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CRITICAL SUCCESS FACTOR OF BUILDING INFORMATION MODELLING IMPLEMENTATION IN FACILITIES MANAGEMENT – AN OVERVIEW

Siti Farahaneza Mohd Misron*, Mat Naim Abdullah @ Mohd Asmoni
Department of Real Estate, Faculty of Built Environment and Surveying
Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

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*Corresponding Author
sitifarahaneza@hotmail.com

ABSTRACT

Building Information Modelling (BIM) is considered as the solution for information handling within facilities management. This paper aims to investigate the current literature for critical success factors (CSFs) of BIM implementations, construct a compilation, and distinguish gaps related to factors of BIM implementation. Hundreds of articles were searched using keywords identified from the literature review. Endless series of article abstract reviews resulted in 33 articles selected for the compilation. CSF constructs were then identified using content analysis methodology and an inductive coding technique. A subsequent critical analysis identified gaps in the literature base. The most significant finding is the lack of research that has focused on the identification of CSFs from the perspectives of key stakeholders. Additionally, it appears that the most widely cited CSFs comprehended around the factors of people, process and little detail on specific implementation tactics. There is a need to focus future research efforts on the study of CSFs as they apply to the perspectives of key stakeholders and to ensure that this stakeholder approach is also comprehensive in its coverage of CSFs. One of the key limitations of this research is the occurrence of duplication in the frequency analysis of the success factors, which led to secondary research being the primary methodology for a large number of the articles cited. This research provides a comprehensive compilation of all previously identified BIM implementation success factors through a clear, structured methodological approach.

1.0 INTRODUCTION

The facilities management (FM) phase is the last but by far, the most extended stage in a building's lifecycle (Nordstrand, 2000). Stated by Mustapa *et al.* (2008), FM in Malaysia is realized only when a building is automatically controlled by computerized software and that the use of such dedicated FM information technology is only to stimulate the advancements in FM. One of the most significant problems in facilities management is considered to be information handling (Hardin, 2011). Both researchers and professionals consider building Information Modeling (BIM) as a solution to the problematic information handling within facilities management (Hardin, 2011; Eastman *et al.*, 2011). BIM offers the possibility to restructure the information handling during the building's lifecycle and thereby also improve the building information quality in FM phase (Nordstrand, 2000). BIM

offers many benefits and has numerous application areas within FM; however, every organization is different and requires a unique approach for BIM implementation (Smith & Tardif, 2012). BIM has been accepted in both academic and the industry as a new approach that can improve productivity and quality of the industry; however, its adoption has been slow (*Eastman et al.*, 2011; Smith & Tardif, 2009). Subsequently, many researches have been focused on the implementation process and its critical success factors (CSFs) (Howard & Bjork, 2008; Wong *et al.*, 2010; Jung & Joo, 2011; Won *et al.*, 2013; Sackey, 2014; Tsai *et al.*, 2014; Mom *et al.*, 2014; Morlhon *et al.*, 2014; Shang & Shen, 2014). However, it appears that from much of the literature, the focus has only been on success factors with very limited or no consideration from the stakeholder perspective. In order to make a possible assessment of the project planning phase and to determine if the concerned stakeholder groups have been addressed adequately requires a comprehensive CSFs understanding of such various groups for a project implementation team. Eventually, the probability of achieving a high success level will be enhanced and, consequently, time-saving, cost savings, quality, and efficiency in their system. Welti (1999) suggested that the focus should be directed on the persons who do not recognize the implementation as being successful in managing a better implementation. If the negative perceptions can be identified, and it belongs to one stakeholder group at that, it might be possible to concentrate on the CSFs that might be important to them and will possibly increase the chance of implementation success. However, stakeholder's interest in information system success lies beyond the implementation stage.

In his seminal work of CSFs from the chief executives' perspectives, Rockhart (1979) states that the process of CSFs identification ensures that those factors received the necessary attention. Additionally, he further suggests that the procedure permits a clear definition of the type of information needed by the company and deviates from trapping in a system built from data that are easy to collect. Rockhart's work was centered on the research of D. Ronald Daniel, where, according to him, Daniel was the first person who discussed "success factors" in management literature. From Rockhart's standpoint, CSFs were the specifically recognised areas that organizations needed to "get them right" for businesses to compete successfully. In terms of BIM implementation, the CSFs are those conditions that must be met for a successful implementation process.

There are critics on the CSF approach being biased since the approach relied only on the opinions of managers (Davis, 1980). In response to such criticism, Munro and Wheeler (1980) proposed the weakness of CSF approach by identifying a method where senior middle managers' ideas are included in information requirement to be decided. Likewise, an interview with a cross-section of management where all management levels were included, as suggested by Boynton and Zmud (1984). CSF approach can still be biased and requires advanced skill possessed by interviewers (Munro, 1983) and also requires a careful technique application (Boynton & Zmud, 1984), even when the weaknesses are addressed. Nevertheless, the CSF approach can be reinforced by allowing a widespread consultation within the organisation (Finney and Corbett, 2007). Given today with enhanced new technologies which expected to affect more than just senior managers or cross-section managers, it is necessary to take into consideration the opinions of those affected stakeholder groups regardless of their posts within the organizational chart. Ideally, it is essential to ask those affected stakeholders what exactly "right" is, if CSFs are said to be those factors that organisations must "get right" to achieve success. Besides, different implementation factors affect different stakeholder groups and some stakeholder groups are more qualified to comment on specific aspects better than the other groups. So, it can be said that this way of widespread consultation can further reinforce the CSF approach. The identified weaknesses of the CSF approach previously identified by previous researchers need to be further studied in terms of how they are addressed in BIM literature.

This paper seeks to advance research on stakeholder's perspective on BIM implementation and to uncover the deeper meaning of the cited CSFs based on the results

of a comprehensive and analysis of BIM implementation success factors. The following sections will be explaining the selected research methodology chosen to prepare the compilation and will be followed by a summary of CSF categories and concepts, as well as BIM CSF literature's critical analysis.

2.0 RESEARCH METHODOLOGY

2.1 CSF compilation

The comprehensive literature review has engaged with extensive note-taking that highlighted all possible references related to CSFs by applying a conceptual analysis approach. Mentioned previously, a CSF is described as a reference to any condition that is necessary for successful BIM implementation. Articles containing references to CSFs of BIM implementation were analysed in-depth for coding purposes. Miles and Huberman (1994) highlighted that this part of the analysis requires data collected being differentiated and combined. Finney and Corbett (2007) stated that the highlight was not really on the words themselves but rather the meaning of them. Therefore, every CSF was noted and sorted in like categories regardless of their description where an inductive coding technique is applied.

According to Strauss and Corbin (1990), "open coding" is a part of the analysis that concerns specifically on naming and categorizing facts through a close data examination. The further adds that during the coding process, data will be broken down into separate parts, examined carefully, compared for similarities and differences, and questions about the facts as reflected in the data are asked. Also, part of this methodology involved the technique described by Strauss and Corbin (1990) that suggest qualitative data category cards preparation. Coded constructs that appeared in individual journal articles were recorded by using a bibliographic software program and were placed in a spreadsheet file to record the frequencies of each construct.

Content analysis was an appropriate analysis approach and a common technique used to analyse texts, as suggested by Silverman (2000), given that the purpose of the study is to gain an in-depth understanding of CSFs identified by previous researchers. Silverman (2000) further adds an excellent coding scheme would show a search for 'uncategorized activities' that could be included, like searching for unusual cases. Accordingly, this analysis has also searched for references to "success" factors that may not have necessarily identified as "success" factors. This part is the reason why some of the search terms used to select articles did not always include "success", "critical success factors", etc.

2.2 Data collection procedures

Carley (1992) suggests eight category coding steps that were applied for the data collection procedure of CSF compilation.

Step 1: *determine the analysis level*. During this stage of the coding process, it is decided whether to search for a single word, set of words, or phrases. The first step of content analysis is to determine at what level the sample will be chosen and what units of analysis will be counted (Berg, 2004). For this research, the unit of analysis or level of analysis involved the entire journal articles. The data collection phase of the literature review has included an extensive search of many journals including, but not limited to:

- Advanced Engineering Informatics
- Automation in Construction
- Built Environment Project and Asset Management
- Canadian Journal of Civil Engineering
- Computers in Human Behaviour
- Computing in Civil and Building Engineering
- Construction Economics and Building
- Construction Innovation
- Economics & Management
- Engineering, Construction and Architectural Management
- ENR: Engineering News-Record
- Facilities
- International Journal of Engineering
- International Review of Management and Marketing
- Journal of Architectural Engineering
- Journal of Building Engineering

- Journal of Civil Engineering and Management
- Journal of Construction Engineering and Management
- Journal of the Chinese Institute of Engineers, Transactions of the Chinese Institute of Engineers
- Procedia Technology
- Structural Survey

In addition to the other journals, the following databases, such as Academic Search Premier, Emerald, IEEEXplore Digital Library, JSTOR, One Petro, ScienceDirect Journal, and Web of Science were also searched. Collectively, these databases include thousands of journals that are categorized in various fields. Articles that were selected from the search results had used the search terms outlined in Table 1.

Table 1: Search terms in journals and databases

Searched: citation, abstract and title

Individual journal searches	**Database searches**
Critical success factors BIM implementation	Critical success factors "AND" building information modelling
Critical success factors BIM	Critical success factors "AND" BIM
Success factors BIM	BIM implementation "AND" success
Critical success factors building information modelling systems	building information modelling software "AND" implementation
Success factors building information modelling systems	building information modelling systems "AND" implementation
BIM implementation	building information modelling planning "AND" implementation
BIM success	building information modelling systems "AND" success
BIM implementation success	building information modelling software "AND" success
BIM	building information modelling planning "AND" success
building information modelling	BIM adoption
	BIM assimilation
	BIM

Keywords chose for this search were the keywords used by the previous authors in previous research. Due to the uniqueness of BIM, the focus has been only on BIM in the facilities management sector, but relevant points from other industries will also be included in the compilation. The selection of articles to be included in the compilation was based on the scanning of title, abstract, introduction, and conclusion of those articles, and if the articles contain the possible information needed for BIM implementation success factors, they will be selected for further review.

Step 2: *determine the number of steps to code*. During this stage of the coding process, it is decided whether to code for a specific pre-determined set of concepts or to allow for a more interactive coding approach. For this research, a more interactive and inductive approach is decided as it would be the most appropriate approach since it allows a full inclusion of all identified CSFs. Theoretical classes are those that "emerge in the course of analyzing the data" (Berg, 2004). Aforementioned, the categories of CSFs are included in the classes to emerge in this research since they exist in the literature.

Step 3: *determine whether to code for the existence or frequency of a concept*. During this stage of the coding process, it is decided to code for the frequency of the concepts for this research so that the researcher can gain a better insight into the factors' relative importance.

Step 4: *determine how to distinguish among concepts*. During this stage of the coding process, it is necessary to decide whether to code the concepts precisely as they appeared, or they could be coded in an altered or collapsed form. Concisely, this stage is referred to as the stage of terms generalization. For this research, any words of the same meaning were categorized under the same construct. For instance, "management support" and "management

advocacy" are of similar meanings and thus, they belonged within the same category.

Step 5: *develop rules for text coding*. During this stage of the coding process, it is necessary to create a set of translation rules which could be practiced throughout the process to ensure consistency and internal validity when coding. The translations rules created and applied are as follows:

- For the first round of reading all articles, the emphasis was directed on recording any reference related to "success factor." The highlighted concepts were enlisted in the bibliographic program. At this point, categories were not yet determined. For the definition of "success factors" terms, there are four degrees of criticality: factors linked to success by a known causal mechanism, factors necessary and sufficient for success, factors necessary for success, and factors associated with success (Williams & Ramaprasad, 1996). The factors compilation for this research included factors considered both essential for and associated with success. Moreover, the data collection for this research involved note-taking of chosen methodology and also the consideration or lack of stakeholder perspective regarding CSFs.
- The purpose of article revision for the second round is to determine similarity in concepts where similar concepts were then put in the same categories.
- Each category and concept was thoroughly examined and reviewed again to determine the possibilities to collapse or subdivide and establish any additional categories.
- When every category was finalized, concepts were then reviewed to determine the construct terms which may come from one of the coded terms or an entirely new construct term.

Step 6: *determine what to do with "irrelevant" information*. During this stage of the coding process, determination of what to do with the information in the text that was not coded was involved. Since the literature compilation for this research focused on the collection of all concepts considered as BIM implementation success factors, the content analysis included the entire document, which coded the text that noted as possible success criteria, and hence, there is no issue with what to do with irrelevant coded information.

Step 7: *code the texts*. During this stage, the actual coding process was conducted by using a manual technique by following all translation rules pinpointed in step 5. Strauss and Corbin (1990, p. 67) state that the name attached to the category is usually the most reasonably related to the data it represents, and it should be detailed enough to explain its referent.

Step 8: *analyze the results*. During this stage, the actual analysis process was conducted by reviewing the constructs in terms of frequency, along with a critical evaluation of the CSF approach. These results will be reviewed in the following sections.

3.0 CSF LITERATURE COMPILATION

3.1 Discovering categories

A total of 49 articles were reviewed, and 33 were considered appropriate to contain "success factors" applicable for this research. The first stage of analysis involved categorizing of same concepts into the same categories. Success factors that refer to the same phenomenon will be grouped together. At the end of this stage, 27 possible success factor categories were identified, but after a successive round of analysis of the concepts resulted in producing 15 CSF categories in total.

3.2 Naming categories

Strauss and Corbin (1990) have notified the dangers of using borrowed terms and suggested that a researcher be precise about the meanings of the terms. So, this research has mainly selected the categories name based on the frequent use of its concept in previous research as the name chosen was evident and clear to explain its referent. Table 2 shows the final 15 critical success factors of BIM implementations.

Table 2: CSF of BIM implementations

Critical Factors affecting BIM implementation	
Top management commitment and support	BIM policy
Training and education	Publicity of BIM (presentation, promotion, liaison)
Change management	Management by objectives
Product information sharing	Attitude
Framework of BIM standards, guideline	Owner assurance / satisfaction / interest
Motivation	Business process reengineering
Effective collaboration among project participant	Communication plan
Perceived ease of use	

3.3 Understanding the CSF categories and the concepts

Each of the identified constructs is outlined below with a detailed description of the concepts it represents.

Top management commitment and support – this concept specified the need to have committed leadership at the high management level. Additionally, the concept also associated with the requirement of management to anticipate any setbacks that might be encountered (Motwani *et al*., 2002) and the need for senior management who would be involved in the strategic planning, who is also technically orientated (Yusuf *et al.*, 2004). Arayici *et al.* (2011) stated that top management support is critical to the success of BIM adoption.

Training and education – a significant number of citations referred to the need to include training and education as a critical aspect of an implementation. For the implementation process, it is necessary to consider the impact of the nature of work changes and the specific job descriptions (Finney & Corbett, 2007). As an emerging technology, industry players with different backgrounds may have a significantly different experience with BIM, which will generate outcomes with variable accuracy. To optimize BIM performance, either companies or vendors or both must find ways to lessen the training and learning curve of BIM trainees (Azhar, 2011). Besides, training programs must be built based on different requirements, from global and standard to specified and advanced (Singh et al., 2011).

Change management – This concept refers to the need for the implementation team to formally prepare a change management program (Nah *et al*., 2001) and be conscious of the need to consider the implications of such a project (Bingi *et al.*, 1999). The implementation of BIM involves substantial changes (Khosrowshahi & Arayici, 2012). The BIM change and adoption program built to deliver the expected benefits in operational performance through program coordination, knowledge transfer, performance management, and education and training (Lan *et al.*, 2015). Change management knowledge should be in a place where the bottom-up approach is more appropriate to deal with resistance to required changes (Arayici *et al*., 2011). BIM provides a useful tool to manage changes in assignments (Peterson *et al*., 2011).

Product information sharing – also referred as the information exchange capability where an essential capacity of the BIM implementation system is exchanging information among different BIM and non-BIM systems without data loss, making an explicit design information and making it available to stakeholders so that the design, construction or operation intent can be easily understood and evaluated (Wong *et al*., 2010).

Framework of BIM standards and guidelines – according to Howard and Bjork (2008), a framework is needed where all BIM standards can fit which includes data definition in order to implement successful BIM. In their research, Wong *et al.* (2010) state that BIM standards or guidelines are usually a component or an expected outcome of the BIM policy in a country.

Motivation – Adriaanse *et al.* (2010) identified personal motivation and external motivation factors to use information and communication technology, including BIM. Personal motivation is defined as the extent to which people are motivated to use the technologies. It is denoted by the perceived benefits and the disadvantages of the technology application, time pressure and temporary relation in construction (Green *et al.*, 2005). External motivations include the availability of contractual arrangements for BIM adoption and the presence of a requesting stakeholder (Adriaanse *et al.*, 2010). It indicates the influence of the competitors, collaborators or other stakeholders in the construction industry (Liu *et al.*, 2010).

Effective collaboration – To enhance the BIM adoption, a project team should have BIM-related capabilities such as collaboration, track record, and prior experience of applying BIM technologies (Mutai, 2009). Therefore, a collaboration between disciplines is pivotal for the success of BIM implementation (Azhar, 2011).

Perceive ease of use - Davis (1980) defines perceive ease of use as "the degree to which a person believes that using a particular system would be free of effort".

BIM policy – Wong *et al.* (2010) has stated that, for effective implementation of BIM in a country, the government needs to establish the specific policy of adopting BIM on all projects. Specific government departments were responsible for setting the BIM policy, which includes in varying degrees the regulatory guidelines, contractual arrangements, setting up of best practices and standards, providing research and educational funding, and so forth. They further discussed that to implement the BIM policy of a country, there should be one or more designated organizations to take up the foremost responsibilities for BIM implementation (Wong *et al.*, 2010).

Publicity of BIM (presentation, marketing, liaison) - Publicity is essential if particular standards are to be more widely used. Property owners should use successful case studies for marketing and identify the benefits they have obtained (Howard & Bjork, 2008). In terms of marketing, Wong *et al.* (2010) stated it is crucial to disseminate the findings of the BIM program once they have established at various outlets such as forums, journals, conferences, and professional bodies for information exchange and recognition.

Management by objectives - known as "a process whereby the superior and subordinate managers of an organization jointly identify its common goals, define each individual's major areas of responsibility in terms of the results expected of him and use these measures as a guides for operating the unit and assessing the contribution of each of its members" (George, 1965). It helps to direct managers' attention toward results and setting objectives to meet their future needs.

Attitude - Petty and Cacioppo (1981) defined attitude as "a general and enduring positive or negative feeling about some person, object or issue". Users' attitude toward computers is a possible predictor of software acceptance, and there is some empirical support for the relationship between attitude and satisfaction (Satzinger & Olfman, 1995; Schiffman *et al.*, 1992). Lucas (1978), Zmud (1979), and Rivard and Huff (1988) emphasized the importance influence of user's attitudes on the success of MIS, and especially on EUC (end-user computing). Satzinger and Olfman (1995) indicate that there is strong support for dependency between attitudes and user satisfaction, and they also found that users' positive attitudes to be a likely indicator of software acceptance.

Owner assurance/satisfaction/interest - is defined as the extent to which users believe the information system available to them meets their information requirements (Ives *et al.*, 1983). According to Fazli *et al.* (2014), a project is considered to successfully delivered to the satisfaction of the client, end-users, and investors.

Business process reengineering – Morlhon *et al.* (2014) defined business process reengineering as the efforts invested to deeply review the current processes and reorganize workflows and ways of doing things in a BIM oriented manner.

Communication plan - Communication among various functions/levels (Mandal & Gunasekaran, 2003) and specifically between business and IT personnel (Grant, 2003) is another identified CSF. The requirement of a communication plan (Kumar *et al.*, 2002) is to ensure that open communication occurs within the entire organization, including the shop-floor employees (Yusuf *et al.*, 2004), as well as with suppliers and customers (Mabert *et al*., 2003).

4.0 ANALYSIS AND DISCUSSIONS OF BIM IMPLEMENTATION LITERATURE

Previously mentioned, part of the content analysis involved recording the frequency of the success citations. Table 3 shows the CSF being cited in the literature.

Table 3: Frequency analysis of CSFs in literature

CSF category	Number of instances cited in literature
Top management commitment and support	14
Training and Education	11
Change management	9
Product information sharing	8
Framework of BIM standards and guidelines	6
Motivation	5
Effective collaboration	4
Perceived ease of use	4
BIM policy	3
Publicity of BIM (presentation, promotion, liaison)	3
Management by objectives	3
Attitude	3
Owner assurance / satisfaction / interest	3
Business process reengineering	2
Communication plan	2

The prior compilation has provided the range of success factors that are cited in the literature and the frequency associated with each factor. Nonetheless, additional analysis has been conducted to seek any apparent gaps in the literature as to date. Resultantly, there is a lack of depth in the CSFs coverage. Also, another compelling observation was the lack of stakeholder perspective in the success factors cited. Either success factors were presented with no explanation of whose perspective was represented, or stakeholder perspective was provided, but for only a single success factor. Finally, the concept of change management, one of the most cited success factors, appeared to have varied definitions, and there was little explanation of the specific tactics that could be used to implement such a program. Each of these limitations will be explored in further detail.

Often, researchers have only focused on a specific aspect of the implementation process or a particular CSF. Consequently, there is little research documented that encompasses all significant CSF considerations. For example, Howard and Bjork (2008) addressed the state of building information models and the condition necessary to become more widely used based on experts' views on standardisation and deployment; Sebastian (2011) studied the changing roles the clients, architects, and contractors through BIM; Arayici *et al.* (2011) used a case study to present a systematic approach for building information modeling (BIM) implementation for architectural SMEs at the organizational level. Research by Won *et al.* (2013) derive the CSF from the questions asked from the survey in order to highlight where to focus for successful adoption of Building Information Modeling within organization; Sackey (2014) develop a BIM implementation assistance model for a better integrated, and better used BIM is proposed, taking into account the different maturity levels of each organization. In each of the prior articles, the investigation was based on primary research (survey, case study, or observation). The following study, on the other hand, has used only secondary sources. Wong *et al.* (2010) has highlighted critical initiatives derived from the review of BIM implementations in both the

public and private sectors in six selected countries and research by Jung and Joo (2011) propose a BIM framework focusing on the issues of practicability for real-world projects through a thorough literature review of computer-integrated construction (CIC) and BIM. Regardless of methodology, all prior studies have been narrowly focused, providing a constricted, yet detailed, view of a specific success factor.

Other researchers were more comprehensive in their coverage of CSFs but attempted to categorize them differently. Wong *et al.* (2010) categorized BIM initiatives according to people, processes and policy categories. Similarly, another study produced a framework of CSFs according to technical collaboration, organizational collaboration, process collaboration and legal issues (Shang & Shen, 2014). Finally, research by Tsai *et al.* (2014), in their article entitled "Developing critical success Factors for The Assessment of BIM technology Adoption: Part I, Methodology and Survey," highlights several CSFs under six key areas that are organizations, applications, tools, project teams, processes, and business models. There is limited research that has attempted to produce an expansive collection of CSFs. Next, consideration is given to the lack of stakeholder perspective, especially from the facilities management sector.

The observation that there has been no research conducted that has considered BIM implementation CSFs from the perspectives of key stakeholders, facility managers, in particular, is a significant finding. While there have been several studies, as outlined below, that have attempted to interview representatives from various stakeholder groups, they have not reported findings so that personal views of different stakeholder groups are represented. Research by Won *et al.* (2013) stated that interviews were conducted at four different continents, including the BIM experts, but there was no further detail than this. Were the interviews with various levels of management? A study by Tsai *et al.* (2014) developed for the assessment of BIM adoption at the organisational level in the architecture, engineering, and construction (AEC) industry, but there is no mention of the respondent's background or posts. Similarly, Yusuf (2018) distributed the questionnaire to the professionals which include architects, engineers, quantity surveyors engaged in contracting firms, consulting firms, public and private clients' organisations but, there is no clear explanation on the management level regardless of their posts in the organisational chart. The relatively small or no degree of stakeholder of facilities management and the lack of reporting of their views, as evidenced in the prior researches, is a significant gap in the current literature base and it demonstrates the main weakness of the CSF approach identified by Davis (1980) as early as 1980.

5.0 CONCLUSION

Research on BIM implementation and critical success factors can be a valuable step toward enhancing the chances of implementation success. A review of the BIM critical success factor/implementation literature reveals that, in many cases, CSFs are presented based on a study of already published literature or limited case studies. As a result, one crucial limitation of this research is the occurrence of duplication in the frequency analysis of the success factors.

As well, there has been no research conducted that has considered the significant BIM implementation CSFs from the perspectives of key stakeholders. While several studies have attempted to interview representatives from various stakeholder groups, they have not reported the results so that personal views of different stakeholder groups are identified. Following the limitations of the abovementioned literature and based on the recommendations of other researchers, there is a need to focus future research efforts on the study of CSFs as they apply to the perspectives of key stakeholders and to ensure that this stakeholder approach is also comprehensive in its coverage of CSFs.

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