Technological Adoption in Building Surveying: Exploring the Impacting Factors and Strategies for Enhancing Utilisation

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Abstract

Purpose: Embracing digitisation within the building surveying profession will enhance its practices and of course improve productivity. However, the level of digitisation within the building surveying profession is very low. Thus, this study aims to identify factors impacting technology adoption within the building surveying professions and provide practical ways of improving the adoption of technology.

Methodology: This study employed a convergent mixed-methods approach to identify digital technologies applicable to building surveying professions. The study also investigate factors influencing technological adoptions and provide ways of improving their adoption. The data collected were analysed using thematic analysis and Ordinary Least Squares regression.

Findings: The study found that business communication platforms and smartphone applications are frequently used, while digital survey equipment and in-house developed applications are less commonly utilised by building surveyors. The influencing factors identified are economy, technical knowledge, culture, efficiency, and regulatory factors. The study recommends increased education and training for building surveyors, promotional opportunities from manufacturers, and government intervention in the form of subsidies or tax breaks to promote further digitisation within the building surveying profession.

Originality: This study provides valuable insight into strategies for the digitalisation of the building surveying profession. Application of the findings would promote further utilisation of digital technologies.

Keywords: *Building Surveying; Digitisation; Influencing Factors; Mixed-methods; Productivity*

1 Introduction

Technological innovation has undoubtedly transformed the entire structure of the world economy, communities, and human identities in general. The last few decades have seen various waves of digital technological advancement which have led to simplified processes, increased production, improved communication and unprecedented processing power and information storage capacity (Delgado *et al.*, 2019). In Building Surveying profession and the entire Architecture, Engineering and construction (AEC) industry, it has been well documented that adopting appropriate technological innovation will enhance safety (Nnaji and Karakhan, 2020), positively impact sustainable development (Ahma *et al.*, 2022), and of course, improves productivity and quality (Cao *et al.*, 2015; Delgado *et al.*, 2019). Despite these, the AEC industries, specifically the building surveying sector have experienced a significantly slower adaption to digital technological changes. The lack of professional knowledge and skills for the adoption of these technologies have been identified as a great challenge in the implementation of many digital technologies and tools that could have benefitted building surveying practise and other AEC professions (Nnaji and Karakhan, 2020; Dauda and Ajayi, 2022). This lack of required skills and knowledge stemmed from a lack of training and updated technical support associated with the technological applications. This is evident in the current situation within the AEC industries, particularly with the building surveying profession currently facing massive challenges in terms of the supply and demand of professionals with sufficient technological knowledge for carrying out building surveying operations (RICS, 2020b).

This recruitment crisis is well documented across literature and is also recognised by governing professional bodies; the Royal Institution of Chartered Surveyors (RICS) and the Chartered Institute of Building (CIOB) declared that the skills gap threatening the future of building surveying professions (RICS, 2020b). Numerous studies such as (Cook, 2015; Thompson *et al.*, 2017; Delgado *et al.*, 2019; RICS, 2020b) argue that the solution to the skills shortage in the building surveying profession lies in a change in orientation and a wider acceptance of emerging digital technologies. However, many building and real estate surveyors are apprehensive about embracing existing and emerging technologies, favouring traditional methods as they are seen as more reliable and dependable and fearful of technology making humans redundant (Thompson, Bezuidenhoudt and Waller, 2018).

However, building surveyors of today must adopt the new processes and trends, or they run the risk of being left behind. In comparison to other industries such as medicine, finance and education, the construction sector, in which the building surveying profession is a component, is the least digitalised of all industrial sectors (Begić, Galić and Dolaček-Alduk, 2022). It is obvious that a full transformation and adoption of technology will bring huge benefits such as the chance to improve productivity, increase efficiency, and attract a younger and more diverse workforce to building surveying professions. Initial evidence revealed that the rate of adoption of the technology in the building surveying profession is very slow (RICs, 2020b; Begić, Galić and Dolaček-Alduk, 2022). As a result, this study aims to identify factors impacting technology adoption within the building surveying professions and provide practical ways of improving the adoption of technology.

In addition to the introduction presented in section 0.0, the remainder of this paper contains an additional four sections with section 2.0 outlining an abridged review of literature pertinent to emerging technologies that are currently available for use within the building surveying profession. Thereafter, section 3.0 presents the methodology comprising data collection and analysis while section 4.0 presents the detailed finding from this study. In section 5.0, the conclusion encloses the paper.

2 Technologies in Building Surveying Professions

It is estimated that approximately $8 billion has been invested in contemporary construction technology, and 61% of AEC professionals and owners expect more digital tools to emerge over the next few years (Bartlett et.al, 2020). Previously, the Royal Institution of Chartered Surveyors (RICs) commissioned Remit Consulting, an independent consultant specialising in real estate. Remit task is to divulge the key potential technologies that will impact real estate and building surveying practice and predict the likely changes that the technologies will bring. Remit's study produced an insight paper for RICS (Thompson, Bezuidenhoudt and Waller, 2018) and highlighted that there are five (5) key emerging technologies (see **Insert Figure *1***) that will impact the practice of building surveying over the coming decade. It is important to clarify that the five technologies listed in Figure 1 are not the only applicable technologies to building surveyor roles, but the focus of this study is to concentrate on the most recent and emerging technologies that have the potential to revolutionise the building surveying practice. Hence, established tools or technologies like laser measurements, scanners, thermal imagery, GPS etc, that building surveyors have already embraced were not reviewed in this paper.

Insert Figure 1

2.1 Brief Review Emerging Technologies

The Internet of Things (IoT) is an emerging paradigm that utilises the internet to facilitate communication between sensors and electronic devices to create practical solutions that enhance productivity, safe, and improve overall human experiences (Kumar, Tiwari and Zymbler, 2019; Li *et al.*, 2019). The collective networks of physical objects such as buildings, vehicles and other items that are embedded with sensors, software, and other technologies to connect and exchange data are generally referred to as IoT (Thompson *et al.*, 2017). Its application in building surveying practices allows for preventive maintenance of infrastructures using sensors that are controlled remotely across existing network infrastructure (Gbadamosi *et al.*, 2021). The adoption of IoT in building surveying and the overall built environment sector will enhance sustainability, building management systems, smart cities, smart energy management systems, and the health and safety of professionals within the general AEC (Apanaviciene, Urbonas and Fokaides, 2020; Nnaji and Karakhan, 2020).

Meanwhile, the fifth generation (5G) network communication has been identified as an enabling technology for the development of IoT (Goudos *et al.*, 2017). The advancement of IoT applications is hinged on 5G communication, a faster network standard that allows for a greater number of devices to be simultaneously connected, allowing for greater reliability and quality of service (QoS) in communications (Liu and Zhang, 2019). In addition to their high speed of internet, 5G communications are uniquely able to provide high QoS guarantees over wide areas as operators can avoid interference and control usage levels (Liu, He and Jia, 2017; Thompson *et al.*, 2017). This thus allows for the creation of a platform for everything in the coming IoT age. Immersive technologies such as augmented reality (AR) and virtual reality (VR), which have also been identified as emerging technologies in the building surveying profession are based on remote enablement delivered by 5G network speeds. As such, 5G communication shall become the bedrock of the fourth phase of the Industrial Revolution. This category of technology will fuel the rise in autonomous vehicles and will allow for the integration of telecommunication technologies like mobile, fixed, optical and satellite, undoubtedly bringing huge benefits to building surveyers (Cook, 2015; Goudos *et al.*, 2017; Liu, He and Jia, 2017; Thompson *et al.*, 2017; Kumar, Tiwari and Zymbler, 2019, Elghaish et al.,2021, Dauda et.al, 2024).

The application of Machine Learning (ML) and Robotics, which is the use of algorithms and models that enable computer systems to complete previously unautomated tasks and the ability of a computer to learn a task without being explicitly programmed, will improve the building surveying professions (Thompson, Bezuidenhoudt and Waller, 2018). It has been widely accepted that the application of technologies such as drones or UAVs will significantly reduce health and safety risks and improve the accuracy and quality of output of building surveying operations and entire construction activities (Nnaji and Karakhan, 2020; Begić, Galić and Dolaček-Alduk, 2022). However, the drawbacks of such technology include the high capital cost, lack of talent and skills, and issues relating to legality and privacy (Apanaviciene, Urbonas and Fokaides, 2020; Turner *et al.*, 2021).

The fourth category of the five identified emerging technologies is Building Data which encompasses BIM, widely described as the process involving the generation and management of digital representation of physical and functional characteristics of a building (Thompson, Bezuidenhoudt and Waller, 2018). Since it emergency, BIM is maturing to be described as the use of technology and digitalisation within the built environment and its benefits are represented by, but not limited to, enhancing performance, reducing the risk of mistakes or discrepancies and minimising unnecessary costs, especially within the construction phase of any building (Ajayi, Oyebiyi and Alaka, 2021). In general, building management systems provide granular data about the operational performance of buildings in real-time. This in turn feeds back into the design process which enhances collaboration and ultimately improves performance (Baldwin, 2019). Contrary to the old preconception, BIM or any other technology does not threaten AEC professions, as many people fear. Their application only demands well-educated and trained industry professionals (Cao *et al.*, 2015; Baldwin, 2019; Turner *et al.*, 2021, Rodrigo et al., 2024).

The last of the five technologies mentioned earlier is Distributed Ledger Technology (DLT), a ledger stored across a decentralised network meaning that no single user is in full control (Thompson, Bezuidenhoudt and Waller, 2018). Underlying this technology is the 'blockchain' which is a type of database that takes many records and puts them in a block (Dounas and Lombardi, 2022). Again, this improves collaboration within the practices and also allows for validation of input because all new entries must be confirmed as valid by all users of the network, in a process known as achieving consensus (Dounas and Lombardi, 2022). This DLT technology involves the use of smart contracts, a software program that runs on a blockchain network which is the record-keeping technology which enables a growing list of information to be kept on the digital ledger.

It is thus obvious that these areas of emerging technologies offer an opportunity to rethink the way the building surveying and construction industry works in general, bringing great positives to the profession. However, the reality on the ground is that the general population of building surveyors are reluctant to embrace this even when the major benefit of BIM and other digital technologies has riffed the literature. Hence, necessitating this kind of research presented in this paper to identify the challenges and propose practical ways of promoting the further utilisation of technology within building surveying roles.

2.2 Theoretical Framework on Technology Adoption

Understanding the theories of innovation and technology adoption is required in studying the rate of adoption of emerging digital tools and technologies in building surveying professions. As such, this section briefly considers theories of innovation and technology adoption such as Diffusion of Innovations (DoI) developed by Rogers (1962), Technology Acceptance Model (TAM) proposed by Davis (1989) and the Unified Theory of Acceptance and Use of Technology (UTAUT) formulated by Venkatesh et al. (2003). DoI suggests that innovation adoption occurs over time and is influenced by several factors. These include its perceived advantages, compatibility with existing values and task nature, complexity, trialability, and observability (Rogers, 1992). Meanwhile, both TAM and UTAUT focus on identifying various factors influencing technology acceptance and ease of use.

It is widely observed that the rates of technology and innovation varies across different organizations within any sector.Some organisations are 'early adopters' who are open to experimenting with new technologies, while others are 'late adopters' who prefer to wait until there is more certainty regarding the benefits and risks. These variations are often influenced by the risk tolerance and cost-benefit considerations of specific organsiation. Venkatesh et al. (2023) argued that the more risk-averse organization tends to be more cautious in adopting new tools. This thus result in a slower rate of adoption that may still be considered optimal under certain circumstances. This is particularly relevant in building surveying professions and other professions within the AEC sector that has been identified as high risky operations (Ajayi et.al, 2024).

While the inherently risky nature of operations within the AEC sector is a key factor in its relatively low technology adoption rates compared to other sectors, zthis study seek to understand if the rate of technology adption in building surveying profession reflects an optimal rate of adoption within the AEC. It will also consider identification of specific factors impacting technology adoption within surveying profession. This approach allows for a more balanced exploration of the complexities surrounding digital transformation in building surveying.

3 Research Methodology

This study adopts a convergent (parallel) mixed methods design to investigate the reason for the slow adoption of digital technologies in building surveying profession and provides practical solutions for improvement. The convergent mixed method allows for concurrent collection and analysis of both qualitative and quantitative data to eliminate and balance any weakness from either approach (Creswell, 2018). The approaches complemented each other to achieve the study objectives by using qualitative and quantitative data to evaluate the factors impacting technology adoption and only qualitative data to collect information on practical solutions to improve digital technology adoption within surveying professions. Both the qualitative and quantitative data were collected simultaneously using a questionnaire comprising multiple-choice and open-ended questions. **Error! Reference source not found.** shows the details of the research methodology.

Insert Figure 2.

3.1 Data Construction

The first phase of the research methodology was data construction, where inferences from the abridged review of literature and brainstorming sessions were used to establish the variables for the construct of the questionnaire. The questionnaire has three key sections comprising questions on the demographic information of the respondents, open-ended questions for qualitative data and multiple-choice questions on a Likert scale for quantitative data. The Likert scale used is a five-point scale starting from a score of 1 to 5 for strongly disagreed, disagreed, neutral, agreed and strongly agreed respectively. Before administering the developed questionnaire, a pilot study was first carried out. Piloting the questionnaire allowed for rephrasing some questions to eliminate ambiguity and subsequently improve the participants' understanding (Ajayi et.al, 2024).

3.2 Data Collection

A non-probable convenient sampling approach where the researcher selects samples based on a subjective judgment rather than through a random selection of the general population was used in this study. This sampling method has been implemented within this research study to ensure the questionnaire was sent to professional building surveyors currently operating within the UK, thus ensuring that the data collected reflects the scope of this study. The recipients of the questionnaire were selected through an open post on LinkedIn which allowed the researchers' professional connections to complete and reshare the survey with other connections. In total, 56 respondents distributed across various characteristics as shown in

Insert Figure *2* participated in the survey. This number is considered suitable as a sample size of more than 30 is appropriate for most research (Lenth, 2001).

Insert Figure 2

3.3 Data Analysis

The first stage of the analysis is the separation of the responses to the semi-structured questions (i.e qualitative data) from the multiple choices questions (i.e quantitative data). The qualitative data were first analysed in Section 3.3.1 because of the exploratory nature of the study which is mainly about why and what will make building surveyors use digital technologies. Doing the qualitative analysis first allows for an in-depth analysis of the reasonings and motivations of surveyors to use digital technologies in their operation by allowing them to provide answers of their own. Thereafter, the quantitative analysis (Section 3.3.2) was done to provide further insight into factors impacting the adoption of digital technologies by building surveyors.

3.3.1 Qualitative Data Analysis – Thematic Analysis

Thematic analysis comprising five distinct processes as outlined in **Error! Reference source not found.** (Dauda et.al, 2023; Alalade et.al, 2024) was employed to analyse the qualitative data collected in this study. Prior to the detailed thematic analysis, qualitative data familiarisation was carried out in the first step. In the data familiarisation step, the entire responses were studied to provide a general overview of the data orientation and also provide the foundation for the subsequent steps in the thematic analysis. Thereafter, inferences, data trends, discrepancies and commonalities between data were noticed and the initial codings to represent the data were generated in the second step (i.e initial coding generation). In the third step (i.e theme searching), the initial codes generated were further examined for classification into different patterns of similar interest and collated as potential themes. These preidentified potential themes were then subjected to critical evaluation in the fourth step (theme reviewing) to first establish if they properly fit within the group. Thereafter, the data were re-sorted, themes were combined, and additional themes were created. After all these four steps were completed, an indication that a refined thematic analysis has been conducted, the final naming and concise description of each already identified theme was carried out in step 5 to complete the thematic analysis.

Insert Figure 4

3.3.2 Quantitative Data Analysis – Empirical Framework

The quantitative data collected from the survey were analysed using Ordinary Least Squares (OLS) models to gain deeper insight into the factors impacting building surveyors' digital technological adoption. OLS is a conventional quantitative technique that is used to estimate coefficients of linear regression equations which analyse the linear relationship between an outcome (*Y*) and predictor (*x*) variables. This estimation technique allows for the identification of trends that are relatively close to the true population values with minimum variation.

The OLS regression in this study is therefore used to analyse the relationship between the level of digital technological adoption (*Y1*) and other predictor variables such as the building surveyors' demographics, work details, company characteristics, behaviours, perceptions and factors impacting digital technology adoption.

$$Digital\ Tech\ Adoption_i = f(Z_{i1}, Z_{i2}, Z_{i3}, \ldots, Z_{i56}, \varepsilon_i) \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

where ε_i is the error term and *Z* represents the characteristics of each of the Surveyors in the survey.

The partial derivative of the $Digital\ Tech\ Adaptation_i$(*) with respect to the k_{th}, ($\frac{\delta Digital\ Tech\ Adoption_i}{\delta Z_k}$) is referred to as the marginal implicit level of awareness which represents the marginal level of digital technologies adoption of the k_{th} surveyor's features in the digital tech proficiency score of the surveyor. This estimates the marginal contribution of each characteristic.

The descriptive and summary statistics of the variables used are reported in Appendix 1.

4 Discussion of Results

The finding of the thematic analysis performed on qualitative data and the OLS regression analysis performed on quantitative data collected were presented in sections 4.1 and 4.2 respectively.

4.1 Themes Emerged from Thematic Analysis

In accordance with the objectives of this study, the thematic produced fourteen (14) different themes as shown in the developed framework for digital technology adoption in the building surveying profession in **Insert Figure *3***. The key issues discussed in this study are technologies currently used by surveyors (with four (4) themes identified), factors impacting the adoption of digital technologies (with six (6) themes identified) and ways of promoting further utilisation (with four (4) themes identified).

Each of these themes was fully discussed under their respective category in sections 4.1.1 - 4.1.3.

Insert Figure 3

4.1.1 Category 1 - Technologies Currently Used by Surveyors

All the respondents identified at least one technology currently being used to improve productivity within their job roles. The identified technologies were grouped into four (4) different themes ranked in the order of their prevalence as follows; (1) Smartphone applications, (2) Business communication platforms, (3) Digital survey equipments and (4) In-house developed applications.

Theme 1: Smart Phone Applications

Smartphones are continually becoming undeniable essential personal devices. Hence the last decade has witnessed a dramatic increase in the number of smartphone users (Li *et al.*, 2022). The finding of this study corroborated this with all respondents claiming to be using at least one smartphone application in their operation. This makes smartphone applications ranked as the most widely used technology by building surveyors in their operations. As revealed by the analysis, Site Audit Pro, Go Report, Kykloud, File Maker Pro, Snag R/List Pro, Winscribe (Dictation App), Pixpro and TF Cloud are the most common smartphone Apps that have found their way into building surveying operations. A common feature of all these Apps is that they are mainly used for easy reporting of condition survey and inspections.

Theme 2: Business Communication Platforms

Being proficient in doing technical survey operations is not only enough to stay ahead of the competition in building surveying industries, great communication skills using flexible and secure channels are essential in this competitive age (RICS, 2019). As such, most survey firms have invested in using digital communication platforms as supported by the claims of all respondents in this study. The analysis revealed that most firms used Emails, Teams, Zooms, Skype, WhatsApp, and other messaging apps to share information and communicate within and outside their company. Often these internal and external forms of communication come with barriers, which can prevent the receiver from understanding the information sent by the sender. As such, building surveyors must embrace the use of advanced digital technologies such as building management systems (e.g BIM) that provide granular data in real-time and allows live feedback which enhances collaboration and ultimately improves performance (Cao *et al.*, 2015; Ghaffarianhoseini *et al.*, 2017; Baldwin, 2019).

Theme 3: Digital Survey Equipments.

Total Station, Digital Theodolites, Matterport Scanner and GIS are the most advanced digital survey equipment identified in this study by a combined total of 12% of the respondents. This shows a low rate of adoption compared to the most common digital survey tools such as the disto meter and telescopic pole camera with all respondents affirmed to the usage in their operations. Many respondents stated that the reason for using disto meter and telescopic pole in building surveying is due to ease of use and the reduction in health and safety risks, especially when access to work areas is complicated. Although some of the respondents stated that they understand the significant advantages of using drones and other sophisticated digital technologies in building surveying operations, but lack of training and operations licenses are the main obstacles. The main deduction from this analysis is that most of these advanced digital technologies, particularly the emerging five groups (IoT, 5G, ML & Robotics, DLT and Building Data) discussed earlier in section 2.0 have not been fully integrated into building surveying operations.

Theme 4: In-house Developed Applications

The use of in-house developed applications has also been identified in this study. Although, this claim was only made by 2 of the respondents (i.e 4% of the total participants). One of the respondents says "we are currently using in-house software developed by our internal team for data collection and building surveys. This is a cost-saving approach compared to buying licenses from the app developer." While it is often believed that developing a customised app is time consuming and requires high initial cost (Stefanowicz and Stempniak, 2020), the time spent during the development process allows for a better understanding of the app usage behaviour, This has great implications on customer satisfaction and full control of the application during usage (Liu *et al.*, 2017).

4.1.2 Category 2 - Factors Impacting the Adoption of Technologies

This analysis identified twenty (20) factors impacting the decision to adopt technology in building surveying operations. These factors were grouped into five (5) different themes which are; Economy, Technical Knowledge, Culture, Efficiency (i.e productivity and safety consideration), and Regulatory factors.

Theme 5: Economic Factors

This theme has been named economic factors because the components of the themes comprise factors such as the cost of digital technology, company growth in terms of revenue and profit margins, and competitive advantages (i.e cost structure and ability to perform operations more efficiently than existing methods for better profit). Overarchingly, the economic factor has been identified as the main factor impacting digital technology adoption by 45 respondents out of the 56 responses collected in this study. This is in line with earlier studies, (Fu *et al.*, 2018; Begić, Galić and Dolaček-Alduk, 2022) that have unanimously agreed that the economic bias of people plays a significant role in the adoption of technology within the AEC industry. For instance, the prioritisation of clients on lowest price tendering in awarding contracts is a limitation to innovation (Loosemore and Richard, 2015), high initial capital investment of technology, and training cost hinders their adoption (Fu *et al.*, 2018). These claims were supported by a direct quote from the responses *"Firms will use digital technology that has a higher benefit-cost ratio, because the payback period will be short, and the company profit margin will grow within a short time".*

Theme 6: Efficiency Factors

Alongside economic factors, efficiency factors measuring the performance of an intended technology both in terms of value creation and safety consideration is another leading factor impacting the adoption of digital technology in building surveying professions. A combined total of 44 respondents mentioned at least one of the ability of digital technology to perform multiple tasks, time efficiency, quality, meeting client requirements, reliability, durability, ease of use and improved safety during operation as factors impacting their decision to adopt any digital technology. Compared to other sectors, productivity in the AEC sector which the building surveying profession belongs to is relatively low. Where on a global level, productivity increases by 2.8% per year on average, the construction sector is behind with an average yearly growth of 1% (Barbosa *et al.*, 2017). As such, building surveyors are very keen to be more efficient and the responses in this study show that building surveying firms might be willing to invest more in digital technology if it guarantees value for money and it is safe as supported by earlier studies (RICS, 2020a).

Theme 7: Technical Knowledge/Training Factors

Similar to other professions within the AEC, the availability of training and technical knowledge of using certain technology is a major factor in adopting digital technology in building surveying profession. In this study, three (3) factors (i.e training, knowledge of implementation, and technical knowledge for improved diagnosis) emerged from the analysis and connoted together under the theme, technical knowledge/training factors. This study outcome reinforced the earlier position of RICS (RICS, 2019, 2020b) which implies that improved training and professional knowledge will improve competency level for the adoption of emerging digital technologies within the building surveying profession.

Theme 8: Perception/Cultural Factors

Perception and cultural orientation have been major bottlenecks for the digitisation of every sector of the economy. The building surveying profession is not left out with many believing that using digital technology within building surveying operations will take them out of jobs. In fact, a direct quote from the responses states that "*If we are increasing the use of tech and AI too much, we will end up with robots undertaking our work if we continue along the route that some seem to wish to go"*. However, a critical analysis of the trend in the responses in this study revealed that age is a crucial factor in this perception. This aligns with the findings from the studies (Schlomann, Memmer and Wahl, 2022), which suggest as age increases, the level of technology adoption decreases. Another component within this cultural factor is compatibility (i.e the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters.

Theme 9: Regulatory Factors

This study identified regulatory factors such as legal requirements and operational licensing considerations, especially for drones, robots and other AI applications in surveying operations as key factors impacting their adoption in building surveying operations. Other factors mentioned in this study that was themed under the regulatory factors are data storage and security. This is interrelated with the safety concern under the efficiency factor, but in this case, respondents refer to data security and the ability of the technology to provide storage without breaches of any data protection act. The provision of responsive outcome-based regulation based on performance data will help the decision-making process in the uptake of any digital technology (Eggers and Turley, 2018). While this study generally suggests that regulatory barriers are not the leading impacting factor for the adoption of digital technology with only 13 out of 56 respondents mentioning this, it is definitely an indication that enabling regulatory frameworks and policies will encourage building surveying firms to consider investing more in digital technologies.

4.1.3 Category 3 - Ways of Promoting Further Utilisation

In this study, four (4) themes (i.e. Education and Training, Business Models and Promotions, Government Aids/Incentive, and Regulations) were established under the way to promote further utilisation.

Theme 10: Education and Training

The ease at which an innovation or technology can be tried in a business will influence it is being adopted. If a user has a hard time using and trying an innovation this individual will be less likely to adopt it (RICS, 2020a). So, the starting point of the integration of digital technology in the building surveying profession will be for the stakeholders (Professional bodies (e,g RICS), Manufacturers of Technology, and Employers) to build an integrated strategy in which training and capacity building are equally embedded into all areas of activities (such as professional registrations, CPD), business training resources. As outlined earlier, promoting the use of digital technology should be focused on the older generation of building surveyors to provide them with the skill set to use the technology more easily and to allow a shift in their attitudes towards technology. Respondents also state categorically that the developer of digital technology should improve the quality of the CPD and access to the training they provide to increase the level of digital technology utilisation.

Theme 11: Business Models and Promotions

The business model is the plan of the company for making profits, as insinuated by the responses in this study, firms are more likely to change their tools or adopt new technology as long as it offers a better benefit-cost ratio. So, manufacturers of digital technology should offer more promotional opportunities by allowing firms to test their tools/applications in live environments. Testing and promotions helped businesses understand how their operations adapt to new technologies. If during testing, they see the benefit in their operations, this will enable them to include the uptake of the technology in their business model. In addition, independent reviews from credible sources such as RICS and other relevant organisations will improve the awareness level and promote further utilisation of digital technology within the profession.

Theme 12: Government Intervention

As high initial cost is one of the fundamental issues in the uptake of new technology, financial aid from the Government will go a long way in addressing this as further substantiated by the finding of this study. The government could provide assistance with the cost or tax breaks on technologies that help carbon reduction such as thermal imaging equipment. Government intervention can also come in terms of funding research that will improve the teaching and training of surveyors on how to use these digital technologies.

Theme 13: Regulation

Regulations struggle to stay ahead of constantly emerging technologies (Eggers and Turley, 2018). For instance, drone regulators struggle to keep up with the rapidly growing technology of applying drones to almost everyday activities (Pasztor and Wall, 2016). However, it is essential that to promote further utilisation of digital technology within building surveying, the users need to be protected and ensure that they are insured on the potential unintended consequences of disruption that the technology adoption might bring. The finding of this study echoed the earlier submission (Eggers and Turley, 2018) that the availability of risk-weighted data-driven and collaborative regulation that consider input from all stakeholders will increase the interest of people in adopting technology and thus will promote further utilisation of digital technology within building surveying professions.

4.2 OLS Results and Inferences from OLS Regression Analysis

Table 1 reports the results of OLS regression analyses, columns 1-7 show the impact of each category of the variables on building surveyors' digital technology adoption without accounting for the effect of other factors. These models are however biased and to minimise the problem of omitted variable bias, the model reported in column 8 (full specification) captures the impact of all the relevant variables while accounting for other categories of variables. The model fit (r2) in column 8 is 0.783 which suggests that 78% of the level of building surveyors' digital technological adoption can be explained using the full spec model. Table 1 reveals the statistically significant coefficients of variables in a tripartite, double, single and no asterisk with tripartite asterisks indicating highly significant variables, single asterisks showing the least statistically significant variables and no asterisk indicating statistically insignificant variables.

Insert Table 1

Table 1 results indicate that, when all other factors are equal, older building surveyors are less likely to embrace digital technology. This aligns with the thematic analysis, which produced a similar conclusion. On the other hand, factors such as being an RICS chartered surveyor, spending more time in a current role, and having a higher number of employees do not significantly affect the adoption of digital technology. This finding is consistent with the qualitative stage, where respondents did not mention whether RICS played a vital role in their technology adoption. Therefore, these factors do not seem to have a significant impact on the level of digital technology adoption among building surveyors.

The results also show that a higher perceived impact of digital technologies such as IoT and distributed ledger technology can lead to a higher degree of digital adoption. This corroborated earlier studies that have argued that if the impact of adopting these emerging technologies is fully appreciated, the rate of adoption will increase.

Furthermore, the results show that being familiar with a tool can reduce the chances of the general adoption of similar or advanced tools that perform similar functions. One of the reasons for this may be that as building surveyors get used to a particular tool, they get accustomed and are thus unmotivated to learn to use other tools. Thompson, Bezuidenhoudt and Waller (2018) and Delgado *et al.*, (2019) simply put this factor as apprehension of people to change and embrace new ideas which is a major hindrance to the adoption of emerging digital technologies.

Clients' requirements are also shown to play a role, albeit negatively, in building surveyor's digital technological adoption. This may be because building surveyors' clients are generally still accustomed to traditional and analogue tools and thus prefer that the surveyors' work and output are in formats that they can use and relate to. Additionally, the findings reveal that building surveyors are more likely to adopt digital technology when they perceive that a specific digital tool is frequently needed and can enhance health and safety. Conversely, the adoption rate is lower among building surveyors who use technologies that are seldom utilised and those who believe that they need to enhance their knowledge to use the technology.

The main implication of the findings presented here is to provide valuable insights on drivers and hindrances to digitalising building surveying professions. The study outcomes will serve as a roadmap for building surveying professionals, policy-makers, and technology providers, offering valuable insights into harnessing the potential of technology to improve efficiency, accuracy, and decision-making in building surveying practices.

5 Conclusion

Adopting appropriate digital technology will enhance the practice of building surveying profession and of course, improves productivity. However, the adoption level of digital technology within the profession is very low. This study thus focussed on identifying digital technologies applicable to building surveyors, investigates the factors impacting their adoption and provides ways of improving their adoption. The study adopted convergent (parallel) mixed methods of data collection involving both qualitative and quantitative data to eliminate and balance any weakness from either approach. Non-probable convenient sampling method was used. The collected qualitative and quantitative data from 56 building surveyors were analysed using thematic analysis and Ordinary Least Squares (OLS) models respectively.

The analysis revealed that there are four main groups of technologies (smartphone applications, business communication platforms, digital survey equipment and in-house developed application) currently being used by building surveying professionals. The professionals highlighted five (5) different factors which impact the rate of adoption of these technologies in surveying operations. These are economy, technical knowledge, culture, efficiency (i.e productivity and safety consideration), and regulatory factors. The economic-related factors are the high initial capital investment for both the acquisition and training of employees to use digital technology. The technical knowledge factors include lack of training, knowledge of implementation, and technical knowledge for improved diagnosis of the emerging digital technological tools. Perception and culture of not willing to change alongside inadequate awareness of cost–benefit of the emerging digital technologies also impacted the ability of stakeholders from buying into their adoption. Finally, the respondents also revealed that regulatory factors such as strict legal requirements and operational licensing considerations, especially for drones, robots and other AI applications in building surveying operations, are key factors impacting technology adoption.

An improved rate of adoption and further utilisation of digital technologies in the building surveying sector may not be possible unless these impediments are addressed. Thus, the outcome of this study provides ways to improve the adoption rate based on the responses of building surveyors who are affected and have identified what will make them embrace the use of digital technologies in their operations. Education and training must be prioritised, manufacturers should also engage in business promotions by offering more promotional opportunities that allow firms to test their tools/applications in live environments to see the benefit in their operation. Government intervention via subsidies or tax breaks on technology that helps carbon reduction such as thermal imaging equipment, AI and collaborative regulation that considers input from all stakeholders will increase the interest of people in adopting digital technology. Thus, this will promote further utilisation of digital technologies within building surveying profession and AEC industry in general.

The main limitation of this study is lack of focus on how technology adoption is impacted by the sizes of participant organisation and the risk-averse nature of their organisation. As such, future studies that will consider the sizes of orgnasation and the nature of their main tasks on their intent to embrace technology is recommended. This will help develop tailored interventions that will enhance further utilisation of technology in surveying profession.

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Technological Adoption in Building Surveying: Understanding the Impacting Factors and Strategies for Enhancing Utilisation

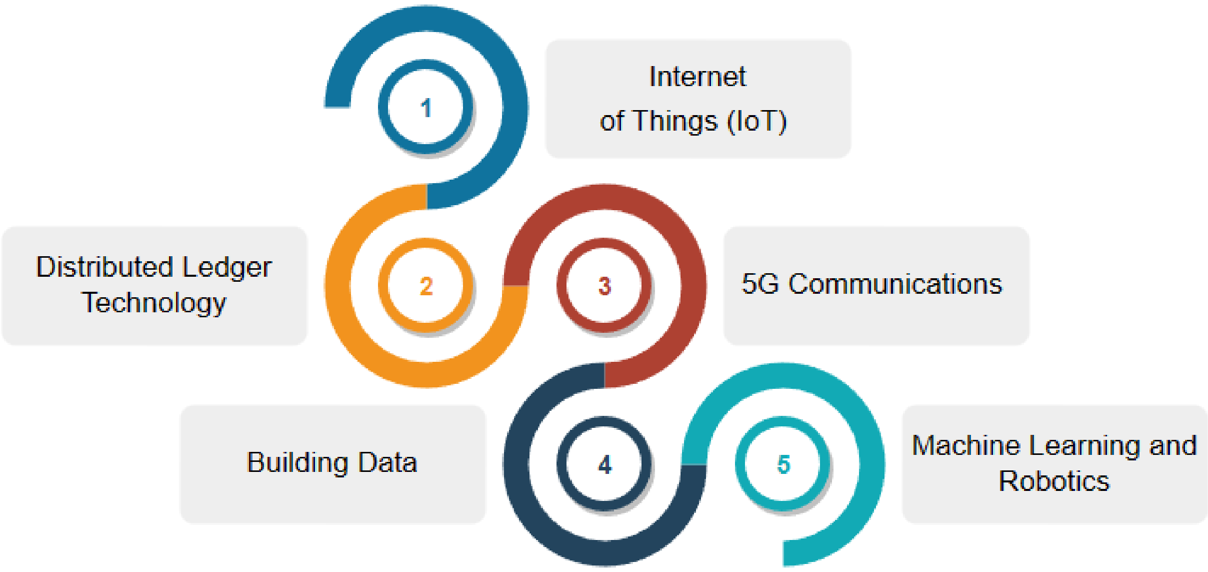

Figure 1. Emerging Technologies in Surveying Professions

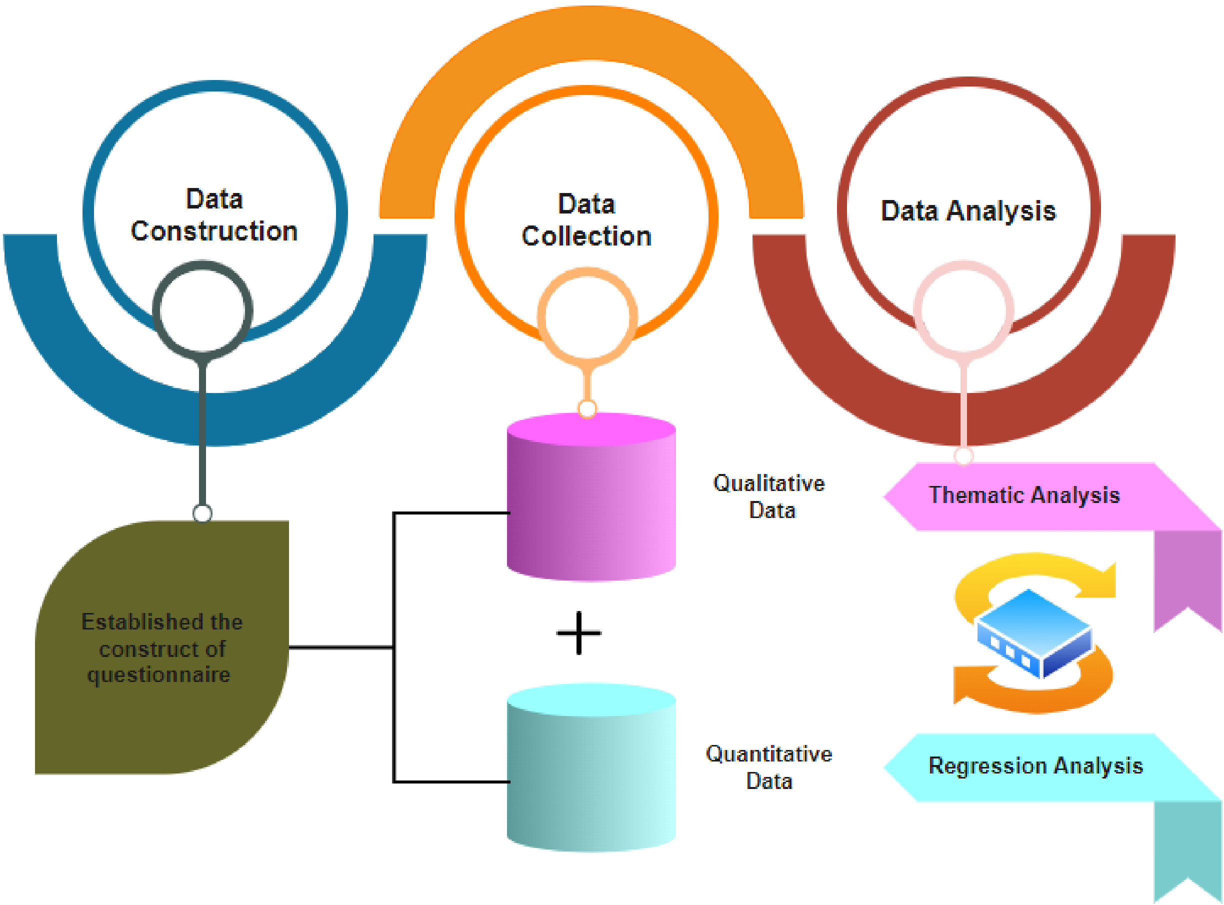

Figure 2. Research Flow Process

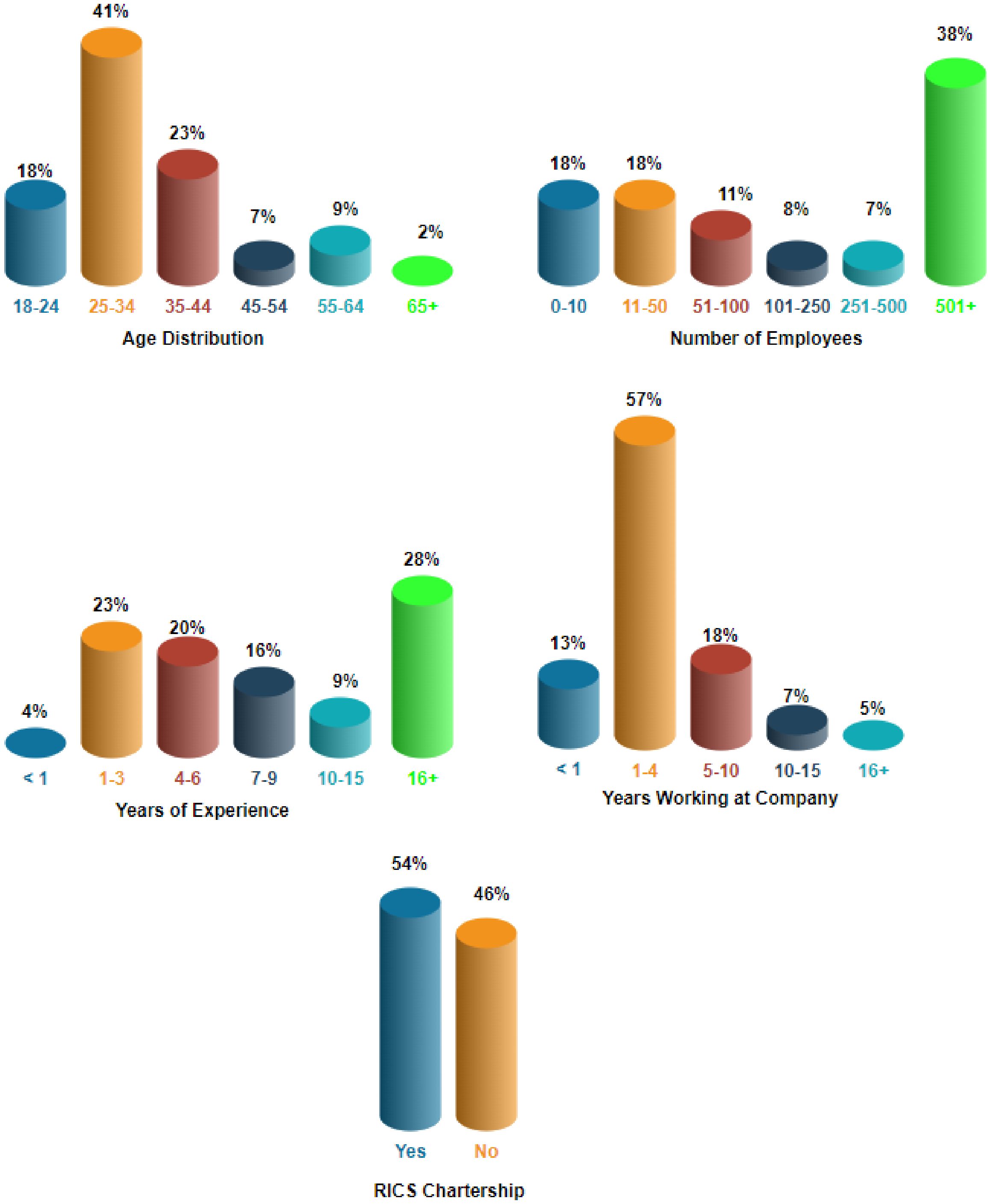

Figure 3. Distribution of Respondents

Figure 4. Overview of the steps involved in the Thematic Analysis

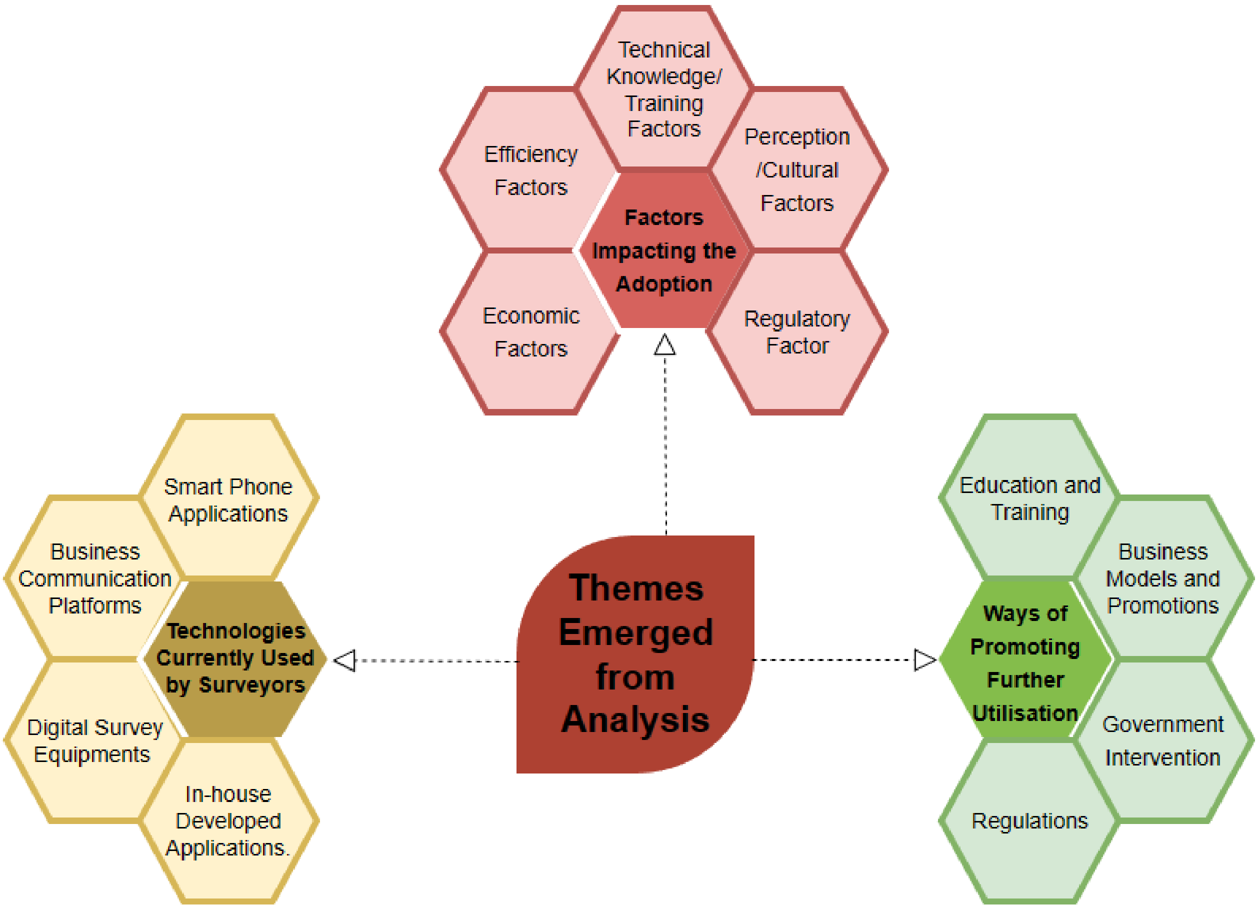

Figure 5. Themes Emerged from the Analysis