Cleaner Engineering and Technology 15 (2023) 100662

Contents lists available at ScienceDirect

Cleaner Engineering and Technology

journal homepage: www.sciencedirect.com/journal/cleaner-engineering-and-technology

Pre-investigation on adaptation of construction 4.0 multi criteria business model by SME contractors in Malaysia

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ARTICLE INFO

Keywords:
Industry revolution 4.0
Construction 4.0
SME business model
Malaysia construction industry

ABSTRACT

Malaysia's Construction Industry has adopted Industry Revolution 4.0 namely Construction 4.0. The program is for the adaptation of new technologies, talented skills, diversified workforce, and to sustain economic growth for the future through smart digital construction transformation. As one of the main economic sectors, the construction industry in Malaysia comprises more than 60 percent of Small and Medium Enterprise (SME) companies. Do the SME contractors agree on the changes of business model in facing Construction 4.0 and stay relevant? Analysis of the pilot-investigation on the adaptation of Construction 4.0 for the SME Contractors' Multi-Criteria Business Model in Malaysia is discussed in this paper. Factors of challenges for SMEs adopting Construction 4.0 were analyzed through a pilot questionnaires survey data collection. Descriptive analysis was used to portray the level of agreement among managing directors of SME contractors. There were 15 respondents involved in the pilot survey who representing the SME contractors from Grade G1 to G5. Management, finance, resources, technology, personnel, and legal matters are six key factors that affect significantly the SMEs' multi criteria business models. Significantly, this study approached the scholars and industry players to understand how the Construction 4.0 transformation affects the SMEs' business models and the construction industry in Malaysia.

1. Introduction

Small and medium-sized businesses (SMEs) play a critical role in the political stability, social advancement, and economic growth of any nation. SMEs come in a variety of forms. In urban or rural areas, SMEs can be developed for any type of commercial activity (Amin Amini, 2004). It might be viewed as the foundation of the country's economy (Edrak et al., 2014). In order to recognize the importance of SMEs in advancing the economy, numerous organizations, especially the government, seriously concerned in their growth. A variety of solutions and services are offered to strengthen SMEs and enhance their performance and affordability. Construction is a massive flat industry that suggests that all other businesses rely on it, and where value creation largely occurs in the intelligence of amenities or assets expansion. There are extensive efforts shall be done to increase SME contractors' proficiency in the Construction 4.0 revolution.

1.1. Construction 4.0

The development of new technologies over the past few decades has resulted in changes to the construction industry's procedures and working techniques. In 2016, the German language coined the term "Construction 4.0″ to describe these changes. The changes are also a part of Industry 4.0, which primarily focuses on the utilization of computer and cyber-physical systems (Boyes et al., 2018). The significant technological and scientific advancements of Industry 4.0 have been developed in the 21st century. This development has also helped the construction sector to be more efficient, giving rise to the phrase Construction 4.0. The idea of Construction 4.0 was first brought forward in 2016 by Roland Berger. It was based mostly on the fact that construction

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https://doi.org/10.1016/j.clet.2023.100662
Received 21 March 2023; Received in revised form 11 July 2023; Accepted 19 July 2023
Available online 20 July 2023

companies had become more aware of the needs for the digitization. The digitalization incorporates four important concepts: digital data, automation, connectivity, and digital access. Construction 4.0 is a "transformative framework" where three changes occur: industrial production and construction, cyber-physical systems, and digital technologies. Examples of the new concepts of digital technologies, as defined by Sawhney et al., include Building information modeling (BIM), Common data environment (CDE), Drones, Cloud based project management, Augmented reality and Virtual reality (AR/VR), Artificial intelligence, Cybersecurity, Big data and analytics, Blockchain, and Laser scanning. On the other hand, robots and automation, sensors, the internet of things, wearable sensors for employees, actuators, additive manufacturing, off-site and on-site construction, and equipment with sensors fall under the umbrella of cyber-physical systems. These technologies now present new prospects For businesses looking to improve their competitiveness, such as the quality of their works, the timely completion of projects, and the additional services they provide to their clients. In addition, some of these technologies, including BIM, sensors, and the internet of things, have demonstrated in recent years that they can help the construction sector in achieving the objectives of stainable built environment (Fokaides et al., 2020). These technologies also have tremendous potentials and prospects for application in the sustainable decision-making in building technology (Zavadskas et al., 2018).

1.2. Malaysia SME contractors facing construction 4.0

At the moment, the SME construction companies in Malaysia are, still using traditional methods of construction. The emergence of Construction 4.0 and the combination of technologies affect the competitiveness of these companies and their supply chains. The Construction 4.0 is inadvertently restructuring the entire construction industries. There are huge challenges facing the SME contractors in Malaysia because they are lacking the exposure to the most recent trends in the construction sector. (Lim et al. (2020) stated that in order to consciously implement Construction 4.0, solid strategies and processes are necessaryIn addition, to remain productive and competitive, the SME contractors need qualified individuals to manage and operate the Construction 4.0's modern technologies. New business models, and innovations are needed to help local businesses succeed globally ((Craveiro et al., 2019; Bosch-Sijtsema et al., 2021).

According to research, bussiness rivalry may speed up the inventions and facilitate information sharing. Additionally, the booming industrial revolution creates new opportunities for resilient SMEs since they can respond to innovation solutions with greater speed and flexibility. The industrial revolution will not only benefit the SME companies but might also result in a total reorganization of market operation. Additionally, centralized digital state-level initiatives would improve the competitiveness of the business in the global market. For example, a new standard is necessary to be established with the use of Building Information Modelling (BIM) in construction projects. However, the SMEs contractors will certainly face several challenges in implementing this technology. According to Haron et al. (2017), the challenges can be divided into cost, time, software, readiness, knowledge and information. The cost to own BIM software is expensive and it is required to engage BIM manager who knows how to operate the software.

SME contractors must improve their current business operation in order to remain competitive. The implementation of Construction 4.0 technology such as BIM has been increasingly identified as the necessary tool by those involved in the construction industry (Rooshdi et al., 2021). The functionality of BIM tools, accessibility of BIM tools, requirement of computable digital design data, need for sophisticated data management and data interoperability are the sub-factors that should be considered for adoption of BIM technology. Beside BIM, finance, management, personnel, and legal matters are also needed to be considered in order to remain competitive. The consideration of financial factor include cost incurred in terms of time and training, cost of hiring specialists, and cost of purchasing required hardware and upgrades. Training of professionals to operate BIM software, habitual resistance of staff to change and not familiar enough with BIM capabilities must be considered under personnel factor. As for the legal matters, ownership of the BIM data and its copyright, contractual environment, safety and reliability of building information, lack of protocols and responsibility between stakeholders are also necessary to be considered.

Table 1
Projects by grades of contractors – year 2015–2016 (Source: Construction industry development board).

Grade of Contractor	Number of Contractors	Number of Projects	Number of Projects (%)	Value of Projects (RM billion)	Value of Projects (%)
Foreign	78	134	1.9%	19.2	15.4%
G1-G2	89	99	1.4%	0.2	0.2%
G3	513	687	10.0%	2.4	1.9%
G4	553	849	12.3%	1.6	1.3%
G5	611	899	13.1%	3.4	2.7%
G6	338	618	9.0%	2.9	2.3%
G7	1531	3599	52.3%	94.7	76.1%
TOTAL	**3713**	**6885**	**100.0%**	**124.4**	**100.0%**

Table 2
Projects by grades of contractors – year 2016–2017 (*Source: Construction Industry Development Board)*.

Grade of Contractor	Number of Contractors	Number of Projects	Number of Projects (%)	Value of Projects (RM billion)	Value of Projects (%)
Foreign	140	183	2.8%	35.4	20.1%
G1-G2	68	71	1.1%	0.2	0.1%
G3	507	621	9.5%	1.3	0.7%
G4	659	888	13.6%	1.9	1.0%
G5	591	762	11.6%	3.5	2.0%
G6	446	622	9.5%	3.5	2.1%
G7	2227	3400	51.9%	130.3	74.0%
TOTAL	**4638**	**6547**	**100.0%**	**176.3**	**100.0%**

Table 3
Projects by grades of contractors – year 2018–2019 *(Source: Construction Industry Development Board)*.

Grade of Contractor	Number of Contractors	Number of Projects	Number of Projects (%)	Value of Projects (RM billion)	Value of Projects (%)
Foreign	194	264	3.5%	36.2	22.2%
G1-G2	111	114	1.5%	0.4	0.3%
G3	465	588	7.8%	1.1	0.7%
G4	668	897	11.2%	1.6	1.0%
G5	672	904	12.0%	3.0	1.8%
G6	449	640	8.5%	2.8	1.7%
G7	2683	4141	55.5%	118.0	72.3%
TOTAL	**5242**	**7548**	**100.0%**	**163.1**	**100.0%**

Table 1, Table 2 and Table 3 show information on the projects awarded to contractors based on the grades from the year 2015 until 2019 as reported by Construction Industry Development Board (CIDB), Malaysia. The tables consist of projects and their values awarded to foreign contractors and Grade 1 to Grade 7 local contractors. SME contractors fall under categories G1 to G5 and big companies are G6 and G7. In the particular period, G1-G2 contractors had secured total projects valued at RM 0.80 billion. G3 contractors secured projects worth RM 4.8 billion, whileG4 contractors managed to grab RM 5.1 billion of contracts. G5 contractors were awarded the contracts valued RM 9.9 billion.

Table 4
Comparison of projects and value of projects between SMEs (G1 to G5) and big companies (G6 to G7).

	SME (G1 to G5)		Big Companies (G6 to G7)	
	Total	%	Total	%
Number of Projects	7379	36.2%	13020	63.8%
Value of Projects	20.6 Billion	5.5%	352.2 Billion	94.5%

Table 5
Topic and author on the construction 4.0 challenges.

No	Topic	Author
1	Customer Relation	Guma et al. (2019)
2	Technological Challenges	Ellahi et al. (2019)
3	Organisation/Knowledge	Cerchione and Esposito (2017)
4	Strategy/Leadership	Hizam-Hanafiah et al. (2020)
5	Creative Thinking	Ellitan et al. (2020)
6	Pandemics	Mckibbin and Fernando (2020)
7	Employees (qualification)	Razali (2018)
8	Productivity Challenges	Chin and Yusoff (2020)
9	Education on IR 4.0	Tandon (2020)
10	Halal Sustainability	Ahmad Zaid (2020)
11	Working Capital Management	Aktas et al. (2015)
12	Management and Profitability	Nguyen and Nguyen (2018)
13	Financial challenges	Kukharuk and Gavrysh (2019)
14	Information challenges	Kukharuk and Gavrysh (2019)
15	Maintenance Operations	Mohd Noor et al. (2021)
16	Technical Competency	Ismail and Hassan (2019)
17	Technological challenges	Kukharuk and Gavrysh (2019)
18	Obstacles associated with automation	Ingaldi and Ulewicz (2020)

Table 4 summarises a comparison number of projects and the value of projects between SMEs and big companies. It reflects that SME contractors just managed to secure 7379 projects (36.2%) compared to 13020 projects awarded to the big companies. In terms of value, it is a very huge gap etween SMEs and big companies. SME contractors only obtained RM20.6 billion worth of projects (5.5%). n other hand, big companies secured RM352.2 billion value of projects (94.5%). It clearly shows that SME contractors must be competitive by upgrade their companies in terms of business model and explore further big projects.

SMEs must be ready to adopt the technologies of Construction 4.0, such as challenges in Big Data, limiting factors on robotic adaptation, barriers in running SME business, etc. SME Corporation of Malaysia have listed four main factors that affect the competitiveness of the SME business due to this Industry Revolution: (i) Customer expectations are shifting towards digitalization; (ii) Products are being enhanced by data, which improves asset productivity; (iii) New partnerships are being formed as companies learn the importance of new forms of collaboration; and (iv) Business and delivery models are being transformed into new digital models. To date, research on business models and their elements are still scarce.

1.3. Challenges faced by SME contractors

Construction 4.0 has already been in the construction business for quite a while and the knowledge is on different levels of maturity. Technologies such as BIM, Cloud Computing, and Modularization have industrialized suggestively while other skills such as Augmented, Virtual and Mixed Reality are still being improved and by some means affect the sustainability in the construction industry. The application of Construction 4.0 within the Construction Industry is still missing extremely despite having user-friendliness of these technologies (Alaloul et al., 2020). Table 5 below lists several other challenges being discussed by other authors.

Besides that, Coleman et al. (2016) have identified problems and challenges in business analytics and big data analytics for SMEs. SMEs are, in numerous cases, not totally alert regarding the effects of digitalization. Subsequently, this causes misunderstanding in the difficulty and cost of digitalization solutions, so that their possible financial assistances cannot be properly projected. The consequences of external pressure as the main driver lead to adaptation of Construction 4.0 technologies have advantages and disadvantages, more so, for small and medium-sized enterprises. This could lead to the late adoption of Construction 4.0, because compared to mass markets catered by large enterprises, niche markets are less competitive. According to (Oesterreich & Teuteberg (2016), there are allegations of digitization and automation in the context of Construction 4.0 towards to construction industry.

1.4. Business model of SME

Although business models are common managerial tools for planning, contrasting, and analyzing an organization's value generating process, they are a topics that are less frequently discussed and studied in construction industries. According to current business model literature, the idea is crucial for a company to be successful since it serves to

Table 6
Critical literature review analysis on business model canvas.

No	Title and Author	Year Published	Keywords	Important Points
1	A Business Model Canvas for Social Enterprise (Vial, 2016)	2016	Business Model, Canvas, Social Entrepreneurship	Six components: value creation – how (1) and who for (2), competencies (3), strategic positioning (4), monetization (5), time, scope and size ambitions (6)
2	A Circular Economy Business Model Innovation Process for the Electrical and Electronic Equipment Sector (Pollard et al., 2021)	2020	Circular Economy Business Model, Innovation, Electric and Electronic Equipment, Circularity Indicators	Fivefold interconnected layers, provides electrical and electronic equipment manufacturers with a comprehensive layered process for developing and implementing a circular economy business model tailored to their business offerings.
3	Adaptation of the Business Model Canvas Template to Develop Business Models for the Circular Economy (Schöllhammer et al., 2020)	2020	Circular Economy, Business Model Canvas, Digital Ecosystem, Industrial Symbioses and Synergies.	Five patterns that extend the existing Business Model Canvas 1) Return diagnostic process; 2) Recovery system; 3) Recovery relationship 4) Recovery channels; 5) Recovery incentive system
4	Business Model Canvas as a Basis for the Competitive Advantage of Enterprise structures in the Industrial Agriculture (Dudin et al., 2015)	2015	Strategy, Competitive Advantages, Business Model Canvas, Enterprise Structures, Industrial Agriculture, Competitiveness.	Enterprise structures develop not only one business model and its canvas, but several business models, in order to increase the performance of the tools.

set it apart from others and provide it an advantage over its rivals (Teece, 2010). A company's operations, value creation for consumers, and method of capturing value from operations in order to turn a profit are all defined by its business model (Yahaya, 2020). As a result, it compels managers to consider their company's operations as a whole. Recent advancements in this field of study have also resulted in the visualization of business models, which has improved understanding of various business concepts and placed business models in a position where they are employed as an efficient management tool to convey and carry out strategy (Das et al., 2020).

Although the most of the studies offer various definitions for business models, there are certain similarities that can be found among the majority of them (Foss and Saebi, 2018; Vial, 2016). Initially, one of the essential components of the majority of business model definitions is the generation of client value. Second, some definitions of business models include references to earning logic. Third, many definitions of business models include discussions of a firm's value network, which sheds light on the interactions a firm has with different value network actors. Finally, business model descriptions frequently incorporate information about a firm's assets and capabilities as well as the kinds of strategic judgements, choices, or guiding principles that it employs (Saebi et al., 2020).

The issue with developing new business models is that few managers are knowledgeable enough about their organizations' current business models to advance them or modify them when necessary (Lanzolla and Markides, 2021). Here is where a thorough analysis of the business model utilizing a set of established business model components is beneficial. Managers may compare, discuss, and most importantly, analyse the interdependencies across business pieces using a common language provided by the described elements. A business model should be consistent both internally and externally, according to (Pekuri et al., 2015). While external consistency refers to how the decisions made regarding the components of the business model fit in the external environment, internal consistency refers to the fitness between various elements as they affect and are affected by one another. How a company develops and extracts value is conceptualized by its business model. It includes the firm's economics, organisational structure, and strategic decisions (Pekuri et al., 2015). There will be a fresh idea for a SME contractor's business plan as well as wide strategies that SMEs can employ to raise their level of competence and current business performance in the direction of Construction 4.0.

1.4.1. Business model canvas

A Business Model Canvas (BMC) established by Osterwalder instrument can be quite operative here in helping users recognize an organisation's business model. The BMC can help users visually represent of the elements of a business model and the potential interconnections and impacts on value creation. Table 6 below shows critical literature review analysis on the Business Model Canvas.

The literature review was conducted by referring articles indexed in Web of Science, Scopus and Science Direct journal. The conditions used were the influence of Construction 4.0 from a SME approach, demonstrate Business Model Innovations from the Construction 4.0 approach and how the acceptance of the Construction 4.0 affects the Business Models components.

1.4.2. Traditional business model

A business model describes a construction for how a firm makes and distributes value to clients and the instruments working to capture a share of that worth. It's a coordinated set of fundamentals surrounding the movements of costs and incomes (Teece, 2018). The creating, modification, application, and conversion of business models are outputs of high-order (dynamic) competences. Energetic capabilities, which are reinforced by administrative habits and executive skills, are the firm's ability to integrate, build, and reconfigure interior capabilities to report, or in some cases to bring about, variations in the business environment. The strong point of a firm's dynamic capabilities is vigorous in many ways to its ability to preserve productivity over the long term, including the capability to plan and regulate business models (Teece, 2018).

1.4.3. Multi criteria business model

Business model canvas (BMC) is enhanced into business model with several additional elements and renamed to multi criteria business model. BMC consist of elements key partners, key activities, key resources, value proposition, customer relationship, channel, customer segment, cost structure and revenue streams. At end of author's research, a new element, project delivery will be added in to multi criteria business model. This project delivery element consists of element manpower, machinery, material, financial and information technology. SME contractors shall adapt these elements in to their existing business model to allow and capable to face Construction 4.0 technologies. Every element under project delivery significantly affects SME contractor to penetrate in to mega projects that involve Construction 4.0 technologies. For example, manpower, SME contractor have to appoint workers that have experience in controlling high tech tools. Under financial, SME contractor shall financially be strong to purchase expensive software and sophisticated machineries.

As to summarize the above, this paper will carry out pre-investigation on the factors that caused SME contractors to adapt Construction 4.0 technologies. SME play a very important role in economy growth of the nation. Wide ranging efforts should be in the pipeline to increase SME contractors' expertise in the Construction 4.0 revolution. According to research, increased competition speeds up innovation even more, and a growing market makes it easier to share information. Additionally, as a result of their increased speed and flexibility in responding to innovation solutions, resilient SMEs are given new chances by the booming industrial revolution. This will help SMEs and cause a complete reconfiguration of the market. Centralised digital state-level initiatives would also increase enterprises' ability to compete on the global market. Construction 4.0 has been around for a while, and the information it possesses is at various stages of maturity. While other skills like augmented, virtual, and mixed reality are still being enhanced and indirectly impact the industry's sustainability, technologies like BIM, Cloud Computing, and modularization have suggestively industrialized. Despite these technologies' user-friendliness, the use of Construction 4.0 inside the construction industry is still severely lacking. After double-checking earlier research, journals, and conference papers, the author concludes that the business model still lacks a few key components. Project delivery components under business models are not the subject of any studies. Further, research needs to be done on the factors of manpower, material, machinery, financial and information technology that have a big impact on how well small and medium-sized businesses succeed.

Table 7
Quantitative method instrumentation.

Items	Description
Research Design	Quantitative Method
Research Instrument	Survey
Instrument Design	A questionnaire, Matrix Questionnaires
Measurement Scale	Likert Scale
Goodness of Measures	Validity (Actuality) Practicality Reliability (Accuracy) – Cronbach's Alpha (>0.7)
Instrument Assessment	Pilot Study
Data Collection	Population – Info from CIDB Malaysia Sample Size – Krejcie and Morgan 1970 Sampling Technique – Probability Samples (Known Cluster)
Data Analysis	SPSS Frequency Analysis

Table 8
Demographic of respondents.

Position of Respondents	Freq. (%)	CIDB Category of Respondents	Freq. (%)	Knowledge of Respondents Scale (0–10)	Freq. (Nos)
Director	6	G1	1	3	1
Manager	3	G3	7	4	1
Owner	6	G4	3	5	5
		G5	4	6	1
				7	3
				8	3

2. Research methodology

Various studies being made on Industry Revolution 4.0, business models, small and medium enterprises and so on since the year 2011, when it was first publicly introduced by Germany. From then, constant research gaps are being filled by various researchers. After cross-checking previous studies, journals, and conference papers, the author feels that there are still missing some elements under the business model. No studies are being made on project delivery elements under business models. Break further, a study needs to be conducted on manpower, material, machinery, finance and information technology which significantly affect the performance of a small and medium enterprises (Ratana et al., 2022).

Two set of questionnaires is prepared for the data collection instrument of this pilot study. Table 7 shows the details of the planned instruments. The pilot data considered accepted based rule of thumb suggest sample size for the pilot study is 12 pax (Julious, 2005), Author managed 15 respondents to participate in this questionnaire. These 15 respondents are from SME companies that covered the Directors, Project Managers, Contract Managers and Project Engineers. These respondents who participated represent the scope of the study which includes: (i) SME contractors in Klang Valley; (ii) the SME contractors who registered under CIDB (G1 to G5 contractors); (iii) Contractors that implement business models in the company management; (iv)Traditional business model, a joint venture (JV), concessionaire, franchise; and (v) G6 and G7 contractors is excluded.

The collected data via hardcopy questionnaires and google forms were analyzed using SPSS Inc. Ver.26 and Microsoft Excel, 2019 software. The analysis utilized descriptive and inferential statistics with the help of the "Statistical Package for Social Studies (SPSS) and Microsoft Excel (MS Excel)". Descriptive statistics were used to generate frequencies, proportions, tables and charts that involved measurements of means, and ranges. For the reliability test, Cronbach's alpha for this questionnaire is 0.941, which is accepted as reliable.

The demographic information of the respondents is summarised in Table 8, which shows the respondent's position frequency. Out of 15 respondents, 6 respondents are a director of an SME company which covers 40% of the total respondents. The same frequency applies to the position of the owner. Managers covered 3 respondents with a percentage of 20%. Likewise, on the CIDB category of SME Contractors category, there is 1 respondent from CIDB grade G1 (6.7%). 7 respondents are from CIDB grade G3 with 46.7%. There are 3 respondents from G4 SME Company with a percentage of 20%. And, 4 respondents are from CIDB grade G5 with 26.7%. No respondents from CIDB grade G2. Meanwhile the level of knowledge of the respondents on the Construction 4.0, all the respondents have some level of knowledge as none of them chooses NIL. 1 respondent chose level 3, level 4, level 6 and 9. The majority of the respondents have chosen level 5 as their level of knowledge. Thus, continue with level 7 and level 8 which were chosen by 3 respondents respectively. From the respondence statistic, 86% of overall respondents have minimum knowledge of 5. This shows SME's quite aware of the Construction 4.0 and its implications. This questionnaire exercise made easy and understandable to SME that took part, where the SME knows and understand the questions being asked.

Table 9
Descriptive statistics for management factor.

Sub-Factor Code	Management Sub-Factors	N	Mean	Std. Deviation
MF1	Fragmented nature of the construction industry	15	4.1333	0.63994
MF2	Well-developed practical strategies and standards	15	4.0667	0.59362
MF3	Managers' and owners' awareness and support	15	4.5333	0.63994
MF4	Changes in workflows and inappropriate business models	15	4.2000	0.56061
MF5	Cooperation from other industry partners	15	4.4000	0.63246

Table 10
Descriptive statistics for finance factor.

Sub-Factor Code	Finance Sub-Factors	N	Mean	Std. Deviation
FF1	Cost in terms of time and training	15	4.4667	0.63994
FF2	Cost of specialised	15	4.3333	0.61721
FF3	Cost of required hardware upgrades	15	4.4667	0.63994

In addition, Table 10 presented the descriptive statistics for the finance factor. 3 sub-factors are drawn under the finance factor. All the sub-factors recorded a minimum value of 3.00 and a maximum value of 5.00. The sub-factors recorded mean values of FF1 (4.4667), FF2 (4.333) and FF3 (4.4667) respectively. The mean values show that all the sub-factors have significantly become one of the factors for SME contractors to adopt Construction 4.0.

Table 11
Descriptive statistics for resources factor.

Sub-Factor Code	Resources Sub-Factors	N	Mean	Std. Deviation
RF1	Manpower readiness	15	4.5333	0.63994
RF2	Emerging technologies	15	4.4000	0.63246
RF3	Financial support	15	4.4667	0.63994
RF4	Advance materials	15	4.5333	0.63994

3. Factors caused to SME contractors in adopting construction 4.0 Vs multi criteria business model

Likert-scale questions were used to identify the factors that caused SME contractors in adopting the 'Construction 4.0′ technologies. Respondents may choose between 1 and 5 on the agreement, where 1 represents strongly disagree, 2 is 'disagree', 3 is neutral, 4 is 'agree' and 5 is 'strongly agree'. Respondents were asked to choose an agreement on the factors given, which may cause SME contractors in adopting the Construction 4.0 technologist. From the literature studies, there are 6 main factors identified; management factor, finance factor, resources factor, technology factor, personnel factor and legal factors (Ratana et al., 2022). All factors have respective sub-factors. Every sub-factor is coded (MF1, MF2, etc) for analysis purposes, followings are the discussion of the analysis outcome.

Table 9 above, showed the descriptive statistics generated by SPSS for the management factor. Respondents agreed with this sub-factor with an MF1 mean value of 4.1333. While, MF2, obtained a mean value of 4.0667 which is basically agreed by respondents. Likewise, MF3 recorded the highest value of mean compared to other sub-factors, which is 4.5333 (strongly agree). Furthermore, MF4 resulted in a mean value of 4.2000 and MF5, recorded a mean value of 4.4000. Looking at all the mean values of each sub-factors, the author concluded that all the sub-factors significantly become one of the factors for SME

Table 12
Descriptive statistics for technology factor.

Sub-Factor Code	Technology Sub-Factors	N	Mean	Std. Deviation
TF1	The functionality of BIM tools	15	4.4667	0.74322
TF2	Accessibility of BIM tools	15	4.2000	0.67612
TF3	Requirement of computable digital design data	15	4.3333	0.61721
TF4	Need for sophisticated data management	15	4.3333	0.61721
TF5	Lack of data interoperability	15	4.2667	0.70373

Table 13
Descriptive statistics for personnel factor.

Sub-Factor Code	Personnel Sub-Factors	N	Mean	Std. Deviation
PF1	Educate professionals about BIM	15	4.4667	0.63994
PF2	Habitual resistance to change	15	4.3333	0.61721
PF3	Not familiar enough with BIM capabilities	15	4.4667	0.63994

Table 14
Descriptive statistics for legal factor.

Sub-Factor Code	Legal Sub-Factors	N	Mean	Std. Deviation
LF1	Ownership of the BIM data and its copyright	15	4.2000	0.67612
LF2	Contractual environment	15	4.3333	0.72375
LF3	Safety and reliability of building information	15	4.1333	0.51640
LF4	Lack of protocols	15	4.1333	0.63994
LF5	Responsibility between stakeholders	15	4.1333	0.74322

contractors to adopt Construction 4.0.

Meanwhile, Table 11 portrayed 4 sub-factors under the resources factor. All 4 sub-factors recorded a minimum value of 3 and a maximum value of 5. Sub-factor RF1 recorded a mean of 4.533, which skewed towards 5.000, where respondents strongly agree with this sub-factor. RF2 mean is 4.400, which falls under agreed opinions. RF3 recorded a mean of 4.4667, also sitting under agreed responses. RF4 recorded a mean of 4.533, the same as RF1, categorised under strongly agreed. Can conclude that the sub-factors listed above mostly fall under agreed and strongly agreed by respondents.

To continue, Table 12 shows the descriptive statistics for 5 sub-factors of technology factor. The highest mean was recorded by TF1, with a value of 4.4667, where most of the respondents agreed that TF1, the functionality of BIM tools play a major factor in SMEs adopting Construction 4.0 technologies. It is followed by TF3 and TF4 with the same mean of 4.333. Ranked 4th is TF5 with a mean of 4.2667 and 5th is TF2 with a mean of 4.2000. The above analysis shows that the technology factor has a minimum value of 3 and a maximum value of 5, which means, all respondents agreed that TF1, TF2, TF3, TF4 and TF5 basically is a factor for SMEs to adopt Construction 4.0 technologies.

Furthermore, is personnel factor is denoted above in Table 13. There are 3 sub-factors represented by PF1 PF2; and PF3. The highest mean was recorded by 2 sub-factors, PF1 and PF3 with a mean of 4.4667. PF2 recorded a lesser mean compared to others with a mean of 4.3333. Overall, all respondents agreed with the sub-factors since all mean values were recorded above 4.000.

Last but not least is the legal factor which designated 5 sub-factors. In referral to above Table 14, the highest mean was recorded by LF2 with 4.3333. Three sub-factors recorded the same mean with a value of 4.1333 that is LF3, LF4 and LF5. And LF1 recorded the least mean of 4.2000. This legal factor recorded a minimum value of 3 and the highest value of 5. All these legal sub-factors were agreed to be a factor affecting SME contractors to adopt Construction 4.0 technologies.

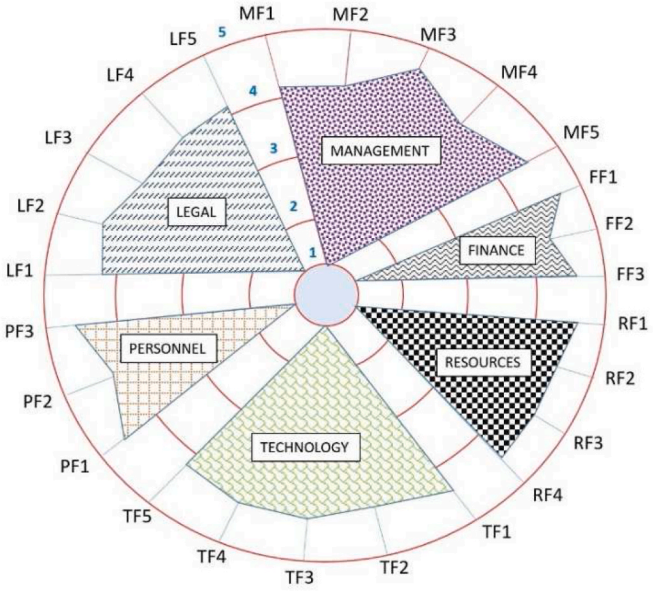

Fig. 1. Overall factors caused to SME contractors in adopting the 'construction 4.0 from pre-investigation.

Followings Fig. 1, shows the overall respondent's mean mapping of 6 main factors and their 25 sub-factors. Under management factor, there are 5 sub-factors (MF1; MF2; MF3; MF4; M5) received 86.7; 86.7; 93.3; 93.4; 93.4 percent of acceptance agreement. Looking at the finance factor, there are 3 sub-factors, (FF1; FF2; FF3) accepted at 93.3; 93.3; 93.3 percent of respondents' agreement. The resources factor offering 4 sub-factors (RF1; RF2; RF3; RF4) which accentuate 93.3; 93.4; 93.3; 93.3 level of agreement. Likewise, for the Technology factor, there are 5 sub-factors (TF1; TF2; TF3; TF4; TF5) that emphasise 86.7; 86.6; 93.3; 93.3; 86.7. While the Personnel factor includes 3 sub-factors (PF1; PF2; PF3) that have a level of agreement 93.3; 93.3; 93.3 percent from respondents. Lastly, is the legal factor comprising 5 sub-factors (LF1; LF2; LF3; LF4; LF5) that responded 86.6; 86.7; 93.3; 86.7; 80 percent agreed and important by respondents.

A further survey was carried out to perceive respondents' opinions on the SME adoption of multi criteria business model. The business canvas model was adopted in developing the measurement instrument. A matrix table that crossed the main factors (Manpower; Material, Machinery, Finance; and Information Technology) versus multi criteria business model was developed and utilized in the matrix questionnaire survey. The respondents marked the level of agreement by using the Likert scale.

Table 15 below shows the average mean value of factors for each multi criteria business model from the opinion of 15 respondents.

The mean value of factor manpower for all business model criteria was recorded between 0.93 (value proposition) and 1.26 (capability). This range of value fall under the category of not applicable and moderately adopted. The next factor is material. The mean value for the factors ranged between 0.96 (revenue model) and 1.20 (value proposition). Also, fall under the category not applicable and moderately adopted. Follow by the factor of machinery. The mean value recorded is between 0.93 (target customer) and 1.21 (cost structure). The level of agreement for this factor was recorded between not applicable and moderate adopted. The fourth factor is money (finance). The factor recorded a mean value of 0.92 (partnership) low and 1.31 (capability& revenue model) high. As for the last factor, information technology, the

Table 15
Matrix of factors versus business model criteria for SME contractors in adopting the 'construction 4.0

		Business Model Criteria								
		2.1	2.2	2.3	24	2.5	2.6	2.7	2.8	2.9
	Business Model Elements	Value Proposition	Target Customer	Distribution Channel	Customer Relationship	Value Configuration	Capability	Partnership	Cost Structure	Revenue Model
3.1	Manpower	0.93	1.07	1.21	1.09	1.06	1.26	1.08	0.95	1.03
3.2	Material	1.20	1.08	0.98	1.08	1.06	1.01	1.10	0.99	0.96
3.3	Machinery	1.01	0.93	0.94	1.09	1.00	0.97	1.07	1.21	1.07
3.4	Money (Financial)	1.10	0.99	1.07	1.02	1.22	1.31	0.92	1.29	1.31
3.5	Information Technology	1.21	1.03	1.00	1.23	0.93	1.17	1.11	0.84	0.99

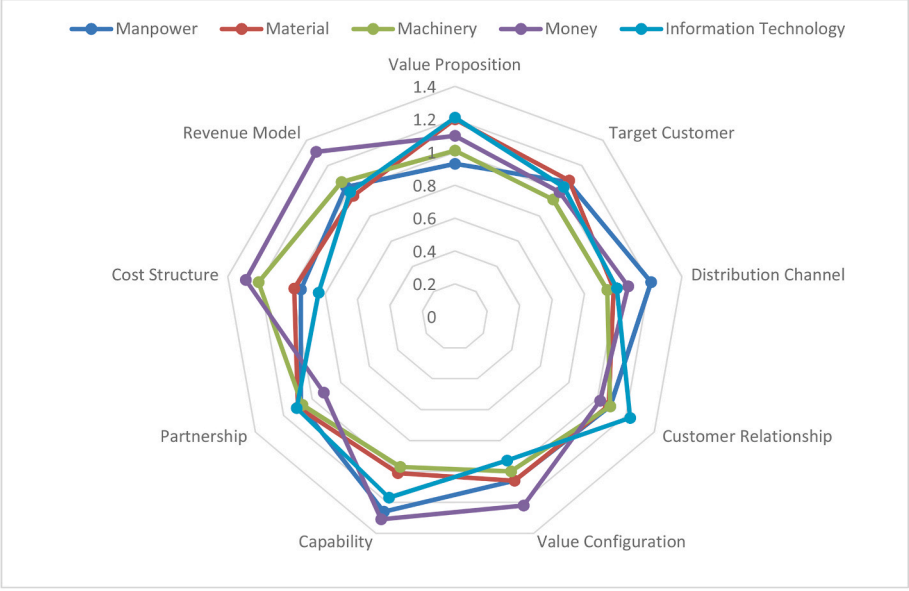

Fig. 2. Mean Value of Responses for factors (Manpower; Material, Machinery, Finance; and Information Technology) vs Multi Criteria Business Model.

mean value recorded for its factor was between 0.84 (cost structure) and 1.23 (customer relationship). The level of agreement falls between not applicable and moderate adopted. Generally, the values reveal that all factors are not yet ready to adopt in the business model criteria for SME contractor's businesses.

Fig. 2 shows the mean value of responses for sub-factors for all business model criteria in the form of a radar chart. The figure shows clearly that the mean values were recorded between 0.90 and 1.30.

4. Conclusion

Construction 4.0 basically affected all the stakeholders in the construction businesses. All stakeholders including developers, contractors, consultants and the supply chain have to adopt the changes created by the revolution, in the order to sustain the construction businesses. Small medium enterprise (SME) contractors are not exempted from this movement of the Construction 4.0 revolution. Gigantic contractors might not face many obstacles to sustain thru this revolution due to companies' financial backup. But, for SMEs, (categorised as Grade1,2,3,4,5 under CIDB Malaysia) it is a big obstacle because business mainly depends on localised finance support. The SME contractor has to take some steps to be able to face the revolution. One of them is, upgrading the existing business model. At end of this research, SME contractors will gain some new knowledge on how to alter and enhance the existing business model, to ready face the Construction 4.0 revolution. There are 6 main factors identified, which are management factor, finance factor, resources factor, technology factor, personnel factor and legal factor. Each factor has its sub-factors. The analysis revealed that SME contractors agreed and strongly agreed to adopt Construction 4.0 technologies. Respondents agreed that all 6 main factors significantly affect the contractors in adopting the Construction 4.0 technologies. However, when perceived on the readiness to embrace Construction 4.0 caused factors in business model criteria, this pre-investigation study explored that the SME Contractors needed much support in bridging Construction 4.0 into their company business model. New elements will be introduced to incorporate in to business model canvas, mainly for project delivery elements such as manpower, material, machinery, financial and information. SME will require to tackle obstacles arise from those project delivery elements in order to adapt Construction 4.0 technologies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

The author acknowledges all the co-authors for their contribution and co-operation in composing this paper. Special thanks were conveyed to **Cleaner Engineering and Technology** for giving the platform to publish this paper. Also, thanks to University Teknologi Malaysia for being the main research hub.

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