The current issue and full text archive of this journal is available on Emerald Insight at:
https://www.emerald.com/insight/1471-4175.htm

Investigating the determents of intelligent construction contract adoption: a refinement of the technology readiness index to inform an integrated technology acceptance model

Alan J. McNamara, Sara Shirowzhan and Samad M.E. Sepasgozar
Faculty of Arts, Design and Architecture, University of New South Wales, Sydney, Australia

Received 13 November 2021
Revised 12 February 2022
6 May 2022
13 June 2022
31 July 2022
16 September 2022
Accepted 8 October 2022

Abstract

Purpose – This paper aims to identify the relevant contributing constructs of readiness for the implementation of intelligent contracts (iContracts) in the construction industry. This study investigates the relationship between the personality dimensions of technology readiness index (TRI) and the system specific factors of technology acceptance model (TAM) within the context of iContracts.

Design/methodology/approach – Drawing insights from the extant literature and the author's previous qualitative investigations into iContract readiness constructs, a quantitative approach is used to operationalise the constructs by offering relevant statements to be measured and validated through a multiple-item scale against the users intent to accept the future iContract technology.

Findings – This study confirms and validates the relationship of the proposed iContract readiness index (iCRI) statements against the established TAM factors by offering 18 new constructs influencing technology readiness of the iContract technology. This study proves 9 of the 12 hypotheses highlighting key factors to be addressed for the successful development of the iContract technology.

Practical implications – This paper contributes to the body of knowledge by proposing a novel iCRI that informs an iContract technology readiness acceptance model (iCTRAM) for a trending technology. The iCTRAM can guide developers in producing an appropriate iContract solution and assess the readiness of users and organisations for the successful adoption of the iContract concept.

Originality/value – This study offers a unique theoretical framework, in an embryonic field, for predicting the success of iContract implementation within construction organisations. This study combines the established studies of TRI and TAM in producing a predictive iContract readiness assessment tool.

Keywords Construction contracts, Intelligent contract, Digitalisation, Automation, Technology readiness, Technology acceptance

Paper type Research paper

1. Introduction

Digital model based information systems have been highlighted by the Mckinsey group's 2020 report as the first priority for development because of the potential for bringing

This research was supported by an Australian Government Research Training Program (RTP) Scholarship.

Construction Innovation

1471-4175
DOI 10.1108/CI-10-2021-0191

profound improvements across the built environment (Ribeirinho *et al.*, 2020). The COVID-19 pandemic has forced construction industry leaders to chart a path towards keeping their employees, contractors and end users safe through increased reliance on technology (Bartlett *et al.*, 2020). The construction sector is becoming increasingly information intensive with the success of any construction project becoming more and more dependent on the availability of accurate and timely data (Atuahene *et al.*, 2018). During the delivery phase of a construction project, a substantial amount of contractual information is generated, processed and stored which construction managers must interpret and process to facilitate up-to-date decision-making. Therefore, the demands for efficient means of data input, processing and dissemination of information are intensifying (Li *et al.*, 2019). The prospect for a central digital contract system to integrate with the increasing volume and sophistication of fourth industrial revolution (Industry 4.0) technologies offers real-time contract scenario analysis to optimise current and future contract performance against that of the contract requirement (Mason and Escott, 2018; McNamara and Sepasgozar, 2020). However, current approaches to dealing with contract information during construction delivery are manual in nature and extremely labour intensive (Son *et al.*, 2012), and poor contract administration continues to be a main cause of construction dispute globally (Arcadis, 2020).

Automated construction technologies are believed to have the potential to change the construction industry in a fundamental way (Bock, 2015), and, in particular, the concept of an intelligent contract offers a truly disruptive solution to the current inefficient contract practices seen in the Sector (Mason and Escott, 2018). Differing from the one-dimensional smart contracts often used in conjunction with blockchain technology, an intelligent contract (iContract) will offer a compilation of transactional-automatic decision points structured in a way to accurately execute a construction contract based on required parameters and conditions being met (Mason, 2017; Mason, 2019; McNamara and Sepasgozar, 2021). iContracts have the potential to remove the need for a trusted third party to administer a contract in a truly autonomous (fully automated) state by integrating with the digital environment to inform the iContract of actual progress and performance allowing payment as per the terms of the contract (Mason, 2017). By introducing a central contractual software platform for the delivery of projects, manual contractual analysis tasks that are both onerous and prone to error (Arcadis, 2020) can be automated through an iContract's digital interface with the growing number of data sources within the construction sector. The requirement to capture the readiness of practitioners for such a disruptive concept is needed to inform the appropriate development of an iContract solution that will meet the needs and appetites of the industry (McNamara and Sepasgozar, 2020). Developers can focus on the exact system architecture and technology stack required to facilitate a robust central iContract system that integrates with the current technological landscape to facilitate contractual analysis of real-time construction delivery events.

This paper consists of seven parts. Section 1 firstly gives the background to the challenges facing the industry to transition the contractual environment into the digital world and how the iContract concept aims to resolve this. Section 2 presents the literature review, giving deeper detail on the current body of knowledge covering the iContract concept and the peripheral topic of Industry 4.0 and contributory technologies. In Section 3, the theoretical background is discussed on iContract readiness and technology acceptance along with integrated technology readiness (TR) theories which informs the establishment of a conceptual framework. From this, a conceptual model and a research framework of hypothesis are proposed. In Section 4, the methodology used to test the proposed model and data collection process is presented. In Section 5, the results of the study are presented in detail along with the analysis of how the proposed model been tested, modified and finalised to achieve the results. Section 6 includes discussion and validation from respondents of the study through relevant comments collected in respect to the proving/disproving of the proposed hypothesis of the study. To conclude, the paper discusses the significance of the findings and presents recommendations for further research in Section 7.

2. Literature review

The impact of the fourth industrial revolution (Industry 4.0) has brought with it the next wave of digital technologies which have stimulate radical technological growth (Li *et al.*, 2019). This includes mobile computing, cloud computing, social media and the Internet of Things and technology acceptance modelling has responded with further studies investigating how user's readiness for particular technologies will be measured for successful adoption (Sepasgozar *et al.*, 2019; Ooi and Tan, 2016; Kim and Shin, 2015).

With this revolution, previous studies (Mason and Escott, 2018) suggest that the appropriate environment for the iContract concept to succeed does now exist, but a prediction tool to ascertain the readiness for the iContract concept is required (McNamara and Sepasgozar, 2020). A lack of understanding pertaining to the readiness of the construction industry for, not only the iContract concept, but digital technologies in general has been identified in numerous studies (Al Yahya *et al.*, 2018; Sepasgozar *et al.*, 2019; Edirisinghe, 2019) highlighting the gap in existing literature for the specific factors that will ensure appropriate development and acceptance of the iContract technology.

The five stages of technology implementation are identified as initiation, adoption, acceptance, routinisation and infusion (Vaidya *et al.*, 2006), but as these stages cover general organisational aspects: people, process, work environment, technology and service providers, there is a requirement for a structured framework to guide organisations towards any specific technological implementation. Organisations that consider transitioning to the digital world must plan for such a change as a measured approach benefits organisations by increasing their capability which results in a practical framework to ensure they have an adequate "readiness" prior to any technology implementation (Al Yahya *et al.*, 2018). Individuals may reluctantly or involuntarily adopt a system because of management intervention, but individuals may be freer to choose among numerous available alternatives (Lin *et al.*, 2007). To align the needs of an organisation with the readiness of its workers, a deep understanding of the technology and the factors which affect its adoption, are therefore important for its successful implementation in an organisation or the industry as a whole (Sargent *et al.*, 2012).

Specific studies predicting acceptance of iContracts in construction have been carried out with relevant themes assessed through the focus of the technology acceptance model (TAM) framework and TR index (TRI) concept (McNamara and Sepasgozar, 2020). Key factors have also been identified for successful adoption of the iContract concept along with research directions to enable future development of the technology (McNamara and Sepasgozar, 2021). These specific iContract studies offered theoretical frameworks to follow but highlighted the gap in current literature for industry readiness to be known to tailor a future iContract solution to the exact requirements of the industry to ensure optimal implementation. Potential limitations and opportunities of the iContract concept have been highlighted in previous studies emphasising the need for a deeper investigation into the readiness of the industry centred around: systems and process, organisational behaviours and environmental factors (Li *et al.*, 2019). Thematic analysis from practitioner discussions on current contractual practices and the potential for an iContract solution offered direction on the potential determinants of readiness through the lens of TRI but stopped short of collecting data and testing a readiness model at large scale (McNamara and Sepasgozar, 2020).

This study aims to address this gap by empirically examining, through a substantial data collection, construction stakeholder's readiness of the future iContract technology to identify the precise factors that will affect user's adoption of the technology. The hypotheses for this study have been developed by considering previous iContract literature's findings (Mason, 2017; Mason, 2019) within the lens of established TR and acceptance models (TRI and TAM) (Parasuraman and Colby, 2015; Venkatesh and Bala, 2008). This paper aims to answer the research question:

RQ1. What specific readiness factors will influence iContract adoption behaviours by construction stakeholders when the technology becomes available?

The study achieves this through the novel application of a modified TR acceptance model (TRAM) framework formed through the validation of, iContract specific, contributory factors from the data collected. This model can be used to predict the construction industry's potential acceptance and readiness for the future iContract technology and give guidance on specific or additional considerations for software developers.

3. Theoretical background

The most influential approach to studying user acceptance of information technology and usage in an organisational context is the TAM), originally developed by Davis (Davis, 1985). The limitation of TAM is that it was initially designed to predict technology adoption in organisational environments (Lin *et al.*, 2007). Parasuraman's TRI theory (Parasuraman, 2000), used for gauging an individual's readiness to new technology, has become widely used by many researchers to considers individual differences (Acheampong *et al.*, 2017). Therefore, Lin *et al.* (2007) broadened the applicability of TAM by augmenting it with the TRI individual-specific dimensions into the TRAM.

While both the TAM and TRI models offer substantial insight, there has been considerable research that has emerged in showing the value of integrating the TRI and TAM into one model (Acheampong *et al.*, 2017; Godoe and Johansen, 2012; Lin *et al.*, 2007; Lin and Chang, 2011). The first integration of the TAM and TRI model was presented by Lin *et al.* (2005), who proposed the TRAM. TRAM merges the general personality dimensions of TRI with system specific factors of TAM which proposes how personality dimensions can influence the way people interact with, experience and use new technology (Godoe and Johansen, 2012). In the TRAM proposal TR was used as a predictor of TAM; however, in a subsequent study, factors comprising TR have been linked directly to the factors of TAM [perceived usefulness (PU) and perceived ease of use (PEOU)], resulting in a more specific model (Walczuch *et al.*, 2007). Some studies suggest that TR is an overall pre-curser to TAM's PU and PEOU predictors (Lin *et al.*, 2007), while others (Godoe and Johansen, 2012; Walczuch *et al.*, 2007) investigated how each dimension of the TRI individually affects the predictors in TAM. This study follows the latter line of thought with the goal to identify aspects that explain and predict user adoption for the conceptual iContract technology.

3.1 Technology acceptance model

TAM explains the causal links between beliefs – PU and PEOU – and intentions to use a technology on one hand with actual usage of the technology on the other. Davis

(Davis, 1989) described these two central determinants of TAM: PU, which refers to "the degree to which a person believes that using a particular system would enhance his or her job performance"; and PEOU, which refers to "the degree to which a person believes that using a particular system would be free of effort". There are a number of studies that have demonstrated that TAM is a valid, robust and powerful model for predicting user acceptance. with PU and PEOU being proven to be reliable and valid cognitive factors (Bertrand and Bouchard, 2008; Lule *et al.*, 2012).

3.2 Technology readiness index

Parasuraman's TRI theory (Parasuraman, 2000) empirically confirms the correlation between people's TR and their propensity to employ technology.

The TRI is a multiple-item scale theory used for gauging an individual's readiness to new technology and consists of four dimensions: optimism, innovativeness, discomfort and insecurity which have been found to predict technology adoption well (Kim *et al.*, 2017).

Results show that the four dimensions are relatively independent, each of them making a unique contribution to an individual's TR (Godoe and Johansen, 2012). The optimism and innovativeness dimensions encourage people to use technological products/services and hold positive attitudes towards technology, whereas a lack of comfort and security in a technology inhibit people's adoption of that technology (Lin and Hsieh, 2012).

3.3 Integrated model: iContract technology readiness and acceptance model

Following the model proposed by Walczuch (Walczuch *et al.*, 2007), this paper adopts the dimensions of TRI as antecedents to the cognitive factors of TAM within the realm of the specific iContract technology while also attempting to provide a clear and simple representation of relationships among different variables within the proposed iContract technology readiness acceptance model (iCTRAM) model. The application of these findings can guide pre-implementation measures to be accounted for during iContract system development and deployment which can lead to greater acceptance of the technology. These interventions are important for at least two interrelated reasons:

(1) minimization of initial resistance to a new system; and

(2) providing a realistic preview of the system to potential users in order for more accurate perceptions for how the system will help them perform their job (Venkatesh and Bala, 2008).

Interventions such as the proposed iCTRAM model can ensure accurate perceptions of future iContract system characteristics and also define the instrumental benefits of the proposed iContract concept, which is of immense importance during pre-implementation phase (Venkatesh and Bala, 2008).

3.4 Intelligent contracts technology readiness acceptance model research model

The proposed research model, shown in Figure 1, is based on an extension of the TAM in which the specific iContract TRI determinants are hypothesised to influence PU and PEOU leading to an overall intention to use of the conceptual iContract technology. The proposed model builds on earlier studies which highlighted the gap in readiness for iContract adoption as a precursor to a validated iCTRAM with iContract specific factors (McNamara and Sepasgozar, 2021). In doing so, iCTRAM offers a technology specific adoption model for the iContract based on established TRAMof TRI and TAM. Statement specific to iContract were used based on the TRI and TAM original statements as presented in Table 1.

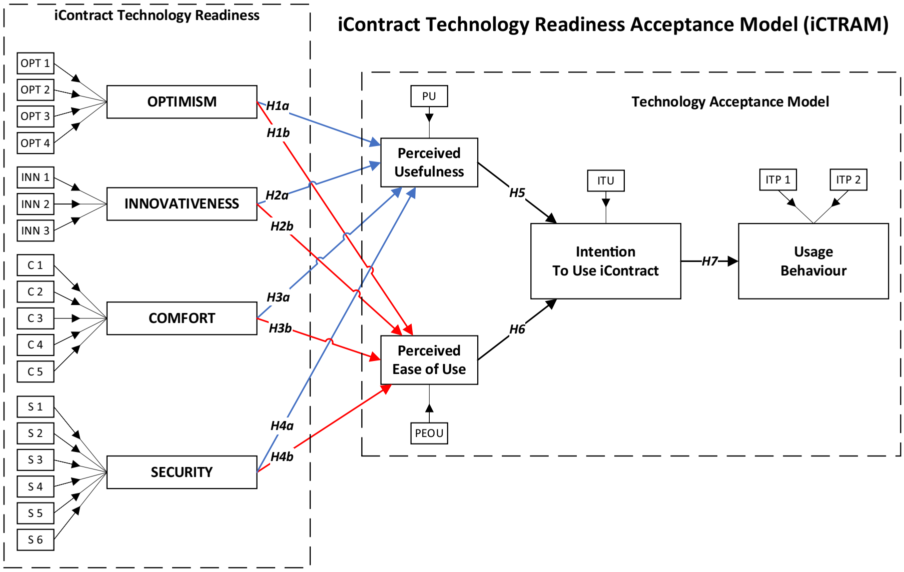

Figure 1.
Schematic illustration of the iContract technology readiness acceptance model (iCTRAM)

To identify key readiness statements influencing users' behavioural intention to use and PU of the iContract technology, a wide range of constructs within the realm of construction contract behaviour and practice were reviewed in the literature and formed from the available evidence.

This study emulates the TRAM theory (Lin *et al.*, 2007); in that it modifies it to the specific iContract technology and aims to test the proposal that iContract TR dimension propensities are positively correlated with the intention to use future iContract technology through the TAM framework of PU and PEOU.

To support this proposal, this paper puts forth eight fundamental hypotheses with a further three TAM-based hypothesis to make a case for and capture the evolution of TAM into the more comprehensive TRAM specific to the iContract technology (Lin *et al.*, 2007). Accordingly, *H1a–H4b* constitute the primary contribution towards understanding people's intention to adopt the iContract technology, once available, through the established TAM framework of PU and PEOU.

H1a–H4a test the hypothesis that iContract TR propensities are positively correlated with the perceptions of iContract usefulness, while *H1b–H4b* aims to test the hypothesis that iContract TR propensities are positively correlated with the perceptions of iContract ease of use. The eight-foundation hypothesis are as follows:

H1a. iContract technology readiness propensities, specific to the optimism dimension, are positively correlated with perceptions of iContract usefulness.

H1b. iContract technology readiness propensities, specific to the optimism dimension, are positively correlated with perceptions of iContract perceived ease of use.

H2a. iContract technology readiness propensities, specific to the innovativeness dimension, are positively correlated with perceptions of iContract usefulness.

DIMENSION	Item	Statement	*TRI/TAM* Reference* Literature source
OPTIMISM	OPT1	I believe digitalisation of contracts (iContracts) would benefit the contract formation and negotiation process	*OPT 3 (TRI 2.0)* Mason (2017), McNamara and Sepasgozar (2018); McNamara and Sepasgozar (2020)
	OPT2	I believe digitalisation of contracts (iContracts) will benefit the contract administration process during construction delivery	*OPT 6* Li *et al.* (2019), Mason and Escott (2018); Cardeira (2015)
	OPT3	I believe iContracts will offer a more accurate contract administration process	*OPT 4* Mason (2017), Li *et al.* (2019); McNamara and Sepasgozar (2020)
	OPT4	I believe digital analysis of contract data, through an iContract, will allow for optimisation of the construction delivery process	*OPT 1 (TRI 2.0)* Li *et al.* (2019), Woodhead *et al.* (2018); Mason (2017)
	OPT5	I think that automated contract payments, executed by an iContract, would improve the security of payment for all contracting parties	*OPT 10* Cardenas and Kim (2018), Cardeira (2017); McNamara and Sepasgozar (2020)
INNOVATION	INN1	I use an appropriate level of IT systems that would support iContract implementation	*INN 5* McNamara and Sepasgozar (2018), Woodhead *et al.* (2018); Mason (2019)
	INN2	I believe digitalisation of the contractual process (iContracts) will improve the performance of a construction project	*OPT 6* Woodhead *et al.* (2018), McNamara and Sepasgozar (2020); Oesterreich and Teuteberg (2016)
	INN3	I think iContracts will offer improved integration of the contractual process with current and emerging construction IT systems	*OPT 4* Oesterreich and Teuteberg (2016), McNamara and Sepasgozar (2020); Mason (2017)
COMFORT	C1	I believe an iContract would offer more logical contract drafting	*DIS 3* Mason and Escott (2018), McNamara and Sepasgozar (2018)
	C2	I would be willing to sacrifice flexibility of traditional contract drafting to adopt iContracts	*INS 2* McNamara and Sepasgozar (2020), Mason and Escott (2018)
	C3	I think an iContract would offer greater definition of contracting party's obligations compared to traditional contracts	*INS 9* McNamara and Sepasgozar (2018), McNamara and Sepasgozar (2020)
	C4	I would be comfortable in handing contractual decision making to an iContract	*DIS 7* Mason (2017), Mason and Escott (2018); Cardeira (2015)
	C5	I would be comfortable with an iContract executing payments automatically	*DIS 7* Cardenas and Kim (2018), Cardeira (2017)

(*continued*)

Table 1. iContract specific readiness and acceptance statements influencing iContract adoption in the construction industry

DIMENSION	Item	Statement	*TRI/TAM* Reference* Literature source
SECURITY	S1	I would trust that sensitive data I would share with an iContract, would be secure and not shared with the wrong parties	*INS 3* Li *et al.* (2019), McNamara and Sepasgozar (2018); Mason and Escott (2018)
	S2	iContracts would promote more collaborative contractual relationships	*INS 3 (TRI 2.0)* Mathews *et al.* (2017), McNamara and Sepasgozar (2020); Mason (2017)
	S3	I think an iContracts contractual terms would be more transparent than traditional contracts	*INS 2 (TRI 2.0)* Wang *et al.* (2017), Chern (2010); Koulu (2016), Turk and Klinc (2017)
	S4	I believe the iContract would be more effective when searching for contractual information	*INS 1 (TRI 2.0)* Koutsogiannis and Berntsen (2017), Chern (2010); Koulu (2016)
	S5	I would trust an automated contract system (iContract) that incorporates human hold points with the ability for human override	*INS 6* Mason and Escott (2018), Mason (2017); McNamara and Sepasgozar (2018)
PERCEIVED USEFULNESS OF THE iCONTRACT CONCEPT	PU	I believe an iContract system would be useful in my role when dealing with contractual matters	*PU (TAM)* Venkatesh and Davis (2000), Venkatesh and Bala (2008); Lin *et al.* (2007)
PERCEIVED EASE OF USE OF THE iCONTRACT CONCEPT	PEOU	I believe an iContract system would be easy to use in my role when dealing with contractual matters	*PEOU (TAM)* Venkatesh and Davis (2000), Venkatesh and Bala (2008); Lin *et al.* (2007)
INTENTION TO USE THE iCONTRACT	ITU	If I had access to an iContract system, I predict I would use it	*ITU (TAM)* Venkatesh and Davis (2000), Venkatesh and Bala (2008); Lin *et al.* (2007)
INTENTION TO PROMOTE THE iCONTRACT	ITP1	I would promote the iContract technology to be trialled within my organisation	*ITU/UB (TAM)* Venkatesh and Davis (2000), Venkatesh and Bala (2008); Lin *et al.* (2007)
	ITP2	I would promote a tried and tested iContract technology to be used within my organisation	*ITU/UB (TAM)* Venkatesh and Davis (2000), Venkatesh and Bala (2008); Lin *et al.* (2007)

Notes: *With reference to the original TRI study (Parasuraman, 2000). TRI 2.0 study (Parasuraman and Colby, 2015) or TAM (Davis, 1989) when stated in brackets

Table 1.

H2b. iContract technology readiness propensities, specific to the innovativeness dimension, are positively correlated with perceptions of iContract perceived ease of use.

H3a. iContract technology readiness propensities, specific to the comfort dimension, are positively correlated with perceptions of iContract usefulness.

H3b. iContract technology readiness propensities, specific to the comfort dimension, are positively correlated with perceptions of iContract perceived ease of use.

H4a. iContract technology readiness propensities, specific to the security dimension, are positively correlated with perceptions of iContract usefulness.

H4b. iContract technology readiness propensities, specific to the security dimension, are positively correlated with perceptions of iContract perceived ease of use.

To establish a comprehensive framework to integrate iContract TR into TAM, *H2*–*H4*, as addressed by past studies (Parasuraman, 2000; Parasuraman and Colby, 2015; Lin *et al.*, 2007), are replicated and confirmed so as to lead to the construction of the iCTRAM model (Lin *et al.*, 2007). The known TAM model elements (PU, PEOU, intention to use and usage behaviour) interconnect through *H1a* to *H4b* forming the integrated iCTRAM model. In the TAM, PU and PEOU are the primary cognitive beliefs that influence user acceptance of a particular technology (Park *et al.*, 2012). It is generally held that a technology will be perceived as more useful if it is easier to use (Venkatesh and Bala, 2008). Previous studies have shown strong empirical support that a positive relationship exists between PU and PEOU (Van der Heijden, 2003; Yang, 2005). Thus, we posited the following hypotheses to form the base TAM framework:

H5. Perceptions of iContract usefulness is positively correlated with the intentions to use the iContract technology.

H6. Perceptions of iContract ease of use is positively correlated with the intentions to use the iContract technology.

Considering the context of the conceptual and disruptive nature of the iContract technology (Mason and Escott, 2018), this study intends to test the users intention to promote the iContract technology. An additional hypothesis is therefore introduced, *H7*, to test the respondent's propensity to actually promote the iContract technology, once the iContract is established, from the view of an initial iteration of the technology versus an established tried and tested product. This is in keeping with the "usage behaviour" factor, seen in TAM (Venkatesh and Davis, 2000) but with a slightly differently approach, as instead of asking metric based questions for the technology, we can predict likelihood that the user would recommend the technology. This was required, as the technology does not yet exist, so no usage metric can be captured:

H7. Intentions to use the iContract technology positively correlates with the intentions to promote the iContract technology.

Within the data analysis of this study the strength of each proposed iContract readiness statement can also be assessed in relation to its influence within each dimension. Each statement was based on a careful cultivation from literature on the iContract topic and has been formed around the established TRI framework (Parasuraman, 2000; Parasuraman and Colby, 2015). Table 1 shows each statement along with the iContract literature source it has drawn from and the original TRI statement it is modified from. Also included in Table 1 are the specific iContract acceptance statements with the related TAM framework factors refenced.

4. Methodology

To examine construction stakeholder's readiness of the future iContract technology and identify the precise factors that will affect user's adoption, a quantitative approach was adopted for this study. This study examines the proposed model that is based on TAM and TRI. Following both the original TRAM and TRI investigations (Lin *et al.*, 2007; Parasuraman and Colby, 2015) and subsequent modified applications of the theories (Van Compernolle *et al.*, 2018; Park *et al.*, 2012; Lai and Lee, 2020) which suggest a structured survey as an appropriate method for data collection, this study adopts the structured survey method. This facilitates a larger sample size, to confirm and validate the novel iCTRAM to predict the acceptance of iContract in the construction context and confirm the readiness factors that are required for iContract acceptance. The research design, shown in Figure 2, shows the path of the research from the literature review through to the conclusions and validation of the study. Figure 2 shows both the purpose of each step and the outcomes achieved as the study progressed through the research methodology. This includes a comprehensive literature review which identifies a list of 18 readiness statements that could influence the adoption of the iContract technology, as shown in Table 1. These statements were constructed by drawing relevant iContract specific themes from the literature that had relevance and matched to the philosophy of the original TRI and TAM dimensions. These statements are shown in Table 1 which also references the associated original TRI/TAM item references that the statement is based on. Table 1 also shows the relevant literature review reference that each statement is drawn from. This follows closely the methodology of the TRAM theory in modifying TRI and TAM statements to a specific technology concept (Lin *et al.*, 2007).

The specific readiness and acceptance statements and their categorisation were also validated by five subject matter experts, from industry and academia, during the pilot study

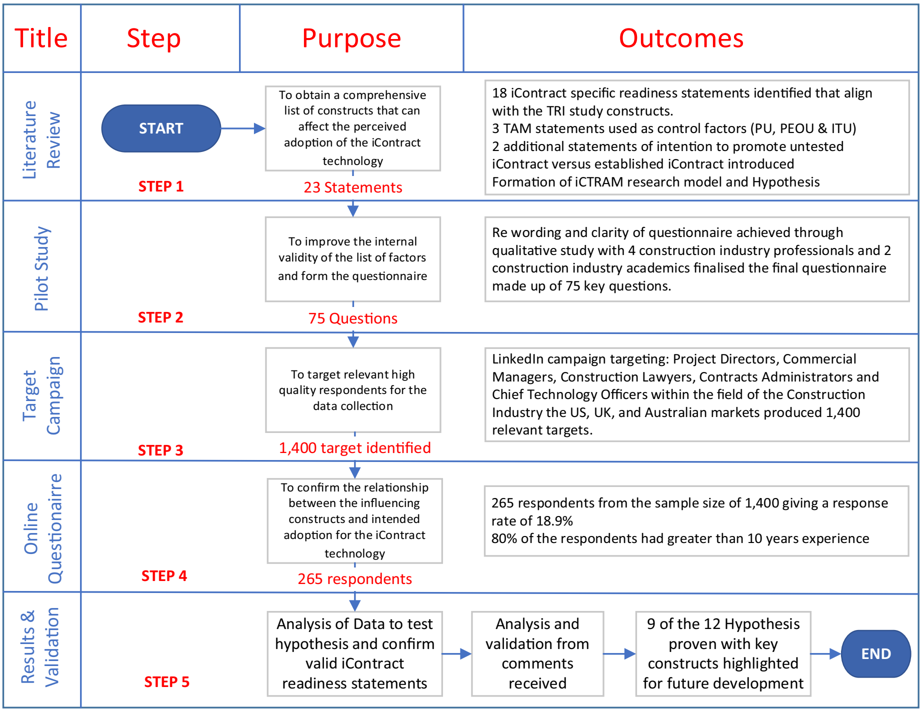

Figure 2.
Research design flowchart including five key steps of developing iCTRAM and conducting a structured survey and hypothesis testing process

phase of the process as described in Section 3.1. As such, it is expected that their experience on innovative technology in the construction industry helped improve and validate the list of statements in Table 1. This follows the qualitative process of constructing readiness statements from the cumulative experience of the author and other subject matter experts before refining the scale through an extensive quantitative phase to assess the scale's psychometric soundness (Parasuraman and Colby, 2015).

In addition to these causational readiness statements, the three TAM control factors of PU, PEOU and intention to use were included in the questionnaire again following the TRAM theory methodology (Lin *et al.*, 2007). Two further factors of intention to promote an untested and established version of the iContract were also gathered to gather predicted usage due, as the iContract is yet to be produced and used.

The overall structure of the questionnaire was based on the four established dimensions from the TRI adapted to incorporate the specifics of the iContract concept. The adapted TRI questionnaire covered 23 specific iContract statements, as shown in Table 1, and included a total of 75 iContract-specific questions to form the questionnaire and evaluate the proposed model. The clarity and structure of the questionnaire was modified and finalised based on the feedback by subject matter experts during the pilot study phase of the process as described in Section 3.1.

Following the methodology of (Parasuraman and Colby, 2015; Lin *et al.*, 2007), this study collected data from an industry wide online questionnaire aimed at construction professionals who had significant exposure to working with construction contracts to return relevant data. The details of the data collection method and sample size and are set out in Section 3.3.

4.1 Pilot study

A pilot survey was conducted to enhance the reliability of the research instrument and clarity of the questionnaire. Other than the research team, six professionals were invited to take part in the pilot study and provide some critical feedback on the structured questions and the online version of the questionnaire in one-on-one interview meetings that included three Construction Project Managers, one Construction Software Vendor and two Construction Academics. Several issues were raised regarding the direction and language of the questionnaire along with some critique of the clarity of some sections. It was found that the overall purpose of the information and questions were overly based on a conceptual idea (the iContract) rather than the respondents own experiences and thoughts on current contractual practices which was rectified. By focusing on actual experience, the data collected is more robust, as it is anchored to an actual event or experience of the respondent rather than thoughts and feelings of a conceptual ideology. The relevance of the iContract themes drawn from the literature and how the proposed iContract specific readiness and acceptance statements aligned with the original TRI/TAM statements were also discussed and validated during this phase. The questionnaire was subsequently revised to allow a more informed opinion on how respondents would perceive an iContract to impact their work.

4.2 Data collection

This study employed a quantitative research approach and used a structured online questionnaire as the only instrument to collect data. A two-part survey instrument was designed to collect data for the study. In the first part, participants were asked to provide their demographic and professional background information along with their construction technology experience. Control questions were used to disregard irrelevant data, such as minimal construction contractual exposure, lack of experience and lack of understanding of the iContract concept. This filtered out any irrelevant respondents by ending the survey immediately and therefore not diluting the data with uninformed responses. Moderator questions assessing the respondent's attitude to innovation and exposure to different construction technologies were also used to reveal the respondent's technology maturity.

In the second part of the questionnaire, the participants indicated their level of agreement with 62 questions relevant to the 23 key readiness and acceptance statements. These statements were adopted from the prior relevant literature and modified for suitability to the iContract context. Each statement was measured on a five-point Likert scale, from 1 = strongly agree to 5 = strongly disagree with a select few statements having an additional "I don't know" option because of the more specific nature of these statements requiring very specific experience. Offering an "I don't know" option for these select statements maintained the integrity of the data by ensuring the data set was not diluted by potential guesses to these statements.

The data was collected by distributing the online questionnaire link via a LinkedIn messaging campaign in early 2020 which targeted construction professional members globally. This resulted in a total of 265 respondents, giving a complete submission, from an initial target pool of 1,400 constituting an acceptable 18.9% response rate. The process was managed by implementing a Customer Relationship Management plug in tool to the LinkedIn platform. Specific searches of relevant professionals were carried out based on job titles; Project Director, Commercial Manager, Construction Lawyer, Contracts Administrator and Chief Technology Officer within the field of the Construction Industry within the US, UK and Australian markets, with approximately 1,400 of the targets invited to participate in the survey.

5. Results

5.1 Descriptive and demographic statistics

The majority of respondents were based in Australia (67%), of which 62% of respondents have greater than 15 years of experience, 18% have between 10 and 15 years, 14% with 5–10 years and 6% have less than 5% years' experience working in the construction industry. Most respondents were Project Managers (40%), 15% Quantity Surveyors, 12% client/owners, with 10% consulting engineers. The remainder were from varied professional background. Another metric captured was the respondent's construction contract knowledge/experience. Most respondents (45%) deemed themselves expert users of construction contracts, with 39% classifying as moderate users and 14% as occasional users. About 2% of respondents claimed no knowledge of construction contracts which, as this question was coded as a control question, deemed them ineligible to complete the questionnaire.

Most respondents, 47%, work in the infrastructure sector, 30% in commercial development with the remainder from various other sectors. IT expertise was also captured with 94% deemed to be expert users of basic IT (email, excel, autocad) and 48% classifying themselves as expert users of more advanced construction IT [building information model (BIM), scheduling, project management and other construction software]. About 34% were moderate users of advanced construction software, 15% were occasional users and only 3% non-users. The majority of respondents were categorised from highly risk adverse to true innovators on the (Rogers and Shoemaker, 1971) scale of innovativeness, with only 7% deemed to be risk adverse or reliant on traditional methods.

5.2 Validity and reliability

To test the hypotheses presented in Figure 1 (iCTRAM model) and to test each hypothesis of this study, structural equation modelling was performed. More specifically, several tests of validity of the relationships among variables and their corresponding strengths were applied. These tests include construct reliability (Table 2), discriminant validity (Table 3) and path coefficient estimations (Table 4).

For the construct reliability (Table 2), a threshold value higher than the 0.6 threshold that is recommended for Cronbach's alpha (Cronbach, 1951) is applied. For composite reliability (Nunnally, 1978) and average variance extracted (AVE), Fornell and Larcker (1981) suggest that AVE requires to have a value higher than 0.5 so that the reliability of a model can be confirmed. As seen in Table 2, all these criteria are met for all the latent variables (i.e. constructs). Validity of the model for the security dimension is confirmed based on both Cronbach's alpha and composite reliability; however, its corresponding AVE is not above 0.5 but very close to this threshold. Therefore, the results of the construct reliability tests validate that almost all criteria were satisfactory since they are above the recommended values.

Besides construct reliability, it is required to determine that the constructs are distinct (Hair, 2009). To do so, Chin (1998) suggest testing whether the correlations of the variables for one construct are stronger than for the other constructs of the model. Additionally, Fornell and Larcker (1981) as well as (Hair, 2009) recommend that the variables of the construct needs to be independent. To test this independency and the expected correlation, AVE was applied.

The results of square root of AVE in the diagonal cells of Table 3 shows that these values are all above the recommended threshold of 0.7 and are higher for one construct compared to

Dimension/Factor	Cronbach's alpha Above 0.6	rho_A	CR	AVE	Q^2 (= 1 − SSE/SSO)	R square	R square adjusted
Comfort	0.836	0.844	0.884	0.605	–	–	–
Innovativeness	0.635	0.789	0.799	0.590	–	–	–
Intention to use iContract	1.000	1.000	1.000	1.000	0.552	0.569	0.566
Optimism	0.806	0.842	0.869	0.581	–	–	–
Perceived ease of use	1.000	1.000	1.000	1.000	0.426	0.462	0.453
Perceived usefulness	1.000	1.000	1.000	1.000	0.500	0.529	0.521
Security	0.715	0.751	0.813	0.471	–		
Usage behaviour	0.763	0.763	0.894	0.808	0.343	0.430	0.428

Notes: Cronbach's alpha; CR = composite reliability; AVE = average variance extracted

Table 2. Construct reliability tests outcomes

Dimension/Factor	Comfort	Innovativeness	Intention to use iContract	Optimism	Perceived ease of use	Perceived usefulness	Security	Usage behaviour
Comfort	0.778							
Innovativeness	0.648	0.768						
Intention to use iContract	0.530	0.544	1.000					
Optimism	0.702	0.777	0.629	0.762				
Perceived ease of use	0.603	0.569	0.655	0.598	1.000			
Perceived usefulness	0.579	0.649	0.699	0.657	0.616	1.000		
Security	0.720	0.656	0.535	0.668	0.610	0.644	0.687	
Usage behaviour	0.518	0.483	0.656	0.538	0.639	0.572	0.475	0.899

Table 3. Discriminant validity based on Fornell–Larcker

Table 4.
Summary of the outcome of validity tests for the structural iCTRAM including estimated path coefficients with *t*-values

Hypothesis	Path	Original sample (O)	Sample mean (M)	SD	*T* statistics	*p*-values	Inner VIF	f^2	Accept/ reject significance
H1a	Optimism → perceived usefulness	0.248	0.251	0.099	2.500	0.013	3.117	0.042	Supported
H1b	Optimism → Perceived ease of use	0.184	0.179	0.100	1.838	0.067	3.117	0.020	Not supported
H2a	Innovativeness → Perceived usefulness	0.237	0.231	0.099	2.397	0.017	2.787	0.043	Supported
H2b	Innovativeness → Perceived ease of use	0.123	0.122	0.099	1.240	0.216	2.787	0.010	Not supported
H3a	Comfort → Perceived usefulness	0.040	0.038	0.076	0.530	0.596	2.569	0.001	Not supported
H3b	Comfort → Perceived ease of use	0.211	0.213	0.082	2.570	0.010	2.569	0.032	Supported
H4a	Security → Perceived usefulness	0.293	0.299	0.086	3.396	0.001	2.439	0.075	Supported
H4b	Security → Perceived ease of use	0.254	0.259	0.081	3.124	0.002	2.439	0.049	Supported
H5	Perceived usefulness→ Intention to use iContract	0.476	0.476	0.062	7.683	0.000	1.612	0.327	Supported
H6	Perceived ease of use → Intention to use iContract	0.361	0.359	0.056	6.481	0.000	1.612	0.188	Supported
H7	Intention to use iContract → Usage behaviour	0.656	0.653	0.050	13.217	0.000	1	0.754	Supported

the other corresponding inter-variable correlations. The only exception is for the security dimension that is very close to 0.7.

5.3 Intelligent contracts technology readiness acceptance model paths and validation tests

In this study, a bootstrapping algorithm is also applied so that a two-tailed *t*-test can be computed. For the bootstrapping algorithm, 5,000 subsamples were created with the original data. For a 95% of confidence level, the null hypothesis can be rejected (so the statistical significance of the relationships in the hypotheses will be proved) if the value of *t*-test is obtained equal or greater than 1.96 (Hair, 2009) and the corresponding *p*-value is achieved to be less than 0.05. Table 4 shows the *t*-tests and *p*-values obtained for all the hypotheses in the model (Figure 1). The values of the *t*-tests and *p*-values do not meet the above-mentioned criteria for the two hypotheses, *H2b*, *H3a* and *H1b*. Therefore, these hypotheses are not supported meaning that the relationship among the constructs in these hypotheses are not statistically significant.

There is another indicator in Table 4, i.e. f^2, representing the effect size. Effect size is calculated to find the level of the impact of independent variables on dependent variables. Hair *et al.* (2014) suggests that thresholds up to 0.02, 0.15 and 0.35 for the f^2 are required to distinguish weak, moderate and large effects of the models, respectively. As seen in the table, except for the low impact of *H2b* and *H3a*, the effect size of other results in Table 4 varies between 0.02 and 0.754 which fall within the thresholds between moderate to large.

The inner variance inflation factor (VIF) indicator is also computed to understand whether there is collinearity among the variables in the study. A threshold less than 5 is considered for the VIF to ensure that there is no problem of collinearity and (Henseler *et al.*, 2009) discuss that higher values than 10 for the VIF represent harmful collinearity among independent and dependant variables. In this study, as seen in Table 4, all the VIF values are obtained less than 5, so all the hypotheses meet this criterion.

5.4 Discussion

This study showed an extremely positive response to the future acceptance of the iContract technology with 84% of respondents confirming an intention to use the technology when available as opposed to only 2% disagreeing which exhibits a desire for the evolution of traditional contractual practice into the digital age.

> I firmly believe the industry requires clarity around the contracts, and that an iContract platform would assist [. . .] It is high time for our industry to go digital and leverage the sustainable competitive advantages embedded in technology [. . .] The iContract concept would be a positive attempt to improve upon the adversarial nature of the Construction industry [. . .]

Based on the values of *t*-test, *p*-value, effect size, f^2 and inner VIF, shown in Table 4, we found that eight hypotheses are supported and three hypotheses of *H1b*, *H2b* and *H3a* are not supported. In the structural model demonstrated in Figure 3, path coefficients are demonstrated along with the *t*-test values in parentheses among the latent variables. *T*-values of the variables and their corresponding latent variables (constructs) are also demonstrated in Figure 3.

Table 4 provides an overview of the hypothesis results. The analysis of the data clearly shows the most significant readiness dimension, affecting the expected acceptance of an iContract solution, being “security” because of both hypotheses being strongly supported in their effects on intended user adoption. The others follow with one hypothesis supported and one rejected for each. Based on the level of the validity scores in both supported and

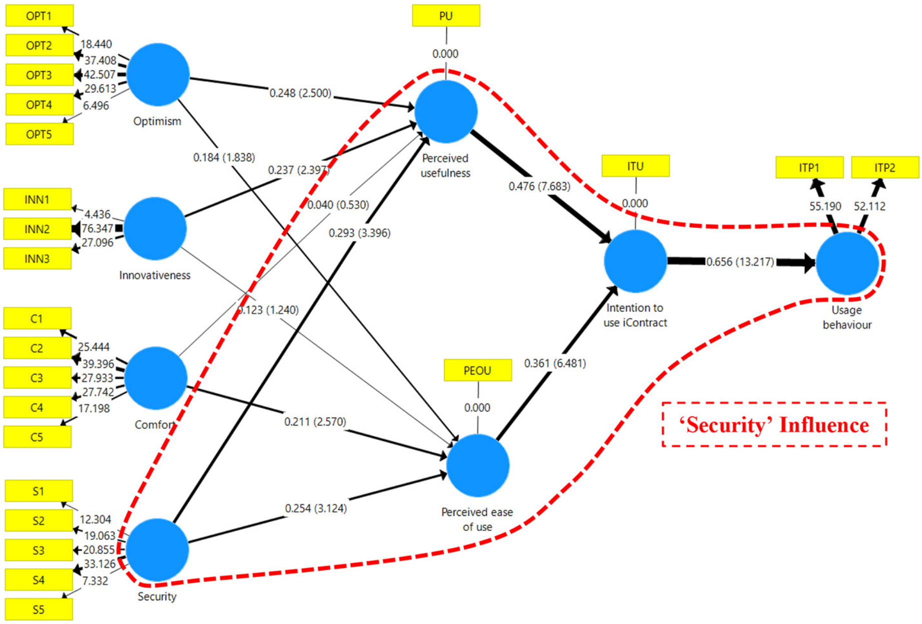

Figure 3.
Structural model demonstrating path coefficients and *t*-values

unsupported hypotheses, the priority of the readiness dimensions within the proposed iCTRAM model can be shown as follows (strongest to weakest):

- security;
- optimism;
- innovativeness; and
- comfort.

5.4.1 Security. H4a (t = 3.39, p = 0.01) and *H4b* (t = 3.12, $p < 0.05$) are both supported and suggest that the security a user feels in terms of the trust one must have in the future iContract will positively reflect their PEOU and PU. This is not in keeping with previous literature where a negative correlation was not found between a person's "insecurity" and PEOU/PU (Godoe and Johansen, 2012; Walczuch *et al.*, 2007, Van Compernolle *et al.*, 2018).

The two strongest statements validated was S3 assuming that an iContracts contractual terms would be more transparent than traditional contracts and S4 the belief that the iContract would be more effective when searching for contractual information. These really speak to the superior approach digitilisation would bring to the contractual process in terms of both, the logical nature of the process offering greater transparency of data and the optimisation of data searching and analysis within the digital environment. The validation that an iContract solution could offer greater security of data and process over traditional methods thereby positively influencing both PU and PEOU is highlighted. Security and efficiency of data was a recuring theme from the respondents with many instilling the need for secure and appropriate data:

> Trust is built over time, and too many projects have been let down by poor data/system integrity [. . ..]. Data integrity and data maintenance will be key for iContracts.

5.4.2 Optimism. Optimism concerns the positive attitude towards technology such as one's perceived level of control, the technology's flexibility, convenience and efficiency (Parasuraman, 2000). *H1a* was supported with the dimension seen to positively influence PU (t = 2.50, p < 0.05). The strongest statement validated was Optimism3, the belief that iContracts offers a more accurate contract administration process, highlighting the optimism and appetite for an alternative to traditional error prone contract administrative practice.

H1b is rejected because the correlation is not statistically significant (t = 1.83, p > 0.05). For people to be optimistic, it is particularly essential that they are confident that the technology is under their control (Dabholkar, 1996). The barrier of control and confidence in data sophistication would explain why *H1b* was not supported. The following quote from the survey validates that there is still concern in attaining adequate data resulting in an unoptimistic view on whether an iContract would be easy to use:

> The lack of quality data is problematic. iContracts will force this data to be provided; however, its quality could still be poor unless controlled.

5.4.3 Innovativeness. An individual's level of innovative attitude has been shown to be a key element in his/her acceptance of new technologies (Turan *et al.*, 2015). This can be explained by the fact that innovative people are more open to new ideas in general (Kwang and Rodrigues, 2002).

H2a was supported with the dimension seen to positively influence PU (t = 2.39, p < 0.05). The strongest statement validated was Innovativeness2 referring to the participants' belief that digitalisation of the contractual process (iContracts) will improve the performance of a construction project. This highlights that there is a high confidence that the innovative iContract solution can positively impact project delivery through evolution of contractual practice.

Similar to the influence of optimism on PEOU (*H1b*), the result of testing *H2b* show that innovativeness is not related to PEOU (t = 1.24, p > 0.05). This highlights that, while optimism and innovativeness have a positive influence on the PU and potential that users expect from the iContract technology, the unknown usability of the technology within the contractual process is still a barrier for user's perceptions at this concept stage. This is validated by the following quote from the survey:

> It is difficult to respond on how iContracts will improve efficiency without trial-based evidence.

5.4.4 Comfort. H3a is not supported (t = 0.53, p > 0.05) because the correlation is not statistically significant which is not consistent with some of previous papers in other fields (Igbaria *et al.*, 1994) where discomfort negatively influenced PU. However, *H3b*, the relationship between comfort and PEOU, is supported (t = 2.57, p = 0.01). The strongest statement validated in the comfort dimension was C2 referring to the willingness to sacrifice flexibility of traditional contract drafting to adopt iContracts. This is a positive sign of a potential adopter's willingness to move away from traditional contracts to a "codified" iContract without sacrificing ease of use. These results imply that if people are comfortable with the iContract concept, they will be more likely to perceive it to being easy to use, but it was clear from many respondents that further development and establishment of the concept is required to provide comfort in an iContract's ability to replace current practice. This is validated by the following quotes from the survey:

> To be comfortable with what is proposed, a better understanding [. . ..] would need to be provided.

> I do think that there could be some level of automation in this but would not be comfortable with full automation.

In line with the original TRAM findings of Lin *et al.* (2007), we see that *H5* (t = 7.68, p = 0.000) and *H6* (t = 6.48, p = 0.000) are strongly supported, demonstrating the strong positive influence of PEOU and PU on the intention to use iContracts. This proves that the overall perceived "ease of uses" of the conceptual iContract technology is associated with the use intention as seen in previous studies (Van Compernolle *et al.*, 2018; Venkatesh and Bala, 2008; Godoe and Johansen, 2012). The stronger correlation of PU and intention to use over the relationship between PEOU and intention to use is also in keeping with the original findings of TAM (Venkatesh and Bala, 2008).

Lastly, *H7* (t = 13.21, p = 0.000) is strongly supported which is in keeping with the previous TAM study showing a correlation between intention to use and positive usage behavior (Venkatesh and Davis, 2000). The results show a slightly more positive result (84% positive) for the promotion of an established iContract versus an initial "prototype" of the technology (68% positive), which was expected given the additional "safety net" established technology provides:

> I am somewhat comfortable with IT systems taking on these traditional contract administration roles – I say this based on a fully matured and tested system.

As seen in Figure 3, based on the path coefficients and t-values, "PU" and "PEOU" both positively influence a respondent's intention to use an iContract. The "security" dimension holds the both the strongest influence over PU and PEOU showing that the pathway to successful iContract development and adoption is to prioritise this dimension.

Table 4 shows that, in line with previous studies, that PU of an iContract is a stronger factor on intention to use over PEOU. Out of the three hypothesis proven, it is seen that tr dimension of "security" has the largest influence of PU followed by "optimism" and "innovation". This is a result of a user's requirement for a "secure" contractual mechanism to run projects such is the importance of infallibility of the contract to any construction project. "Security" was also proven to have the most positive impact on PEOU solidifying the significance of this dimension. Focus on the data management and technology environment contributing an iContract's inputs and outputs and the need for infallibility of data in the process is therefore highlighted by the strength of this metric. "Optimism" was also seen to be impactful to both PU and PEOU framing the belief that an optimistic outlook to the iContract has a significant impact on the PU and PEOU of the concept. The TR dimension of comfort was not seen to be an indicator of PU but was proven as an indicator for PEOU which was seen to be a sign that a user's comfort in using a technology has no direct relation on the user's PU of an iContract. However, "comfort" would prove to be the strongest indicator of PEOU showing this is still an important dimension to improve the usability of the iContract concept. Innovativeness was shown to have the opposite effect by having a positive correlation on PU but minimal impact on PEOU.

The practical implication of this investigation lies in highlighting the required readiness factors to be addressed in order for an iContract solution to be developed and accepted by industry. The iCTRAM can also be applied to other data sets to either validate the findings of this study or identify alternate focus for bespoke iContract solution development. Also, the accepted hypothesis based on the conducted survey reveals that security and trust in an iContract solution should therefore be a focus for iContract developers with the specific importance of the following factors being highlighted within this dimension:

- security in not sharing sensitive data with the wrong parties;
- more collaborative contractual practice;

- greater transparency of the contract environment;
- effectiveness of data retrieval; and
- trusting an iContract system with appropriate human hold points.

Taking these insights into consideration by integrating these findings of the iCTRAM in future, iContract development will maximise acceptance by the industry for an iContract solution. This study identifies several measures to address data concerns that should inform development of an iContract solution. The huge potential to incorporate blockchain technology to facilitate a transparent and decentralised data environment, incorporating a data environment around the iContract to enable seamless data retrieval and facilitating human hold points within a future iContract system are confirmed by the iCTRAM as priorities for the construction industry in accepting an iContract software solution.

6. Conclusion

This paper aimed to identify the key factors affecting user's adoption of the iContract technology through the lens of the established TRAM, TRI and TAM frameworks. The paper, consequentially, developed a novel conceptual model, the iCTRAM, that can be used to assist the development of the iContract concept by highlighting the key iContract specific readiness and acceptance areas to be addressed to inform clear pathways for iContract adoption in the construction sector. The novel model, validated by the data collected from 256 respondents, proved eight of the eleven hypothesis therefore showing key factors needed to inform the development of a successfully adjusted iContract system.

The iCTRAM- and iContract-specific readiness and acceptance statements can be used in bespoke applications for iContract investigations in organisations or alternate geographical locations with differing data sets to further the iContract body of knowledge. With the accelerating digital landscape occurring within the construction sector as part of the Industry 4.0 movement, the iCTRAM model can be used as an informative tool in the development of tailored solutions within differing environments, both from and organisation, geographical and even digital maturity perspective. Application of the iCTRAM can be applied using differing data sets to determine the necessary acceptance criteria for the iContract in specific organisations or geographical locations to inform specific iContract application development. Unlike previous studies focusing on BIM, this study addresses the gap in the knowledge by identifying and confirming key influential factors of the iContract acceptant and the relationship among these factors and the readiness variables. The implications of this are the focus on the statements within the "security" dimension as priority when considering the functional requirements during iContract development. The validated iCTRAM has shown that a focus on alleviating contract administration process through digitalisation while maintaining data security with human hold points interfacing throughout a solution's process will be defining factors that will determine acceptance of an iContract within the industry.

The theoretical contribution of this paper to the body of knowledge is to develop a framework for predicting iContract adoption by the integration and adjustments to the TRAM and TAM frameworks. Key relationships and correlations were identified between the iContract-specific readiness dimensions and the established TAM framework building on TRAM and TAM which are reliable models but are limited in their general nature, as they are not targeted to any specific technology. This paper offers 18 new factors influencing TR of the iContract technology which was formulated from a comprehensive literature review in alignment with the original TRI framework. In addition, three control constructs of PU, PEOU and intention to use were considered in the modified model to combine the TAM framework. Because of the predictive nature of the study, on account of the iContract not being in use yet, two further constructs of intention to promote the iContract were also collected to ascertain the prospective appetite from the industry for the technology in the near future. The interpretation of the findings through the iCTRAM framework shown in Section 6 has highlighted the areas for future investigations and development of the iContract technology. The strength and weakness of the proposed iCTRAM hypothesis, shown through the data validation analysis, has given previously unknown insights on future areas of focus for further iContract technology investigation and development. The study has also highlighted the value in modifying the TRAM framework to a technology specific application given the focus of future development the iCTRAM has highlighted in this study.

This study for the first time proposes a conceptual model for the further development of the iContract technology in the construction industry, thus providing an understanding of the relationships between the influential factors for both the academics and industry practitioners. It gives insight into the key areas that developers can focus on to ensure any solution addresses the needs of the industry. The proposed iCTRAM also offers a predictive tool to assess the readiness of construction practitioners for the adoption of the iContract technology and to highlight areas to be addressed to ensure alignment with the needs of the organisation and successful implementation of the technology.

There are a few limitations that can be considered in the future investigations. Firstly, the 18 factors identified from the literature review may not be exhaustive with the passage of time. Additionally, the single-source data are very likely to cause common method biases which is a common limitation of studies using questionnaire survey. The limitation of respondents being asked their opinion or perceptions on a future technology, while 93% of respondents believed they had a good understanding of the iContract concept, can also be viewed speculatively which is a challenge and a barrier when dealing with conceptual proposals. Lastly, the findings from this study were, for the majority, from respondents within Australia, which may be different from the context of other countries. Further application if the iCTRAM within varying organisational and geographical backgrounds would further increase the body of knowledge in this embryonic field.

Future studies should investigate the precise pain points within the contractual process that offer an opportunity to not only offer an automated solution through the iContract concept but also shape any solution through the lens of the iCTRAM model offered by this study to maximise adoption throughout the industry. While this approach will benefit the development of the iContract concept to an actual artefact, revision of the model, when actual usage of the technology is possible, is something that would benefit organisational adoption strategies.

References

Acheampong, P., Zhiwen, L., Antwi, H.A., Otoo, A., Mensah, W.G. and Sarpong, P.B. (2017), "Hybridizing an extended technology readiness index with technology acceptance model (TAM) to predict e-payment adoption in Ghana", *American Journal of Multidisciplinary Research*, Vol. 5, pp. 172-184.

Al Yahya, M., Skitmore, M., Bridge, A., Nepal, M. and Cattell, D. (2018), "E-tendering readiness in construction: the posterior model", *Construction Innovation*, Vol. 18 No. 2, pp. 183-205.

ARCADIS (2020), "Global disputes report 2020: Collaborating to achieve project excellence", Arcadis.

Atuahene, B.T., Kanjanabootra, S. and Gajendran, T. (2018), "Towards an integrated framework of big data capabilities in the construction industry: a systematic literature review", *34th Annual Association of Researchers in Construction Management Conference, 3-5 September, 2018 2018 Belfast, United kingdom. Association of Researchers in Construction Management*, pp. 547-556.

Bartlett, K., Ribeirinho, M.J., Blanco, J.L., Johnson, J., Fitzgerald, B. and Mullin, A. (2020), *Rise of the Platform Era: The Next Chapter in Construction Technology*, McKinsey and Company, Zurich, Switzerland.

Bertrand, M. and Bouchard, S. (2008), "Applying the technology acceptance model to VR with people who are favorable to its use", *Journal of Cyber Therapy and Rehabilitation*, Vol. 1, pp. 200-210.

Bock, T. (2015), "The future of construction automation: technological disruption and the upcoming ubiquity of robotics", *Automation in Construction*, Vol. 59, pp. 113-121.

Cardeira, H. (2015), *Smart Contracts and Their Applications to the Construction Industry. 2015 Bucharest*, Romanian Society of Construction Law, Bucharest.

Cardeira, H. (2017), *The Benefits of Integrating Smart Contracts and BIM during Construction*, Unpublished, Sydney.

Cardenas, I.S. and Kim, J.H. (2018), "Robot-human agreements and financial transactions enabled by a blockchain and smart contracts", *Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, ACM, pp. 337-338.

Chern, C. (2010), *The Law of Construction Disputes*, Routledge, London.

Chin, W.W. (1998), "Commentary: issues and opinion on structural equation modeling", JSTOR.

Cronbach, L.J. (1951), "Coefficient alpha and the internal structure of tests", *Psychometrika*, Vol. 16 No. 3, pp. 297-334.

Dabholkar, P.A. (1996), "Consumer evaluations of new technology-based self-service options: an investigation of alternative models of service quality", *International Journal of Research in Marketing*, Vol. 13 No. 1, pp. 29-51.

Davis, F.D. (1985), *A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results*, MA Institute of Technology, Boston.

Davis, F.D. (1989), "Perceived usefulness, perceived ease of use, and user acceptance of information technology", *MIS Quarterly*, Vol. 13 No. 3, pp. 319-340.

Edirisinghe, R. (2019), "Digital skin of the construction site: Smart sensor technologies towards the future smart construction site", *Engineering, Construction and Architectural Management*, Vol. 26 No. 2, pp. 184-223.

Fornell, C. and Larcker, D.F. (1981), "Evaluating structural equation models with unobservable variables and measurement error", *Journal of Marketing Research*, Vol. 18 No. 1, pp. 39-50.

Godoe, P. and Johansen, T. (2012), "Understanding adoption of new technologies: technology readiness and technology acceptance as an integrated concept", *Journal of European Psychology Students*, Vol. 3 No. 1, pp. 38-52.

Hair, J.F., Jr., Sarstedt, M., Hopkins, L. and Kuppelwieser, V.G. (2014), "Partial least squares structural equation modeling (PLS-SEM): an emerging tool in business research", *European Business Review*, Vol. 26 No. 2, pp. 106-121.

Hair, J.F. (2009), "Multivariate data analysis".

Henseler, J., Ringle, C.M. and Sinkovics, R.R. (2009), "The use of partial least squares path modeling in international marketing", in Sinkovics, R.R. and Ghauri, P.N. (Eds), *New Challenges to International Marketing*, Emerald Group Publishing.

Igbaria, M., Schiffman, S.J. and Wieckowski, T.J. (1994), "The respective roles of perceived usefulness and perceived fun in the acceptance of microcomputer technology", *Behaviour and Information Technology*, Vol. 13 No. 6, pp. 349-361.

Kim, K.J. and Shin, D.-H. (2015), "An acceptance model for smart watches", *Internet Research*, Vol. 25 No. 4, pp. 527-541.

Kim, J., Geum, Y. and Park, Y. (2017), "Integrating customers' disparate technology readiness into technological requirement analysis: an extended Kano approach", *Total Quality Management and Business Excellence*, Vol. 28 Nos 5/6, pp. 678-694.

Koulu, R. (2016), "Blockchains and online dispute resolution: smart contracts as an alternative to enforcement", *SCRIPTed*, Vol. 13 No. 1, pp. 40-69.

Koutsogiannis, A. and Berntsen, N. (2017), "Blockchain and construction: the how, why and when", BIMPlus.

Kwang, N.A. and Rodrigues, D. (2002), "A big–five personality profile of the adaptor and innovator", *The Journal of Creative Behavior*, Vol. 36 No. 4, pp. 254-268.

Lai, Y.L. and Lee, J. (2020), "Integration of technology readiness index (TRI) into the technology acceptance model (TAM) for explaining behavior in adoption of BIM", *Asian Education Studies*, Vol. 5 No. 2, p. 10.

Li, J., Greenwood, D. and Kassem, M. (2019), "Blockchain in the built environment and construction industry: a systematic review, conceptual models and practical use cases", *Automation in Construction*, Vol. 102, pp. 288-307.

Lin, J.S.C. and Chang, H.C. (2011), "The role of technology readiness in self-service technology acceptance", *Managing Service Quality: An International Journal*, Vol. 21 No. 4, pp. 424-444.

Lin, J.S.C. and Hsieh, P.L. (2012), "Refinement of the technology readiness index scale", *Journal of Service Management*, Vol. 23 No. 1, pp. 34-53.

Lin, C.H., Shih, H.Y. and Sher, P.J. (2007), "Integrating technology readiness into technology acceptance: the TRAM model", *Psychology and Marketing*, Vol. 24 No. 7, pp. 641-657.

Lin, C.-H., Shih, H.-Y., Sher, P.J. and Wang, Y.-L. (2005), "Consumer adoption of e-service: integrating technology readiness with the technology acceptance model", *A Unifying Discipline for Melting the Boundaries Technology Management*, *IEEE*, pp. 483-488.

Lule, I., Omwansa, T.K. and Waema, T.M. (2012), "Application of technology acceptance model (TAM) in m-banking adoption in Kenya", *International Journal of Computing and ICT Research*, Vol. 6 No. 1, pp. 31-43.

Mcnamara, A. and Sepasgozar, S.M. (2018), "Barriers and drivers of intelligent contract implementation in construction", *42nd Australasian Universities Building Education Association Conference, 2018 Singapore*, pp. 281-293.

Mcnamara, A.J. and Sepasgozar, S.M. (2020), "Developing a theoretical framework for intelligent contract acceptance", *Construction Innovation*, Vol. 20 No. 3, pp. 421-445.

Mcnamara, A.J. and Sepasgozar, S.M. (2021), "Intelligent contract adoption in the construction industry: concept development", *Automation in Construction*, Vol. 122, p. 103452.

Mason, J. and Escott, H. (2018), "Smart contracts in construction: views and perceptions of stakeholders", *Proceedings of FIG Conference, Istanbul May 2018*.

Mason, J. (2017), "Intelligent contracts and the construction industry", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, Vol. 9 No. 3, pp. 1-6.

Mason, J. (2019), "BIM fork: are smart contracts in construction more likely to prosper with or without BIM?", *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, Vol. 11 No. 4, p. 2519002.

Mathews, M., Robles, D. and Bowe, B. (2017), "BIM+ blockchain: a solution to the trust problem in collaboration?".

Nunnally, J.C. (1978), "An overview of psychological measurement", in Wolman, B.B. (Ed.), *Clinical Diagnosis of Mental Disorders A Handbook*, Boston, MA, Springer US, pp. 97-146.

Oesterreich, T.D. and Teuteberg, F. (2016), "Understanding the implications of digitisation and automation in the context of industry 4.0: a triangulation approach and elements of a research agenda for the construction industry", *Computers in Industry*, Vol. 83, pp. 121-139.

Ooi, K.-B. and Tan, G.W.-H. (2016), "Mobile technology acceptance model: an investigation using mobile users to explore smartphone credit card", *Expert Systems with Applications*, Vol. 59, pp. 33-46.

Parasuraman, A. and Colby, C.L. (2015), "An updated and streamlined technology readiness index: TRI 2.0", *Journal of Service Research*, Vol. 18 No. 1, pp. 59-74.

Parasuraman, A. (2000), "Technology readiness index (TRI) a multiple-item scale to measure readiness to embrace new technologies", *Journal of Service Research*, Vol. 2 No. 4, pp. 307-320.

Park, Y., Son, H. and Kim, C. (2012), "Investigating the determinants of construction professionals' acceptance of web-based training: an extension of the technology acceptance model", *Automation in Construction*, Vol. 22, pp. 377-386.

Ribeirinho, M.J., Mischke, J., Strube, G., Sjödin, E., Blanco, J.L., Palter, R., Biörck, J., Rockhill, D. and Andersson, T. (2020), *The Next Normal in Construction: How Disruption is Reshaping the World's Largest Ecosystem*, McKinsey and Company, Zurich, Switzerland.

Rogers, E.M. and Shoemaker, F.F. (1971), "Communication of innovations; a cross-cultural approach".

Sargent, K., Hyland, P. and Sawang, S. (2012), "Factors influencing the adoption of information technology in a construction business", *Australasian Journal of Construction Economics and Building*, Vol. 12, p. 72.

Sepasgozar, S.M., Hawken, S., Sargolzaei, S. and Foroozanfa, M. (2019), "Implementing citizen centric technology in developing smart cities: a model for predicting the acceptance of urban technologies", *Technological Forecasting and Social Change*, Vol. 142, pp. 105-116.

Son, H., Park, Y., Kim, C. and Chou, J.-S. (2012), "Toward an understanding of construction professionals' acceptance of mobile computing devices in South Korea: an extension of the technology acceptance model", *Automation in Construction*, Vol. 28, pp. 82-90.

Turan, A., Tunç, A.Ö. and Zehir, C. (2015), "A theoretical model proposal: personal innovativeness and user involvement as antecedents of unified theory of acceptance and use of technology", *Procedia – Social and Behavioral Sciences*, Vol. 210, pp. 43-51.

Turk, I. and Klinc, R. (2017), "Potentials of blockchain technology for construction management", *Creative Construction Conference, CCC 2017, June 19, 2017–June 22, 2017 Primosten*, *Croatia. Elsevier*, pp. 638-645.

Vaidya, K., Sajeev, A. and Callender, G. (2006), "Critical factors that influence e-procurement implementation success in the public sector", *Journal of Public Procurement*, Vol. 6 Nos 1/2, pp. 70-99.

Van Compernolle, M., Buyle, R., Mannens, E., Vanlishout, Z., Vlassenroot, E. and Mechant, P. (2018), "'Technology readiness and acceptance model' as a predictor for the use intention of data standards in smart cities", *Media and Communication*, Vol. 6, pp. 127-139.

Van Der Heijden, H. (2003), "Factors influencing the usage of websites: the case of a generic portal in the Netherlands", *Information and Management*, Vol. 40 No. 6, pp. 541-549.

Venkatesh, V. and Bala, H. (2008), "Technology acceptance model 3 and a research agenda on interventions", *Decision Sciences*, Vol. 39 No. 2, pp. 273-315.

Venkatesh, V. and Davis, F.D. (2000), "A theoretical extension of the technology acceptance model: four longitudinal field studies", *Management Science*, Vol. 46 No. 2, pp. 186-204.

Walczuch, R., Lemmink, J. and Streukens, S. (2007), "The effect of service employees' technology readiness on technology acceptance", *Information and Management*, Vol. 44 No. 2, pp. 206-215.

Wang, J., Wu, P., Wang, X. and Shou, W. (2017), "The outlook of blockchain technology for construction engineering management", *Frontiers of Engineering Management*, Vol. 4 No. 1, pp. 67-75.

Woodhead, R., Stephenson, P. and Morrey, D. (2018), "Digital construction: from point solutions to IOT ecosystem", *Automation in Construction*, Vol. 93, pp. 35-46.

Yang, K.C. (2005), "Exploring factors affecting the adoption of mobile commerce in Singapore", *Telematics and Informatics*, Vol. 22 No. 3, pp. 257-277.

Corresponding author
Alan J. McNamara can be contacted at: alan_mc9@hotmail.com