Collaborative contracting in the Singapore construction industry: current status, major barriers and best solutions

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Abstract

Purpose – Collaborative contracting (CC) is the direction that Singapore is venturing into in line with the Construction Industry Transformation Map. For its successful adoption, it is necessary to examine the potential barriers and possible solutions. Therefore, this study aims to explore the current status, major barriers and best solutions for the adoption of CC in the Singapore construction industry.

Design/methodology/approach – To achieve these objectives, a comprehensive literature review was carried out and 26 barriers, as well as 21 solutions, were identified. Then a questionnaire was designed to assess the priority of these barriers and solutions. After a pilot study, 165 questionnaires were distributed, and 31 responses were received. And the survey result was validated by post-survey with three industry professionals.

Findings – Results revealed that only a small percent of projects adopted CC in Singapore. Seven significant barriers hindering CC implementation were found out. They are "inherent difficulties in changing organizational culture," "lack of incentives/financial support," "lack of legislative regulations," "resistant to change the current way of working," "seeking for the lowest cost" and "difficulties in converting strategic decisions to operational levels" and "unclear contract terms and objectives." Also, five best solutions were suggested to overcome the identified barriers.

Originality/value – The findings of this study could enable industry practitioners to be aware of the potential barriers to adopting CC and choose suitable solutions to overcome these barriers. It is also helpful for authorities to come up with effective policies to promote the adoption of CC.

Keywords Collaborative contracting, The Singapore construction Industry, Barriers, Solutions

Paper type Research paper

Introduction

Players (i.e. designers, consultants, engineers, contractors, facility managers and the like) in the Singapore construction industry have a culture of working in silos, causing the sector to be lagging with sluggish productivity (Sen, 2017). The detachment or noncollaborative behavior brought constant change requests from clients (Hasan *et al.*, 2018; Jarkas and Bitar, 2011; Jarkas and Radosavljevic, 2012), resulting in a productivity loss of 25–50% (Arashpour and Arashpour, 2015). Given that the building industry takes up an estimated 6% of Singapore's gross domestic product valued at $23 to $35 billion SGD (BCA, 2017), it is

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imperative for the industry to progress in order not to stump economic growth. One critical way to achieve progress in the industry is to encourage a collaborative working culture in the industry.

Collaborative contracting (CC) as a practice where organizations or individuals work together for knowledge and resource sharing (Bygballe *et al.*, 2010), it has been one of the key catalysts for improving construction productivity (Rahman *et al.*, 2014). That is because such effective working relations is a necessary condition for innovative performance in projects, in which it will enable progress in the industry (Gambatese and Hallowell, 2011). Furthermore, such an abstract concept of aligning project stakeholders across the value chain could foster better relations between them to develop joint solutions and achieve the desired outcome (Kumaraswamy *et al.*, 2005b; Amirkhanyan *et al.*, 2012). Given the benefit of reducing transactions and increasing efficiencies, CC is critical for the progress of the Singapore construction industry.

Other than attaining a reduction in cost, variation and time, CC would come in handy as it complements prior initiatives by the BCA like BIM adoption and Early Contractor Involvement (ECI). ECI was introduced since 2010 and it encourages the engagement of contractors from the design stage to provide perspective for consultant architects in the areas of productivity and constructability (BCA, 2018). The implementation of CC can further enhance the values of trust and cooperation, which is the core focus of ECI and the Construction Industry Transformation Map (Construction ITM). Also, the adoption of CC could be the catalyst for integrating the construction value chain by promoting mutual trust and collaboration among stakeholders. For achieving the complementation of prior efforts relating to integration, this is one of the main objectives of BCA's endeavor in introducing CC in Singapore.

However, the adoption of CC involves many problems such as lack of trust, communication barriers, adversarial mentalities among project stakeholders, and disputes (Sparkling *et al.*, 2017). Moreover, the local industry tends to be more conservative and relied on the usual contracting models, resulting in resistance to adopt CC (Pheng *et al.*, 2015). For moving toward CC, there is a need to explore potential barriers and possible solutions for CC to be effectively adopted in the Singapore construction industry, which has not been done in the existing studies.

Thus, the objectives of this research are to (1) evaluate the current status of CC adoption in the Singapore construction industry; (2) identify potential barriers hindering the implementation of CC and assess their importance; (3) propose feasible solutions to promote the adoption of CC. This study will disclose the major barriers and possible solutions for adopting CC in the Singapore construction industry to bridge the knowledge gap in past studies. In addition, this paper would contribute the BCA to refining the CC policy and aid practitioners in adopting CC successfully.

Literature review

CC in Singapore

To promote the adoption of CC, the Singapore government made great efforts. $4.5 billion was set aside to address obstacles in 23 industries and to foster a greater partnership among the authorities, companies, trades associations and chambers (MTI, 2018). And the key thrust marked for transformation in the construction industry is to build progressive and collaborative firms, which aims to create a paradigm shift in the current segregated and noncollaborative culture (BCA, 2017). BCA has also developed a set of CC clauses, which are designed to promote mutual trust between contract parties (Mohamad, 2019). Furthermore, the Building Construction Authority (BCA) will be kicking off a pilot project to adopt CC with the newly drafted clauses.

Although CC is not yet adopted extensively in the Singapore construction industry, past policies such as the ECI and BIM are implemented with the aim of fostering firms' closer collaboration (Pheng *et al.*, 2015). ECI was introduced since 2010, and its main purpose is to close the gap between the Design and Construction phase, thus improving productivity. This policy promoted changes at the procurement stage, where stakeholders can attain greater collaboration. And compulsory BIM submission for regulatory building plans was implemented in 2013 (Hwang *et al.*, 2018b). It aims to assist firms in growing their collaborative capability through BIM and reducing design clashes, as well as rework (BCA, 2018). Such initiatives that promote greater collaboration in the project team have always been moving forward in Singapore. The importance of "progressive and collaborative firms" in Singapore is also reflected in the recent Construction ITM as the government emphasizes the need to cultivate this spirit for further integration in the industry (BCA, 2017).

Barriers for the adoption of CC

Collaboration can be defined as the behavior of working together with others (Salim, 2018). Meanwhile, CC can be regarded as a tool to encourage contract administration in the way of cooperation (CASG, 2017). It is a re-design of traditional contracts to encourage developers, consultants and contractors to work towards common project goals (Mohamad, 2019). Three key features of CC were proposed by Salim (2018), i.e. stimulation for collaborative working, stimulation for dispute avoidance and early resolution, and provisions for handling timely resolution of variation and time extension.

Rather than focusing on contracting approaches that involve long-term relationships, CC focuses on contracting models that only involve one construction project. Specifically, CC embraces a wide and flexible range of models whereby there are varying levels of collaboration between project owners and other project participants, including partnering, D&C (design and construct) contract with cooperation obligations, managing contractor, EPCM (engineering, procurement, construction management), delivery partner and IPD (integrated project delivery) (Owen, 2018).

Due to the limited amount of studies on CC, the barriers to the implementation of CC can hardly be identified from prior literature. In view of the concept of CC, the challenges in implementing CC would come from the definition of "collaboration" itself (Salim, 2018). Those studies on partnering and relational contracting, which are highly involved with collaboration practice, may provide valuable guidance. Therefore, this study carried out a comprehensive literature review on the topic of relational contracting and partnering to identify the barriers hindering the adoption of CC in the Singapore construction industry.

Several studies have done excellent work relevant to the barriers hindering the implementation of CC. Kumaraswamy *et al.* (2005b) summarized many barriers from the cultural aspect, such as distrust between project stakeholders, communication difficulty, lack of team working spirit and uncoordinated corporate culture. Challender *et al.* (2014) emphasized the importance of trust and communication. Ey *et al.* (2014) divided barriers into two categories, i.e. human-related barriers (e.g. behaviors, entrenched attitudes, understanding of collaborators, cultural difference and relationships) and commercial-related barriers (e.g. lack of financial support, lack of commercial control and loss of identity and protection of IP). Erik Eriksson *et al.* (2009) identified three kinds of barriers. They are cultural barriers (e.g. attitudes, a collaborative project atmosphere, and team spirit), organizational barriers (e.g. traditional procurement procedures, lack of high relevant competence, lack of key subcontractors and focusing on lowest price), and industrial barriers (e.g. lack of legislative regulations). Mollaoglu *et al.* (2015) summarized four categories of barriers, i.e. cultural barriers, organizational-program level barriers, project team related barriers and legislative-governance barriers. Additionally, Olatunji *et al.* (2017) listed many

barriers, such as unclear partnering methodology, the inflexibility of representatives to new roles and procedures, failure of senior management, communication problems, unstructured risk and reward framework, and cultural problems.

Also, there are several studies done about CC overseas (e.g. the UK and Hongkong). According to Beach *et al.* (2005), Main Contractors (MC) in the UK have been taking active moves in adopting partnering principles with the Main Subcontractors (MSC) that they work with. However, despite the positive outlook of its adoption, partnering is far from becoming a standard practice in reality. Furthermore, clients are the main group of project stakeholders that are less willing to take on partnering (Beach *et al.*, 2005). That could be attributed to their inclination to hold steadfast to the lower cost that the traditional procurement method offers. Moreover, consultants reflected that the concern of losing control is still a barrier for uptake, and they generally hold a negative outlook on the future on partnering (Black *et al.*, 2000).

Another case in point would be the Hong Kong's Construction Industry, which faces a similar set of problems and culture with Singapore. According to Hong Kong's Construction Industry Review Committee (CIRC), one of the most compelling issues faced is a disjointed industry and hostile attitudes (Chan *et al.*, 2008). The industry has always been fraught by many barriers in the area of relationship management. Breakdowns in communication, lack of teamwork and trust are relatively common (Chan *et al.*, 2004). Also, legislative barriers from larger organizations and profit-oriented motives hindered parties from embodying the "partnering attitude" (Chan *et al.*, 2004; Ning and Ling, 2013).

Eventually, by reviewing relevant literature and CC practice in other regions, 26 barriers that may hinder the implementation of CC were identified and listed in Table 1. To better understand the nature of these barriers, they were divided into six categories, i.e., financial barriers, political barriers, management barriers, knowledge barriers, technical barriers and cultural barriers.

Solutions for overcoming the barriers of implementing CC

For overcoming the barriers impeding the implementation of CC, many solutions have been proposed. For example, Erik Eriksson *et al.* (2009) proposed a series of approaches to overcome cultural barriers, organization barriers and industrial barriers, such as constructing a shared IT-supported database, organizing team building activities, adopting early procurement and pre-qualification, conducting soft parameters, establishing joint objectives and sharing profits. Kumaraswamy *et al.* (2005b) identified six factors facilitating relational contracting. They are top management and clients' support, alignment of team objectives, trust, open communication and team-working culture, equitable risk allocation, prior experience and flexible contracts. Anvuur and Kumaraswamy (2007) suggested many solutions form the view of top management support, team incentives and periodic performance assessments. Mollaoglu *et al.* (2015) emphasized the benefit of trust-building and management support. Finally, 21 possible solutions were identified and classified according to their target barrier categories (see Table 2).

Methodology and data presentation

Various methods were adopted in this study. Firstly, an extensive literature review was conducted to draw out knowledge about the potential barriers and possible solutions for adopting CC. Then, a questionnaire was designed to assess the relative importance of each barrier and solution. Before the large-scale questionnaire survey, pre-survey interviews were carried out with four industry professionals to validate the survey questions and to improve the quality of the questionnaire. After the pre-survey interviews, the questionnaires were distributed to targeted respondents, and the survey results were validated by three industry

Table 1. Possible barriers hindering the adoption of CC

Groups	No.	Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Financial barriers	B01	Uncertain economic climate		√			√										
	B02	Seeking for lowest cost	√	√		√	√			√	√			√		√	
	B03	Abuse of collaborative relationships for financial benefits		√										√	√	√	
	B04	Potential conflict between commercial pressures and forms of collaboration	√		√	√	√			√	√			√	√	√	
	B05	Inefficient and demanding to commit to collaborative initiatives						√		√					√		
Political Barriers	B06	Lack of legislative regulations	√			√										√	√
	B07	Lack of incentives/financial support from the government		√		√											
Management Barriers	B08	Inherent difficulties in changing organizational culture	√		√		√	√	√	√	√	√	√	√			√
	B09	Lack of support/initiative from top manager	√		√			√	√						√	√	
	B10	Bureaucratic organizational setting	√		√			√			√	√	√				√
	B11	Unclear management system and responsibilities			√			√		√	√	√	√		√	√	√
	B12	Difficulties in converting strategic decisions to operational levels			√		√		√	√							√
Knowledge Barriers	B13	Unknown risks and uncertainties from the adoption		√	√				√	√	√	√	√	√		√	
	B14	Misunderstanding of Collaborative/Partnering concepts			√		√	√	√		√				√		
	B15	Lack of education and training	√		√			√			√			√	√		
	B16	Lack of case studies	√		√			√			√			√	√		
Technical Barriers	B17	Absence of key subcontractors	√			√		√								√	√
	B18	New competencies required			√	√			√	√					√		√
	B19	Lack of competence			√	√			√	√					√		
	B20	Unclear contract terms and objectives	√		√				√	√	√		√	√		√	
	B21	Lack of the collaborative tools			√										√		
Cultural Barriers	B22	Historical adversarial cultural in the industry		√		√	√	√				√	√	√	√		√
	B23	Collision of different corporate cultures	√			√			√	√	√			√	√	√	
	B24	Distrust between project stakeholders	√	√	√		√	√	√	√	√	√	√	√	√	√	√
	B25	Conservative industry culture				√								√			√
	B26	Resistant to change the current way of working	√	√		√			√	√				√	√		

Note(s): [1] = Kumaraswamy *et al.* (2005b); [2] = Challender *et al.* (2014); [3] = Loraine and Williams (2000); [4] = Erik Eriksson *et al.* (2009); [5] = Bresnen and Marshall (2000); [6] = Chan *et al.* (2003); [7] = Olatunji *et al.* (2017); [8] = Anvuur and Kumaraswamy (2007); [9] = Jacobsson and Roth (2014); [10] = Lau and Rowlinson (2009); [11] = Bygballe *et al.* (2010); [12] = Ey *et al.* (2014); [13] = Ling *et al.* (2014); [14] = Kumaraswamy *et al.* (2005a); [15] = Erik Eriksson *et al.* (2009)

Target barrier	No.	Solutions	1	2	3	4	5
Financial barriers	S01	Government provides funds to offset initial uncertainties for projects adopting CC		√		√	√
	S02	Tighter legislations to prevent abuse of collaborative relationships	√	√	√		√
	S03	Revamping traditional procurement method			√		
	S04	Lower interest on loans for projects with CC		√			
Political barriers	S05	Implementing a structured framework codes for CC		√			
Management barriers	S06	Management to take the lead in ensuring a collaborative company culture	√	√	√	√	√
	S07	Increasing awareness of the benefits of CC	√	√	√	√	√
	S08	Ensuring effective communication with key players involved	√	√			√
	S09	Focusing on long-term opportunities of collaborative initiatives	√		√	√	
Knowledge barriers	S10	Involving middle management in collaborative talks to promote knowledge transfer		√	√	√	√
	S11	To educate and train industry professionals				√	√
	S12	Adopting CC on public projects mandatorily	√	√		√	
Technical barriers	S13	Mining a structured CC guide/best practice for different stakeholders to adopt		√	√	√	
	S14	Involving consultants and subcontractors		√			
	S15	Contractual Obligation for amiable dispute resolution	√	√	√	√	
	S16	Contractual obligation to provide early notice for any issues		√			
	S17	Encouraging and motivating risk-rewards plan for project stakeholders	√	√			
	S18	Clearly defined risk allocation and project objectives	√	√		√	√
	S19	Spurring R&D in collaborative platforms/tools			√	√	
Cultural barriers	S20	Formalized team building among project stakeholders – Partnering workshops	√	√	√		√
	S21	Selecting Project stakeholders with a collaborative mindset	√	√	√	√	√

Note(s): [1] = Kumaraswamy *et al.* (2005b); [2] = Anvuur and Kumaraswamy (2007); [3] = Erik Eriksson *et al.* (2009); [4] = Ling *et al.* (2014); [5] = Mollaoglu *et al.* (2015)

Table 2.
Possible solutions to address the barriers in adopting collaborative contracting

practitioners via the post-survey interviews. Finally, a series of statistical tests were carried out to analyze the collected data.

For collecting data, a questionnaire survey was conducted from January 2019 to February 2019. This questionnaire contained four sub-sections except for the respondents' basic information (e.g. occupation, work experience with CC, the information of projects undertaken in the past three years, etc.) and the open-ended segment. In the first section, respondents were requested to rank the barriers for adopting CC on a five-point Likert scale. The second section aims to solicit opinions on the potential solutions to overcome the barriers. Section three is about the relative importance of the critical success factors identified from the existing studies. Section four surveys the perception-based performance where respondents are required to give their opinions on the extent of performance improvement with the adoption of CC. All respondents were requested to fill in all the sections of the questionnaire, depending on their experience and knowledge. Given the limit of words and space, this paper only focuses on the first sub-section and the second sub-section, which indicated the major barriers and the best solutions for implementing CC in Singapore.

Due to the objective of surveying CC adoption in the Singapore construction industry, the target respondents should be various types of practitioners in the

Singapore construction industry, such as contractors, consultants, developers, quantity surveyors, etc. of the private and public sectors. Hence, the sample frame is composed of individual stakeholders and firms from the BCA's Contractors Registration System, Singapore Institute of Surveyor and Valuers, Society of Project Managers and Singapore Institute of Architects. Also, the respondents were chosen at random within the sample frame.

Eventually, a total of 165 questionnaires were distributed via email and LinkedIn InMail. Among them, 31 questionnaires were received with a response rate of 18.8%, which is sufficient compared with the general response rate of Singapore construction industry surveys range of 10–15% (Teo *et al.*, 2007). Furthermore, the statistical analysis can be conducted because the central limit theorem holds true for sample sizes larger than 30 (Ott and Longnecker, 2015; Ngo *et al.*, 2020). As shown in Table 3, the respondents belong to a variety of backgrounds with occupations involving directors (29.03%), project managers (25.81%), quantity surveyors (22.58%) and engineers (22.58%). More than 60% of respondents are working on a project with a value of more than 4 million SGD, which benefits the high quality of the survey result as big projects usually involve more coordination and collaboration problems. Table 3 also shows the organization profile that the respondents are from, suggesting that the majority of the firms (87.1%) have more than 20 years of practice in the industry. Also, among the 31 respondents, 20 of them have been in the construction industry for more than 10 years and 10 of them have directly experienced working in a project with CC elements. Given that CC is not widely adopted in Singapore yet, the presence of the 32.36% who undertaken projects with CC elements is a bonus in value-adding the responses received.

Category	Characteristic	Frequency	%
Designation in company	Director	9	29.03
	Project Manager	8	25.81
	Quantity Surveyor/Contract Manager	7	22.58
	Engineers	7	22.58
Years of experience	<10 years	11	35.48
	>10 years	20	64.52
[1] Value of project ([2] SGD)	0.65 < but < 1.3 million	7	22.58
	1.3 but < 4 million	5	16.13
	4 but < 13 million	5	16.13
	13 but < 40 million	7	22.58
	40 but < 85 million	7	22.58
Organization's age	<10 Years	0	0
	10–20 Years	4	12.9
	21–30 Years	8	25.81
	>30 Years	19	61.29
Respondents' experience with CC	Yes, project adopted CC elements	10	32.26
	No	21	67.74
Years of experience with CC (for respondents)	<3 years	6	60
	3–5 years	2	20
	6–10 years	1	10
	>10 Years	1	10

Note(s): 1. The project value was classified according to the Construction Work Heads Classification from BCA;
2. 1 SGD ≈ 0.73 USD

Table 3.
Respondents' profiles

Data analysis and discussion

Current adoption status of CC in the Singapore construction industry

Table 4 presents the statistical breakdown of the total projects that respondents were involved in for the past three years. Out of the 341 projects that respondents undertook, only 86 projects (25.22%) adopted CC principles or forms, while the remaining 255 projects (74.78%) were done without collaborative initiatives. Therefore, it can be observed that the receptiveness to collaborative principles is still rather underwhelming. And the industry is just at its initial phase in pushing for the adoption of CC and a greater collaborative climate.

Table 4 also shows the profile of projects that adopted CC elements. The type of building that implements CC principles most is commercial (36.05%), followed by industrial (32.56%), infrastructure (18.60%), residential (8.14%) and institutions (4.65%). This could be due to the nature of commercial and industrial projects, which is closely relevant to private sectors. Thus, having a tighter collaboration would improve productivity, reduce rework, shorten the construction period and then better aid in its project success. And most of the projects adopted CC elements are new constructions (61.7%). That might be because new constructions have to go through more construction phases and need more collaborations among project members. In contrast, addition and alteration projects usually have a small scale and require little cooperation work.

Major barriers to the adoption of CC

Testing the normality of the data set is the first step for data analysis (Thode, 2002). If the data distribute normally, parametric statistics tests should be used for further data analysis. Otherwise, nonparametric statistics tests should be used in the following sections (Razali and Wah, 2011). Due to the sample size of less than 50, this study adopted the Shapiro–Wilk test to check the data distribution (Leech *et al.*, 2013). As shown in Table 5, the *p*-values of the Shapiro–Wilk test are all less than 0.05, implying that the data does not follow the normal distribution, and nonparametric statistics test should be considered in the further data analysis. Also, to test the reliability of the data set, Cronbach's alpha was carried out. The result shows that each item's Cronbach's value is bigger than 0.8, suggesting the survey result has good reliability.

Total number of projects involved for past three years	Projects with CC elements for past three years	%	Projects without CC elements for past three years	%
341	86	25.22	255	74.78

Project Type	Projects with CC elements Frequency	%	Total
Residential	7	8.14	86
Commercial	31	36.05	
Institution	4	4.65	
Industrial	28	32.56	
Infrastructure	16	18.6	

Project Nature	Frequency	%	Total
New Construction	53	61.7	86
Addition and Alteration	33	38.3	

Table 4.
Profile of projects that adopted CC

No.	Cronbach's alpha	Mean value	Rank	Median	Shapiro–Wilk test *p*-Value	One sample Wilcoxon signed rank test *p*-Value	Intergroup test [2] *p*-value	Intergroup test [3] *p*-value
B08	0.881	4.161	1	4.000	0.000	0.000[1]	0.968	0.699
B07	0.891	4.097	2	4.000	0.000	0.000[1]	0.356	0.562
B06	0.878	4.065	3	4.000	0.000	0.000[1]	0.865	0.848
B26	0.879	3.968	4	4.000	0.000	0.000[1]	0.392	0.270
B02	0.894	3.903	5	4.000	0.001	0.000[1]	0.841	0.887
B12	0.883	3.903	5	4.000	0.000	0.000[1]	0.996	0.716
B20	0.878	3.903	5	4.000	0.001	0.000[1]	0.438	0.168
B09	0.881	3.871	8	4.000	0.001	0.000[1]	0.316	0.339
B05	0.881	3.774	9	4.000	0.000	0.000[1]	0.212	0.049
B11	0.882	3.774	10	4.000	0.000	0.000[1]	0.733	0.479
B24	0.879	3.774	11	4.000	0.000	0.000[1]	0.182	0.128
B13	0.880	3.710	12	4.000	0.000	0.000[1]	0.654	0.993
B15	0.876	3.710	13	4.000	0.000	0.001[1]	0.824	0.893
B18	0.881	3.710	14	4.000	0.001	0.000[1]	0.587	0.203
B21	0.878	3.710	15	4.000	0.001	0.000[1]	0.404	0.601
B17	0.879	3.677	16	4.000	0.001	0.000[1]	0.938	0.704
B10	0.886	3.613	17	4.000	0.006	0.005[1]	0.556	0.278
B04	0.881	3.516	18	4.000	0.000	0.001[1]	0.430	0.525
B14	0.880	3.516	19	4.000	0.001	0.004[1]	0.832	0.420
B19	0.878	3.484	20	4.000	0.002	0.005[1]	0.584	0.168
B22	0.877	3.452	21	4.000	0.003	0.015[1]	0.431	0.146
B25	0.879	3.452	22	4.000	0.000	0.003[1]	0.916	0.651
B03	0.892	3.323	23	3.000	0.001	0.043[1]	0.389	0.238
B16	0.879	3.323	24	3.000	0.008	0.088	0.063	0.027
B01	0.886	3.290	25	4.000	0.000	0.147	0.687	0.619
B23	0.876	3.290	26	3.000	0.006	0.098	0.965	0.858

Note(s): [1]The *p*-value of the One sample Wilcoxon signed-rank test was significant with a *p*-value less than 0.05;
[2]The *p*-value of the Kruskal Wallis Test;
[3]The *p*-value of the Jonckheere–Terpstra Test

Table 5.
Mean ranking of barriers for the adoption of CC

For identifying the major barriers, a mean score ranking was conducted since it has been regarded as the most effective tool to achieve the goal (Deng *et al.*, 2014; Zhang *et al.*, 2019). The result shows that the mean value ranges from 3.290 to 4.160 and seven most significant barriers were found out. They are B08 "inherent difficulties in changing organizational culture," B07 "lack of incentives/financial support," B06 "lack of legislative regulations," B26 "resistant to change the current way of working," B02 "seeking for the lowest cost," B12 "difficulties in converting strategic decisions to operational levels" and B20 "unclear contract terms and objectives." The *p*-values of One sample Wilcoxon signed-rank test are smaller than 0.05, suggesting that the respondents' assessment value was statistically different from the test median 3, except the variable B16, B01 and B23 (Hwang *et al.*, 2018a).

Since there are four kinds of occupations of respondents (i.e. directors, project manager, quantity surveyor and engineers), the Kruskal Wallis Test and the Jonckheere–Terpstra Test were conducted to evaluate the agreement of the barriers' ranking among the four groups. That is because both approaches are often used to test the similarity for more than two independent samples (Wei, 1981). Table 5 shows that the *p*-values are all bigger than 0.05; it means the four groups have similar opinions regarding the importance of barriers for CC implementation (Hwang *et al.*, 2018a).

B08 inherent difficulties in changing organizational culture. The variable B08 is the biggest barrier, with a mean score of 4.161. It is acceptable since there is no easy feat to revamp or change mindsets in an organization. As culture itself is a complicated and multifaceted subject, changing the culture in an organization would not end at a "Top-down approach" from the management (Dainty *et al.*, 2007). Also, there are many sociological, psychological and external factors affecting the organizational culture, causing changing it to be a presumably difficult, tedious and time-consuming process (Alvesson and Sveningsson, 2015). Moreover, the Singapore construction industry is known to have a passive culture, reluctant to adopting changes (Sen, 2017). Therefore, it is foreseeable that the difficulty in changing organizational cultures would pose a huge challenge in the adoption of CC.

B07 lack of incentives/financial support. B07 "lack of incentives/financial support" is the second significant barrier with the mean value reaching 4.097. Financial incentives have always been one of the key drivers in promoting the adoption of new initiatives. Especially in Singapore, the building construction industry is heavily reliant on the governing authority (i.e. BCA) in achieving progress (Hwang *et al.*, 2018a). From the adoption of technology to move for sustainability and ensuring quality assurance, the industry's progress in many of these aspects has been directed by an array of incentives and schemes rolled out by the authorities. For example, for improving productivity, the Construction Productivity and Capability Fund was implemented. A sum of $800 million was set aside and pumped into incentive schemes that aid firms in developing its workforce, capability and in adopting new technologies (BCA, 2018; Hwang *et al.*, 2018b). Given that CC is still rather new and does not have any financial incentives, it is inevitable for this variable to be one of the top barriers in Singapore.

B06 lack of legislative regulations. The variable of "lack of legislative regulations" ranked the third (mean value 4.065). Present legislative regulations are catered to conduct competitive tendering or traditional procurement methods, which puts potential adopters of collaborative practices at a disadvantage since the legal clauses and conditions are drafted contrary to the concept of "trust-based negotiations" in CC (Ng *et al.*, 2002; Naoum, 2003). In addition, the use of common familiar contract forms and legal practices is inherent in many practitioners, causing collaborative initiatives that do not work well (Cheung *et al.*, 2003; Erik Eriksson *et al.*, 2009). Therefore, the incompatibility of current regulations and contracts acts as a barrier to the adoption of CC.

B26 resistant to change the current way of working. The variable of "resistant to change the current way of working" ranked the fourth with a mean value of 3.968. CC implementation might bring the change of work processes, organization structure even the traditional procurement approach. Many contractors are comfortable and familiar with the traditional working ways, thus find it a chore to adopt such a novel and unconventional initiatives like CC (Suprapto *et al.*, 2015). Olatunji *et al.* (2017) also listed the unwillingness to change as a pertinent barrier in the adoption of CC. Meanwhile, there are about 1.32 million foreign workers in Singapore, and the construction industry employs a significant proportion of them (Tan, 2014). Due to the deeply entrenched differences in traditions, languages and working methods, it is difficult to adopt a new initiative and change the current way of working.

B02 seeking for the lowest cost. The variable of "seeking for the lowest cost" received an assessment of 3.903. Although CC may bring superior cost performance, the adoption of CC requires consistent investment throughout the project cycle, which can be resource-demanding (Olatunji *et al.*, 2017). For example, to improve communication and quality of collaboration, it is necessary for firms to use CC tools such as workshops and a joint collaborative platform. However, such IT tools are expensive and might increase the project cost dramatically (BCA, 2018). CASG (2017) also highlighted four additional costs that may occur while implementing CC, i.e. cost in collaborators evaluation and selection, cost in monitoring contract relationships, cost in contract development and cost associated with

greater involvement of executive leaders. Moreover, many firms believe that an open and competitive market is the only way to achieve a low price for the project. Due to the desire to seek the lowest cost and retain control, some project stakeholders might cause a stump in the wider adoption of CC (Bygballe *et al.*, 2010).

B12 difficulties in converting strategic decisions to operational levels. The variable "difficulties in converting strategic decisions to operational levels" got the same mean value with the variable of "seeking for the lowest cost." Even if the manager actively promotes CC, it is not easy for translating the initiative into actions (Bresnen and Marshall, 2000). One reason is that the strategy might be misinterpreted by the staff down the hierarchy. Another reason is that actions and attitudes on the operational level can be affected by many other factors such as environment, working habits, culture, etc. As the situation in dealing with other stakeholders might be far from the ideal or the theoretical scenario, it poses a real challenge in translating the formal partnering arrangement on the ground level.

B20 unclear contract terms and objectives. The variable "unclear contract terms and objectives" also got a mean score of 3.903. Generally, common goals and objectives concerning target cost, maintainability, site environment and collaboration will be set in a CC agreement (Erik Eriksson *et al.*, 2009). However, there will be conflicts and misalignments between partnering organizations as each might have a different focus in goal setting (Anvuur and Kumaraswamy, 2007). Some might be looking at long-term goals, while others are pursuing short-term profit. Personal and project goals might also cause some contention in an attempt to be aligned with the entire project team (Chan *et al.*, 2003). Hence, the unclarity in the firm's contract terms and objectives in CC would be a factor of hindrance in adoption.

Respondents with and without CC experience

Given the respondents can be classified into two groups based on their experience in CC, it is necessary to conduct an independent sample test to check the consistency of respondents' opinions. In this study, Moses test of the extreme reaction, Mann–Whitney *U* and Kolmogorov–Smirnov tests were conducted as these methods are defaulted for an independent test of two samples in IBM SPSS Statistics 25. The Moses test of the extreme reaction was used to test the extreme behavior between two independent samples. Its null hypothesis is two samples have a similar extreme number (Bronson, 1959). Also, the Mann–Whitney *U* test was conducted to check whether there is a significant difference in the mean value between respondents with and without experience (McKnight and Najab, 2010). Meanwhile, the Kolmogorov–Smirnov test was carried out to evaluate two independent samples' consistency on the cumulative distribution function (Lopes, 2011).

As shown in Table 6, the results indicate that the two independent groups have no different opinions on the importance of these variables except on variable B02 "seeking for the lowest cost," which failed the Mann–Whitney *U* test with a *p*-value of 0.035 (<0.05). In terms of this variable, the respondents with CC experience expressed a much higher level of agreement. This might because respondents with CC experience went through many difficulties in dealing with problems involving project cost. Due to the firms' nature of profit-earning, it can be imagined that various reasons would be carried out to prevent project cost increase in the CC process, and hence block the road for implementing CC. Another reason might be that the implementation of CC would increase the cost dramatically in nature, which might go beyond the prediction and even exceed the participants' budget.

Also, there are nine failed variables in the Moses test of extreme reaction with a significant level of less than 0.05. They are: B01 "uncertain economic climate," B02 "seeking for the lowest cost," B03 "abuse of collaborative relationships for financial benefits," B04 "potential conflict between commercial pressures and forms of collaboration," B06 "lack of legislative regulations," B09 "lack of support/initiative from top manager," B13 "unknown risks and

Code	Mean value With	Mean value Without	*p*-value of Moses test of extreme reaction	*p*-value of Mann–Whitney *U* test	*p*-value of Kolmogorov–Smirnov test
B01	3.700	3.100	0.004*	0.105	0.185
B02	4.400	3.670	0.004*	0.035**	0.293
B03	3.600	3.190	0.004*	0.268	0.901
B04	3.500	3.520	0.001*	0.755	0.999
B05	4.000	3.670	0.810	0.492	0.939
B06	4.100	4.050	0.015*	1.000	1.000
B07	4.300	4.000	0.284	0.393	0.967
B08	3.900	4.290	0.284	0.135	0.166
B09	3.700	3.950	0.004*	0.574	0.854
B10	3.400	3.710	0.528	0.306	0.721
B11	3.800	3.760	0.810	0.884	1.000
B12	4.000	3.860	0.528	0.693	1.000
B13	4.100	3.520	0.048*	0.053	0.175
B14	3.700	3.430	1.000	0.393	0.887
B15	4.000	3.570	0.810	0.327	0.967
B16	3.400	3.290	0.528	0.950	0.974
B17	3.700	3.670	1.000	0.819	0.871
B18	3.700	3.710	1.000	0.884	1.000
B19	3.700	3.380	1.000	0.327	0.700
B20	3.700	4.000	0.015*	0.327	0.854
B21	3.900	3.620	1.000	0.416	0.871
B22	3.700	3.330	0.810	0.327	0.700
B23	3.200	3.330	0.810	0.693	1.000
B24	3.900	3.710	0.284	0.466	0.980
B25	3.600	3.380	0.004*	0.370	0.700
B26	3.900	4.000	0.128	0.519	0.974

Table 6. The result of independent sample test

Note(s): *The Moses test of extreme reaction was significant with the *p*-value less than 0.05, implying the respondent's assessment exist difference in data dispersion;
** The Mann–Whitney *U* test was significant with the *p*-value less than 0.05, revealing that the barrier has a significantly different mean score between respondents with experience and without experience

uncertainties from the adoption," B20 "unclear contract terms and objectives," B25 "conservative industry culture." Although these barriers have different dispersion in the extreme reaction test, they have similar accumulative dispersion as the *p*-value of the Kolmogorov–Smirnov test all surpassed 0.05.

Best solutions in adopting CC

By relying on an extensive literature review, 21 possible solutions were identified to promote the implementation of CC. And the questionnaire survey asked for the respondents' agreements on these possible solutions. According to the frequency ranking, the survey results presented five best solutions, i.e. S07, S06, S10, S01 and S08, as shown in Table 7.

S07 increasing awareness of the benefits of CC. The solution of "increasing awareness of the benefits of CC" received the most commendations from 90.32% of respondents. This solution can be done by a "Top-down" approach where the authorities work together with the established societies in the construction industry like the Singapore Institute of Architects and Society of Project Managers to educate the industry practitioners, especially the leaders. Successful case studies from other countries and literature proved that the benefits of CC could be published in newsletters for conveying to the leaders and masses. There could even be open-dialogue sessions for management staff to clear their doubts and have an open conversation with other industry leaders. At the post-survey interviews, all three

No.	Solutions	Frequency	%	Rank
S07	Increasing awareness of the benefits of CC	28	90.32	1
S06	Management to take the lead in ensuring a collaborative company culture	27	87.1	2
S10	Involving the middle manager in collaborative talks to promote knowledge transfer	26	83.87	3
S01	Government provides funds to offset initial uncertainties for projects adopting CC	25	80.65	4
S08	Ensuring effective communication with key players involved	23	74.19	5
S09	Focusing on long-term opportunities of collaborative initiatives	21	67.74	6
S21	Selecting Project stakeholders with a collaborative mindset	20	64.52	7
S14	Involving consultants and subcontractors	20	64.52	8
S05	Implementing a structured framework codes for CC	19	61.29	9
S12	Adopting CC on public projects mandatorily	18	58.06	10
S03	Revamping traditional procurement method	18	58.06	11
S20	Formalized team building among project stakeholders – Partnering workshops	17	54.84	12
S04	Lower interest on loans for projects with CC	17	54.84	13
S18	Clearly defined risk allocation and project objectives	16	51.61	14
S11	To educate and train industry professionals	16	51.61	15
S19	Spurring R&D in collaborative platforms/tools	15	48.39	16
S15	Contractual Obligation for amiable dispute resolution	15	48.39	17
S13	Mining a structured CC guide/best practice for different stakeholders to adopt	14	45.16	18
S17	Encouraging and motivating risk-rewards plan for project stakeholders	10	32.26	19
S02	Tighter legislations to prevent abuse of collaborative relationships	10	32.26	20
S16	Contractual obligation to provide early notice for any issues	9	29.03	21

Table 7. Respondents' agreements on identified solutions

practitioners agreed that this approach would be helpful in overcoming the misconceptions about CC. Also, BCA could leverage on ongoing building construction conferences to promote CC. Foreign practitioners who have experienced CC can be invited to share their experiences with the building professionals in Singapore (Salim, 2018).

S06 management to take the lead in ensuring a collaborative company culture. The solution of "management to take the lead in ensuring a collaborative company culture" was assessed to be the second-best solution. Miltenberger and Sloan (2017) also highlighted the importance of leadership in the process of CC adoption. Building up culture is not something that can be done overnight. The organizational policy they formulated will be a marker of the organization's culture and conveys the expectations that employees are to abide by. Moreover, Devilbiss and Leonard (2000) pointed out the concept of a "Transformational Leader" that management staff should embody by being the change as an example for all in embracing the collaborative culture. Additionally, Wong *et al.* (2008) developed a framework for trust-building and organizational learning in the context of partnering that is worthy of looking into for management to implement culture changes.

S10 involving the middle manager in collaborative talks to promote knowledge transfer. S10 "involving the middle manager in collaborative talks to promote knowledge transfer" was recommended as the third-best solution. There are many barriers hindering the fluid of knowledge, such as bureaucratic organizations and the inherent difficulties in converting strategic decisions. Also, the low literacy levels of the workers employed would hinder the basic communication needed for effective collaboration due to the limitation of their understanding of instructions and technical details (Alinaitwe *et al.*, 2007). As the nature of CC demands a working relation that embraces a fluid and informal climate for collaboration (Jacobsson and Roth, 2014), involving the middle manager in collaborative initiatives would

be necessary. One reason is it could shorten the distance between top managers and workers and then promote the transfer of strategic decisions to operation actions. Another reason is that involving middle managers might be more likely to create a relaxed atmosphere and facilitate the communication and knowledge transfer among workers.

S01 government provides funds to offset initial uncertainties for projects adopting CC. The solution of "government providing funds to offset initial uncertainties for projects adopting CC" was proposed as the fourth-best solution with support from 80.65% of respondents. The majority of the respondents feel that the S01 would be the most effective in overcoming the financial barriers such as uncertainties and the tendency to gravitate towards the lowest cost (Ey *et al.*, 2014). Firms are almost always profit-oriented. Thus, they might be averse to trying unconventional methods like CC, which might be financially risky. Like the other strategies that BCA has been adopting to promote a new directional change in the industry, such as green building and improving productivity (Hwang *et al.*, 2018b), funds can be provided to help firms kick start with adopting CC.

S08 ensuring effective communication with key players involved. S08 "ensuring effective communication with key players involved" was suggested as the fifth-best solution. When collaborative practices are still new, professionals will still be rather unaware of the concept, and therefore, unable to see the gains from collaborating, causing a hindrance in adoption (Yeung *et al.*, 2012). The general unawareness of collaborative practices would repel practitioners, acting as a barrier for adoption (Glagola and Sheedy, 2002). Also, the absence of key subcontractors in a collaborative arrangement will lead to inequity in the risk-reward register, impeding the formation of integrated culture. There would be looming problems in developing a favorable mechanism to resolve issues that arise (Ling *et al.*, 2014). Hence, ensuring effective communication with key players involved is of great importance.

Validation

For validating the obtained results, the postsurvey interview was held with three industrial professionals. The profile of post-survey interviewees was shown in Table 8. Due to confidentiality issues, their names were not revealed. Three industrial professionals come from the statutory board, developer and subcontractor respectively. All of them have rich work experience in the Singapore construction industry and have experience with CC implementation.

Three industrial professionals all supported the survey results and proposed that barriers hindering CC adoption are associated with organizational culture, financial support, legislative regulations, mutual objectives and commercial benefit. They indicated that the most significant cause of inefficiency is the misalignment of incentives amongst the participants involved in the delivery of construction projects. To encourage collaboration among the key players involved, ensuring effective communication and establishing a common incentive pool based on the overall project performance is necessary. Also, the middle management is the key for knowledge transfer in collaborative talks.

Moreover, the paradox between seeking for low cost and investment on CC adoption would be a big barrier. CC requires persistent investment in building trust and instilling collaborative behaviors. Due to the principle of seeking for the lowest cost, players rarely

Table 8. Profile of post-survey interviewees

No.	Title	Organization	Designation	Years of experience	Experience with CC
1	Mr.A	Statutory Board	Senior Contracts Manager	20	Yes
2	Mr.B	Private Developer	Director	18	Yes
3	Mr.C	Sub-contractor	Director	23	Yes

invest on their own if there are no definite returns. That can hinder the industry moving from a traditional contacting approach to CC adoption. They also argued that conventional contracting models have long been favored for their simplicity and the certainty risk transfer. Practitioners may resist to change in the current way of working. Hence, the government can publicize the benefits of CC to the industrial professionals, and in the meanwhile, provide funds to offset uncertainties for projects adopting CC.

Conclusion and recommendations

The study investigated the current status, major barriers and possible solutions for the adoption of CC in the Singapore construction industry. First, an extensive literature review was carried out with the identification of 26 barriers, as well as 21 possible solutions. Then, a questionnaire survey was disseminated to firms and industry professionals after receiving validation from 4 industry experts. The survey result reveals that only a mere 32.23% of respondents have participated in projects with CC form/principles. In addition, for the past three years of all the projects that the respondents were involved in, only 25.22% of projects adopted CC elements. By mean score ranking, the top barriers of this study came out to be: (1) inherent difficulties in changing organizational cultures; (2) lack of incentives/financial support; (3) lack of legislative regulations; (4) resistant to change the current way of working; (5) seeking for the lowest cost; (6) difficulties in converting strategic decisions to operational levels; (7) unclear contract terms and objectives. Respondents also gave their opinions on the best solution to overcome the barriers. The top five solutions are: (1) increasing awareness of the benefits of CC; (2) management to take the lead in ensuring a collaborative company culture; (3) involving the middle manager in collaborative talks to promote knowledge transfer; (4) government provides funds to offset initial uncertainties for projects adopting CC; and (5) ensuring effective communication with key players involved. Finally, to validate the obtained results, a post-survey was conducted by interviewing three industrial professionals.

The obtained results should be interpreted in the context of study limitations. First, the survey results are based on the respondents' perceptions and their experiences, which might be affected by personal bias. Respondents might withhold information especially when it comes to organizations or projects, if they deem it as sensitive information. Second, the survey was carried out in the case of the Singapore construction industry, causing the findings might change in other areas. However, the research findings are still useful because they investigated the current status, major barriers and possible solutions for the Singapore construction industry adopting CC. Specifically, for construction industry practitioners, it could contribute them to improving the awareness and understanding of the impending barriers to overcome. For the Singapore authorities, it could provide them with guidance and reference for their policy development.

Moreover, this study unfolds several recommendations. First, the government could provide financial subsidies to push the adoption of CC. Singapore's construction industry is known to be passive and slow in adopting new initiatives. Especially in such a situation that firms would have to bear the tangible additional cost in establishing tools like IT platforms, organizing partnering workshops and developing CC competencies. Providing financial incentives might be an impetus for adoption CC. Second, the top managers should lead the change of mindsets and cultures. It is an uphill task to change mindsets and the way of doing things, especially in the older generation. BCA could first educate firm leaders about the benefits and technicalities of CC, then push the leaders to inculcate a culture of trust and collaboration. Third, awareness about CC should be raised. The benefits of adoption CC should be made known to the masses, especially to the clients who tend to be reluctant to adopt CC. And practitioners who have been through CC in other countries can be invited to share their experience and successful stories.

Last, it is recommended that future research could discuss the critical success factors and the potential impacts of adopting CC in the Singapore construction industry. It might also be interesting to conduct an in-depth case study, expecting to introduce the best CC practice and draw on the successful experience for industry practitioners.

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