Case Study

Cloud Computing Adoption in the Construction Industry of Singapore: Drivers, Challenges, and Strategies

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Abstract: Fragmented knowledge in the construction industry is impeding project operation and success. With useful information and communication technology, the industry can integrate such fragmented knowledge and increase its performance, leading to successful project execution. Strategic implementation of digital technologies such as cloud computing (CC) has provided organizations with enhanced collaboration and communication opportunities. However, limited research has attempted to understand the status quo of CC adoption from the perspectives of the drivers, challenges, and strategies, which would optimize the adoption process and facilitate its successful implementation in the construction industry. Therefore, this study aims to fill the gap with the following research objectives: (1) derive drivers, challenges, and strategies for CC adoption, (2) investigate and analyze the status of CC adoption in the construction industry, and (3) propose feasible recommendations to enhance the CC adoption in the construction industry. To achieve these goals, 9 drivers, 12 challenges, and 7 strategies relevant to the construction industry were identified through a comprehensive literature review, followed by a structured questionnaire survey administered to industry practitioners in the construction industry. Further analyses were conducted to determine if organization size, respondent's experience, and respondent's role influence the drivers, challenges, and strategies, followed by postinterviews conducted to echo the analysis results, and the outcomes could advocate the reliability of the findings from this study. The findings are worthy of note and contribute to the body of knowledge in the sense that this study made a novel effort to firstly examine the perceptions of practitioners on the drivers, challenges, and strategies for CC adoption, including the status quo of its implementation. The assessed CC adoption status serves as a starting point of sustainable development for the industry to reap the benefits throughout the project life cycle. Furthermore, this study provides a guide for construction companies in adopting CC technology, which has shown great potential in improving the building and construction industries' performance and sustainability. **DOI: 10.1061/(ASCE)ME.1943-5479.0001001.** © *2021 American Society of Civil Engineers.*

Author keywords: Digital technology; Information and communication technology; Cloud computing (CC); Technology adoption; Construction industry; Singapore.

Introduction

Innovation and sustainability are essential in the technology industry because they affect business communication and result in ever-changing landscapes (Chesher and Kaura 2012). With a useful communication tool, an organization can perform tasks on time and accomplish more. The convenience of digitally storing data and files enables documentation to be readily available (Inglis et al. 2003). The rise of information and communications technology (ICT) offers tremendous opportunities for improving communication to enhance the effectiveness of construction processes and create business innovations (Peansupap and Walker 2005). Strategic adoption of ICT has not only enhanced the work practices of the architecture, engineering, and construction (AEC) industries, but it has also shifted such work practices to innovative approaches that are necessary to facilitate new and creative alternatives in organizing and operating such organizations (Lu et al. 2015).

Several studies have addressed information technology (IT) adoption implications in the construction industry, which includes the study having identified the positive and negative factors of adopting robotics and automation technology in the US through semistructured interviews (Bademosi and Issa 2021). Hasan et al. (2019) empirically investigated the consequences of using mobile IT and how the use the technology can ultimately affect construction productivity. Based on the necessity of IT in the construction industry, some studies also proposed a decision-making framework to aid in the technology adoption (Nnaji et al. 2019, 2020). Moreover, some case studies were conducted for understanding the behavioral logic of IT adoption (Wang et al. 2020) and implementation process (Sepasgozar et al. 2018). Nevertheless, recent studies have shown that the construction industry has yet to entirely adopt the concept of IT due to various barriers (Peansupap and Walker 2006; Kamar et al. 2009; Alaghbandrad et al. 2011).

In Singapore, the Construction Industry Transformation Map (CITM) that was rolled out by the government calls for a digital revolution through the advent of smart buildings, new construction technologies, and digitalized work processes (BCA 2019a). Digitalized work processes fully integrate the processes and stakeholders along the value chain through advanced ICT and smart technologies (BCA 2018). This digital push encourages the streamlining of work processes and connecting stakeholders across the project life cycle from design, construction, and fabrication to

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Note. This manuscript was submitted on July 21, 2021; approved on October 11, 2021; published online on December 3, 2021. Discussion period open until May 3, 2022; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Management in Engineering***, © ASCE, ISSN 0742-597X.

facilities management. Otherwise, the blurred lines between physical and digital spheres resulting from the fusion of technologies have created a new practice that is referred to as cyber-physical systems. A critical tool that exists within these systems is cloud computing (CC). The role of CC technology in cyber-physical systems (CPS) is that of a centralized platform that serves as a link between the physical system and the cyber system (Guo et al. 2015). A series of actions such as transmission, reception, storage, and processing of data acquired from the physical system is performed in CC, followed by the processed data (information) expressed in the cyber system (Zhang et al. 2015). At this time, the user can decide with the information reflected in the physical system through CC (Simmon et al. 2015).

Although it is not a novel idea, CC aims to interconnect vast computers through a real-time network that provides utility-based IT services (Shyam and Chandrakar 2018). From a business perspective, CC can offer both IT efficiency and business agility to respond in real-time to the user's requirements (Marston et al. 2011). CC is a technology to access computational services offered on the internet, including computing resource services, soft applications of distributed systems, and data storage (Low et al. 2011). In general, CC service is referred to as software, platform, and infrastructure, which is broken into infrastructure as a service, platform as a service, and software as a service (Amarnath et al. 2011). In this study, the adoption of CC is defined as introducing such a service to a company.

The nature of the construction industry is often viewed as conceptually fragmented when compared with other industries (Amarnath et al. 2011). In general, a construction project involves a design and construction phase, followed by the operation and maintenance phases after the project's completion. Information and data shared within each phase influence the project's progress and its quality (Goulding et al. 2014). Errors that could arise due to design flaws, if not acted on promptly, could result in a waste of resources in the following phases (Hong et al. 2016). Strategic implementation of CC has provided contractors with enhanced collaboration and communication opportunities. Provided the nature of the project is suitable, such as that of a large-scale project, CC can serve as a centralized platform for collaborative design for engineers and architects (Amarnath et al. 2011).

Organizations are aware of the benefits that CC provides and its capabilities as the enabler in Singapore's Smart Nation plan (Ng 2018). Additionally, the efforts to push for digitalization are focused on utilizing integrated digital delivery, where CC technology has a crucial role. The government hopes to fully integrate building processes and stakeholders to transform the way buildings are developed. Thus, movements to promote the adoption of IT, such as CC, in the construction industry are highly active in Singapore.

However, there is limited research that attempts to understand the state of CC adoption from a comprehensive perspective, considering what factors influence the introduction of CC into the construction industry, what are the challenges to promoting it, and what are the strategies for promoting the adoption of CC. To address the issues regarding the necessities and limited studies about CC adoption and to promote its successful adoption in Singapore's construction industry, it is essential to identify the drivers, challenges, and strategies that optimize the adoption process. Therefore, this study investigated the perceptions of professionals in Singapore's construction industry concerning the drivers, challenges, and strategies in CC adoption. In particular, the research objectives were to (1) derive the drivers, challenges, and strategies for CC adoption, (2) investigate and analyze the status of CC adoption in the construction industry, and (3) propose feasible recommendations to enhance the CC adoption in the construction industry.

Literature Review

A literature review was conducted extensively to derive and highlight the CC drivers, challenges, and strategies that are practiced in different industries, and was not only limited to the construction industry. Using the keywords of cloud computing and technology adoption in the construction industry, the literature was searched through the search engines of Google and Google scholar. As a result, over 100 publications were reviewed, of which 26 publications from 12 journals, 3 publishers, and 2 government institutions were finally utilized to derive CC drivers, challenges, and strategies.

A total of 9 drivers, 12 challenges, and 7 strategies factors were identified, which were further reviewed and validated by industry practitioners. Additionally, it was found through the literature review that the study of CC adoption in the Singaporean construction industry is limited. Therefore, additional references were considered regarding the adoption of CC technology in other industries as well as in other countries with similar demographics to Singapore's, such as Malaysia and India.

Drivers in CC Adoption

The Singapore government has played a crucial role in the technological push of organizations. Besides the government's efforts, the drivers to encourage such technology adoption are the organization's needs and aims. Table 1 lists the factors that could drive CC adoption in contractor companies. Regarding the Government Plans and Policies Initiatives, the CITM in 2018 includes the government's outlook on Singapore's construction industry in the coming years (BCA 2019a). The CITM's focus is based on the global trend to stimulate a digital revolution in the construction industry. Other than the CITM, the small to medium-sized enterprises (SMEs) Go Digital program introduced in early 2019 is a government initiative that aims to help SMEs build a robust digital capability to seize opportunities for growth in the current digital economy. SMEs can tap into the funds that are available as they search for solutions to funding support (Lee 2019).

Likewise, Technology Advancement has been used by businesses to facilitate decision-making processes (Gatautis and Vitkauskaitė 2009). However, businesses, such as SMEs, have to follow the latest advancements carefully to be more competitive and productive (Boychev 2014). Moving to cloud technology is an innovative solution that facilitates the development of tools that allow organizations to increase productivity and perform tasks on time.

Regarding the Decreased Reliance on Labor driver, the cost of labor is expected to remain high in Singapore because of the shrinking workforce and drop in foreign employment (Pheng and Chuan 2001; Boon et al. 2018). As a result, the construction industry has to seek innovative technological solutions that assist and encourage a reduced dependence on manual labor while increasing productivity. According to a publication by the Centre for Liveable Cities Singapore (2015), the scale and complexity of construction have increased tremendously over the years. The industry's focus has shifted from the need to obtain enough manual labor to using technology and labor-saving initiatives. This shift is considered necessary because the industry faces new challenges, such as the increase in land, workforce, and construction materials costs that come as a result of Singapore's growth and development.

Additionally, the adoption of such cloud technology early on in the business, especially for SMEs, would provide for a more substantial competitiveness (Boychev 2014). Moreover, the adoption of CC in organizations would provide an edge by forging business relationships and long-term alliances that allow the business to stay

Table 1. Drivers in CC adoption

No.	Driver	Description	References
1	Government plans and policies initiative	The Singapore government aims to fully integrate the processes along the value chain with advanced technologies such as CC technology.	Lin et al. (2017)
2	Technology advancement	The advancement in technology has facilitated the development of tools that allow organizations to perform tasks on time as well as achieving even more.	Peansupap and Walker (2005); Taherdoost (2018)
3	Decreased reliance on labor	Labor cost is expected to remain high with the increasing cost of construction materials, which influences tender prices during project procurement. The use of cloud technology would encourage a reduced dependence on manual labor while increasing productivity.	Pheng and Chuan (2001)
4	Competitiveness	Forging relationships and long-term alliances allow for the business to stay ahead of its competitors.	Love et al. (2002)
5	Project life cycle management	Streamlining work processes and connecting stakeholders across the project life cycle. The storage of information and data on the cloud and on a real-time network allows businesses to have access to such information and data no matter where they are.	Shyam and Chandrakar (2018); BCA (2019b)
6	Systematic project management	Systematic project management reduces the chances of errors that would potentially result in a waste of resources. Where the nature of the construction industry is often viewed as conceptually fragmented, enabling information and data accessible in real-time would influence the project's progress and its quality.	Amarnath et al. (2011); Goulding et al. (2014); Hong et al. (2016)
7	Workplace safety and health	Information and data management is being universalized, which enables identifying hazards and promoting workplace safety and health.	Pheng and Chuan (2001); Izvercian et al. (2013); Cioca and Ivascu (2014)
8	Sustainable data management	Reduced paper load and reliance on hard-copied information.	Dastbaz et al. (2015)
9	Business continuity	The reliable and scalable storage nature of CC offers quick access to storage infrastructure by web services and high-performance computing.	Matar and Imad Fakhri (2016)

ahead of its competitors as per Singapore's Smart Nation plan. Therefore, it is envisaged that 70% of Singapore companies plan to adopt CC regardless of the industry (Singapore Business Review 2011).

It is undeniable that the construction industry is perceived as mostly fragmented in terms of Project Life Cycle Management. Extensive information and data are transferred between processes and stakeholders to ensure the proper delivery of the project. The use of CC would streamline these work processes and connect stakeholders across the project life cycle: design phase, construction phase, operation phase, and maintenance phase after the project's completion (Deloitte 2014). The storage of information and data on the cloud and real-time networks allows businesses to have access to such information and data from anywhere (Shyam and Chandrakar 2018).

The success of a construction project can influence the reputation of the organizations involved. Systematic Project Management encompasses the effectiveness and efficiency of project management, which are influenced by the implementation of a systematic and standardized project management system (Guzmán et al. 2016). Because CC can provide information sharing among stakeholders, it could reduce the chances of errors that would potentially result in a waste of resources. A proper systematic design for data collection and real-time information accessibility would positively influence a project's progress and its quality. Furthermore, identification of hazards can be performed more effectively and efficiently to ensure Workplace Safety and Health (WSH) through the information that has been fed into the cloud system. According to Martínez-Rojas et al. (2016), related information on construction safety is often not shared, even among project staff, threatening workforce safety. The strategic adoption of CC and its implementation in construction projects enables effective information sharing among the stakeholders.

Greater awareness of the environment has caused construction companies to be more sustainable and eco-friendly regarding their data management (Flammer 2013). Sustainable Data Management has reduced paper consumption as well as reliance on hard-copy information, with soft-copy information that can be accessed anytime and anywhere with the use of technological devices that offer real-time viewing (Konstantinos 2015). Moreover, having an appropriate business continuity plan (BCP) through proper management is vital for every business or organization in the survival against threats. For Business Continuity, the reliable and scalable storage nature of CC has been considered as a promising technology that offers quick access to storage infrastructure by web services and high-performance computing (Matar and Imad Fakhri 2016).

Challenges in CC Adoption

A challenge in CC adoption is defined as the factor that becomes an obstacle when adopting CC technology. According to

Table 2. Challenges of CC adoption

No.	Challenges	Description	References
1	Organization size	Compared with large companies, SMEs face constraints of resources such as funding and workforce.	Love et al. (2002)
2	Top management support	If top management is resistant to adopt new technology, it will negatively influence the organization, which causes a lack of motivation and implementation efforts.	Premkumar and Potter (1995)
3	Lack of staff expertise	Getting people who are competent in new technology will be required to take up additional job scopes beyond the capabilities of the existing staff. Especially, there is a shortage of personnel within the SME organizations.	Lin et al. (2017)
4	Intellectual property rights	The design and development of the model, copyright on the design, as well as confidentiality of data and information about the project are required.	Lin et al. (2017)
5	Risk ownership	Responsibility for any possible errors if they are shared or transferred to the owner.	Lin et al. (2017)
6	Complexity of new technology	New technologies may not be as user-friendly or easy to use, which decreases the adoption rate because people are reluctant.	Alshamaila et al. (2013)
7	Interface issues	Issues of compatibility and the need to transfer models from an earlier version of the software to a new version could lead to significant downtime and compromise productivity.	Lin et al. (2017)
8	Lack awareness of the relative advantage	The benefits of adopting CC systems are not clear and the opinion is that the existing infrastructure is satisfactory to meet their business operation needs.	Lin et al. (2017); Alshamaila et al. (2013)
9	Sensitivity of data	Level of security of where data is stored. The uncertainty of the exact location of the data storage.	Moravčík et al. (2017)
10	Large initial cost	A great deal of commitment will be required in terms of time, training, and equipment.	Lin et al. (2017); Thong et al. (1996)
11	Maintenance cost	Retraining of staff, the constant need to upgrade technological skills, and maintenance of servers can be an overbudget cost.	Lin et al. (2017)
12	Lack of standards	Lack of standards raises issues of interoperability and manageability among different stakeholders.	Moravčík et al. (2017)

Lin et al. (2017), the challenges that contractor firms face in adopting CC can be categorized into (1) a multidisciplinary approach, (2) uncertainties in legal responsibilities, and (3) technical issues. The complexity of adopting new technology could be the reason for the low adoption in SMEs. Adopting such technology may "confront SMEs with challenges in terms of changing the processes in which they may interact with their business systems" (Parisot 1995). The 12 challenges in the adoption of CC retrieved from the literature are summarized in Table 2.

According to a survey from the Experian Credit Services Singapore Pte (2018), half of all SMEs experience challenges in managing cash flow, liquidity, and credit risk for the year ahead. In comparison with large contractor firms, SMEs face difficulties adopting CC into their business practices due to resource constraints, such as funding and human resources. Because of such limitations, SMEs, by default, lack collaborative capabilities (Love et al. 2002). Therefore, support from top management for the adoption of CC could be a crucial factor that influences the level of implementation of such systems. According to Thong et al. (1996), top management has the authority to influence members of the business and are more likely to succeed in overcoming any form of organizational resistance toward the acceptance of such implementation. Successful implementation is achievable should sufficient organizational resources be directed toward motivating and sustaining the implementation effort. The sufficient allocation of such resources is the catalyst to create a more conducive environment for implementation (Thong et al. 1996).

Strategies to Motivate CC Adoption

After conducting an extensive literature review, seven strategies that could motivate the adoption of CC in Singapore's contractor companies were identified (summarized in Table 3). Distinct Adoption Expectations is a clearly defined advantage that will provide the organization with clear and distinct expectations, which is influenced by the top management's attitude toward CC adoption (Lin et al. 2017). This strategy could be transferred to the company's goal to sustain firm operations in the current competitive market. Clear Direction of Action was highlighted as a challenge where negative top management support would lead to a negative outlook on the adoption of CC in the organization. Hence, where the top management is supportive of the adoption, a designed program will guide and provide the organization with clear and logical processes from the start through to the end of implementation (Adane 2018).

The Cooperation between Different Organizations strategy refers to organizations complementing each other and specializing to overcome prevalent problems, hence obtaining a collective efficiency and penetrating markets that could be beyond their individual reach (Adane 2018). Willingness to Change is the

Table 3. Strategies for promoting CC adoption

No.	Strategy	Description	References
1	Distinct adoption expectations	Clearly defining the organization's competitive advantage in order to sustain itself in the current competitive market.	Lin et al. (2017)
2	Clear direction of action	With the support of top management, design a program that will guide and provide the organization with clear and logical processes from the start to end of implementation.	Barney (2014); Adane (2018)
3	Cooperation between different organizations	A combination of firms with a shared focus that will complement each other and specialize in order to overcome prevalent problems, hence obtaining a collective efficiency and penetrate markets that could be beyond their reach individually.	Adane (2018)
4	Willingness to change	The responsiveness and flexibility of an organization to respond to changes that can come in the form of opportunities and threats. The rate of responsiveness to changing situations is critical for competitive advantage.	Alshamaila et al. (2013)
5	Larger awareness to government incentives	SMEs can take advantage of government incentives that are available to them as a way to encourage CC adoption within the organization.	Ministry of Finance (2019)
6	Reduce capital expenditure	By having a third party control the organization's IT infrastructure, this could reduce expenditure to maintain such infrastructure, yet maximize the asset utilization.	Alshamaila et al. (2013)
7	Standards for cloud computing	The availability of standards to regulate the use of CC in order to raise user confidence.	Branco et al. (2017)

responsiveness and flexibility of an organization to respond to changes, which can come in the form of opportunities and threats. The rate of responsiveness to changing situations is critical for competitive advantage. The willingness of organizations to adopt new technologies is based on the innovativeness of the decision-maker as well as the organizational strategy that is in place (Alshamaila et al. 2013). Regarding the Larger Awareness of Government Incentives, the Singapore government has set aside additional funds to assist SMEs in their new technology adoption quests through the SMEs Go Digital program. Therefore, SMEs can take advantage of government incentives that are available to them as a way to encourage CC adoption (Lee 2019).

By having a third party control the organization's IT infrastructure, the expenditure to maintain such infrastructure could be reduced and the asset utilization maximized. According to Alshamaila et al. (2013), CC offers organizations a vast pool of computing resources that, especially for SMEs, would enable a faster market entrance without the need to produce significant upfront capital investments. Standards for cloud computing have yet to be fully unified and standardized (Moravčík et al. 2017). The lack of standards governing this new IT industry has resulted in the low confidence of users. However, with more standardization bodies coming forward to ensure standards are rolled out for CC, SMEs and large enterprises should have the assurances required to encourage information and data storage.

Methods and Data Collection

As shown in Fig. 1, the factors of drivers, challenges, and strategies were derived through a literature review, and based on this, questionnaire development and surveys were conducted for

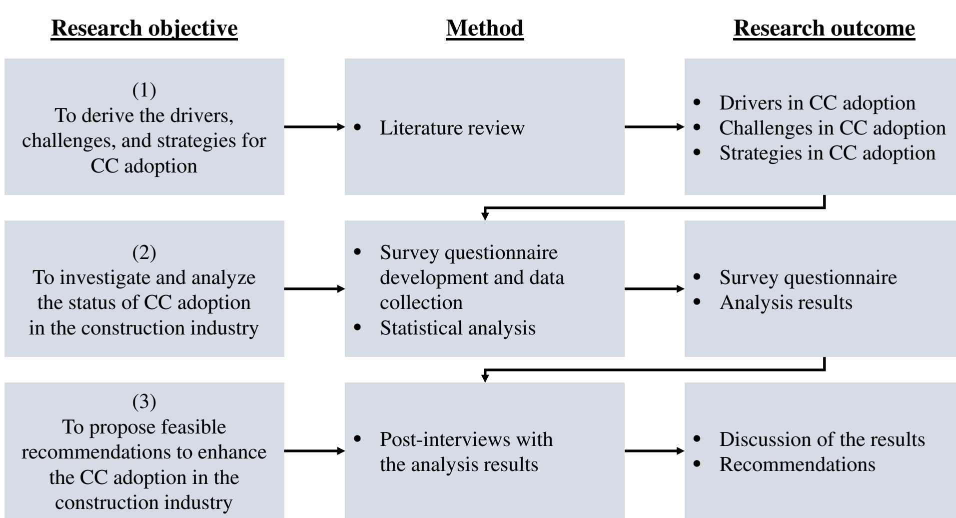

Fig. 1. Research framework.

practitioners. Besides, feasible recommendations were proposed to enhance the construction industry's CC adoption through statistical analysis of survey results and postinterviews.

Survey Questionnaire Development

Based on the literature review, a total of 9 drivers, 12 challenges, and 7 strategies for CC adoption in construction companies were identified. The factors presented were gathered from an extensive literature review and were validated by industry professionals to determine their relevance. An online survey questionnaire was composed to demonstrate the perceptions of Singapore's construction professionals based on these factors. Preceding the distribution of the survey questionnaire, industry practitioners reviewed the survey questionnaire to test its validity and relevance. Singapore construction industry professionals with more than 10 years of experience and good knowledge of CC were consulted. They all anonymously agree with each factor's relevance and validity. There were only minor modifications to the wording. Their feedback was considered, and the relevant changes were made.

The main survey questionnaire was composed using an online survey platform, which was chosen to allow convenient access with a link that was provided to participants. The first three sections of the survey were designed to gather information on respondents' demographics and organization profiles. The fourth section of the survey focused on the organization's CC implementation status. Additionally, the last three sections of the survey listed the 9 drivers, 12 challenges, and 7 strategies in the adoption of CC. The respondents were asked to rate each factor according to a five-point Likert scale (Table 4). Firstly, respondents were asked to provide a rating based on the level of importance of drivers that could influence organizations in adopting CC. The respondents were also asked to check the level of impact and likelihood of challenges that could hinder an organization's decision to adopt CC. Lastly, the strategies were rated based on the respondent's experience. Each factor was rated by the importance of each strategy.

Data Collection

A survey was conducted to investigate the CC adoption status in the construction industry. The targeted respondents were SME contractors and large companies under the Building and Construction Authority (BCA) Contractors Registration System. The BCA registry contains a total of 1,598 contractors that are classified under Grade B2 and below, which have both paid-up capital and a net worth below S$3 million (BCA 2019c). A total of 189 out of the 1,598 contractors were randomly contacted to participate in the survey questionnaire, whereas 107 out of 204 contractors were from large enterprises. In addition, a total of 107 out of 204 contractors from Grade A1 to B1 that have both minimum paid-up capital and a minimum net worth over S$3 million were randomly contacted (BCA 2019c). Among the 296 organizations contacted, 75 companies responded, resulting in a response rate of 25.3%. The profile of the participant organizations is summarized in Table 5, ensuring a balanced and reliable output with high validity.

SMEs made up 64.0% of the responses represented by Grade B2 to C3 companies. Similarly, a total of 27 (36.0%) large enterprises represented by Grade A1 to B1 contractors participated in the survey. Most of the respondents' organizations (85.3%) had fewer than 20 years of experience, which means the majority of the respondents were relatively new firms in the industry. The demographics of the survey respondents consisted of 21 project administrators (28.0%), 11 engineers (14.67%), 5 directors (6.67%), 11 BIM modelers (14.67%), 11 contract managers (14.67%), and 5 supervisors (6.67%), as summarized in Table 5. Each respondent's role and years of experience in their current organization and in the industry are also given.

Additionally, postinterviews were conducted with three industry professionals after the data from the main survey were analyzed. All of them had 10 or more years of experience working in the construction industry. With their years of experience, they were able to provide insights into the changes that the industry has undergone with the introduction of IT. Their opinions further validated the results and provided a deeper understanding of the importance of the drivers, challenges, and strategies in CC adoption. The interviews allowed the exploration of reasons for the differences in perceptions associated with CC based on the different contractor companies and respondents' roles.

Table 4. Five-point Likert scale for rating CC drivers, challenges, and strategy

Five-point Likert scale	CC driver	CC challenge: Level of likelihood	CC challenge: Magnitude of impact	CC strategy
1	Least important	Least likely	Insignificant	Least important
2	Less important	Less likely	Minor	Less important
3	Neutral	Neutral	Moderate	Neutral
4	More important	More likely	Major	More important
5	Most important	Most likely	Severe	Most important

Table 5. Demographics of respondents' organizations

Respondents	Frequency	Percentage
Organization size		
Large enterprises	27	36.0
SMEs	48	64.0
Experience		
Fewer than 20 years	64	85.3
More than 20 years	11	14.7
Role in organization		
Project administrators	21	28.0
Engineer	11	14.7
Director	5	6.7
BIM modeler	11	14.7
Drafter	11	14.7
Contract manager	11	14.7
Supervisor	5	6.7
Experience		
0 to 10 years	48	64.0
Fewer than 10 years	27	36.0
Total	75	100.0

Data Analysis and Discussion

This section reviews and analyzes the survey data collected. The results provided a deeper understanding of the current implementation status of CC for Singapore's contractors, both for SMEs and large companies. First, to test the normality of the data, the Shapiro-Wilk test was conducted to determine the distribution of the survey data. The later sections include the analysis of the drivers, challenges, and strategies for CC adoption to establish the differences among the firm sizes, the respondents' roles, and the number of years of experience in their organization through several statistical methods, such as the Mann-Whitney U-test (Mann and Whitney 1947) and Kruskal-Wallis test (Kruskal and Wallis 1952).

Normality Test

Data normality is determined to provide an insight into the selection of data analysis methods to be conducted. If the variable is normally distributed, parametric statistics can be used based on the assumption of normality.' The Shapiro-Wilk test was conducted on the data set to determine the distribution because this has been found to be the most powerful test as it is the ratio of two estimates of the variance of normal distribution based on a random sample of n (Shapiro and Wilk 1965). The null hypothesis and alternative hypothesis are as follows:

H_0: The data are normally distributed.

H_1: The data are not normally distributed.

A significance level (α) of 0.05 was used to assess the hypotheses. The analysis of all drivers, challenges, and strategies shows that every p-value of each factor is 0.000, which is less than 0.05, confirming that the data significantly deviate from a normal distribution. As a result, nonparametric methods were used to conduct further data analysis.

Adoption Rates of CC

This section provides an insight from the sample of the contractor companies that have opted to implement CC into their organizations in Singapore. CC adoption status in SMEs and large contractor firms were explored and compared with each other. Precisely 68.75% of SME contractors have adopted CC in their companies, and 77.78% of the large firms utilized CC technology in their companies. Overall, 72% of the total sample in this survey applied CC in their companies. This adoption rate highlights that Singapore's construction industry has been actively using CC technology compared with other industries and countries worldwide that are embracing CC.

For example, 26% of European Union enterprises used CC in 2018, mostly for email and storage of files, with the highest adoption rate being 65.3% in Finland (Kaminska and Smihily 2018; Vu et al. 2020). In the industrial sectors, however, the adoption rate was the highest in the IT sector (64%) but less than 25% in the construction and manufacturing sectors (Vu et al. 2020). This also implies that although the Singaporean construction industry is currently somewhat advanced in adopting CC technology, at this point, it would be timely and meaningful to grasp the current level of CC adoption in Singapore as well as the drivers, challenges, and strategies, which is the aim of this study.

Drivers in Adopting CC

This section explores how CC drivers have an impact on CC adoption. The drivers were analyzed and presented according to organization size, experience in the construction industry, respondent's role, and experience in their role. The means of the drivers and distributions of the responses were analyzed and discussed. The Mann-Whitney U-test was applied to examine whether each factor of the drivers, challenges, and strategies would differ based on the organization size and experience in the industry. Similarly, a Kruskal-Wallis test was conducted to test an intergroup comparison that checks the differences that lie within the different roles. Table 6 summarizes the results of the three tests regarding CC drivers.

After the means of the drivers were computed, D7: Workplace Safety and Health, D8: Sustainable Data Management, and D9: Business Continuity emerged as the top three drivers in organizations adopting CC. Regarding D7: WSH, the construction industry is perceived as a dangerous industry, and constant progress in WSH performance is required to ensure excellent site safety. In this context, the Singapore government has implemented firmer WSH practices to achieve the highest standard set of having the world's safest and healthiest workplaces (Seow 2019). Through the Ministry of Manpower, the government has accepted the proposal of creating a 10-year strategy on WSH practices, which aims to enhance the focus on WSH and increase the use of technology (Seow 2019). In this context, CC can provide organizations with a collaborative framework for WSH through its centralized storage nature, fewer visibility barriers, and opportunities to establish simplified and standardized processes by integrating CC into WSH processes (Izvercian et al. 2013; Cioca and Ivascu 2014; Zou et al. 2017).

D8: Sustainable Data Management was classified as one of the top three drivers. The construction industry is often regarded as an industry that has a significant environmental impact (Ortiz et al. 2009; Shen and Tam 2002; Eras et al. 2013). However, the adoption of CC would enable a more sustainable approach toward its data management with the reduction of paper waste, which is further highlighted by the cause of corporate social responsibility (Dastbaz et al. 2015). Innovative technological systems could bring about the realization of sustainability, which would, in addition, result in optimized performance and a cleaner production process (Waga 2013; Konstantinos 2015; Deakin and Reid 2018).

Similarly, D9: Business Continuity was also found to be a top driver. Having a suitable BCP is fundamental in every business or

Table 6. Results of the tests: CC drivers

No.	Driver	Mean	Rank	p-value: Mann-Whitney U-test (organization size)	p-value: Mann-Whitney U-test (experience)	p-value: Kruskal-Wallis (respondent's roles)
D1	Government plans and policies initiative	3.85	5	0.066	0.000[a]	0.000[a]
D2	Technology advancement	3.69	8	0.850	0.000[a]	0.000[a]
D3	Decreased reliance on labor	2.45	9	0.002[a]	0.002[a]	0.002[a]
D4	Competitiveness	3.85	5	0.066	0.000[a]	0.000[a]
D5	Project life cycle management	3.72	7	0.854	0.000[a]	0.000[a]
D6	Systematic project management	4.01	4	0.854	0.000[a]	0.000[a]
D7	Workplace safety and health	4.16[b]	1	0.019[a]	0.000[a]	0.000[a]
D8	Sustainable data management	4.15[b]	2	0.066	0.000[a]	0.000[a]
D9	Business continuity	4.15[b]	2	0.066	0.000[a]	0.000[a]

[a] p-value < 0.05.

[b] Top three drivers.

organization in the survival against threats (Low et al. 2010; Mano et al. 2012). To establish an appropriate BCP, the trustworthy and ascendable depository nature of CC has been regarded as an auspicious technology offering quick data access infrastructure through web services and high-performance computing (Matar and Imad Fakhri 2016; Hong et al. 2018). Additionally, new threats such as terrorism and cybercrime must be considered (Low et al. 2010). Organizations must now take measures to ensure that in the event of such happenings, the business is able to recover with as little downtime as possible. With the adoption of big data technology such as CC, the information would be safely stored on the cloud database that could be accessed readily, which ensures that organizations can pick up from any threats of business and recover efficiently (Papadopoulos et al. 2017).

Drivers and Company Size

The Mann-Whitney U-test was adopted to test and analyze if the distribution of responses varied by the size of companies, such as SMEs and large companies. The null hypothesis and alternative hypothesis are established as follows:

H_0: The factor has the same impact on CC adoption by the size of companies.

H_1: The factor has a different impact on CC adoption by the size of companies.

The p-values for each factor recorded were larger than 0.05, except for D3: Decreased Reliance on Labor and D7: Workplace Health and Safety. The p-values for D3 and D7 are lower than 0.05, which means that these factors have different impacts on CC adoption depending on the size of the firm. Because the construction industry is highly labor-intensive, ensuring that the organization employs the right people for the right job is essential. However, this is not sustainable in the long run because it leads to a far more significant need for foreign employees (Ng 2018). A constraint in worker availability is an obstacle that will eventually hold back or defer projects. Increasing labor costs have led construction companies to scout for other resource alternatives that could reduce their reliance on labor while improving productivity levels. The implementation of CC would mean that data would be available online and integrated into processes that support less reliance on the workforce. The availability of data is essential for SMEs due to the restricted resources available at their disposal. Implementing such cloud technology would allow SMEs to be more productive and competitive than large companies, helping SMEs overcome any current growth challenges (Shakeabubakor et al. 2015; Rüßmann et al. 2015).

Furthermore, the adoption of CC would ensure that information about any project is readily available, thus helping to identify hazards more efficiently. This is an essential contributor to the safety and health of the workplace because it leads to higher compliance and also eliminates communication errors between those who are onsite and off-site (Martínez-Rojas et al. 2016). As a result, the chances of work-related accidents can be reduced, especially for an industry that is regarded to be high-risk and that has high numbers of work injuries. A good record of WSH gives organizations higher credibility in the industry. Although both SMEs and large companies can benefit from such compliance, CC can give the large companies a competitive advantage more when tendering for projects. This is because large companies are dealing with a relatively large number of projects compared with SMEs, and the nature of the projects is more likely to be large or complex.

Drivers and Experience in the Industry

To determine if the response distributions of the drivers differ according to experience in the construction industry, the Mann-Whitney U-test was conducted. The null hypothesis and alternative hypothesis are as follows:

H_0: The factor has the same impact on CC adoption by experience in the industry.

H_1: The factor has a different impact on CC adoption by experience in the industry.

The appropriate analysis is to compare the differences that come from the same population when the dependent variable is ordinal (Morgan et al. 2012). The test result listed in Table 6 ascertained that there are differing views on the drivers for the adoption of CC. All the recorded p-values are below 0.05 (the level of significance). Therefore, the null hypothesis is rejected, which is evident because younger organizations are more likely to experience organizational difficulties, such as limitations in resources, because efforts are channeled into breaking into the market (Deloitte 2014).

Intergroup Comparison: Drivers and Roles

The Kruskal-Wallis H-test was applied as an intergroup comparison to check the different impacts on the response distributions of CC drivers according to the different roles. The null hypothesis and alternative hypothesis are as follows:

H_0: There is no difference in the median between groups.

H_1: There are differences in the median between groups.

All the p-values of CC drivers obtained are below the level of significance (0.05), as summarized in Table 6. This rejects H_0 and indicates a statistically significant difference in the distributions of the CC drivers between roles. The test establishes the notion that the roles have different input due to the difference in responsibility that each role carries in the organization and how they would benefit from the adoption of CC. The success of new technology introduction is dependent on the acceptance of the intended user (Dasgupta et al. 2002; Sitorus et al. 2016).

Challenges in Adopting CC

To deeply understand the challenges of CC adoption, each factor of the challenge was evaluated by its criticality, which was defined as follows:

$$\text{Criticality} = (\text{Level of likelihood}) \times (\text{Magnitude of impact})$$

The survey questionnaire required the respondents to answer with a five-point Likert scale to mark the likelihood and magnitude of impact on the challenge factors. As shown in Fig. 2, the criticality matrix shows that nine (3×3) represents neutral, more than 9 and less than 16 represents more critical, more than 16 represents

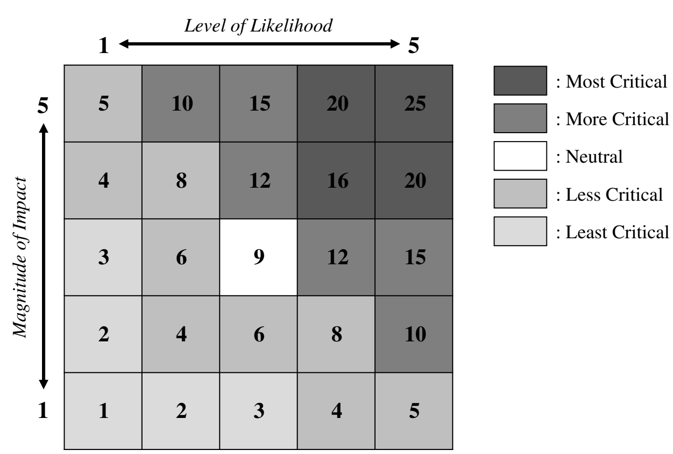

Fig. 2. Criticality matrix of the challenges for CC adoption.

most critical, lower than 9 and more than 3 represents less critical, and less than 3 represents least critical.

Each criticality was analyzed and discussed according to organization size, experience in the construction industry, and respondents' roles in their organization through Mann-Whitney U-test and Kruskal-Wallis test (Table 7 gives a summary of the test results). First, the means of the challenge factors were computed. C6: Complexity of New Technology, C2: Top Management Support, and C1: Organization Size emerged as the top three challenges with the highest impact that could hinder the adoption of CC. C6: Complexity of New Technology could hinder the process of adoption because organizations are reluctant to invest in new technology (Alshamaila et al. 2013)—especially in the construction industry where the adoption of new technology is low. The introduction of new technology would also mean having to acquire a new computer skill and adjust to a new method of work (Weinberg 2004), which involves not only technical skills but also inculcating a new work culture. The misconceptions of small enterprises often concern the fear of complexity, lack of understanding of the potential benefits, and lack of technical resources (Javid and Dalian 2014).

Without C2: Top Management Support, the organization does not have the motivation and direction to adopt CC (Thong et al. 1996; Ding et al. 2014). As a result, having top management support is critical for creating a supportive climate and providing adequate resources for the adoption of new technologies (Lin and Lee 2005; Liang et al. 2007; Wang et al. 2010). Some empirical studies have pointed out that there is a positive relationship between top management support and the adoption of new technologies (Zhu et al. 2006; Pan and Jang 2008). Therefore, adequate upper management support can be one of the most influential factors for innovation implementation in construction firms (Gambatese and Hallowell 2011). Top management can provide insight into and guarantee the creation of a positive environment for the adoption of technologies and innovations, especially when the complexity and sophistication of technologies increase (Lee and Kim 2007).

C1: Organization Size is the third critical factor. The larger an organization, the more resources it has to support development within the company because the adoption of new technology would mean that these resources must be stretched out to meet the demands (Harris and Katz 1991; Dozier and Chang 2006). Compared with large companies, SMEs are organizations with a limited workforce and financial capabilities (Love et al. 2002). It is often reported that large firms tend to adopt more innovations, primarily due to their greater flexibility and ability to take the risk (Zhu et al. 2006; Pan and Jang 2008). Moreover, previous studies conducted in the last few decades have found that the size of an organization is a significant determinant of IT innovation (Dholakia and Kshetri 2004; Hong and Zhu 2006; Pan and Jang 2008). Consequently, organization size is a crucial factor that affects the adoption of CC in innovative technological development.

Critical Factors and Organization Size

The Mann-Whitney U-test was conducted on the data set to test if the impact of the critical factors on the adoption of CC would differ according to an organization's size. The null and alternative hypotheses are as follows:

H_0: The factor has the same impact on CC adoption by organization size.

H_1: The factor has a different impact on CC adoption by organization size.

As summarized in Table 7, it was determined that p-values for the critical factors were less than 0.05 (level of significance) except for the C1: Organization Size and C6: Complexity of New Technology. Therefore, the null hypothesis was rejected, indicating that organizations of different sizes do not share the same consensus in the distribution of critical factors. However, C1 and C6 have p-values that are larger than the significance level, finding the null hypothesis to be accurate, with the challenge factors having the same impact on CC adoption by organization size. The critical factors C1 and C6 are shared between the organization sizes, such as SMEs and large firms. Understanding new technologies is a task that both large companies and SMEs have to undergo, where training is required to equip staff with a proper understanding of the latest technology.

Critical Factors and Experience in the Construction Industry

To determine if the impact of the critical factors would differ according to experience in the construction industry, another Mann-Whitney U-test was conducted. The null and alternative hypotheses are as follows:

H_0: The factor has the same impact on CC adoption by experience in the construction industry.

H_1: The factor has a different impact on CC adoption by experience in the construction industry.

Table 7. Results of the tests: Criticality of challenges

No.	Challenge	Mean	Rank	p-value: Mann-Whitney U-test (organization size)	p-value: Mann-Whitney U-test (experience)	p-value: Kruskal-Wallis (respondent's roles)
C1	Organization size	14.11[a]	3	0.148	0.038[b]	0.000[b]
C2	Top management support	14.53[a]	2	0.001[b]	0.068	0.000[b]
C3	Lack of staff expertise	11.71	11	0.000[b]	0.052	0.000[b]
C4	Intellectual property rights	12.67	7	0.000[b]	0.282	0.000[b]
C5	Risk ownership	12.67	7	0.000[b]	0.282	0.000[b]
C6	Complexity of new technology	14.75[a]	1	0.148	0.001[b]	0.000[b]
C7	Interface issues	12.27	9	0.000[b]	0.282	0.000[b]
C8	Lack of awareness of the relative advantage	13.07	5	0.000[b]	0.276	0.000[b]
C9	Sensitivity of data	13.89	4	0.000[b]	0.010[b]	0.000[b]
C10	Large initial cost	12.48	6	0.000[b]	0.057	0.000[b]
C11	Maintenance cost	10.29	12	0.000[b]	0.001[b]	0.000[b]
C12	Lack of standards	11.84	10	0.000[b]	0.212	0.000[b]

[a]Top three challenges.
[b]p-value < 0.05.

The results in Table 7 ascertained that there is no difference in the impact of these factors between the two groups of different experiences because the p-values recorded are larger than the 0.05 level of significance, except for C1: Organization Size, C6: Complexity of New Technology, C9: Sensitivity of Data, and C11: Maintenance Cost. C1, C6, C9, and C11 show that some p-values are below 0.05; as such, the null hypothesis was rejected where there was a difference in the distributions of the challenge factors between the two groups.

C6: Complexity of New Technology has a different impact on new technology adoption, such as CC, according to the firm size. Although the absolute value of the complexity of new technology would be the same regardless of the size of the company, the impact of this absolute value on each company differs. SMEs have limited resources, such as physical resources and human resources, which causes increased burdens due to the new technology adoption.

Furthermore, the lack of investable capital intensifies the fear of adoption of a new technology, which reduces SMEs' understanding of the potential benefits (Javid and Dalian 2014); conversely, large contractor companies have enough resources to invest in the introduction of new technologies to their companies. Therefore, there is less fear of adopting new technologies in large companies than in SMEs. The sufficient investable resources of the large firms also allow them to see the long-term benefits of the CC technology and care about future investments.

C9: Sensitivity of Data is vital to both SMEs and large companies because data security is a crucial issue. The rapid growth in the field of CC has also increased severe security concerns, and C9: Sensitivity of Data has remained an untapped issue for internet and information technologies (Shaikh and Haider 2011). Therefore, the lack of security is a hurdle in the wide adoption of CC regardless of how large a company is. However, the impact of the barrier is different according to the size of the company because the amount of data produced is different.

Generally, the amount of data produced by a company is proportional to its size because the larger the contractor company, the more staff and resources they have. Moreover, the number of projects or the size of the projects the company deals with is also more and larger than those managed by smaller companies, which means that large companies can produce more data than SMEs. Similarly, the issue of data security is proportional to the amount of data retained. Therefore, this means that larger companies with more data could be more sensitive to this critical factor (Chang and Ho 2006).

C11: Maintenance Cost is also similar in context to C6. The fixed costs needed to introduce new technology to a company and maintenance costs, such as retraining of staff, the constant need to upgrade technological skills, and maintenance of the server, vary somewhat depending on the size of the company. However, these costs are not usually considered a big expense for large companies. Furthermore, if companies regard the costs as an investment in their future, it becomes less of a challenge for them. In the case of SMEs, the companies do not have enough extra money and resources to invest in CC adoption because they are mostly required to focus on costs that generate immediate profits for their survival (Ghobakhloo et al. 2011; Kurnia et al. 2015). Investing in new technology adoption is expensive, and there are no immediate returns or benefits; this can be translated to a high risk for SMEs. Moreover, the cost of maintaining a new technology, such as CC, is a significant burden and is over budget for SMEs (Neves et al. 2011).

Intergroup Comparison: Critical Factors and Roles

To verify the different impacts of CC challenge factors by the different roles, the Kruskal-Wallis H-test was conducted as an intergroup comparison. The test determines if the different roles have a different impact on the criticality of the challenge factors. The null and alternative hypotheses are as follows:

H_0: There is no difference in the median between groups.

H_1: There are differences in the median between groups.

As a result, all the factors that have p-values below 0.05 (which rejects the null hypothesis) mean that different roles have a different impact on the response distributions of the criticality, as summarized in Table 7. Therefore, different roles do not share similar views on the critical factors and adoption of CC in organizations.

Strategies to Motivate the Adoption of CC

Table 8 provides a summary of the result of the mean comparisons. These values show that S2: Clear Direction of Action, S3: Cooperation between Different Organizations, and S4: Willingness to Change are the top three strategies that could influence the adoption of CC. S2: Clear Direction of Action is the roadmap that the organization can follow to ensure successful adoption (Adane 2018). When there is a clear direction for the employees to follow, it guides them in the direction of the organization's objectives, increasing the chances of a successful adoption (El-Kassar and Singh 2019). Having an appropriate time frame also establishes a clear adoption strategy for the organization's employees (Lee et al. 2009).

Because SMEs are limited by resources, they need to work with other organizations within their cluster to form S3: Cooperation between Different Organizations. This encourages the sharing of skills and resources, enabling them to complement one another and specialize to overcome common problems and achieve a common goal (Adane 2018). Even with the success of CC implementation, some SMEs remain reluctant to commit to S4: Willingness to Change due to possible misconceptions, such as fear of complexity and lack of understanding of the potential benefits (Javid and Dalian 2014). Therefore, these SMEs need to change and adopt a new organizational structure by aligning technology with their business strategy to ensure that the full potential of CC is harnessed for the organization's development (Adane 2018).

Strategies and Organization Size

To determine how the size of an organization changes the level of importance of strategies, the Mann-Whitney U-test was applied. The null and alternative hypotheses for the test are as follows:

H_0: The factors have the same impact on CC adoption by organization size.

H_1: The factors have a different impact on CC adoption by organization size.

The results recorded in Table 8 reveal that all the p-values are larger than the level of significance. The null hypothesis holds true, and there is no difference in perception of the strategies based on organization size. In other words, regardless of the organization's size, the suggested strategies for CC adoption are statistically the same. Therefore, the strategies might be applicable to all contractor firms regardless of their size according to the degree of importance identified in the survey.

Strategies and Experience in the Construction Industry

Another Mann-Whitney U-test was conducted on the data to compare the response distributions of the strategy factors based on experience in the construction industry. The null and alternative hypotheses are as follows:

H_0: The factors have the same impact on CC adoption by experience in the construction industry.

H_1: The factors have a different impact on CC adoption by experience in the construction industry.

Table 8. Results of the tests: Strategies

No.	Strategy	Mean	Rank	*p*-value: Mann-Whitney U-test (organization size)	*p*-value: Mann-Whitney U-test (experience)	*p*-value: Kruskal-Wallis test (respondent's roles)
S1	Distinct adoption expectations	4.12	4	0.123	0.003[a]	0.000[a]
S2	Clear direction of action	4.27[b]	1	0.223	0.001[a]	0.000[a]
S3	Cooperation between different organizations	4.27[b]	1	0.223	0.001[a]	0.000[a]
S4	Willingness to change	4.27[b]	1	0.223	0.001[a]	0.000[a]
S5	Larger awareness of government incentives	3.60	7	0.133	0.005[a]	0.000[a]
S6	Reduce capital expenditure	4.12	4	0.123	0.003[a]	0.000[a]
S7	Standards for cloud computing	3.61	6	0.347	0.001[a]	0.000[a]

[a]p-value < 0.05.
[b]Top three strategies.

According to Table 8, all the p-values were recorded below 0.05, which rejects the null hypothesis. Hence, the test confirmed that there is a difference in the distributions of the strategies by the years of experience that an organization has in the industry. This is because practitioners' or managers' beliefs are derived from their experience, which forms their perspective (Bowman and Daniels 1995). Even if practitioners see the same phenomenon, their interpretation also varies according to their expertise. The tendency is especially true in the contract industry, where experience in practice is crucial (Faridi and El-Sayegh 2006). Therefore, it can be inferred that all the presented CC adoption strategies were evaluated differently according to respondents' experience in the industry.

Intergroup Comparison: Strategies and Roles

Furthermore, to check the differences that lie among the different roles, the Kruskal-Wallis H-test was applied as an intergroup comparison. The null hypothesis and alternative hypothesis are as follows:

H_0: There are no differences in the median between the groups.

H_1: There are differences in the median between the groups.

The results of the test are found in Table 8. The recorded p-values are all smaller than the significance level; hence, all of the null hypotheses are rejected. The test highlights that the respondents' roles influence the response distributions of the strategies because they do not share the same consensus. This means that all members of the company, regardless of their job titles, have different beliefs for each strategy. Therefore, when an organization applies the proposed strategies, the process of the application might be complicated and ambiguous for the organization because it needs to take into account the differences in understanding of the strategies among job titles.

Conclusions and Recommendations

Despite CC gaining more attention from the construction industry, limited research has attempted to analyze the status of CC adoption in the industry from a comprehensive perspective. In this context, this study first investigated the CC adoption status and the perception of professionals in Singapore's construction industry. The extensive literature review highlighted 9 drivers, 12 challenges, and 7 strategies relevant to CC adoption practiced in the construction industry, followed by a survey conducted with industry practitioners in Singapore's construction industry. According to the analysis results, a relatively high adoption rate of CC among SMEs and large companies was reported at 68.75% and 77.78%, respectively. In line with the global trend of IT adoption, Singapore's construction industry seems to be actively utilizing CC technology compared with other sectors and countries. Additionally, the survey results revealed that the top three significant drivers for CC adoption are C7: Workplace Safety and Health, C8: Sustainable Data Management, and C9: Business Continuity. The top three challenges were found to be C2: Top Management Support, C6: Complexity of New Technology, and C1: Organization Size. The top three strategies were found to be S2: Clear Direction of Action, S3: Cooperation between Different Organizations, and S4: Willingness to Change. Moreover, postinterviews were conducted with construction professionals, echoing the analysis results and findings obtained from the questionnaire survey, advocating that the findings from this study are reliable.

Further analyses were conducted to determine if organization size, respondent's experience, and respondent's role influenced the drivers, challenges, and strategies. The analyses results highlighted that organization size did not impact most of the drivers that motivate the adoption of CC, although there was a statistically significant difference in the challenges faced by the organizations of different sizes. Furthermore, it was concluded that the strategies proposed for CC adoption could be applicable to and practical for both SMEs and large companies. On the other hand, the perceived importance of all the drivers, challenges, and strategies was significantly different depending on the respondent's experience, except for eight challenge factors (C2, C3, C4, C5, C7, C8, C10, and C12). In addition, the different roles of the respondents resulted in different influences when they assessed the relative importance of the drivers, challenges, and strategies. After all the analyses were carried out, postinterviews were also conducted, echoing the analysis results; the outcomes advocate the reliability of the findings from this study.

Although the objectives of this study were achieved, there were a few limitations that were involved during the process of the study that need to be acknowledged. First, the sample size was not large, and thus one should be cautious when interpreting and generalizing the results. Therefore, a larger sample size would enable a better representation of the implementation of CC in the construction industry. Although the findings from this study were interpreted in the context of Singapore, they have global contributions. This is because the targeted survey respondents included global construction companies from various countries, which makes the findings applicable to the global construction industry. Additionally, these findings contribute to the body of knowledge in terms of providing a better understanding of the strategic adoption of IT in the industry.

The Singapore government has been pushing for a digitalized economy and has been actively involved in the digital movement

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that has paved the way for businesses to adopt a similar strategy. In this context, the findings of this study accentuate several focal points for the government and organizations to consider when adopting and managing CC to improve communication among stakeholders. The findings highlight that the availability of financial subsidies and funding for SMEs are critical in increasing technology uptake by SME contractors. Therefore, in order for organizations to proceed with the adoption of CC, the government should acknowledge the set of challenges that SMEs face, such as a lack of resources and costs, and recognize that they are dissimilar to those of large companies. This study has a practical contribution in that the findings inform both the government and industry practitioners, providing a better understanding of the strategic implementation of CC.

Data Availability Statement

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

Acknowledgments

This research is supported by National University of Singapore, Office of the Deputy President (Research and Technology), HSS Seed Fund. This research was conducted with the support of the National R&D Project for Smart Construction Technology (No. 21SMIP-A158708-02) funded by the Korea Agency for Infrastructure Technology Advancement under the Ministry of Land, Infrastructure and Transport, and managed by the Korea Expressway Corporation.

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