Key Dimensions of the Technical Readiness of Small Construction Businesses That Determine Their Intention to Use ICTs

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ABSTRACT

While information communication technologies (ICTs) have the potential to significantly improve construction project outcomes for small builders, their take up is relatively poor as they often face severe resource constraints. Previous construction studies have examined a range of adoption determinants, but there has been no previous research into how much small construction businesses' *readiness* to use ICTs predicts their *intention* to use ICTs − readiness being assessed by reviewing the business management's beliefs about ICTs, which are argued to have an important influence on the use of ICTs. The widely validated *technology readiness* (TR) model is used to test four hypotheses concerning the relationship between small builders' readiness and intention to use ICTs in project management. Data from an online survey of 110 small Australian builders are analyzed, with six semi-structured expert interviews later conducted to help validate and interpret the results and provide some context-specific interpretation of the quantitative results. The main finding is that the readiness dimensions of optimism, innovativeness, and insecurity are key determinants of small construction businesses' intention to use ICTs. Thus, this study shows that the use of ICTs is largely dependent on management's beliefs about their benefits and the risks involved. This is particularly significant since small businesses contribute a large proportion of industry output.

KEYWORDS: Technology readiness, technology intention to use, small businesses, construction industry, ICT usage, performance

Introduction

The construction industry is highly fragmented, operating in a dynamic and highly competitive environment (Goulding and Lou, 2013): it is driven by specific construction teams integrating many heavily involved small and medium enterprises (SMEs) (Balaban-Ökten and Gundes, 2018) in most developed countries (e.g., Shelton et al., 2016) and many developing countries (e.g., Saka and Chan, 2020). They have been defined by different agencies based on various characteristics, such as turnover, assets, employment numbers, and management characteristics (Hardie and Newell, 2011), and vary across different economies, sectors, regions, and countries. For example, SMEs are defined in Canada as businesses with less than 500 employees and an annual turnover of less than CAD 5 million (Seens, 2015), businesses with fewer than 250 employees in the United Kingdom (Chris, 2016), and businesses employing less than 200 employees in Australia where most small businesses have less than 20 employees (Australian Bureau of Statistics, 2013).

Small construction businesses play a vital role in national economies globally in being key contributors to competitiveness and productivity through growth, employment, and wealth creation (Shelton et al., 2016). For example, they contribute significantly to the Australian economy, accounting for 41% of total private sector industry employment and contributing approximately 32% of private sector industry value added (The Australian Small Business and Family Enterprise Ombudsman, 2020). However, they continue to face challenges to stay profitable and successful in a dynamic economy, with improving business performance a key objective of contractors to cope with the highly competitive project-based construction environment (Mokhtariani et al., 2017). Their managers face many operational challenges − the nature of small businesses leading to a lack of focus on efficiency improvements and poor productivity (Fulford and Standing, 2014). Consequently, they typically have relatively higher failure rates (e.g., Mayr et al., 2020).

ICTs present many opportunities for businesses to improve their performance, particularly in the face of COVID-19 (Kumar and Ayedee, 2021), as well as becoming increasingly necessary for construction firms as increasing numbers of owners and construction clients are now requiring digital project delivery, including specific information requirements through BIM and other digital ways of working (e.g., Cavka et al., 2017). However, small businesses have relatively limited resources to identify their needs for innovation (e.g., Temel & Durst, 2020) as they are owned and operated independently (Productivity Commission, 2013). They are less likely to engage in innovative activity or focus on improving their ICT capabilities (Soto-Acosta et al., 2018) and have been criticized for relying heavily on 'business as usual' solutions, leading to relatively higher rates of failure (Hardie and Newell, 2011: 619).

Of relevance are several theories that explain technology adoption, including the *theory of reasoned action* (TRA) (Ajzen and Fishbein, 1980), *theory of planned behavior* (TPB) (Ajzen, 1991), *technology acceptance model* (TAM) (Davis, 1989), and the *unified theory of acceptance and use of technology* (UTAUT) (Venkatesh et al., 2003). There have also been many studies of the technology readiness of construction businesses (e.g., Akunyumu et al., 2021; Chaurasia and Verma, 2020). However, none consider the influence of technology *readiness* on *intention to use* (Lin et al., 2007), which very often affects the level of actual ICT *use* (e.g., Eze and Chinedu-Eze, 2018).

In response, this empirical study's important contribution is the use of the reliable and validated *technology readiness* (TR) model to identify the key TR dimensions that determine the intention of small construction businesses to use new ICTs. This involves the development and testing of four associated hypotheses. Drawing broadly on the SME literature, as this captures the cohort of interest, the influence of TR on technology use intention is explored and the significant TR factors that influence management's decision to use ICTs are assessed. The term 'management' here includes all types of senior decision-makers, such as owners, managers, senior managers, senior employees, and partners. The population comprises small builders operating in Queensland, Australia, who hold licenses provided by the Queensland Building and Construction Commission (QBCC). The study is limited to businesses that hold a financial Category 1 license, with a maximum revenue between $600,001 and $3,000,000 (the smallest of its seven license categories) and with 5-20 employees.

The research contributes to the limited literature concerning small construction businesses' use of ICTs, with a particular focus on individual builder's decision-making. Its academic contribution is matched by a practical industry contribution, with recommendations for improved ICT adoption through a better understanding of the link between TR and use intention. The results will be helpful for practitioners and policy makers, ICT vendors and developers, and financial institutions in creating, developing, and strengthening a setting to support the growth and long-term survival of small construction businesses. There is also the potential for use in selecting companies for outreach based on their TR model, or to sort subcontractors for selection.

Literature review

This review examines the recent literature relating to the emergence of new technologies, technical readiness, ICTs and small businesses, and the associated role of management, often drawing more broadly on studies of SMEs as these necessarily cover such businesses and have relevance to small builders.

Emergence of new technologies

Hwang et al. (2022) use a comprehensive literature review, pilot interviews with industry experts, a survey, and postsurvey interviews to investigate the challenges and strategies for the adoption of smart technologies in the Singapore construction industry. Their findings show the main challenges perceived by industry practitioners to be data and information sharing, regulatory compliance, and data ownership, while the most effective strategies are training of skilled construction workforce, provision of government incentives, and communication and change management. The study is considered to provide an essential starting point to progress the managers' adoption of smart technologies to facilitate the industry's digital transformation.

Similarly, Jia et al. (2022) use a survey of Chinese construction industry managers to study the factors influencing BIM integration with emerging technologies. Their structural equation modelling reveals the positive and negative influence of experience inertia and learning inertia respectively, with both formal and informal knowledge governance also having a positive effect. The negative effect of learning inertia suggests that managers need to extend their external sources of knowledge and pay close attention to technological advances instead of focusing solely on advances in traditional technologies, cultivate new work ways by creating an organizational climate favoring knowledge activities (such as knowledge creation and sharing) in which employees are willing to accept new knowledge, and use formal knowledge governance such as reward systems and job design.

Yeo et al. (2020) develop a method for quantitatively evaluating the effectiveness of Internet of Things (IoT) technologies for construction accident prevention involving the use of two different types of survey and statistical records about accidents by type. The method is considered to be of potential use in justifying investments in technology, leading to the deployment of more IoT technologies for safety management, which will eventually contribute to decreasing the number of construction industry accidents.

Sepasgozar et al. (2018) use interviews with 98 experienced construction practitioners from Australia and the United States, and thematic analysis, to extract the process used by customers during technology adoption decisions, and to study the main activities, assessment criteria, and mechanism through which it influences future technology purchase decisions. An original framework is developed, including the key subprocesses of technology implementation describing the activities of customers and vendors. The findings show that customers assess the implementation based on assessment criteria, including down time, interpersonal relationships, and technology operation quality rapport with the vendor being more important in large markets, whereas lead time and disposal are more important in remote markets. The findings contribute to the body of knowledge by validating a framework that incorporates both customer and vendor activities.

Li et al. (2018) develop an advanced simulation game for prefabrication housing production (PHP) to help overcome the lack of availability of appropriate training or pedagogical approaches to transfer and share the lean knowledge and information techniques in the adoption of lean construction principles and information technologies, e.g., Radio Frequency

Identification Device (RFID) and Building Information Modeling (BIM). The game simulates the process of PHP from manufacturing and logistics to on-site assembly by integrating an RFID-enabled BIM platform with lean construction into training students and practitioners. Tests show that the game can significantly improve the understanding of various knowledge concepts in PHP and can be adopted as a useful platform to effectively train practitioners in the PHP sector on the use of lean, BIM, and other innovative information technologies.

Jang et al. (2018) develop a sustainable performance index (SPI) for assessments of green technologies (GTs) related to urban infrastructures from the early stages of a project lifecycle by firstly identifying 31 infrastructure-related GTs from a literature review. They then establish the SPI, including environmental, economic, and social categories, and 12 subfactors using the fuzzy-analytic hierarchy process (fuzzy-AHP) to help eliminate the ambiguity and uncertainty in weighting the SPI factors. The illustrative case application shows that the SPI has the potential to support decision-making processes for selecting appropriate GTs and provide a balanced view that accounts for the economic and social impacts involved.

Technology readiness

While BIM readiness, for example, has received considerable research attention in recent years (e.g., Adam et al., 2021; Mohanta and Das, 2021; Phung and Tong, 2021), technology readiness (TR) is a framework developed for the marketing and service sectors that relates to technology in general (Walczuch et al., 2007). It is defined as the individual's general opinion concerning technology, which is related to the individual's preparedness to adopt ICTs and ability to fully exploit their benefits (Parasuraman and Colby, 2014). It assumes that traits differ between individuals and, therefore, their beliefs around technology vary, with the relative strength of each attribute indicating a person's readiness to embrace a new technology (Parasuraman and

Colby, 2014). Therefore, TR reflects a set of beliefs about technology *but does not indicate a person's capability in handling technology* (Walczuch et al., 2007).

TR has four dimensions, comprising *optimism*, *innovativeness*, *discomfort,* and *insecurity*, to predict individual differences. *Optimism* denotes a positive view about a technology, while *innovativeness* denotes the management's intention to try new products and be a pioneer in their adoption (Parasuraman and Colby, 2014), with both optimism and innovativeness beliefs influencing *use intention*. Individuals with high levels of optimism and innovativeness view technology positively and ask for little evidence of its capacity to bring a return on investment (Oh et al., 2014). According to Stratman and Roth (2002), SMEs typically experience a substantial delay in the realization of return on investment from a particular adoption. As a result, they tend to be more conservative in technology adoption and less willing to be an innovator or to take risks, which affect their use intention (She et al., 2010). *Discomfort*, on the other hand, leads to a sense of being overwhelmed by the technology, as individuals believe their knowledge of technology is insufficient, while *insecurity* means a person is very critical regarding the technology's security and privacy (Parasuraman and Colby, 2014). Management's perceptions of the degree of complexity, risk, and uncertainty associated with an ICT highly influences the likelihood of it being used (She et al., 2010).

According to Parasuraman and Colby (2014), people who are receptive to technology generally retain higher levels of optimism and innovativeness than discomfort and insecurity because a positive feeling drives people towards new technologies, while a negative feeling holds them back. The term "users" can denote individual users, employees or managers within a company, or the external customers of an organization (Aboelmaged, 2014). In the case of the present research, the user is the management of a construction business.

ICTs and small businesses

ICT implementations in businesses are categorized into two major categories as identified by Peansupap and Walker (2006): standalone IT implementations such as CAD systems or project planning, estimating, and scheduling software, and organization-wide ICT implementation such as groupware or intranet applications (Braglia & Frosolini, 2014). The standalone ICT applications are designed for specific tasks to be performed by specific groups of participants, such as engineers, designers, or architects, while organizational groupware is designed to be used within a group for external communication (Peansupap & Walker, 2005b). The present study focuses on both types, given their dual importance to business outcomes. The application of ICT within the construction industry includes communication: within the business, between business and site, and between business and other construction stakeholders (like client, contractors, and/or other suppliers) (Peansupap & Walker, 2005a).

There are several organization-wide technology solutions such as E-mail; Internet; intranet; extranet; web-based project management; E-procurement; E-commerce; Project Management Information Systems (PMIS); Building Information Modelling (BIM); Electronic Document Management Systems (EDMS); video conferencing; material tracking systems using Radio Frequency Identification Device (RFID) technology; and standalone software applications such as 3D modelling, nD modelling, project management tools, and estimating software (Forcada et al., 2007; Froese, 2010; Lopez-Nicolas & Soto-Acosta, 2010; Peansupap & Walker, 2006; Samuelson & Björk, 2014; Scupola, 2009; Tran et al., 2011; Vitkauskaite & Gatautis, 2008).

The above-mentioned ICTs enable smooth flow of richer information quickly to aid decision-making, improved communication by enabling real-time access to information, improved coordination and collaboration, and greater management control (Braglia & Frosolini, 2014; Peansupap & Walker, 2005b). The other benefits highlighted are increased quality, accuracy and speed of documents produced, improved financial mechanism and communications, and quick access to common data (Ahuja et al., 2009; Van der Vlist et al., 2014). ICTs have already been widely adopted in construction to support various intra- and inter-organizational processes (Hadaya & Pellerin, 2010; Van der Vlist et al., 2014), including the tendering process, the awarding of contracts, project monitoring and controlling, and the material purchasing (Hadaya & Pellerin, 2010; Ruikar, Anumba, & Carrillo, 2006).

Increasingly, small construction businesses are using cloud-based applications to assist creation, storing and sharing of project information, and improve timely progress of project delivery (Abedi, Fathi, & Rawai, 2012), with advancement in technologies such as integrated high definition photography, mobile-based field supervision, 3D scanning, drone, unmanned aerial vehicle (UAV) technology, and real-time information sharing ensuring transparency, improving quality and avoiding delays, and also bringing operational benefits to businesses (Siebert & Teizer, 2014).

They potentially play an important role in all aspects of performance and competitiveness by facilitating information integration between organizational units and construction project members, the assessment of a business's market position to formulate future directions, and the adequate flow of information to enable informed decision making (Ahuja et al., 2010). However, full advantage of the evolutions in ICT practices is yet to be realized (Ahuja et al., 2009; Froese, 2010), with the traditional ways of conducting business continuing to dominate, such as exchanging information through face-to-face communications and hardcopy drawings and documents (Braglia & Frosolini, 2014). Poor communication and coordination, errors and reworks, and poor schedule performance are commonly reported issues due to a lack of real time communication (Lu et al., 2014), with a tendency to use ICT solutions that only focus on performance of specific tasks that prevent the smooth sharing of real time information between project participants (Braglia & Frosolini, 2014; Forcada et al., 2007; Peansupap & Walker, 2006).

Management's role and readiness

Management usually has sole power to make decisions in a SME (Hardie and Newell, 2011), and adoption and investment in technology often relies on its technology readiness and acceptance: an individual-level acceptance or rejection can substantially affect the success of ICT initiatives in SMEs (Mudalige et al., 2019).

The influence of owners'/managers' TR on the readiness to use ICTs is supported by Ramayah et al.'s (2003) survey of 102 SME owners/managers from the manufacturing sector operating in the northern region of Peninsular Malaysia, which concluded that they were optimistic and innovative but at the same time experienced discomfort and insecurity as a result of their decisions. They also identified significant differences in terms of TR across various demographic variables (e.g., age, gender, and educational level). Despite some similarities to the present research, however, Ramayah et al.'s (2003) study does not examine the link between TR and intention to use ICTs, and was conducted in the manufacturing sector, which does not involve the challenges posed by project-based production, such as those faced by the construction industry.

The Australian construction industry is dominated by small businesses, which face several future productivity challenges because of inadequate enterprise-level project management and lack of appreciation of the incentives for innovation by managers (e.g., Arashpour et al., 2017, 2020), while their use of ICTs is relatively small (Shelton et al., 2016), pointing to the importance of the determinants of their intention to adopt ICT, with the focus on management to address this problem and improve the industry's performance and productivity. However, little is known to date of these determinants, particularly in terms of *readiness* and *intention*.

http://www.sciencedirect.com/science/article/pii/S0926580511001774 - s0065**Methodology**

Research question, problem, and objective

This study aims to address the following research question:

> "What are the key dimensions of technical *readiness* that determine the *intention* of small construction businesses to use ICTs?"

The research objective is to answer this question.

Research hypotheses

The review of both theoretical and empirical studies suggests that the TR model has the potential to provide a powerful and flexible framework for measuring the readiness level of small builder management and, thus, for examining the critical knowledge gaps. Based on the assumption that ICT readiness is concomitant with ICT intention (i.e., management's TR level is positively correlated with its use intention), we use the TR constructs developed by Parasuraman and Colby (2014) to hypothesize that:

H1. Optimism has a significant positive effect on use intention of ICTs.

H2. Innovativeness has a significant positive effect on use intention of ICTs.

H3. Discomfort has a significant negative effect on use intention of ICTs.

H4. Insecurity has a significant negative effect on use intention of ICTs.

To test these, a questionnaire survey of small construction businesses was first carried out, followed by a series of interviews to help explain and interpret the findings of the survey.

Survey

The questionnaire comprises the tested and validated instruments developed by Davis (1989) and Parasuraman and Colby (2014). This involves a pre-existing 16-item measurement scale, comprising Parasuraman and Rockbridge Associates' Technology 2014 *Readiness Index 2.0* (Parasuraman and Colby, 2014) employed to assess the four dimensions of technology beliefs that influence the management's TR based on the list of ICTs presented in Part 2 Q1 of the instrument (Fig. 1). Use intention is usually established by a number of declarative statements requesting respondents to rate them in terms of ordinal level categories such as agreement or disagreement (Lin et al., 2007). In this case, two validated measurement items are employed to measure the use intention of ICTs: (1) "I will consider adopting ICTs into my system" and (2) "I will implement the necessary ICT tools into my system in the near future" (Lin et al., 2007).

A Likert measurement scale is used to measure each independent variable, with a five-point scale to ensure quality and encourage the respondents to accurately express their views in a minimal response time. After piloting with Category 1 contractors listed on the Queensland Building and Construction Commission (QBCC) website, an online survey was conducted via an e-mailed link in the period June-August 2015, with the list of registered contractors published by the QBCC used to derive the population. The owners/managers were asked to state their number of employees and the ABS definition was used to capture those which are small businesses (i.e., 5-20 employees).

All data were cleaned to eliminate incomplete responses from the final analysis. Of the 858 targeted respondents, 119 respondents identified as small businesses returned the questionnaire. However, after attempting the first question, nine of these did not complete the remainder of the survey, resulting in 110 completed questionnaires. This resulted in a response rate of 13%. Similar studies by Grandon and Pearson (2004), Hadaya and Pellerin (2010), Ifinedo (2011), and Rodgers et al. (2015) published in leading journals produced response rates of 12%, 13.2%, 11.8%, and 13% respectively, indicating the difficulty in collecting data from small businesses, especially on innovative topics in the construction industry. In the current case, response rates are low because such businesses in the construction industry are reluctant to see ICTs as integral to their business. Also, there are known to be inadequate levels of trust between the construction industry and researchers to share information, creating difficulties in conducting research (Thorpe et al., 2009). Given the context, therefore, it is taken that the response rate achieved by the current study achieves best practice and robust standards.

Interviews

The follow-up interviews to provide some context-specific interpretations of the quantitative results were semi-structured as the interviewer adjusted the questions and their sequence based on the participants' responses. The protocol comprised three parts. In Part-1, participants were given a list of technologies and questions based on the technologies of their choice. For example: "Why do you mainly choose this technology?" and "How do you feel about applying it as part of your work?" Typical questions for Part-2 are: "What are your expectations from a good technology?" and "How experienced would you say you are when using the technology?" Similarly, typical questions for Part-3 include: "According to our survey results, businesses are slow to adopt advanced technologies. Why do you think they are slow?" and "What are your suggestions to avoid this situation?"

The views of the participants were audio-recorded in an approximately one-hour meeting conducted at their premises. Anonymity was preserved and the data gathered was guaranteed to be used for this research only. Participants were able to withdraw from the project without comment or penalty and were assured that the decision to participate or not participate would not impact upon current or future relationships. The point of data saturation, after which no significantly new ideas emerged, occurred after six interviews. Table 1 summarizes the backgrounds of those involved.

The interviews also improved data validity by providing a means of triangulation to facilitate cross-verification across the survey and interviews. As the sample size for the survey was comparatively small, the post-survey interviews helped reduce concerns over the relatively low survey response rate (e.g., Rodgers et al., 2015).

Data analysis

The data gathered from the survey were prepared for the analysis by first using a data-cleaning process to exclude all incomplete responses from the data file, and then coded, verified, and visually checked. They were then carefully screened to check for any errors, unusual patterns, outliers, and violations of normality. As this study focuses on predicting the use intention of the management of small builders and does not involve any comparison between groups, both associational type questions and descriptive questions are used, and the data analyzed with associational statistics to test the hypotheses.

Cronbach's alpha coefficient value of each variable is calculated to assess the validity and reliability of the scales, with inferential statistics including correlation, multiple regression, and mediation used to test the hypotheses. The intercorrelations of the variables are computed using Spearman's rho. The final phase of analysis uses multiple linear regression and mediation analysis[1] to examine the process by which an independent variable (technology readiness constructs) is thought to directly affect a dependent variable (use intention of ICTs) (*H1*) as influence beliefs (TAM) constructs → (use intention of ICTs) (testing *H2*) or indirectly through a mediator, (technology readiness constructs) → (TAM constructs) → (use intention of ICTs) (testing *H3*). In addition, multiple regression is used to test the direct effect of extended TAM

[1] An introduction to these procedures can be found in Keith (2019).

constructs (perceived ease of use (PEOU) and perceived usefulness) with extension variables (self-efficacy and facilitating conditions) on the dependent variable (use intention of ICTs) (*H4*).

Mediation analysis is also used to test (*H3*) the potential mediating effect of TAM on the relationship between technology readiness and use intention using Baron and Kenny's (1986) causal-steps test. Multiple regressions are used to estimate path c (total effect), a, b, c' (direct effect), as shown in Table 2. Here, the first three steps are used to establish the existence of zero-order relationships between the variables, and step 4 is conducted after confirming the existence of a significant relationship from steps 1-3. This means that TAM is considered a mediator if (1) technology readiness significantly predicts use intention, (2) technology readiness significantly predicts TAM, and (3) TAM significantly predicts use intention.

Mediation is identified when (1) the effect of TAM on use intention remains significant even after the inclusion of technology readiness (path b), with (2) the perfect mediation occurring when the effect of technology readiness on use intention is not significant with the inclusion of TAM (path c'), and (3) partial mediation occurring when the effect of technology readiness on use intention is significant but decreases with the inclusion of TAM.

For the hierarchical multiple regression, the independent variables of technology readiness, TAM, and extension variables are entered in steps and the change in R^2 is observed at each step because R^2 and adjusted R^2 are useful to assess the overall adequacy of the model (Montgomery, Peck, & Vining, 2021) and assess overall predictability.

The post-survey interviews are analyzed by uploading the transcribed interviews uploaded into NVivo and using a thematic analysis method to group statements together. The main themes, TAM, technology readiness, extension variables, and use intention, were developed based on the hypotheses. Subsequently, the interview data were arranged into parent nodes and split into child nodes.

Research results

Survey results

Table 3 contains the personal profiles of the survey respondents, showing them to be mainly owners, partners, managers, and senior employees that have the authority to make decisions.

Most respondents are firm owners (67%), followed by managers (15%). Taken together, this group of 82% of respondents are in senior positions and are likely to have first-hand experience with the use of ICTs in their businesses. For brevity, all the survey respondents are referred to as owners/managers. The interviewee sample is comprised primarily of business owners/managers with more than 15 years of experience and having 0-19 full time employees.

Table 4 summarizes the descriptive statistics. This shows the measurement reliabilities to be satisfactory as all the Cronbach's alpha coefficients are higher than 0.8 for all the variables. Non-parametric Spearman's rho is applied, as the Likert scale measurement (ordinal data) is used to measure each variable. As expected, Spearman's rho analysis indicates optimism (r = .49, $p<.001$) and innovativeness (r = .37, $p<.001$) are significantly positively correlated with use intention, while discomfort (r = -.19, $p=.05$) and insecurity (r = -.27, $p<.001$) are significantly negatively correlated with use intention.

Table 5 contains the results of the multiple linear regression to predict use intention based on the four TR dimensions of optimism, innovativeness, discomfort, and insecurity. This shows that, for *H1*, there is a significant positive regression relationship, $F(1,101)= 31.88$, $\beta = 0.490$, $p<.001$, with an R^2 of 0.24, which indicates that optimism significantly predicts use intention − accounting for 24% of the explained variability in use intention. The analysis for *H2* shows a significant positive regression relationship $F(1,102)= 23.42$, $\beta = 0.432$, $p<.001$, with an R^2 of

0.187, which indicates that innovativeness significantly predicts use intention and accounts for 18.7% of the explained variability in use intention. A positive view about technology and a respondent's tendency to lead in adopting technology significantly influenced use intention. Similarly, *H4* is also supported, with insecurity having a significant negative regression relationship, $F(1,101) = 7.49$, $\beta = -.262$, $p<.01$, with an R^2 of 0.068, showing a lack of confidence in potential ICTs being able to find alternative ways to solve the potential concerns they might have when using technology. *H3* is not supported, and discomfort is therefore not a key driver of use intention, indicating that a reluctance of owners/managers to move outside their comfort zone is less of an inhibitor than hypothesized.

Post-survey interview findings

Interviewees with highly positive views of technology were found to be receptive to adopting technology. Several interviewees reinforced this view, confirming that a positive view of technology brought about relative success in its adoption in their business. As evidenced by Interviewee 6, for example:

> *"Estimating software allows you to become as accurate as possible. So, the people that can do that have to embrace the estimating software, A: if they're going to be successful with tenders, but also B: if they're going to make any money on the jobs." (Interviewee 3)*

In contrast, owners/managers who have fewer positive views of technology have less tolerance for risk, as they foresee significant problems related to technology usage, mostly due to their insufficient knowledge of ICTs. For example, as Interviewee 2 expressed:

> *"When you see it working, you hear people talking about it, and then you feel secure. I think it is that how applicable it is to me is more important than being innovative. Want to see it work first for someone else; don't want to be an early adopter or an early implementer." (Interviewee 2)*

Interviewee 2 further helped explain the reasons for not adopting new technologies:

"Generally, innovation will come from the larger players and we either follow them or it may be [that a] particular supplier [who has] never considered adapting a technology just leads the market to be more innovative than my competitors. I can't turn it into a square with innovation on one corner. All I can do is compete on, again as I said, time, cost, and quality." (Interviewee 2)

The interview results fleshed-out the survey findings, showing how owners/managers have a general concern over insecurity and still they are using ICTs, as individuals find alternative ways to increase the system performance in order to have a satisfied user interaction. One interviewee emphasized the need for finding an alternative system to perform the task effectively and efficiently if you feel insecure with one system:

"My own databases cover all aspects of my business. There wasn't that much on the market and there was a lot of tailoring required to suit me anyway as they are often too complicated to be useful." (Interviewee 1)

This was supported by other interviewees, who continue to use some ICTs despite the fact they are insecure at times. For example, Interviewee 3 and 6 mentioned that:

"There's a lot of stuff that you can get on the iPad that you can use to work on drawings, for example. But from a management point of view, it's almost impossible to control what a person puts on an iPad. When you have 200 users and you have a mix of Windows and Mac platforms, it makes management of the IT environment very difficult." (Interviewee 3)

"We also have a drive on our computer with all our data because there is that concern that if the Internet goes down, you have no access to any of your data – a backup as well. That's the only concern about cloud-based information, is if your provider goes down for whatever reason, then you've got nothing. So, we've got to have a backup in place." (Interviewee 6)

To summarize, the perception of inability (insecurity) and distrust about the capability of new technology influences willingness to use ICTs. This may be because potential ICT users are not confident in finding ways to work around the concerns they might have by creatively customizing the way they use the ICTs.

Discussion

The major finding is that, as expected, the readiness dimensions of optimism and innovativeness are significantly and positively related to use intention, and insecurity is significantly and negatively related to use intention. However, in contrast with Ramayah et al.'s (2003) survey of Malaysian SME owners/managers from the manufacturing sector, discomfort is not found to be significant despite the construction industry's well-known reluctance to depart from traditional methods (Lam et al., 2010). The drivers behind optimism and innovativeness are revealed to be the openness and enthusiasm of the management to collect information about ICTs and trial versions of those systems. After being exposed to a system, they may decide on whether to accept it or reject it. Therefore, being optimistic and innovative may increase the possibility of forming a use intention to adopt a technology. Similar findings can be found in the literature. For example, Ghobakhloo et al.'s (2011) study of Iranian manufacturing SMEs found that the management's positive attitude towards E-commerce applications and innovations are key factors determining an initial receptiveness to E-commerce. That insecurity is significantly negative in the current study suggests that the management has no desire to 'throw caution to the wind' but needs to carefully consider the selection and implementation of new technologies. In contrast with the industry's well-known reputation for reluctance to change *per se*, this points to a commendable willingness to minimize the risks involved in the adoption of new ICTs. Management tends to focus on simple and common ICTs, which are frequently used in most businesses in the industry and so are perceived as being easy to use (Lam et al., 2010): if ICTs are easy to use, there is little discomfort or insecurity in terms of adaption difficulty, which is likely to be modest for common ICTs.

The results of this study suggest there is a potential to increase small builders' use of ICTs and the construction industry's overall performance by improving management's *perceptions* of ICTs. Recent previous studies summarized in the literature review provide some helpful suggestions for this, such as in Huang et al.'s (2022) finding of the need to improve data and information sharing, regulatory compliance, and data ownership, while the most effective strategies are training, provision of incentives, and communication and change management. Similarly is Jia et al.'s (2022) finding that managers need to extend their external sources of knowledge and pay close attention to technological advances, cultivate new work ways by creating an organizational climate favoring knowledge activities, and use formal knowledge governance such as reward systems and job design.

Conclusion

Although small construction businesses are relatively less innovative, they dominate the Australian construction industry in terms of value-addedness. Despite the potential advantages of ICTs, they are also slow adopters. Their performance is often driven by management decision-making patterns, which are influenced by its beliefs about ICTs and the risks involved. Only limited research so far has attempted to investigate ICT adoption from this perspective, and few previous studies on this topic have been conducted for such businesses in the Australian construction industry.

The main finding is that the readiness dimensions of optimism and innovativeness are significant drivers of use intention, while insecurity is a significant inhibitor. This indicates the value of a proactive approach to improve the benefits derived from optimism, innovativeness, and security consideration, and the need for a clear understanding of the risks involved.

Practical implications

This research has practical implications for two groups: (1) the management of small businesses, and (2) project stakeholders interested in their use of ICTs as an important influence on project outcomes (particularly given the strong moves towards the greater use of BIM in the industry globally). One key advantage of understanding the determinants of management's use intention is the opportunity that it presents for construction stakeholders to tailor future knowledge dissemination by emphasizing information that encourages optimism, enthusiasm, and trust in adopting new and improved techniques and technologies.

Construction stakeholders such as government, ICT vendors, and other industry participants can create an awareness by communicating relevant information for potential ICTs.

Academic contribution

The main contribution of this paper to the body of knowledge of the "management in engineering" domain is that it is the first study in the construction industry to examine the influence of TR on management's intention to use ICTs. It also follows on from other recent studies in advocating improved data and information sharing, regulatory compliance, data ownership, training, provision of incentives, and communication and change management, with managers paying close attention to technological advances and creating an organizational climate favoring knowledge activities. The study also responds to the research gap by identifying the determinants of the intention of small builders to use ICTs, using the TR model to empirically explore the significant belief influence on use intention.

Limitations

The study is limited to the relationship between the TR and use intention of ICTs and not their actual use. Although this is a common approach, it is possible that intentions do not result in actual behavior. Moreover, the definition of small business follows Australian standards but may be inconsistent with international standards. Finally, the study is restricted by its scope involving a particular group of ICTs and a particular population of small builders.

Opportunities for future research

The paper provides a platform for other researchers to focus on expanding similar studies to SMEs operating in other industries, sectors, and jurisdictions. Future studies can further improve this field by considering new variables, depending on the context in question. Further work is also needed to identify the impact of COVID-19 in changing management perceptions of ICTs. This work can be extended and tested in different organizational hierarchies or other types and sizes of construction businesses. Finally, new work may identify areas where ICTs need to be improved for construction SMEs.

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TBA

Data availability

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

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Figure and Tables

Fig. 1. Questionnaire part 2 question 1

Information Communication Technologies (ICTs) are hardware and software used to manage information. Examples are given below. What sort of ICTs are currently used in your business? (Tick all that apply)

- Internet
- Intranet (a network built on internet technologies with access restricted to within the business)
- Extranet (Intranet expanded to include other users like customers or suppliers)
- Web-based project management systems
- E-Procurement
- E-commerce
- E-tendering
- Electronic Document Management Systems (EDMS)
- Project Management Information Systems (PMIS)
- Building Information Modelling (BIM)
- Material tracking systems using Radio Frequency Identification Device (RFID) technology
- Video conferencing
- 3D modelling
- Primavera
- Estimating software
- Project management tools
- Structural analysis tools
- CAD
- GPS equipment for survey, mapping, and other purposes
- Tendering software
- Other tools – Please list

Table 1. Interviewees' details

Interviewee identifier	Position	Experience (years)	Number of employees	Mode of interview
1	Owner/manager	>15	5-19	In-person
2	Owner/manager	>15	5-19	In-person
3	Administration manager	7	200+	Phone
4	Owner/manager	>15	0-4	Skype
5	Owner/manager	>15	0-4	Phone
6	Administration and compliance manager	10	5-19	Skype

Table 2. Mediation analysis steps

Step	Mediation Analysis (conduct regression analysis)	Process
1	"Technology readiness constructs" → "use intention"	Path c
2	"Technology readiness constructs" → "TAM constructs"	Path a
3	"TAM constructs" → "use intention"	Path b
4	"Technology readiness constructs" and "TAM constructs" → "use intention"	Path c'

Table 3. Survey respondents' profile

Variable	No.	%
Position in business		
Owner	68	66.7
Manager	15	14.7
Senior employee	9	8.8
Partner	8	7.8
Other	2	2.0

Table 4. Cronbach's alpha coefficient values of constructs and correlation coefficient analysis

Variable	Mean	Std. deviation	Cronbach α	1	2	3	4	5
1. Optimism	3.7095	.86428	.889 [a]	1.00	.449**	-.341**	-.327**	.493**a
2. Innovativeness	2.9495	.96942	.899 [a]		1.00	-.349**	-.329**	.371**b
3. Discomfort	3.1194	.83113	.838 [a]			1.00	.493**	-0.19*c
4. Insecurity	3.4111	.85326	.812 [a]				1.00	-.265**d
5. Use intention	3.43	.94052	.815 [a]					1.00

Notes: [a] Cronbach α value >0.7.
* and ** mean that the correlation is significant at 0.05 and 0.01 level (2-tailed) respectively, for all variable associations in the table.
Bi-variate association specific to study hypotheses. a H1, b H2, c H3, d H4.

Table 5. Multiple linear regressions for hypothesis testing

Independent variable	Dependent variable	Use intentions					
		B	SE	β	P	R^2 change (adjusted R^2)	$F(R^2)$ change
H1- Optimism	Use intentions	.537	.095	.490	.000	.24	31.88
H2- Innovativeness	Use intentions	.420	.087	.432	.000	.187	23.42
H3- Discomfort	Use intentions	-.190	.111	-.167	.090	.028	2.93
H4- Insecurity	Use intentions	-.289	.106	-.262	.007	.068	7.49
Technology readiness	Use intentions					.302	10.61

Figure caption list

Fig. 1. Questionnaire part 2 question 1