International Journal on Emerging Technologies **12**(1): 188-203(2021)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Critical Success Factors for Adopting Industry 4.0 in Construction: A Review

Nurul Syazwana Mohammad Suferi[1] and Md Motiar Rahman[2]
[1]Ph.D. Candidate, Civil Engineering Programme Area, Faculty of Engineering,Universiti Teknologi Brunei, Tungku Highway, Gadong, BE1410, Negara Brunei Darussalam.
[2]Senior Assistant Professor,Civil Engineering Programme Area, Faculty of Engineering, Universiti Teknologi Brunei, Tungku Highway, Gadong, BE1410, Negara Brunei Darussalam.

(Corresponding author: Nurul Syazwana Mohammad Suferi)
(Received 11 November 2020, Revised 12 January 2021, Accepted 26 February 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Generally, organisations in construction industry achieve success and maintain stability of operations by accomplishing goals of multiple projects. This is usually done by applying, and with the help of, project management. However, the dynamic business environment and consequent increased project complexities (i.e., the 'changes') often create issues that directly influence the project performance, and eventually influence the organisational performance. In order to adapt to those evolving changes, it is important to continuously identify suitable strategy. This is likely to be achievable by applying the principles of strategic management. Currently, the emergence of Industry 4.0 is creating 'changes' in the business environment, which is posing a challenge of developing a suitable strategy for adopting Industry 4.0. This was planned to overcome by identifying the critical success factors, and their respective success factors, of project management, strategic management and Industry 4.0; and then developing a framework for adopting Industry 4.0 in construction industry. Structured literature review was considered as the research methodology for initial extraction of the factors, which created another challenge of bringing the three concepts under one umbrella, since their focus areas are apparently different. This was also overcome by considering the application of all three areas in terms of applying and delivering projects in construction industry. The results show that the three identified sets of critical success factors have a number of common focus areas for implementing Industry 4.0 in construction, namely management, strategy, organisation, environment, innovation, project related issues and human/social issues. The issues under these collated common focus areas need to be suitably addressed for delivering construction projects with the help of technological blessings offered under Industry 4.0, in order to achieve project objectives that is set under an organisational strategy, and thereby achieving organisational goals. However, a country- or region-specific adjustment to the generic issues is necessary to incorporate and prioritise any local concerns. Therefore, the next step will be to refine and validate the identified factors/issues, conceptualising a framework for their combined application.

Keywords: Strategic management; project management; Industry 4.0, construction industry, critical success factors.

Abbreviations: SM, strategic management; PM, project management; IR4.0, industry 4.0/ industrial revolution 4.0; CSF, critical success factor; SF, success factor; QS, quantity surveyor; E&M, electrical and mechanical.

I. INTRODUCTION

Achieving organisational successes is one of the major concerns in construction industry [1]. It is measured differently in different organisations (i.e. by considering organisational growth or employee satisfaction) [2]. The key to determine organisational success is its ability to achieve goals [3]. However, it is often obstructed by complexities that arise from the dynamic business environment comprising natural environment (e.g. climate changes, natural disasters, and act of God) and external environment (e.g. economic, legal, and technological issues). In addition, construction projects are also dynamic as project nature, project participants and project requirements and goals (i.e. time, cost, and quality) are different for every project [4-5]. Although project successes are observed, the complexities increase with time, such as global warming, which eventually contributes to changes to natural environment [6], and the current emergence of Industry 4.0 that is already changing the technological factor of the external environment in construction industry [7]. The need for construction industry to continuously improve itself in order to cope with changes in such dynamic business environment and ensure stability of operation is crucial. Thus, this paper focuses on modernising construction industry and updating business entity of construction organisation, which is the key for its eventual survival.

In general, the extents to which organisational successes are achieved vary as organisations practice different operational approaches and have variety of experiences and skills [1, 8]. In construction industry, organisational success is mainly determined on the basis of performance at project level [9]. This is because construction industry is a project-based industry, where the project refers to new buildings, infrastructures, and refurbishments or extensions of existing buildings, as well as other construction works. Compared to other industries, such as manufacturing and education, the project level is more prioritised than corporate level.

Therefore, it aims to achieve project successes, i.e. completing goals of multiple projects, to maintain stability and eventually achieving organisational goals. This is done generally through the execution of project management (PM) [4, 10]. Construction industry frequently considers the advantage of PM that unifies the various functions of participants and resources of projects within uncertain and complex environments of projects and organisations [11]. With this, the execution of PM has enabled the industry to accomplish project goals. PM is responsible to plan, control and schedule all stages of a project, as well as ensuring involvement of the project participants [12-13]. However, project performances in construction industry are time-dependent [9]. Thus, the changing business environment directly influences the performances of organisations. The changes create issues at corporate level, such as administrative and strategic issues. For example, the current emergence of Industry 4.0 (IR4.0) pushes organisations to apply advancements of digital technologies, where administrative issues arise relating to technology adaptation, and strategic issues too arise relating to achieving organisational goals, as the technology is adopted. Traditionally, focusing on executing PM at project level is likely to satisfy goals at corporate level, as achieving goals of multiple projects eventually attains organisational goals. So, when the changes occur over time, corporate level should also overcome and adapt to the changing business environment, on which PM is dependent. Since the application of PM is limited to project level, organisations need a management approach at corporate level that can adjust the organisations with changes occurring in the business environment. Strategic management (SM) is likely to be the management approach that can overcome such issues. SM allows organisations to continuously study and analyse the dynamic business environment to determine the business strategy, based on which PM can be applied in executing the business strategy. For example, SM may help in assessing and adopting issues and relevant policies regarding sustainability, ICT, IR4.0, among others, which are beyond the scope of PM, as it mainly focuses on project execution. Although SM may appear as generic in construction industry, its strength lies in the fact that SM leads organisation to change strategy successfully, as changes in business environment occurs. In particular, PM focuses on delivering and meeting project goals, whereas SM focuses on the organisational goals. Both are important for organisational success, especially when changes occur either in the business environment, such as the current emergence of IR4.0 and its adoption in construction industry.

IR4.0 was initially introduced to transform manufacturing industry positively through the use of digital technologies [14]. Observing the satisfying outcome of manufacturing industry through the implementation of IR4.0, construction industry is urged to adopt IR4.0 and transform into a modernised industry [15]. Organisations in construction industry have maintained stability by executing PM for project success. Nowadays, the integration of technological tools in construction is beneficial, despite its minimal use. The common programmes used are the Building Information Modelling (BIM) and Lean Construction [15]. The use of both the tools is argued to be useful in minimising fragmentation, improving efficiency and lowering the high costs of interoperability in construction industry [16]. Use of other IR4.0 drivers, such as cloud-based manufacturing and internet of things, may also minimise cost overruns, accomplishing project requirements, and enabling improvements in collaboration [17-18]. With IR4.0, the traditional operating practice and procedures change toward improvements, this is beneficial in efforts to modernising construction industry [19]. However, considering construction industry being a project-based industry, PM needs to be maintained for project success. As such, the modernisation of construction industry will potentially be achieved by merging SM and PM together, as construction industry adopts IR4.0. Evidently, there is an urgent need for further study to assess and/or compare exactly which specific critical aspects or factors of PM and SM affects organisational success in construction industry.

On the basis of the foregoing conceptualisation, a study was undertaken targeting adoption of IR4.0 in construction industry, by identifying and examining the critical success factors (CSFs) of SM and PM for organisational success, comparing these two sets of CSFs with that of IR4.0, and to developing a framework that unifies SM and PM for the adoption of IR4.0 in construction industry. Overall methodology involves literature review, questionnaire survey, and interviews of local industry experts, with necessary adjustments during the course of the study as seem suitable. As the beginning of the overall study, this paper reports the outcome of the structured review of literature that is focused on extracting the three sets of CSFs. The outcomes are expected to contribute to form parts of the questionnaire survey, and to develop the framework. The following section briefly discusses the concept and suitability of CSFs in pursuing this research, before outlining the methodological approach adopted for this paper, and extraction of the three sets of CSFs.

II. CRITICAL SUCCESS FACTORS

Critical success factors (CSFs) are a few key areas that enable success to organisations, through using precise and most relevant information [20]. Managers, as the key persons to organisations, need to ensure continuous provision of information and then apply it efficiently and effectively for the benefit of the organisations. However, earlier study by Rockart highlighted that the managers struggle to examine the broad spectrum of information, to determine the preciseness and effectiveness of information for a solution [21]. Thus, the concept of CSFs was developed as a method that determined critical information for the managers [22]. The CSF method was developed in such a way that it can be applied for any organisations [21]. The method ensures that the information is customised based on the structure of the industry, the organisation's business entity, the business environmental factors and the internal organisational factors. This shows that the method specifically considers the factors that are affecting projects. Based on this, present study finds the CSF method very useful for the purpose of enabling construction industry to adopt IR4.0.

CSFs generally consists a list of factors that particularly affect a project, which is subjected to evaluation by managers [23]. This means that, one list of CSFs is especially for one type of project only, i.e., the list is more likely to vary as changes in 'environment' occur. This is very crucial in construction industry, since construction industry operates in a dynamic business environment, and every construction project is unique to some extent. For example, the current emergence of IR4.0 brings about technological advancements that make the project goals more demanding and different than before (i.e., shorter time, higher quality and lower cost). Thus, implementing IR4.0 in construction will itself require identifying a set of CSFs. Moreover, organisational goals are determined by the type of project to be undertaken. This requires determining the strategy, which is decided by the key persons (i.e. the managers) of the organisation. As suggested, SM enables organisations to adapt to changes. However, the essential information needed for managers to utilise SM is limited due to the minimal utilisation of SM in construction industry. This too can be overcome by determining the CSFs of SM, in terms of its application in construction. Therefore, with respect to achieving goals at corporate and project levels, the current study aims to bring the 3 aspects (PM, SM and IR4.0) in one stream as a way to uptake the current emergence of IR4.0.

III. METHODOLOGY

This paper is based on structured review of literature, which focuses on identifying the three sets of CSFs, namely for PM, SM and IR4.0 in construction. The initial process was to search for basic knowledge of the relevant aspects of the review, i.e. on CSF in general. The first step was to search for relevant information among the broad collection of documents in three different research databases, namely the Science Direct, Emerald Insight and Taylor and Francis. Eight different keywords were used for the search: SM, PM, IR4.0, CSF of SM, CSF of PM, factors affecting IR4.0, construction industry and implementation of IR4.0. The criterion for search was by 'relevance'. Table 1 shows the produced search results for each keyword, revealing a very high number of publications. Due to the high number of publications, the next step of elimination or screening process was applied. First round of screening was to use all keywords together in one search, which eliminated the number of publications significantly, leaving still a high number of publications (1,483 + 282 + 324 = 2,089).

Table 1: Number of publications from search result.

	Science Direct	Emerald Insight	Taylor and Francis
Keywords/Sites			
SM	252,829	123,991	807,905
PM	770,178	142,462	760,906
IR4.0	215,887	102,553	61,284
CSFsSM	69,348	53,621	219,225
CSFsPM	128,852	51,444	188,865
CSFs IR4.0	16,533	34,172	8,033
Construction industry	406,626	61,190	477,313
Implementation of IR4.0	63,554	41,842	19,458
All keywords in one search	1483	282	324
After elimination process	**116**		

Further screening steps applied were: (i) eliminating publications of same title; and (ii) examining the abstracts of the publications to ensure that the papers mainly deal with the 3 aspects (i.e. PM, SM and IR4.0) of the review. The last step applied was to ensure that the publications used in this study are relevant to construction industry. This again reduced the number of publications to 116.

IV. OVERVIEW OF PROJECT MANAGEMENT

Project management (PM) is needed in construction industry. This is because projects in construction industry involves a series of complex activities that need to be accomplished from the earliest stage of a project to completion of project, i.e. planning, design, construction, handover and occupancy/use of building or structure [13]. Generally, a project is defined as a unique collection of activities and interdependent processes for production of goods or service, with definite beginning and end [24-25]. A project is undertaken by an individual or organisation to meet specific objectives, i.e. to complete a project within specified time, cost and quality parameters [26]. Projects are unique and temporary/one-off undertakings typified with progressive elaboration that requires proper preparation [24, 27]. Uniqueness means that projects have their own respective specifications, circumstances and activities, which differ from one another. One-off/temporary undertaking means that projects have their own limited period of time with specific beginning (i.e. commencement of the project), and specific end (i.e. completion), within which the goals of the project are expected to be achieved. Progressive elaboration means that projects are undertaken in a series of successive steps, in order to meet all the details specified within the scope of the project. Projects can be of several types, such as manufacturing projects, innovation projects, new product development projects, and expansion projects, among others [28]. Projects carried out by different industries differ considerably, e.g., projects in manufacturing industry produce goods as outcome, whereas projects in construction industry produce buildings or infrastructure as finished products. However, all projects are similar in terms of aiming to design a manufacturing line to produce a product, at a minimal production cost and maximum efficiency/efficacy.

Projects are bounded by time, cost and quality requirements and the environment. Theoretically, PM unifies various functions of participants (i.e. the project team) and resources within an organisation, but in practice, it is the role and responsibility of a project manager to manage those [4]. Project manager's role and responsibility includes motivation, time, cost, scope, quality management and various administrative duties [29]. Due to that, PM highly depends on the competency

of a project manager to successfully execute project [30]. This includes the ability to have different approach of management, to complete tasks within time, taking risks, delegating responsibilities to subordinates, problem solving skills, and skills that befalls under PM [31-32]. PM is still an important approach used in many industries, especially in construction industry, which is in effort to master skills of planning, control and scheduling of projects.

Organisations in construction industry highly depend on PM as a standard management approach that functions as a medium in achieving project success [4]. The fact that PM makes project success achievable is the important strength of PM. In general, success is the ability of an organisation to achieve its goals [3]. Construction projects are considered success when the goals or criteria of the project are met, i.e. completion within time and cost, and quality in accordance with the project specifications. This is also known as the "iron triangle", which has been widely mentioned in literature, such as by Hawk [33], Atkinson [34], Bernroider and Ivanov [35], among others. Meeting these has become the standard way of project controlling in PM. Based on these criteria, PM focuses on the ability to deliver the end product in accordance with the project scope, scheduled time, budgeted cost and specified quality. However, PM is not limited to meet the three criteria only. Project successes are influenced by other factors as well, such as environment, project participants (i.e. their attitude, behaviour, and culture), health and safety concerns, knowledge, value and risks [36]. Therefore, while the iron triangle (of time, cost and quality) maintains to be the key areas of concern, the additional factors that surround the project are also taken into account in PM.

Success of PM is limited to the type of project undertaken by organisation. However, projects are of continuous and perpetual nature, where end of one project means another project is to begin [27]. This constitutes a cycle of projects and thus, the cycle of PM applies similarly whenever organisations undertake a project. Eventually, the PM becomes a standardised process of projects where project performances are managed while maintaining focus on the PM performances [37]. Construction industry depends on PM for continuous project successes to maintain stability, as organisations operate in the dynamic business environment [38]. Thus, organisation's capability in executing PM most likely determines the performance of the project they undertake, and overall, the performance of the whole organisation. This includes identifying, executing/applying, monitoring and controlling the factors that influence the performance of PM, i.e. CSFs of PM. Varieties of case studies identified CSFs of PM of organisations operating in a project-based business environment, where the factors differ as project characteristics differ from each other [10, 39-40].

V. CSFs OF PROJECT MANAGEMENT

Exposing the CSFs from various backgrounds is important for organisations to execute PM efficiently. In this study, the CSFs of PM have been extracted from literature. Firstly, papers identifying CSFs of PM were gathered and studied. Then the CSFs were refined to eliminate repetition of similar factors, ranked based on their frequency in studied literature, and then arranged according to their rankings (Table 2). Further review on success factors (SFs) of such CSFs were carried out in order to understand their influence or support to the CSFs. As a result, seven CSFs with a total of 40 SFs were compiled. The CSFs have been codified numerically as 'CSF PM 1' to 'CSF PM 7', whereas their respective SFs have been codified alphabetically, e.g. 'CSF PM 1a'. The following subsection briefly discusses the seven CSFs and their respective SFs.

Table 2: CSF of PM and its source.

Factors/Source	Belassi&Tukel [23]	Naoum et al [40]	Ugwu et al [41]	M0rris & H0ugh [42]	Toor et al [43]	Turner et al [44]	Martarella [45]	Park [46]	Mulder [47]	Morris [48]	Clarke [49]	Cooke-Davie [50]	Turner [51]	Rockart [52]	Pinto & Kharbanda [53]
Management ability to accomplish project-related tasks	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓
Effective project delivery method	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓
Strategic abilities of organisations	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓			✓
Project team structure	✓	✓		✓					✓			✓		✓	✓
Technical ability of project team		✓	✓		✓				✓		✓		✓		✓
Influence of business environment	✓			✓			✓			✓				✓	
Innovative working environment			✓	✓					✓	✓					✓

A.CSF PM 1: Management ability to accomplish project-related tasks

This CSF focuses on the key persons of the organisation, who are the project managers and leaders, to have the required skills such as leadership skills, critical thinking and good decision making [23, 40, 47]. This is important when accomplishing project-related tasks while overcoming challenges, such as adaptation to changes in business environment [41]. The key persons are expected to establish clear and effective communication, monitor and control performances and uncertainties/risks, and ensure participation of stakeholders and project teams, to take quality decisions, when necessary [40-42, 44-46, 48-51, 53]. Overcoming such challenges also usually require top management power and support to create a working environment that encourages employees to accept and commit to any changes occurring within the organisation [41, 46-48]. As such, this CSF was seen to comprise the following success factors:

- CSF PM 1a: Top management support
- CSF PM 1b: Clear and effective communication
- CSF PM 1c: Project manager characteristics
- CSF PM 1d: Performance management
- CSF PM 1e: Uncertainty/Risk management
- CSF PM 1f: Stakeholder management
- CSF PM 1g: Level of participation in decision making process by project team
- CSF PM 1h: Change management of organisation level
- CSF PM 1i: Leadership and team management

B. CSF PM 2 Effective project delivery method

This CSF focuses on the project specifics and characteristics mainly to ensure precise allocation of resources for successful project delivery [23, 42, 45-46,48, 51]. This includes awareness of the budget estimate, expected time of completion, and quality to be met that are usually stated in the project briefs [40, 42, 46-50]. The proper preparation of project briefs is also needed for determination of suitable framework and clarity of contract [41-42, 45-48, 51, 53]. Furthermore, the project information enables proper planning for allocation of skilled persons and manpower, and provision of financial support, to ensure successful project delivery [41, 46, 48-49]. As such, this CSF was seen to comprise the following success factors:

- CSF PM 2a: Framework conditions
- CSF PM 2b: Precise project budget estimate
- CSF PM 2c: Clear and precise briefing documents
- CSF PM 2d: Fixed construction period
- CSF PM 2e: Material and quality
- CSF PM 2f: Mutual and trusting relationships
- CSF PM 2g: Manpower's skills in understanding construction process
- CSF PM 2h: Availability of manpower
- CSF PM 2i: Clarity of contract
- CSF PM 2j: Financial support

C. CSF PM 3 Strategic ability of organisations

This CSF focuses on project goals and outcomes from project reviews, which is required for the planning, formulation and implementation of strategy [23, 40, 42, 44, 47, 49-50]. Changes in business environment often challenge organisations from accomplishing organisational goals [45]. However, as projects are undertaken based on strategy set by the organisation [33], the clarity of scope and work definition, the targeted project goals, and review of projects are vital for organisations, to implement a strategy and to offer solutions to overcome challenges faced [23, 40-42, 44, 48, 53]. As such, this CSF includes the following success factors:

- CSF PM 3a: Establishing project goal
- CSF PM 3b: Establishing client criteria
- CSF PM 3c: Clarity of scope and work definition
- CSF PM 3d: Implementation process
- CSF PM 3e: Defined solution offerings
- CSF PM 3f: Project review

D. CSF PM 4 Project team structure

This CSF urges the identification of client's organisational structure and involvement of end user to enhance the understanding between project team members [23, 40, 42, 47, 52]. This includes determining the extent to which project manager has authority and influence on [40]. Such identification is expected to create a better relationship that enhances teamwork and allows better understanding of future use, such as to accommodate special design requests (e.g. laboratories, hospitals) [23, 40, 50, 53]. This CSF consists of the following success factors:

- CSF PM 4a: Project team work
- CSF PM 4b: Client's organisational structure
- CSF PM 4c: Project manager authority and influence
- CSF PM 4d: User involvement

E. CSF PM 5 Technical ability of project team

This CSF highlights the importance of planning and programming techniques, especially for project cost estimate [40, 43, 47, 49, 51, 53]. Ability of application of these techniques is one of the skills that lead to proper execution of PM, particularly in controlling project cost, and thus meeting the project goal [40-42, 47, 49, 51]. This CSF comprises the following SFs:

- CSF PM 5a: Planning and programming techniques
- CSF PM 5b: Project cost estimate and control

F. CSF PM 6 Influence of business environment

The dynamic business environment plays a critical role in project performances [1, 10]. This refers to external natural environment, such as weather conditions, natural disasters, act of God, and land condition [23, 52]. It also refers to the external environment relating to politics occurring and legal factors that may change over time [42]. In addition, a construction project itself is dynamic, due to the multiple phases of construction and involvement of different project participants at different phases [24-25]. Business environment, therefore, may influence complexities, unless managed properly [7]. Thus, organisations need to create demand in order to keep the business running [45]. Therefore, PM needs to constantly gather, monitor and analyse sufficient information relevant to the organisation's market, such as trends, competitors and customers, to overcome business environment related concerns [48]. Thus, the CSF covers the following SFs:

- CSF PM 6a: External natural environment

- CSF PM 6b: Politics
- CSF PM 6c: Demand creation
- CSF PM 6d: Legal factors
- CSF PM 6e: Market intelligence

G. CSF PM 7 Innovative working environment

The construction industry is often criticised for the lacking in innovation and low productivity [1]. Apart from the complication in terms of operation within construction organisations, innovative changes (i.e. technological developments and digitisation) appear as additional concerns [54]. Considering the current change occurring (i.e., IR4.0), construction industry needs to be open towards innovation, from different aspects [19]. SM enables construction industry to constantly be aware of any changes and find any suitable ways to adapt those changes within an organisation [55]. With SM, more appropriate tools are available for organisations to gain benefit from (e.g. balanced scorecard, SWOT analysis and Porter's five forces) [41, 49]. Furthermore, while maintaining the practice of PM, organisations may gain from IR4.0 adoptions where exploitation of modern technology and the use of standard software infrastructure may assist in developing team knowledge [41-42, 47, 53]. This CSF comprises the following success factors:

- CSF PM 7a: Availability of appropriate tools
- CSF PM 7b: Exploitation of modern technology
- CSF PM 7c: Development of team knowledge
- CSF PM 7d: Standard software infrastructure

VI. OVERVIEW OF STRATEGIC MANAGEMENT

PM enables construction industry to accomplish project goals and eventually to achieve organisational goals. However, organisations are concerned with issues relating to changes occurring over time [54]. Applying PM at project level may no longer satisfy goals at corporate level (i.e., organisational goals) under such changes. Organisations need to overcome and adapt to such changes in order for PM to operate under strategically oriented suitable organisational goals. SM appears to offer such strategic basis, in setting suitable organisational goals that can deal with emerging issues, and also allow PM to operate and execute at project level to assist in meeting organisational goals.

SM is largely practiced in business organisations, as it is fundamental to leading organisations towards success [55]. SM requires the key persons to fully understand the overall concept of SM, even from the starting point of SM [4, 56]. It is therefore indicative that the SM draws a clear step-by-step procedure that enables organisations to cope with emergent changes/issues. SM drives organisations to clarify its procedures in detail and proactively drives towards achieving long term goals.Organisations operate in highly competitive and dynamic environment. This refers to the changes in business environment that are always complex and rapidly occurring [57]. This situation is seen as one of the key challenges and is arguably disadvantageous for organisations to survive and succeed in long run, i.e. achieving organisational success. For this, organisations are required to think differently and proactively [8]. The target is organisational success that is in the forms of organisational growth and/or employee satisfaction [2]. Thus, SM became prominent as a significant structured act of management approach that provides momentum and enables organisations to overcome the challenges created by the changes in dynamic environment [57-58]. SM also drives organisations to think differently to determine and implement a strategy that suits the environment [8]. SM is seen to be effective in leading organisations towards survival and success in such environment [40]. This suggests the importance of SM within the field of business.

SM is executed through three elements of strategic thinking, strategic planning and strategic momentum [8]. These become a series of procedures to be undertaken under SM. A successful SM means achieving strategic competitiveness through successfully formulating and implementing a value-creating strategy [59]. However, the success of SM is not solely dependent on these elements, but on efficiently addressing the variety of key areas/issues (i.e. CSFs). SM itself is a challenge on top of the business challenges that organisations face. This is due to the fact that the strategy changes as there is a change in business environment, and this suggests that SM itself is dynamic. In addition, organisations also face difficulties in implementing the strategy formulated through SM, including construction industry [54]. Thus, the key persons within the organisation also need to overcome the increase in business and strategic challenges, while operating in dynamic business environment [58]. This means, the key persons (or managers) within the organisations play a role as the key persons in SM as well, i.e. strategic leaders. These strategic leaders are the persons responsible to undertake the elements of strategic management, while appreciating the key areas/issues (i.e. CSFs) of SM, for SM to perform effectively and successfully.

VII. CSFs OF STRATEGIC MANAGEMENT

As shown in Table 3, seven CSFs of SM were extracted, along with their 27 SFs. The steps and coding of CSFs and SFs used are similar to that of PM. They are briefly discussed in the following subsections.

A. CSF SM 1 Influence of organisational behaviour/culture

This CSF focuses on the employee within organisation and highlights the importance of their awareness on the organisation's specifics and activities, involvement in accepting new ideas, and setting their mind set on the accomplishments of organisational values [60-64]. This is because SM is the creation of new strategies, based on what the organisation to operate [59]. This requires cooperation of employees, which influences the success of strategic momentum for strategy implementation [2, 55, 58].

Table 3: CSF of SM and its source.

Factors/Source	Wohlfeil&Terzidis [19]	Farzin et al [60]	Amoli&Agashahi [61]	Slavik et al [62]	Volosin [63]	Misankova&Kocisova [64].	Hanzelkova[65]	Rowley &Shermann [66]	Mallya [67]	Niven [68]	Rae et al [69]	Gurowitz [70]	Gavurova [71]	Beer &Eisenstat [72]	Himme [73]	Sassi et al [74]	Applebaum & Hung [75]
Influence of organisational behaviour/culture	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	
Management abilities towards changes	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
Employee orientation within organisation		✓	✓	✓		✓	✓	✓	✓		✓	✓					✓
Strength of organisational strategy		✓						✓	✓	✓	✓	✓		✓		✓	
Role of organisational structure to facilitate changes				✓	✓		✓					✓	✓	✓			
Organisational innovation skills	✓		✓					✓									
Ambient business environment	✓	✓													✓	✓	

This CSF comprises the following success factors:

- CSF SM 1a: Organisational specifics and activities
- CSF SM 1b: Involvement of employees
- CSF SM 1c: Processing system
- CSF SM 1d: Mind set on organisational values

B. CSF SM 2 Management abilities towards changes

This CSF focuses on adapting new ideas by managers/leaders that are able to lead the organisation towards changes. Such strategic leaders should have leadership and communication skills, in order to undertake the elements of strategic management and deliver the strategic changes clearly, to motivate employee involvement [19, 60, 62, 65-69]. Moreover, top management involvement and their commitment to the strategic changes are required, especially when planning for resources, in accordance with the new strategy to be implemented [19, 60, 67-70, 73, 75]. This CSF includes the following four SFs:

- CSF SM 2a: Leadership
- CSF SM 2b: Effective communication
- CSF SM 2c: Involvement of top management
- CSF SM 2d: Resources planning

C. CSF SM 3 Employee orientation within organisation

This CSF focuses on the employee satisfaction, which is one of the significant aspects of measuring organisational success [2]. Employees are an important indicator of organisational success, which can be maintained by meeting employee satisfaction. This requires expertise of human resource, for proper allocation of employees in accordance with their skills and experience [65-66]. Employees sacrifice their time, energy and resources to carry out their responsibilities in the organisation they work for [60-61, 69-70, 76]. Therefore, employee's loyalty will strengthen when there are opportunity for continuous learning and security of service [75, 77]. Continuation of experience and trained employees are important to realise the objectives of the organisation [60, 70, 78, 79].

Through employee satisfaction, organisational growth is allowed and both aspects thus drive organisations to organisational success. The SFs of this CSF are as follows:

- CSF SM 3a: Security of service
- CSF SM 3b: Expertise of human resource
- CSF SM 3c: Trust
- CSF SM 3d: Employee's commitment
- CSF SM 3e: Employee's loyalty

D. CSF SM 4 Strength of organisational strategy

This CSF focuses on the strength of strategy formulated and implemented, for the determination of organisation performance. This is because the new strategy should be driving organisation towards success and acting in compliance with law [60, 66, 68-70, 72, 74]. Furthermore, the performance of the strategy will eventually become critical information for strategy evaluation, which becomes the basis for the next cycle of SM [67, 74]. This CSF covers the following SFs:

- CSF SM 4a: Strategy formulation and implementation
- CSF SM 4b: Strategy evaluation
- CSF SM 4c: Acting in compliance with law

E. CSF SM 5 Role of organisational structure to facilitate changes

This CSF focuses on the organisation structure of the organisation, and highlights that the key persons of organisations play a significant role in SM [4]. The key persons of an organisation act as the decision maker, and the leader in the execution of SM. They are identified from the organisational structure, along with other employees within the organisation [62-63, 70-72]. Furthermore, the importance of organisational structure is to highlight the roles and responsibilities of each employee, which forms a control system and ensures that each stage of the organisation can be communicated and controlled properly from different perspectives [62, 65, 70-72]. This CSF includes the following SFs:

- CSF SM 5a: Creation of organisational structure
- CSF SM 5b: Assembly of control system

F. CSF SM 6 Organisational innovation skills

This CSF focuses on the organisation's innovation skills, when organisations need to think differently and proactively [8]. This includes, being innovative, such as utilising modern technologies [61]. By exploiting and applying modern technologies, the strategies derived may comprise of appropriate application of modern tools and techniques for better- and high-quality output [61, 66]. This CSF comprises the following SFs:

- CSF SM 6a: Feasibility analysis
- CSF SM 6b: Exploitation of modern technology
- CSF SM 6c: Application of modern technology

G. CSF SM 7 Ambient business environment

This CSF focuses on competitive market environment, where awareness and practice of cost culture is required, since organisations work in dynamic business environment [73]. Changes in environment are always complex and rapidly occurring [57]. Unfavourable environment is one of the key challenges for organisations to operate sustainably [60]. Construction industry is frequently in need of innovation in the form of product development, market introduction and diffusion [19]. As such, the innovations will most likely improve cost, time and quality, while maintaining high quality of service delivery [72]. This CSF comprises the following SFs:

- CSF SM 7a: Competitive market
- CSF SM 7b: Awareness and practice of cost culture
- CSF SM 7c: Innovative improvements of cost, time and quality
- CSF SM 7d: Product development
- CSF SM 7e: Market introduction
- CSF SM 7f: Diffusion

VIII. OVERVIEW OF INDUSTRY 4.0

Industry 4.0 (IR4.0) is the current emerging issue, and its consequent changes is affecting construction industry. IR4.0 is pushing organisations to apply advancements of digital technologies, which is causing administrative problems relating to technology adaptation, and strategic issues relating to achieving organisational goals. However, it is essential for construction industry to adopt IR4.0, despite these issues, in order to harvest benefits in planning, conducting and controlling various activities for improved project delivery.

The fourth industrial revolution, or simply known as IR4.0, is a phenomenon that surfaces as a result of the emergence and rapid development of modern technologies, such as augmented technology, big data, data analytics, internet of things and prototyping [80]. IR4.0 was an outcome of an initiative regarding high-tech strategy noticed by the German government [81]. IR4.0 is recent, so studies on its attributes to organisations are still scarce. However, IR4.0 involves the high practical and theoretical relevance of digital and connected manufacturing technologies making it necessary to explore and understand the underlying dynamics of their implementation [82]. IR4.0 refers to the digitisation and automation of the manufacturing process, in the form of Cyber Physical System (CPS) [14]. It was developed to increase productivity and efficiency of an industry [83]. IR4.0 involves the connection of all parts of machines via integrated data chains and operations that add value to the whole product lifecycle [84-85]. Moreover, it also fuses the virtual and real world with the emphasis on engineering applications, such as robotics, digitisation and automation [83]. Through IR4.0, human role in the production systems is evolved to meet the integrated smart working approaches in the whole product manufacturing cycle [7, 86-88].

IR4.0 is powered by nine foundational technology advances, which are big data and data analytics, autonomous robots, simulation, horizontal and vertical system integration, Industrial Internet of Things (IoT), the cloud, additive manufacturing, augmented reality and cyber security [89-90]. These technology advancements transform production in a way that isolated but optimised cells (i.e. units of work) will come together as a fully integrated, automated and optimised production flow [89]. This leads to convert traditional practices, to improve performance and management, by interacting with the surrounding environment, such as relationships among suppliers, producers and customers, and between human and machine [88]. The nine advancements are eventually categorised into four main drivers of IR4.0, namely Cloud based manufacturing, IoT, Smart Manufacturing and Industrial Internet [91].

IR4.0 is not only changing the manufacturing industry, but also the construction industry [7]. Technological developments and digitisation brought about by IR4.0 are creating changes in environment to construction industry and it is affecting organisational capability to survive sustainably [8]. Usually, organisations in construction industry maintain sustainability by achieving project success through PM [92]. However, the current change in business environment with regards to technological advancements and developments is even interfering the typical PM approach [19]. This suggests a strong encouragement for construction industry to adopt and adapt to IR4.0.

Despite the rapid development of IR4.0, construction industry is relatively slow to adapt new ideas and hence the integration of IR4.0 in construction industry is still minimal. At present, the common programme that involves the use of technology is Building Information Modelling (BIM) and Lean Construction [15]. BIM describes the production and management processes, whereby construction procedures including physical and functional characteristics of buildings are represented digitally before the actual construction [93]. Lean construction is the application of lean thinking and techniques (e.g. just-in-time delivery, value-stream mapping and process improvement) that lead to new form of production management to construction [94]. The use of BIM and Lean Construction in construction is argued to be a useful tool for reducing the construction industry's fragmentation, improving its efficiency and lowering the high costs of inadequate interoperability [16].

Considering the advances brought about by Industry 4.0, construction industry is likely to gain further by adapting to it. Concerns with regards to cost overrun can be minimised with the use of robotics and

automation workflows [17]. Achieving the "iron triangle" of a project, including collaboration improvements between actors/stakeholders is made possible by merging cloud computing and BIM technology [18]. In fact, IR4.0 offers a platform for improvements to construction industry. Although the main aim of organisations is to achieve and maintain organisational goals, adopting IR4.0 in construction industry may need organisations to adjust their goals and strategy. It is therefore envisaged that construction industry may successfully implement IR4.0 by bringing together PM for project success, SM for organisational success and IR4.0 for the technological advances.

Implementation of new concept is rather challenging in practice. Organisations are yet to be completely familiar and understand the attributes brought about by IR4.0. Application of new technologies and the transformation of processes will significantly affect the field of work and demand new competencies from employees [95]. For a successful implementation of IR4.0, it is important to understand certain key areas or factors that may encourage organisations to move toward this approach. There are issues on social challenges, such as declining population and aging society means reduced workforce [96]. The growing levels of competition among organisations also increase innovation pressure [97]. The desire to produce products at lowest cost without sacrificing qualities is also an important area of improvements that organisations seek [98]. The concept of IR4.0 and its drivers, offers solutions to such concerns and desires. This includes organisations in construction industry. On the other hand, there are barriers to implement IR4.0 successfully. One of the major challenges to the implementation of IR4.0 is in relation to human factor, such as lack of skilled workforce and the need to retrain staff to meet the changes [99-101]. Shortage of financial resources is another issue [100, 102]. Integration of IR4.0 requires a substantial amount of investments in new digital technologies. Overall, challenges to implement IR4.0 in any industries, including construction industry, are uncertainties [95]. Organisations need to be aware of the factors that affect the implementation, whether positively or negatively, and basically ensure the reliability and stability of the systems.

IX. CSFs OF INDUSTRY 4.0

As shown in Table 4, five CSFs of IR4.0 were extracted, along with their 37 SFs. The steps and coding of CSFs and SFs used are similar to that of PM and SM. They are briefly discussed in the following subsections.

A. CSFIR4.0 1 Human/Social influence on implementation

This CSF focuses on human/social involvement, regardless of the increase of automation in the industry, as IR4.0 is adopted [7, 86-88]. The advancements in fact require employees to have the skills to operate IR4.0 technologies [82, 103, 111, 113]. However, the usual manual repetitive tasks are converted to automated tasks, where human roles support the automated systems and machines are assigned to perform tasks [103-105, 110-112]. As such, health and safety and ergonomic awareness become the concern, because IR4.0 increases human-machine interactions [106-109]. This CSF comprise of the following SFs:

- CSF IR4.0 1a: Employee skills
- CSF IR4.0 1b: Automated tasks
- CSF IR4.0 1c: Human-machine interactions
- CSF IR4.0 1d: Health and safety
- CSF IR4.0 1e: Ergonomic

Table 4: Factors affecting Industry 4.0 and its source.

Factors/ Source	Muller *et al* [82]	Arnold *et al* [98]	Kagermann *et al* [83]	Bauer *et al* [97]	Kerpen *et al* [103]	Dombrowski *et al* [104]	Stern & Becker [105]	Scheuemann *et al* [106]	Horvarth & Erdos [107]	Romero *et al* [108]	Borisov *et al* [109]	Hummel *et al* [110]	Fantini *et al* [111]	Mazali [112]	Yeh *et al* [113]	Jie *et al* [114]	Kumar *et al* [115]	Sung *et al* [116]	Wei *et al* [117]	Oliveira *et al* [118]	Wang *et al* [119]	Oesterreich *et al* [120]
Human/Social influence on implementation	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓								
Business environment effects	✓	✓													✓	✓	✓	✓	✓	✓	✓	
Organisational support on implementation		✓													✓	✓	✓	✓	✓	✓	✓	
Technological factors		✓													✓	✓	✓	✓	✓		✓	
Effects to business strategy	✓		✓	✓																		✓

B. CSFIR4.0 2 Business environment effects

This CSF focuses on the changes in business environment as adopting IR4.0 brings organisation to a new business market and new competitors, which may require organisations to consider the existing trading partner, but with higher market expectation [82, 98, 113, 119]. It may be overcome by having high information intensity to study on product and value chain, especially for marketing purposes [113, 19]. Adopting IR4.0 also creates changes in production. Therefore, organisations should also be aware of the regulatory changes, different government policy, availability of outside support and consumer readiness and stakeholders trusting relationship [98, 113, 115-116]. Environment perspective is related to the external environment of the organisation. This includes the SFs, as follows:

- CSF IR4.0 2a: Competition
- CSF IR4.0 2b: Environmental uncertainty
- CSF IR4.0 2c: Regulatory environment
- CSF IR4.0 2d: Trading partner
- CSF IR4.0 2e: Perceived outside support
- CSF IR4.0 2f: Expectations of market trends
- CSF IR4.0 2g: Government policy
- CSF IR4.0 2h: Consumer readiness
- CSF IR4.0 2i: Institutional based trust
- CSF IR4.0 2j: Information intensity

C. CSFIR4.0 3 Organisational support on implementation

This CSF highlights that top management of the organisation needs to support the implementation of IR4.0 [98, 113, 115, 118-119]. The success of IR4.0 implementation within organisation is influenced by the firm size (such as number of employees, and annual turnover), the organisation's capacity and ability to appreciate changes (in the form of having sufficient knowledge and financial strength), and ability and readiness towards changes in working practice [98, 113-114,116-118]. The IR4.0 implementation also depends on the organisation business model, and aim and objectives for the determination of suitable new technology to be adopted [114-115]. It also highly depends on the employees' motivation to comply with the changes, as they are the actors of the organisation [99-101]. This CSF comprises the following 10 SFs:

- CSF IR4.0 3a: Top management support
- CSF IR4.0 3b: Firm size
- CSF IR4.0 3c: Absorptive capacity
- CSF IR4.0 3d: Managerial obstacles
- CSF IR4.0 3e: Technology readiness
- CSF IR4.0 3f: Organisational readiness
- CSF IR4.0 3g: Firm scope
- CSF IR4.0 3h: Subjective norms
- CSF IR4.0 3i: Decision makers knowledge
- CSF IR4.0 3j: Financial strength

D. CSFIR4.0 4 Technological factors

This focuses on the technology of IR4.0 to be adopted, especially suitable awareness on its relative advantages, in terms of compatibility, complexity and infrastructure requirement, with respect to reliability and stability [98, 113, 115-117, 119]. This is because organisations need to ensure that the technology adopted is suitable with the business model and its operation will be beneficial to the organisation [113, 115, 117, 119]. Organisations also need to consider perceived challenges, impact of technology integration (particularly relating to human-machine interface), and perceived usefulness as to ensure confidence on cost-effectiveness to invest in the new technology [98, 113-114, 116]. Thus, the SFs include the following:

- CSF IR4.0 4a: Relative advantage
- CSF IR4.0 4b: Compatibility
- CSF IR4.0 4c: Complexity
- CSF IR4.0 4d: Technology infrastructure
- CSF IR4.0 4e: Perceived challenges
- CSF IR4.0 4f: Technology integration
- CSF IR4.0 4g: Perceived usefulness
- CSF IR4.0 4h: Cost

E. CSFIR4.0 5 Effects to business strategy

This CSF focuses on the innovativeness of business strategy, because implementation of IR4.0 comprises change in the established business models and the creation and development of new business models [82-83, 97, 120]. Furthermore, organisations need to be innovative as to enhance organisational competitiveness, capacity and productivity, as well as to ensure stability of operation [82, 120]. Thus, the SFs are as follows:

- CSF IR4.0 5a: Business model innovation
- CSF IR4.0 5b: Enhances competitiveness
- CSF IR4.0 5c: Innovation capacity and productivity
- CSF IR4.0 5d: Sustainability

X. COMBINED FOCUS

While the organisational success is the eventual target of organisations, there are various approaches of achieving. Therefore, techniques in adopted approaches are also different. As such, the foregoing sections identified three different sets of CSFs, but all targeting organisational success operating in construction industry, hence the commonality. As such, the three identified sets of focus areas (i.e. CSFs) and their relevant SFs were collated to seven common areas. Those are briefly discussed in the following subsections.

A. Management

Irrespective of the selected approach, the management of an organisation considerably influences performances both at project and organisation level [19, 23, 40, 47, 60, 62, 66-70]. Managerial aid comes in the form of support, communication, skills and techniques [41, 42, 44-47, 23, 60, 62, 67-71], as well as through participation in the team, and playing roles as leaders, and in team management [40, 46]. Management involves understanding the objectives and achieving them [10]. Through management, the key persons possess the role to make decision, plan resources, coordinate a group of individuals and lead the organisation through changes [23, 41, 47]. Moreover, challenges for implementing IR4.0 in construction require understanding the objectives, changes in practise and the relevant resource allocation [41, 65-69].

B. Strategy

Organisations operate based on the strategy adopted that is efficient and effective to driving organisations to achieve their short-term / project objectives and long-term organisational goals [23, 33, 40-41, 44, 47, 49-50]. The dynamic environment surrounding construction organisation and construction projects requires participating parties to react quickly to changes and proactive to survive [8, 45, 60]. Focusing on the strategic aspects within the organisation enables the organisation to realise when changes in strategy is required, and thus planning, formulation, implementation and review of new strategy takes place for the benefit of achieving the end goals of the organisation [66-70]. Both PM and SM highlights the importance of strategy to achieve project and organisational success [48, 67, 74]. Furthermore, implementation of Industry 4.0 in construction industry will cause changes in environment of construction organisations, i.e. in the form of technological advancements and developments [19, 82-83, 97, 120].

C. Organisation

Organisational structure, organisational behaviour/culture, and organisational orientation are central to implement any strategy in an organisation [40, 42, 47-48, 52, 68-72]. As for organisational structure, it is crucial for the employees to be able to understand their respective roles and responsibilities toward the organisation and thus establishing proper communication channels between different members [10]. Organisational behaviour/culture includes employees' awareness of the organisation's specifics and activities, to be involved in the acceptance of new ideas, and to set their mindset on the accomplishments of organisational values [60, 73-74]. Furthermore, an organisation comprises employees of different experiences and skills [1]. Therefore, organisational orientation is crucial in determining employee satisfaction, which is one of the significant aspects of measuring organisational success [2]. Organisation should meet employee satisfaction, such as offering opportunity for continuous learning and career path, through which employees may be able to develop their willingness, commitment, loyalty and more trust towards the organisation [77]. These strengthen the organisation's ability to adapt and adopt new ideas into practice. Support from top management, as well as the employees within the organisation, helps the organisation to facilitate and implement strategies for the successful implementation of IR4.0 [40, 98, 113-116].

D. Environment

Environment that is external to organisations also has an impact on the performance of organisations in construction industry [10]. Environment plays a critical part, as organisations operate in dynamic environment, as such project performance may be affected at multiple phases of the project life cycle [23]. Considering that changes in environment are always complex and rapidly occurring [57], environment is argued as one of the key challenges commonly faced by organisations in their attempt to operate sustainably [92]. The external environmental factors, such as factors related to nature, politics, legal, economic and social issues are among the common factors affecting projects' and organisations' performances [19, 23, 42, 45, 48, 73, 98, 113, 115-116, 119]. These are significantly influential to cause a construction project to be delayed, risking opportunity cost for many parties, or worsen to cause termination of project [10].

E. Innovation

Innovation is integral to addressing changes and critical to both PM, SM and IR4.0. Innovation assists in creating competitive advantage and improving organisational growth [19, 41-42, 47]. It proposes the organisation to innovate itself and in terms of technology and technical skills [61, 66]. Innovation allows increase in organisational capabilities, which will further allow organisations to better adapt to Industry 4.0. Organisations will then be transformed to practice technology-based project management, influencing the traditional technical aspects of project management [98, 113-119]. Innovation leads to application of new technologies and transformation of processes and hence will significantly affect the field of work and performances [95].

F. Project related issues

It has been suggested that project-related issues are often overlooked. They are critical to project performances, and overlooking causes many projects to fail [10]. Projects differ from each other and are carried out in stages of project life cycle, where each stage has its own primary objective(s) [51]. Projects differ in terms of their own specifics and characteristics such as budget, time/ period, quality, project activities, nature and background [23]. In many cases, projects fail as project performance criteria are not met, i.e. exceeding budget and time, and not meeting expected quality. This is because lack of understanding of project is likely to cause improper planning (i.e. scheduling, allocation of resources, etc) [42, 46, 48-49]. Implementation of IR4.0 will bring about various technological advancements, which are expected to effectively address the uniqueness of individual project activities, and positively influence their planning, scheduling and resource allocation. All these are expected to eventually improve the performance levels of construction projects, as well as relevant organisations [4, 36-38].

G. Human/social aspect

Increased use of advanced and improved technologies through implementing IR4.0 does not replace the need of human involvement. Instead, the continued need suffers from inadequacy of skilled workforce and the need to retrain staff to meet the changes [99-101]. Application of new technologies and the transformation of processes are expected to significantly affect the field of work and demand new competencies from employees [95]. Moreover, declining population and aging society means reduced workforce numbers [96]. Therefore, tailor-made skill improvement and development programmes are necessary, to update/upgrade the existing employees targeting to suit the advanced/improved technologies, as well as to train fresh employees [83, 103-105, 110-113].

XI. CONCLUDING OBSERVATIONS

Construction industry operates in a dynamic environment, and therefore, needs to continuously improve itself, in order to cope with both internal and external changes. While maintaining achievements in project success through PM, itis expected to gain benefits by practising SM to achieve overall organisational success. Further benefits may be gained if it transforms itself into a modernised industry, such as adopting IR4.0. This paper summarised the outcomes of a structured review of literature and identified seven CSFs of PM, seven CSFs of SM and five CSFs affecting the implementation of IR4.0 in construction. The CSFs of PM include: management ability to accomplish project-related tasks, effective project delivery method, strategic abilities of organisations, project team structure, technical ability of project team, influence of business environment, and innovative working environment. The CSFs of SM include: influence of organisational behaviour/culture, management abilities towards changes, employee orientation within organisation, and strength of organisational strategy, role of organisational structure to facilitate changes, organisational innovation skills, and ambient business environment. The CSFs of IR4.0 include: human/social influence on implementation, business environment effects, organisational support on implementation, technological factors, and effects to business strategy. Further analysis of the identified three sets of CSFs, along with their respective SFs, allowed to consolidate them in seven common areas. Those are related to management, strategy, organisation, environment, innovation, project related issues, and human/social issues. Various roles and techniques/tactics under these seven common areas are expected to lead to successful implementation of IR4.0, and allow success at organisation level, in construction industry. However, they require further adjustments and consolidation, and guidance to jointly work towards successful implementation of IR4.0 to benefit construction organisations, as indicated in the next section.

XII. FUTURE SCOPE

As briefly mentioned above, this study points out that adopting IR4.0 in construction industry is beneficial, particularly with regards to construction organisation being able to cope with changes in business environment and maintain stability and sustainability of operation. As such, three sets of CSFs, along with their 104 SFs have been identified. These have further been consolidated to seven broad areas. However, the research conducted in this paper is based onextant literature of different management and technological aspects. Although they all focus organisational success in construction industry, a further analysis and adjustment is necessary for their effective use.

As such, all the SFs will be refined and adjusted to the identified seven broad areas. Those refined SFs and the seven areas will then be used to develop suitable hypotheses, as well as to formulate a conceptual framework showing their commonality and flow of inter-related activities. The CSFs, along with their respective SFs, and hypotheses will be validated through a questionnaire survey, and the framework will be adjusted accordingly. Finally, an interview-based survey will assist formulating, developing and validating an action plan for the overall framework to implement in construction.

ACKNOWLEDGEMENTS

This research is funded by Government of Brunei Darussalam Scholarship under the Ministry of Education.

Conflict of Interest: None.

REFERENCES

[1]. Neluheni, G. N., Pretorius, W., & Ukpere, W. I. (2014). The role of quality strategic planning on organisational success. *Mediterranean Journal of Social Sciences*, *5*(1), 697–708, 2014, doi: 10.5901/mjss.2014.v5n1p697.

[2].C. G. Brush and P. A. Vanderwerf, “A comparison of methods and sources for obtaining estimates of new venture performance,” *J. Bus. Ventur.*, vol. 7, no. 2, pp. 157–170, 1992, doi: https://doi.org/10.1016/0883-9026(92)90010-O.

[3]. C. G. Brush and P. A. Vanderwerf, “A comparison of methods and sources for obtaining estimates of new venture performance,” *J. Bus. Ventur.*, vol. 7, no. 2, pp. 157–170, 1992, doi: https://doi.org/10.1016/0883-9026(92)90010-O.

[4]. A. H. A. Yusof, M. N. & Bakar, “Strategic management in construction industry: Case study in Indonesia,” *Conf. Manag. Constr. Res. Assoc. MICRA 2008*, no. December 2014, pp. 275–295, 2008, doi: 10.13140/2.1.3407.0085.

[5]. S. Xu, K. Liu, L. C. M. Tang, and W. Li, “A framework for integrating syntax, semantics and pragmatics for computer-aided professional practice: With application of costing in construction industry,” *Comput. Ind.*, vol. 83, pp. 28–45, 2016, doi: 10.1016/j.compind.2016.08.004

[6]. M. U. Hossain and C. S. Poon, “Global warming potential and energy consumption of temporary works in building construction: A case study in Hong Kong,” *Build. Environ.*, vol. 142, no. June, pp. 171–179, 2018, doi: 10.1016/j.buildenv.2018.06.026

[7]. P. Dallasega, E. Rauch, and C. Linder, “Industry 4.0 as an enabler of proximity for construction supply chains: A systematic literature review,” *Comput. Ind.*, vol. 99, no. March, pp. 205–225, 2018, doi: 10.1016/j.compind.2018.03.039.

[8]. E. Titov and L. Umarova, “Impact of Real and Propagated Values on Organisational Success,” *Congruence Pers. Organ. Values*, no. March, 2017, doi: 10.5772/intechopen.69460.

[9]. D. Arditi, A. Koksal, and S. Kale, “Business failures in the construction industry,” *Eng. Constr. Archit. Manag.*, vol. 7, no. 2, pp. 120–132, 2000, doi: 10.1046/j.1365-232x.2000.00143.x.

[10]. C. H. Thi and F. W. Swierczek, “Critical success factors in project management: Implication from Vietnam,” *Asia Pacific Bus. Rev.*, vol. 16, no. 4, pp. 567–589, 2010, doi: 10.1080/13602380903322957.

[11]. M. Freeman and P. Beale, “Measuring project success,” 1992
[12]. P. O. Gaddis, “The Project Manager, Harvard Business Review, pp 89-97, august,” 1959
[13]. R. Salleh, “Critical success factors of project management for Brunei construction projects: improving project performance.” Queensland University of Technology, 2009
[14]. N. Durakbasa, G. Bas, and J. Bauer, “Implementing Education Vision in the Context of Industry 4.0,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 448, no. 1, pp. 0–6, 2018, doi: 10.1088/1757-899X/448/1/012045
[15]. J. Redwood, S. Thelning, A. Elmualim, and S. Pullen, “The Proliferation of ICT and Digital Technology Systems and their Influence on the Dynamic Capabilities of Construction Firms,” *Procedia Eng.*, vol. 180, pp. 804–811, 2017, doi: 10.1016/j.proeng.2017.04.241.
[16]. H. Aladag, G. Demirdögen, and Z. Isık, “Building information modeling (BIM) use in Turkish construction industry,” *Procedia Eng.*, vol. 161, pp. 174–179, 2016.
[17]. J. M. Sardroud, “Influence of RFID technology on automated management of construction materials and components,” *Sci. Iran.*, vol. 19, no. 3, pp. 381–392, 2012
[18]. C. Merschbrock and B. E. Munkvold, “Effective digital collaboration in the construction industry–A case study of BIM deployment in a hospital construction project,” *Comput. Ind.*, vol. 73, pp. 1–7, 2015
[19]. F. Wohlfeil and O. Terzidis, “Critical success factors for the strategic management of radical technological innovation,” *2014 Int. Conf. Eng. Technol. Innov. Eng. Responsible Innov. Prod. Serv. ICE 2014*, no. June, 2014, doi: 10.1109/ICE.2014.6871529
[20]. C. V Bullen and J. F. Rockart, “A PRIMER ON CRITICAL SUCCESS FACTORS Christine V. Bullen John F. Rockart,” no. 69, 1981.
[21]. J. F. Rockart, “A new approach to defining the chief executive’s information needs,” *MIT Work. Pap.*, vol. CISR 37, no. 1008–78, pp. 1–35, 1978
[22]. A. C. Boynton and R. W. Zmud, “Assessment of Critical Success Factors.,” *Sloan Manage. Rev.*, vol. 25, no. 4, pp. 17–27, 1984
[23]. W. Belassi and O. I. Tukel, “A new framework for determining critical success/failure factors in projects,” *Int. J. Proj. Manag.*, vol. 14, no. 3, pp. 141–151, 1996
[24]. A. M. Keshk, I. Maarouf, and Y. Annany, “Special studies in management of construction project risks, risk concept, plan building, risk quantitative and qualitative analysis, risk response strategies,” *Alexandria Eng. J.*, vol. 57, no. 4, pp. 3179–3187, 2018
[25]. P. M. Institute, *A Guide to the Project Management Body of Knowledge (PMBOK Guide).*, vol. 2. Project Management Inst, 2017
[26]. P. Fewings and C. Henjewele, *Construction project management: an integrated approach*. Routledge, 2019.
[27]. W. Chmielarz and M. Zborowski, “Determinants of using project management in the implementation of information systems,” *Procedia Comput. Sci.*, vol. 126, pp. 1224–1236, 2018.
[28]. A. B. L. de Sousa Jabbour, C. J. C. Jabbour, C. Foropon, and M. G. Filho, “When titans meet – Can industry 4.0 revolutionise the environmentally-sustainable manufacturing wave? The role of critical success factors,” *Technol. Forecast. Soc. Change*, vol. 132, no. October 2017, pp. 18–25, 2018, doi: 10.1016/j.techfore.2018.01.017
[29]. K. Dziekoński, “Project Managers’ Competencies Model for Construction Industry in Poland,” *Procedia Eng.*, vol. 182, pp. 174–181, 2017, doi: 10.1016/j.proeng.2017.03.157.
[30]. M. Huemann, A. Keegan, and J. R. Turner, “Human resource management in the project-oriented company: A review,” *Int. J. Proj. Manag.*, vol. 25, no. 3, pp. 315–323, 2007.
[31]. D. HODGSON, “DISCIPLINING THE PROFESSIONAL: THE CASE OF PROJECT MANAGEMENT*,” *J. Manag. Stud.*, vol. 39, no. 6, pp. 803–821, Sep. 2002, doi: https://doi.org/10.1111/1467-6486.00312
[32]L. William and Z. Carol, “Linking emotional intelligence abilities and transformational leadership styles,” *Leadersh. Organ. Dev. J.*, vol. 25, no. 7, pp. 554–564, Jan. 2004, doi: 10.1108/01437730410561440
[33]. D. Hawk, “Conditions of Success: a platform for international construction development,” *Constr. Manag. Econ.*, vol. 24, no. 7, pp. 735–742, 2006.
[34]. R. Atkinson, “Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria,” *Int. J. Proj. Manag.*, vol. 17, no. 6, pp. 337–342, 1999.
[35]. E. W. N. Bernroider and M. Ivanov, “IT project management control and the Control Objectives for IT and related Technology (CobiT) framework,” *Int. J. Proj. Manag.*, vol. 29, no. 3, pp. 325–336, 2011.
[36]. A. Caccamese and D. Bragantini, “Beyond the iron triangle: year zero,” 2012.
[37]. M. Vučeković and G. Avlijaš, “Modern Approach to Project Management, Usage, and Success Rate of Agile Methodologies: an Evidence From Serbia,” pp. 154–159, 2020, doi: 10.15308/sinteza-2020-154-159.
[38]. L. P. Gates, “Strategic Planning with Critical Success Factors and Future Scenarios : An Integrated Strategic Planning Framework,” no. November, 2010.
[39]. I. Hyväri, “Project management effectiveness in project-oriented business organizations,” *Int. J. Proj. Manag.*, vol. 24, no. 3, pp. 216–225, 2006.
[40]. S. NAOUM and D. FONG, “Critical success factors of project management,” *Univ. Teknol. Malaysia*, no. 1996, pp. 827–838, 2011.
[41]. O. O. Ugwu and M. M. Kumaraswamy, “Critical success factors for construction ICT projects - Some empirical evidence and lessons for emerging economies,” *Electron. J. Inf. Technol. Constr.*, vol. 12, no. September 2006, pp. 231–249, 2007.
[42]. P. W. G. Morris and G. H. Hough, “The anatomy of major projects: A study of the reality of project management,” 1987.
[43]. S. Toor and S. O. Ogunlana, “Problems causing delays in major construction projects in Thailand,” *Constr. Manag. Econ.*, vol. 26, no. 4, pp. 395–408, 2008.
[44]. R. T. J., L. Ann, and K. John, “Project management in small to medium□sized enterprises: A comparison between firms by size and industry,” *Int. J. Manag. Proj.*

Bus., vol. 2, no. 2, pp. 282–296, Jan. 2009, doi: 10.1108/17538370910949301.
[45]J. Marteralla, "The eight success factors of a high performance sales and marketing organisation," *A Chally Focus Artic. Sales Mark. Exec. Strateg. Growth*, 2007.
[46]. S. H. Park, "Whole life performance assessment: critical success factors," *J. Constr. Eng. Manag.*, vol. 135, no. 11, pp. 1146–1161, 2009.
[47]. H. Mulder, "The Chaos Report," no. January, 2017.
[48]. M. P. W.G., "Cleland and King: project management and the systems approach," *Int. J. Manag. Proj. Bus.*, vol. 5, no. 4, pp. 634–642, Jan. 2012, doi: 10.1108/17538371211268951.
[49]. A. Clarke, "A practical use of key success factors to improve the effectiveness of project management," *Int. J. Proj. Manag.*, vol. 17, no. 3, pp. 139–145, 1999.
[50]. T. Cooke-Davies, "The 'real' success factors on projects," *Int. J. Proj. Manag.*, vol. 20, no. 3, pp. 185–190, 2002.
[51]. J. R. Turner and R. Müller, "The project manager's leadership style as a success factor on projects: A literature review," *Proj. Manag. J.*, vol. 36, no. 2, pp. 49–61, 2005.
[52]. . J. F. Rockart, "Chief executives define their own data needs.," *Harv. Bus. Rev.*, vol. 57, no. 2, pp. 81–93, 1979.
[53]. J. K. Pinto and O. P. Kharbanda, "Lessons for an accidental profession," *Bus. Horiz.*, vol. 38, no. 2, pp. 41–50, 1995.
[54]. . A. Franken, C. Edwards, and R. Lambert, "Executing strategic change: Understanding the critical management elements that lead to success," *Calif. Manage. Rev.*, vol. 51, no. 3, pp. 49–73, 2009.
[55]. . J. Bracker, "The historical development of the strategic management concept," *Acad. Manag. Rev.*, vol. 5, no. 2, pp. 219–224, 1980.
[56]. P. M. Ginter, W. Dunkun, L. E. Swayne, and S. Sood, *Strategic Management of Health Care Organizations*, vol. 1, no. 1. 2013.
[57]. C. L. Culp, *The risk management process: Business strategy and tactics*, vol. 103. John Wiley & Sons, 2002.
[58]. M. D. . Cullen, A. . Calits, and N. Nel, "Project management for Strategic Management Implementation in Energy Sector," *Conf. Pap.*, no. October, pp. 0–19, 2015.
[59]. D. Hanson, M. A. Hitt, R. D. Ireland, and R. E. Hoskisson, *Strategic management: Competitiveness and globalisation*. Cengage AU, 2016.
[60]. M. R. Farzin, M. S. Kahreh, M. Hesan, and A. Khalouei, "A Survey of Critical Success Factors for Strategic Knowledge Management Implementation: Applications for Service Sector," *Procedia - Soc. Behav. Sci.*, vol. 109, pp. 595–599, 2014, doi: 10.1016/j.sbspro.2013.12.512.
[61]. S. J. Amoli and F. Aghashahi, "An Investigation on Strategic Management Success Factors in an Educational Complex," *Procedia - Soc. Behav. Sci.*, vol. 230, no. May, pp. 447–454, 2016, doi: 10.1016/j.sbspro.2016.09.056.
[62]. J. Slavik, A. Putnova, and A. Cebakova, "Leadership as a Tool of Strategic Management," *Procedia Econ. Financ.*, vol. 26, no. 15, pp. 1159–1163, 2015, doi: 10.1016/s2212-5671(15)00946-6.
[63]. . M. Volosin, *Strategicky manazmenet podniku.* Ekonom, 2003.
[64]. M. Mišanková and K. Kočišová, "Strategic Implementation as a Part of Strategic Management," *Procedia - Soc. Behav. Sci.*, vol. 110, pp. 861–870, 2014, doi: 10.1016/j.sbspro.2013.12.931.
[65]. A. Hanzelková, M. Keřkovský, D. Odehnalová, and O. Vykypěl, *Strategický marketing. Teorie pro praxi*. Nakladatelství CH Beck, 2009.
[66]. Rowley. D J., Sherman, H., "Issues of Strategic Implementation in Higher Education: The special concern for Institutions and Developing Economies.," no. January 2001, 2001.
[67]. T. Mallya, *Základy strategického řízení a rozhodování*. Grada Publishing as, 2007.
[68]. P. R. Niven, *Balanced scorecard step-by-step: Maximizing performance and maintaining results*. John Wiley & Sons, 2002.
[69]. D. Rae and L. Martin, "Enterprise and Entrepreneurship in English Higher Education : 2010 and beyond," pp. 1–21, 2010.
[70]. Gurowitz, "Ed Gurowitz , PhD."
[71]. Gavurova, *MERANIE VÝKONNOSTI V ORGANIZÁCIÁCH S DÔRAZOM NA APLIKÁCIU*, no. May. 2014.
[72]. M. Beer and R. A. Eisenstat, "The silent killers of strategy implementation and learning," *IEEE Eng. Manag. Rev.*, vol. 28, no. 4, pp. 35–45, 2000.
[73]. A. Himme, "Critical success factors of strategic cost reduction: Results from an empirical survey of German cost reduction projects," *J. Manag. Control*, vol. 23, no. 3, pp. 183–210, 2012, doi: 10.1007/s00187-012-0157-8.
[74]. M. Sassi, U. Pihlak, and T. Haldma, "Factors affecting strategic management attitudes and practices in creative industries organisations," *Encatic J. Cult. Manag. Policy*, vol. 7, no. 1, pp. 71–87, 2017.
[75]. S. H. Appelbaum, A. Everard, and L. T. S. Hung, "Strategic downsizing: Critical success factors," *Manag. Decis.*, vol. 37, no. 7, pp. 535–552, 1999, doi: 10.1108/00251749910285674.
[76]. F. F. Reichheld, "The one number you need to grow," *Harv. Bus. Rev.*, vol. 81, no. 12, pp. 46–55, 2003.
[77]. C. Pandey and R. Khare, "Impact of job satisfaction and organizational commitment on employee loyalty," *Int. J. Soc. Sci. Interdiscip. Res.*, vol. 1, no. 8, pp. 26–41, 2012.
[78]. R. Silvestro, "Dispelling the modern myth: Employee satisfaction and loyalty drive service profitability," *Int. J. Oper. Prod. Manag.*, 2002.
[79]. N. J. Allen and J. P. Meyer, "Construct validation in organizational behavior research: The case of organizational commitment," in *Problems and solutions in human assessment*, Springer, 2000, pp. 285–314.
[80]. A. Hidayatno, A. R. Destyanto, and C. A. Hulu, "Industry 4.0 technology implementation impact to industrial sustainable energy in Indonesia: A model conceptualization," *Energy Procedia*, vol. 156, pp. 227–233, 2019, doi: 10.1016/j.egypro.2018.11.133.
[81]. S. S. Kamble, A. Gunasekaran, and R. Sharma, "Analysis of the driving and dependence power of

barriers to adopt industry 4.0 in Indian manufacturing industry," *Comput. Ind.*, vol. 101, no. March, pp. 107–119, 2018, doi: 10.1016/j.compind.2018.06.004.
[82]. J. M. Müller, O. Buliga, and K. I. Voigt, (2017). "Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0," *Technol. Forecast. Soc. Change*, vol. 132, no. December 2017, pp. 2–17, 2018, doi: 10.1016/j.techfore.2017.12.019.
[83]. H. (national academy of science and engineering) Kagermann, W. (German R. C. for A. I. Wahlster, and J. (Deutsche P. A. Helbig, "Recommendations for implementing the strategic," no. April, 2013.
[84]. J. Tupa, J. Simota, and F. Steiner, "Aspects of Risk Management Implementation for Industry 4.0," *Procedia Manuf.*, vol. 11, no. June, pp. 1223–1230, 2017, doi: 10.1016/j.promfg.2017.07.248.
[85]. L. S. Dalenogare, G. B. Benitez, N. F. Ayala, and A. G. Frank, "The expected contribution of Industry 4.0 technologies for industrial performance," *Int. J. Prod. Econ.*, vol. 204, no. December 2017, pp. 383–394, 2018, doi: 10.1016/j.ijpe.2018.08.019.
[86]. T. Stock, M. Obenaus, S. Kunz, and H. Kohl, (2018). "Industry 4.0 as enabler for a sustainable development: A qualitative assessment of its ecological and social potential," *Process Saf. Environ. Prot.*, *118*, pp. 254–267, 2018.
[87]. F. Longo, L. Nicoletti, and A. Padovano, (2017). "Smart operators in industry 4.0: A human-centered approach to enhance operators' capabilities and competencies within the new smart factory context," *Comput. Ind. Eng.*, vol. 113, pp. 144–159, 2017.
[88]. J. Lee, B. Bagheri, and H.A. Kao, (2015). "A cyber-physical systems architecture for industry 4.0-based manufacturing systems," *Manuf. Lett.*, vol. 3, pp. 18–23, 2015.
[89]. Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. *Boston Consulting Group*, *9*(1), 54-89.
[90]. S. Vaidya, P. Ambad, and S. Bhosle, (2018). "Industry 4.0 - A Glimpse," *Procedia Manuf.*, *20*, pp. 233–238, 2018, doi: 10.1016/j.promfg.2018.02.034.
[91]. H. Meissner, R. Ilsen, and J. C. Aurich, (2017). "Analysis of Control Architectures in the Context of Industry 4.0," *Procedia CIRP*, *62*, pp. 165–169, 2017, doi: 10.1016/j.procir.2016.06.113.
[92]. N. S. M. Suferi and M. M. Rahman, (2018). "The role of strategic management & project management to organisational success," *IET Conf. Publ.*, vol. 2018, no. CP750, pp. 1–4, 2018, doi: 10.1049/cp.2018.1549.
[93]. C. M. Herr and T. Fischer, (2019). "BIM adoption across the Chinese AEC industries: An extended BIM adoption model," *J. Comput. Des. Eng.*, *6*, no. 2, pp. 173–178, 2019.
[94]. R. F. Aziz and S. M. Hafez, (2013). "Applying lean thinking in construction and performance improvement," *Alexandria Eng. J.*, *52*, no. 4, pp. 679–695, 2013.
[95]. D. Horváth and R. Z. Szabó, (2019). "Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities?," *Technol. Forecast. Soc. Change*, *146*, pp. 119–132, 2019.
[96]. M. Götz and B. Jankowska, (2017). "Clusters and Industry 4.0–do they fit together?," *Eur. Plan. Stud.*, vol. 25, no. 9, pp. 1633–1653, 2017.
[97]. W. Bauer, M. Hämmerle, S. Schlund, and C. Vocke, (2015). "Transforming to a hyper-connected society and economy–towards an 'Industry 4.0,'" *Procedia Manuf.*, *3*, pp. 417–424, 2015.
[98]. D. Kiel, J. M. Müller, C. Arnold, and K.-I. Voigt, "Sustainable industrial value creation: Benefits and challenges of industry 4.0," *Int. J. Innov. Manag.*, vol. 21, no. 08, p. 1740015, 2017.
[99]. S. Adolph, M. Tisch, and J. Metternich, "Challenges and approaches to competency development for future production," *J. Int. Sci. Publ. Altern.*, vol. 12, no. 1, pp. 1001–1010, 2014.
[100]. S. Erol, A. Schumacher, and W. Sihn, (2016). "Strategic guidance towards Industry 4.0–a three-stage process model," in *International conference on competitive manufacturing*, 2016, *9*, no. 1, pp. 495–501.
[101]. S. Shamim, S. Cang, H. Yu, and Y. Li, (2016). "Management approaches for Industry 4.0: A human resource management perspective," in *2016 IEEE Congress on Evolutionary Computation (CEC)*, 2016, pp. 5309–5316.
[102]. J. Müller and K. I. Voigt, (2017). "Industry 4.0—integration strategies for small and medium-sized enterprises," in *Proceedings of the 26th International Association for Management of Technology (IAMOT) Conference*, 2017, pp. 14–18.
[103]. D. Kerpen, M. Löhrer, M. Saggiomo, M. Kemper, J. Lemm, and Y.-S. Gloy, "Effects of cyber-physical production systems on human factors in a weaving mill: Implementation of digital working environments based on augmented reality," in *2016 IEEE International Conference on Industrial Technology (ICIT)*, 2016, pp. 2094–2098.
[104]. U. Dombrowski, T. Richter, and P. Krenkel, (2017). "Interdependencies of Industrie 4 . 0 & Lean Production Systems - a use cases analysis -," *Procedia Manuf.*, vol. 11, no. June, pp. 1061–1068, 2017, doi: 10.1016/j.promfg.2017.07.217.
[105]. T. Becker and H. Stern, (2016). "Future trends in human work area design for cyber-physical production systems," *Procedia Cirp*, vol. 57, pp. 404–409, 2016.
[106]. C. Scheuermann, S. Verclas, and B. Bruegge, (2015). "Agile factory-an example of an industry 4.0 manufacturing process," in *2015 IEEE 3rd International Conference on Cyber-Physical Systems, Networks, and Applications*, 2015, pp. 43–47.
[107]. G. Horváth and G. Erdős, (2017). "Gesture control of cyber physical systems," *Procedia Cirp*, *63*, pp. 184–188, 2017.
[108]. D. Romero, S. Mattsson, Å. Fast-Berglund, T. Wuest, D. Gorecky, and J. Stahre, (2018). "Digitalizing occupational health, safety and productivity for the operator 4.0," in *IFIP International Conference on Advances in Production Management Systems*, 2018, pp. 473–481.
[109]. V. N. Borisov, D. B. Kuvalin, and O. V Pochukaeva, (2018). "Improving the factor efficiency of machinery in the regions of the Russian Federation," *Stud. Russ. Econ. Dev.*, *29*, no. 4, pp. 377–386, 2018.

[110]. F. Ranz, V. Hummel, and W. Sihn, (2017). "Capability-based task allocation in human-robot collaboration," *Procedia Manuf.*, *9*, pp. 182–189, 2017.
[111]. P. Fantini, M. Pinzone, and M. Taisch, (2020). "Placing the operator at the centre of Industry 4.0 design: Modelling and assessing human activities within cyber-physical systems," *Comput. Ind. Eng.*, *139*, p. 105058, 2020.
[112]. T. Mazali, (2018). "From industry 4.0 to society 4.0, there and back," *AI Soc.*, vol. *33*, no. 3, pp. 405–411, 2018, doi: 10.1007/s00146-017-0792-6.
[113]. C.C. Yeh and Y.F. Chen, (2018). "Critical success factors for adoption of 3D printing," *Technol. Forecast. Soc. Change*, vol. *132*, pp. 209–216, 2018.
[114]. Q. Jia, Y. Guo, and S. J. Barnes, (2017). "Enterprise 2.0 post-adoption: Extending the information system continuance model based on the technology-Organization-environment framework," *Comput. Human Behav.*, *67*, pp. 95–105, 2017.
[115]. K. N. Kumar, S. Chandra, S. Bharati, and S. Manava, (2016). "Factors influencing adoption of augmented reality technology for e-commerce," 2016.
[116]. S. Sun, C. G. Cegielski, L. Jia, and D. J. Hall, (2018). "Understanding the factors affecting the organizational adoption of big data," *J. Comput. Inf. Syst.*, *58*, no. 3, pp. 193–203, 2018.
[117]. J. Wei, P. B. Lowry, and S. Seedorf, (2015). "The assimilation of RFID technology by Chinese companies: A technology diffusion perspective," *Inf. Manag.*, *52*, no. 6, pp. 628–642, 2015.
[118]. T. Oliveira, M. Thomas, and M. Espadanal, (2014). "Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors," *Inf. Manag.*, *51*, no. 5, pp. 497–510, 2014.
[119]. Y.M. Wang, Y.S. Wang, and Y.F. Yang, (2010). "Understanding the determinants of RFID adoption in the manufacturing industry," *Technol. Forecast. Soc. Change*, vol. *77*, no. 5, pp. 803–815, 2010.
[120]. T. D. Oesterreich and F. Teuteberg, (2016). "Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry," *Comput. Ind.*, vol. *83*, pp. 121–139, 2016, doi: 10.1016/j.compind.2016.09.006.

How to cite this article: Nurul Syazwana Mohammad Suferi and Md Motiar Rahman (2021). Critical Success Factors for Adopting Industry 4.0 in Construction: A Review. *International Journal on Emerging Technologies, 12*(1): 188–203.