID Journal*. http://www.itrco.jp/libraries/RFIDjournal-That%20Internet%20of%20Things%20Thing.pdf

Atta, N., & Talamo, C. (2020). Digital Transformation in Facility Management (FM). IoT and Big Data for Service Innovation. In (pp. 267-278). https://doi.org/10.1007/978-3-030-33570-0_24

Axelrod, R. (2015). *Structure of decision: The cognitive maps of political elites*. Princeton university press.

Bauer, M., Bui, N., De Loof, J., Magerkurth, C., Nettsträter, A., Stefa, J., & Walewski, J. W. (2013). IoT Reference Model. In A. Bassi, M. Bauer, M. Fiedler, T. Kramp, R. van Kranenburg, S. Lange, & S. Meissner (Eds.), *Enabling Things to Talk: Designing IoT solutions with the IoT Architectural Reference Model* (pp. 113-162). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-40403-0_7

Baumgartner, R. J., & Ebner, D. (2010). Corporate sustainability strategies: sustainability profiles and maturity levels. *Sustainable development*, *18*(2), 76-89.

Beecham Research. (2020). *Why IoT Projects Fail*. B. Research. https://www.whyiotprojectsfail.com/

Belassi, W., & Tukel, O. I. (1996). A new framework for determining critical success/failure factors in projects. *International journal of project management*, *14*(3), 141-151.

Berman, S. J. (2012). Digital transformation: opportunities to create new business models. *Strategy & Leadership*, *40*(2), 16-24. https://doi.org/10.1108/10878571211209314

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Brunello, G., & Wruuck, P. (2019). Skill shortages and skill mismatch in Europe: A review of the literature.

Brynjolfsson, E., Hitt, L. M., & Kim, H. H. (2011). Strength in numbers: How does data-driven decisionmaking affect firm performance? *Available at SSRN 1819486*.

Buckman, A. H., Mayfield, M., & Beck, S. B. (2014). What is a smart building? *Smart and Sustainable Built Environment*.

Bullen, C. V., & Rockart, J. F. (1981). A primer on critical success factors. *Center for Information Systems Research Working Paper*, *69*.

Cambridge University Press. (n.d.). Inhibit. In *Cambridge Business English Dictionary*. Retrieved 29 January 2023, from https://dictionary.cambridge.org/dictionary/english/inhibit

Capgemini Research Institute. (2017). *Unlocking the business value of Industrial IoT*. C. R. Institute. https://www.capgemini.com/wp-content/uploads/2018/03/IoT-in-Ops-Research_Digital.pdf

Carcary, M., Maccani, G., Doherty, E., & Conway, G. (2018). Exploring the Determinants of IoT Adoption: Findings from a Systematic Literature Review: 17th International Conference, BIR 2018, Stockholm, Sweden, September 24-26, 2018, Proceedings. In (pp. 113-125). https://doi.org/10.1007/978-3-319-99951-7_8

CBRE. (2021). *The Future of the Office - 2021 U.S. Occupier Sentiment Survey*. CBRE. Retrieved 19 February 2022 from https://www.cbre.com/insights/articles/the-future-of-the-office-2021-us-occupier-sentiment-survey

CFO Research Services, & Accenture. (2009). *The CFO's Role in Achieving Operational Excellence*. C. P. Corp. https://www.criticaleye.com/inspiring/insights-servfile.cfm?id=1793

Chow, T., & Cao, D.-B. (2008). A survey study of critical success factors in agile software projects. *Journal of systems and software*, *81*(6), 961-971.

Chui, M., May, B., Narayanan, S., & Shah, R. (2019). *What separates leaders from laggards in the Internet of Things*. McKinsey. https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/what-separates-leaders-from-laggards-in-the-internet-of-things

Cisco. (2014). The Internet of Things Reference Model. https://www.cisco.com/c/dam/global/en_ph/assets/ciscoconnect/pdf/bigdata/jim_green_cisco_connect.pdf

Cisco. (2017). *Cisco: The Journey to IoT Value: Challenges, Breakthroughs, and Best Practices*. Cisco. https://www.iotjournaal.nl/wp-content/uploads/2017/05/Cisco_IoT_2017.pdf

Čolaković, A., & Hadžialić, M. (2018). Internet of Things (IoT): A review of enabling technologies, challenges, and open research issues. *Computer Networks*, *144*, 17-39. https://doi.org/https://doi.org/10.1016/j.comnet.2018.07.017

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Deloitte. (2021). *CEO Survey 2021 Survey on the Role of CEOs in Advancing Sustainability & ESG*. https://www2.deloitte.com/content/dam/Deloitte/id/Documents/risk/id-risk-ceo-survey-on-esg-2021.pdf

Deloitte Touch Tohmatsu India LLP, & Confederation of Indian Industry. (2020). *Internet of Things (IoT) The rise of the connected world*. C. o. I. I. (CII). https://www2.deloitte.com/content/dam/Deloitte/in/Documents/technology-media-telecommunications/in-tmt-IoT_Theriseoftheconnectedworld-28aug-noexp.pdf

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: a ten-year update. *Journal of management information systems*, *19*(4), 9-30.

Dryjanski, M., Buczkowski, M., Ould-Cheikh-Mouhamedou, Y., & Kliks, A. (2020). Adoption of Smart Cities with a Practical Smart Building Implementation. *IEEE Internet of Things Magazine*, *3*(1), 58-63. https://doi.org/10.1109/IOTM.0001.1900050

Ebert, C., & Duarte, C. H. (2018). Digital Transformation. *IEEE Software*, *35*, 16-21. https://doi.org/10.1109/MS.2018.2801537

EDU, W. S. O. (2021). PropTech 3.0: the future of real estate. *Retrieved May*, *10*, 2018-2007.

Emergen Research. (2021). Smart Buildings Market Size to Reach USD 141.71 Billion in 2028 | Rise in Adoption of IoT Enabled Building Management Systems and Increasing Construction and Industrial Activities to Build Smart Infrastructure are Key Factors Driving Industry Revenue, says Emergen Research. Retrieved 19 February 2022, from https://www.prnewswire.com/news-releases/smart-buildings-market-size-to-reach-usd-141-71-billion-in-2028--rise-in-adoption-of-iot-enabled-building-management-systems-and-increasing-construction-and-industrial-activities-to-build-smart-infrastructure-are-key-factors-driv-301449743.html#:~:text=In%2DLanguage%20News-,Smart%20Buildings%20Market%20Size%20to%20Reach%20USD%20141.71%20Billion%20in,Industry%20Revenue%2C%20says%20Emergen%20Research

Engvall, R., & Larsson, A. (2021). Digital Transformation in Commercial Real Estate A Case Study on Creating Digital Twins of Existing Buildings.

European Commission. (2013). *EU Buildings Factsheets*. Retrieved 1 January from https://ec.europa.eu/energy/eu-buildings-factsheets_en

European Commission. (2022). *Just and sustainable economy: Commission lays down rules for companies to respect human rights and environment in global value chains*. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1145

Faugier, J., & Sargeant, M. (1997). Sampling hard to reach populations. *Journal of advanced nursing*, *26*(4), 790-797.

Fortune Business Insights. (2021). *Internet of Things (IoT) Market Size, Share & COVID-19 Impact Analysis, By Component (Platform, Solution & Services), By End-Use Industry (BFSI, Retail, Government, Healthcare, Manufacturing, Agriculture, Sustainable Energy, Transportation, IT & Telecom, Others), and Regional Forecast, 2021-2028* (FBI100307). F. B. Insights. https://www.fortunebusinessinsights.com/industry-reports/internet-of-things-iot-market-100307

Fortune Business Insights. (2022). *The global smart building market is projected to grow from $80.62 billion in 2022 to $328.62 billion by 2029, at a CAGR of 22.2% in forecast period, 2022-2029*. https://www.fortunebusinessinsights.com/industry-reports/smart-building-market-101198

Goad, D., & Gal, U. (2017). *IoT design challenges and the social IoT solution* Twenty-third Americas Conference on Information Systems, Boston.

Gokhale, P., Bhat, S., & Bhat, O. (2018). Introduction to IoT. *International Advanced Research Journal in Science, Engineering and Technology*, *5*(1). https://doi.org/10.17148

Goumagias, N., Whalley, J., Dilaver, O., & Cunningham, J. (2021). Making sense of the internet of things: a critical review of internet of things definitions between 2005 and 2019. *Internet Research*, *31*(5), 1583-1610. https://doi.org/10.1108/INTR-01-2020-0013

Grimshaw, R. (2003). FM: the professional interface. *Facilities*, *21*, 50-57. https://doi.org/https://doi.org/10.1108/02632770310469352

Gupta, B. B., & Quamara, M. (2020). An overview of Internet of Things (IoT): Architectural aspects, challenges, and protocols. *Concurrency and Computation: Practice and Experience*, *32*(21), e4946. https://doi.org/https://doi.org/10.1002/cpe.4946

Hammarberg, K., Kirkman, M., & de Lacey, S. (2016). Qualitative research methods: when to use them and how to judge them. *Human Reproduction*, *31*(3), 498-501. https://doi.org/10.1093/humrep/dev334

Horch, A., Kubach, M., Roßnagel, H., & Laufs, U. (2017, 3-5 Nov. 2017). Why Should Only Your Home Be Smart? - A Vision for the Office of Tomorrow. 2017 IEEE International Conference on Smart Cloud (SmartCloud),

Hossein Motlagh, N., Mohammadrezaei, M., Hunt, J., & Zakeri, B. (2020). Internet of Things (IoT) and the Energy Sector. *Energies*, *13*, 494. https://doi.org/10.3390/en13020494

Ichsan, R. N., Santosa, S., Shara, Y., & Liriwati, F. Y. (2020). Investigation of strategic human resource management practices in business after covid-19 disruption. *PalArch's Journal of Archaeology of Egypt/Egyptology*, *17*(7), 13098-13110.

Iqbal, K. M. J., Khalid, F., & Barykin, S. Y. (2021). Hybrid workplace: The future of work. In *Handbook of Research on Future Opportunities for Technology Management Education* (pp. 28-48). IGI Global.

Isa, N. M., Kamaruzzaman, S. N., Mohamed, O., Jaapar, A., & Asbollah, A. Z. (2016). Facilities management practices in Malaysia: a literature review. MATEC Web of Conferences,

Jahja, A. S., Ramalu, S. S., & Razimi, M. S. A. (2021). Generic qualitative research in management studies. *JRAK (Jurnal Riset Akuntansi Dan Bisnis)*, *7*(1), 1-13.

Jia, M., Komeily, A., Wang, Y., & Srinivasan, R. S. (2019). Adopting Internet of Things for the development of smart buildings: A review of enabling technologies and applications. *Automation in Construction*, *101*, 111-126. https://doi.org/https://doi.org/10.1016/j.autcon.2019.01.023

JLL. (2021). *Physical office space remains in demand*. JLL. Retrieved 19 February 2022 from https://www.us.jll.com/en/trends-and-insights/research/global/gmp/office

Kaleva, J. (2020). Change Management as a Support to the Organizations'

Digital Transformation – State of the Art. 31st Central European Conference on Information and Intelligent Systems, Varazdin, Croatia.

Kim, E. (2018). *Field Survey System for Facility Management Using BIM Model* 23rd International Conference of the Association for Computer-Aided Architectural Design

Research in Asia (CAADRIA), Hong Kong.

Korstjens, I., & Moser, A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing. *European Journal of General Practice*, *24*(1), 120-124.

Kranz, M. (2017). Success with the Internet of Things Requires More Than Chasing the Cool Factor. *Harvard Business Review*.

https://hbr.org/2017/08/success-with-the-internet-of-things-requires-more-than-chasing-the-cool-factor

Kumar, R., Wallace, N., & Funk, C. (2020). *Into the Mainstream: ESG at the Tipping Point*. https://corpgov.law.harvard.edu/2020/01/13/into-the-mainstream-esg-at-the-tipping-point/

Larios, V., Robledo, J., Gómez, L., & Rincon, R. (2013). Ieee-gdl ccd smart buildings introduction. http://smartcities.ieee.org/images/files/images/pdf/whitepaperphismartbuildingsv6.pdf

Law Insider. (n.d.). *Office Building definition*. Retrieved 24 April from https://www.lawinsider.com/dictionary/office-building

Lawal, K., & Rafsanjani, H. N. (2021). Trends, benefits, risks, and challenges of IoT implementation in residential and commercial buildings. *Energy and Built Environment*.

Lecomte, P. (2019). What is smart? A real estate introduction to cities and buildings in the digital era. *Journal of General Management*, *44*(3), 128-137. https://doi.org/10.1177/0306307018823108

Liere-Netheler, K., Packmohr, S., & Vogelsang, K. (2018). *Drivers of Digital Transformation in Manufacturing*. https://doi.org/10.24251/HICSS.2018.493

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*. SAGE Publications Inc.

MarketsandMarkets. (2022). *Smart Buildings Market by Componenet (Solution (Safety and Security Management, Building Infrastructure Management, Network Management, and IWMS) and Services), Building Type (Residential, Commercial, and Industrial), and Region (2022-2026)* (TC 3445). https://www.marketsandmarkets.com/Market-Reports/smart-building-market-1169.html?gclid=Cj0KCQiAz9ieBhCIARIsACB0oGKQTfw92Ga8w6xtJ3G47eOiEfdzZqRvJ0XVBK23Se7WOd8QW484pR4aAjsPEALw_wcB

McKinsey & Company. (2021). *The Internet of Things: Catching up to an accelerating opportunity*. M. Company. https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/iot%20value%20set%20to%20accelerate%20through%202030%20where%20and%20how%20to%20capture%20it/the-internet-of-things-catching-up-to-an-accelerating-opportunity-final.pdf

Mehmood, Y., Ahmad, F., Yaqoob, I., Adnane, A., Imran, M., & Guizani, S. (2017). Internet-of-things-based smart cities: Recent advances and challenges. *IEEE Communications Magazine*, *55*(9), 16-24.

Melton, T., Iles-Smith, P., & Yates, J. W. (2011). *Project benefits management: linking your project to the business*. Butterworth-Heinemann.

Merriam, S. B. (2002). Introduction to qualitative research. *Qualitative research in practice: Examples for discussion and analysis*, *1*(1), 1-17.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Metallidou, C. K., Psannis, K. E., & Egyptiadou, E. A. (2020). Energy efficiency in smart buildings: IoT approaches. *IEEE Access*, *8*, 63679-63699.

Microsoft, & Hypothesis Group. (2021). *IoT Signals*. https://azure.microsoft.com/en-us/resources/iot-signals/

Milasi, S., González-Vázquez, I., & Fernández-Macías, E. (2021). Telework before the COVID-19 pandemic. https://doi.org/doi:https://doi.org/10.1787/d5e42dd1-en

Morakanyane, R., Grace, A. A., & O'reilly, P. (2017). Conceptualizing Digital Transformation in Business Organizations: A Systematic Review of Literature. *Bled eConference*, *21*, 428-444.

Myeda, N. E. (2014). Facilities management: the business enabler. *Journal of facilities management*, *12*(4). https://doi.org/10.1108/JFM-07-2014-0022

Nabizadeh, A. H., Jorge, A., & Leal, J. (2019). Estimating time and score uncertainty in generating successful learning paths under time constraints. *Expert Systems*, *36*. https://doi.org/10.1111/exsy.12351

Nicolescu, R., Huth, M., Radanliev, P., & De Roure, D. (2018). *State of the Art in IoT - Beyond Economic Value*. https://doi.org/10.13140/RG.2.2.24165.45289

Okoro, C., & Musonda, I. (2019). The future role of facilities managers in an era of industry 4.0. Creative Construction Conference 2019,

Papadopoulou, P., Kolomvatsos, K., Panagidi, K., & Hadjiefthymiades, S. (2017). *Investigating the business potential of Internet of Things*.

Pereira, C., & Aguiar, A. (2014). Towards efficient mobile M2M communications: Survey and open challenges. *Sensors*, *14*(10), 19582-19608.

Pinto, J. K., & Mantel, S. J. (1990). The causes of project failure. *IEEE transactions on engineering management*, *37*(4), 269-276.

Prasher, V. S. (2018). Internet of Things (IoT) and Changing Face of Project Management. https://digitalcommons.harrisburgu.edu/pmgt_dandt/49

Raghu, R. V. (2018). The many dimensions of successful IoT deployment. *Network Security*, *2018*(12), 10-15. https://doi.org/https://doi.org/10.1016/S1353-4858(18)30126-0

Raiwani, Y. (2013). Internet of things: a new paradigm. *International Journal of Scientific and Research Publications*, *3*(4), 323-326.

Rose, K., Eldridge, S., & Chapin, L. (2015). The internet of things: An overview. *The internet society (ISOC)*, *80*, 1-50.

Saldaña, J. (2014). Coding and analysis strategies. *The Oxford handbook of qualitative research*, 581-605.

Salosin, A., Gamayunova, O., & Mottaeva, A. (2020). The effectiveness of the Smart Office system. *Journal of Physics:Conference Series*, *1614*(1), 012028. https://doi.org/10.1088/1742-6596/1614/1/012028

Sayar, D., & Er, Ö. (2018). The antecedents of successful IoT service and system design: Cases from the manufacturing industry. *International Journal of Design*, *12*(1).

Shahinmoghadam, M., & Motamedi, A. (2019). Review of bim-centred iot deployment–state of the art, opportunities, and challenges. Proceedings of the 36th International Symposium on Automation and Robotics in Construction (ISARC 2019),

Shenhar, A. J., Tishler, A., Dvir, D., Lipovetsky, S., & Lechler, T. (2002). Refining the search for project success factors: a multivariate, typological approach. *R&d Management*, *32*(2), 111-126.

Shukla, A., Chaturvedi, S., & Simmhan, Y. (2015). A Review on Internet of Things, Internet of Everything and Internet of Nano Things. *Int. J. Comput. Appl*, *975*(8887), 1-7.

Silverio, M., Renukappa, S., & Suresh, S. (2019). Evaluating critical success factors for implementing smart devices in the construction industry: An empirical study in the Dominican Republic. *Engineering, Construction and Architectural Management*, *26*. https://doi.org/10.1108/ECAM-02-2018-0085

Singhania, M., & Saini, N. (2022). Quantification of ESG regulations: a cross-country benchmarking analysis. *Vision*, *26*(2), 163-171.

Siniak, N., Kauko, T., Shavrov, S., & Marina, N. (2020). The impact of proptech on real estate industry growth. *IOP Conference Series: Materials Science and Engineering*, *869*, 062041. https://doi.org/10.1088/1757-899X/869/6/062041

Sinopoli, J. (2016). *Advanced technology for smart buildings*. Artech House.

Sorri, K., Mustafee, N., & Seppänen, M. (2022). Revisiting IoT definitions: A framework towards comprehensive use. *Technological Forecasting and Social Change*, *179*, 121623. https://doi.org/https://doi.org/10.1016/j.techfore.2022.121623

Souza, C. A. d., Szafir-Goldstein, C., & Aagaard, A. (2020, 3-3 June 2020). IoT in the Context of Digital Transformation and Business Model Innovation: the case of a traditional Brazilian wholesaler. 2020 Global Internet of Things Summit (GIoTS),

Spanyi, A. (2011). How to be a transformational cfo. *Strategic Finance*, *93*(6), 29.

Statista. (2021). *In what area are you suffering a skills shortage?* https://www.statista.com/statistics/662423/worldwide-cio-survey-function-skill-shortages/#:~:text=The%20statistic%20reveals%20the%20IT,big%20data%20and%20analytics%20functions.

Steiner, J. (2005). The art of space management: Planning flexible workspaces for people. *Journal of facilities management*, *4*(1), 6-22.

Streeton, R., Cooke, M., & Campbell, J. (2004). Researching the researchers: using a snowballing technique. *Nurse researcher*, *12*(1), 35-47.

Taherdoost, H., & Keshavarzsaleh, A. (2015). A theoretical review on IT project success/failure factors and evaluating the associated risks. *Mathematical and Computational Methods in Electrical Engineering*.

TechNavio. (2022). *Smart Buildings Market by Product, Solution, and Geography - Forecast and Analysis 2023-2027*. https://www.technavio.com/report/smart-buildings-market-industry-analysis

Texas Instruments. (1988). *A Guide to Information Engineering Using the IEF* (2nd, Ed.). Texas Instruments.

Tornatzky, L. G., Fleischer, M., & Chakrabarti, A. K. (1990). *Processes of technological innovation*. Lexington books.

Trzaskoma, B. (2020). *Critical success factors for IoT implementation and how they differ for organizations with low digital maturity* http://hdl.handle.net/10400.14/31196

United States Energy Information Administration. (2018). *2018 Commercial Buildings Energy Consumption Survey building characteristics results*. United States Energy Information Administration. https://www.eia.gov/consumption/commercial/data/2018/pdf/CBECS_2018_Building_Characteristics_Flipbook.pdf

Voas, J. (2016). Networks of 'things'. *NIST Special Publication*, *800*(183), 800-183.

Vogelsang, K., Liere-Netheler, K., Packmohr, S., & Hoppe, U. (2018). Success factors for fostering a digital transformation in manufacturing companies. *Journal of Enterprise Transformation*, *8*(1-2), 121-142.

Vugec, V. B. V. a. L. I. a. D. S. (2018). A Preliminary Literature Review of Digital Transformation Case Studies. *International Journal of Computer and Information Engineering*, *141*, 737 - 742. https://publications.waset.org/pdf/10009516

Walls, J. L., & Berrone, P. (2017). The power of one to make a difference: How informal and formal CEO power affect environmental sustainability. *Journal of Business Ethics*, *145*, 293-308.

Westerman, G., Calméjane, C., Bonnet, D., Ferraris, P., & McAfee, A. (2011). Digital Transformation: A roadmap for billion-dollar organizations. *MIT Center for digital business and capgemini consulting*, *1*, 1-68.

Whitmore, A., Agarwal, A., & Da Xu, L. (2015). The Internet of Things—A survey of topics and trends. *Information Systems Frontiers*, *17*(2), 261-274. https://doi.org/10.1007/s10796-014-9489-2

Williams, J., & Ramaprasad, A. (1996). A taxonomy of critical success factors. *European Journal of Information Systems*, *5*(4), 250-260.

Wong, J. K. W., Ge, J., & He, S. X. (2018). Digitisation in facilities management: A literature review and future research directions. *Automation in Construction*, *92*, 312-326. https://doi.org/https://doi.org/10.1016/j.autcon.2018.04.006

World Economic Forum. (2021). *Driving Digitalization: Value Creation for Commercial Real Estate*. W. E. Forum. https://www3.weforum.org/docs/WEF_Driving_Digitalization_Real_Estate_2021.pdf

Zumente, I., & Bistrova, J. (2021). ESG Importance for Long-Term Shareholder Value Creation: Literature vs. Practice. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(2), 127. https://www.mdpi.com/2199-8531/7/2/127

APPENDIX A – Participant Information Sheet

Dear Sir / Madam (Or insert prospective participant's name)

My name is Zahir Mamoojee, and I am a master's student in Digital Business at Wits Business School, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the drivers and inhibitors of internet of things (IoT) solutions in office buildings under the supervision of Miss Ayanda Magida.

Despite the growing popularity and impact of IoT solutions, they have been shown to have a high failure rate. The aim of this research project is to uncover what the key drivers and inhibitors to successfully deploying IoT solutions in office building environments are. The hope is that practitioners can use an understanding of these factors provided by the research to improve deployment success.

As part of this project, I would like to invite you to take part in an interview. This activity will involve an in person or online interview where you will be expected to answer questions based on the research topic and will take around 60 minutes. Additionally, you might be requested to do a follow-up interview of the same duration to confirm my interpretation of data gathered from you. With your permission, I would also like to audio record the interview using a digital device. This recording will be stored on my personal laptop, in a password protected location, and only I will have access to this recording. It will be deleted after 3 years.

There will be no personal costs to you if you participate in this project, you will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The interview will be completely confidential, and your name and organisation will be anonymized in the research report. The information you give to me will be held securely not disclosed to anyone else. I will be using a pseudonym (false name) to represent your participation in my final research report. If you

experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report. If you wish to receive a summary of this report, I will be happy to send it to you. The data collected from this research project will be stored on my personal, password protected laptop, and will be kept for 3 years. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

Zahir Mamoojee

Researcher: Zahir Mamoojee, 609101@students.wits.ac.za, 072 290 8135

Supervisor: Ayanda Magida, ayanda.magida@wits.ac.za, 011 717 3953

APPENDIX B – Participant Agreement Form

Exploring the drivers and inhibitors of internet of things (IoT) solutions in office buildings

Researcher: Zahir Mamoojee

I, ……..., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his / her research report	YES	NO
I agree that the interview may be audio recorded	YES	NO
I agree that the information I provide may be used anonymously after this project has ended, for academic purposes by other researchers, subject to their own ethics clearance being obtained.	YES	NO

Participant's Name:_____

Signature:_____

Date:_____

Researcher's Name:_____

Signature: _____

Date:_____

APPENDIX C – Interview Guide

Introduction

- Introduce yourself and let participant introduce themselves.
- Explain the purpose of the interview and give some background.
- Explain the interview structure.
- Reinforce confidentiality.
- Ask if the participant has any questions and if they are still happy to proceed.
- Ask for permission to record.
- *Start recording if permission is granted

Ice breakers

1. How long have you been involved in IoT projects?
2. In what capacity have you been involved in IoT project delivery in smart buildings?
3. What are some of the projects you have been involved in?

Theme 1: Drivers of IoT Deployment in Office Buildings

Main question - In your experiences what are the key drivers to deploy IoT solutions in office buildings?

Probes:

1. Who are the main stakeholders that these drivers are important to?
2. Are different drivers important to different stakeholders?
3. What are some of the most important IoT use cases in office buildings in your opinion?

Theme 2: Successful deployments

Main question - What are the factors of successful deployments?

Probes:

1. In your opinion are IoT deployments in office buildings largely successful or not?
2. What proportion of those that you have been involved in succeed?
3. What use cases are typically successful?

Theme 3: Inhibitors to deployment

Main question - What are the inhibitors to successful IoT deployments in office spaces in your opinion?

Probes:

1. What categories can inhibitors to deployment be put into? e.g., business, technical.
2. Which one of the inhibitors that you mentioned do you think is the most common inhibitor?

Extra Information:

- Are there any other notable points regarding the subject matter that you would like to mention that hasn't been covered?

Ending

- Request referrals for further interviews
- Thank participant.

APPENDIX D – Ethics Approval Notification

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/DB609101/883
This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below)

Project title	The drivers, success factors, and inhibitors of the internet of things (IoT) in office buildings
Investigator / Researcher	Mr Zahir Mamoojee
Nature of Project	MM (Digital Business)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	10 02 2023
Expiry date	Date of submission of the project / research report
Chairperson	Prof Anthony Stacey ☎ +27 11 717 3587 +27 82 880 4531 anthony.stacey@wits.ac.za

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Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Signature

10 February 2023
Date: