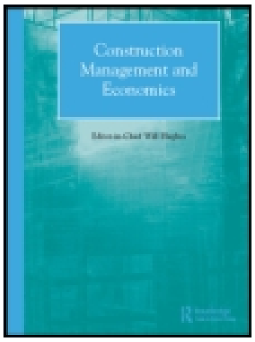

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Critical success factors for enterprise risk management in Chinese construction companies

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Construction businesses are risky ventures and enterprise risk management (ERM) has been advocated in construction companies. To ensure ERM success and the subsequent benefits, it is necessary to understand the key activities of ERM. The objectives are to identify the critical success factors (CSFs) for ERM and analyse the interrelationships among these CSFs in Chinese construction companies (CCCs). To achieve this objective, 16 CSFs were identified through a comprehensive literature review and 89 completed survey questionnaires were received. The results of the analysis show that the three most important CSFs are 'commitment of the board and senior management', 'risk identification, analysis and response' and 'objective setting'. Additionally, the three underlying CSF groupings are (1) execution and integration; (2) communication and understanding; and (3) commitment and involvement of top management. The commitment and involvement of top management positively contributed to the communication and understanding as well as the execution and integration of ERM, while the communication and understanding facilitated the execution and integration of ERM. The proposed framework indicating the key ERM practices and the inter-grouping relationships provides an in-depth understanding of ERM in CCCs, compared with the existing not so relevant ERM frameworks in various other industries.

Keywords: Construction companies, critical success factors, enterprise risk management, factor analysis, structural equation modelling.

Introduction

Construction businesses are inevitably plagued with complex and diverse risks. Thus, construction companies, especially those venturing into the overseas market, have emphasized and practised risk management. In most cases, construction companies just emphasize risk management at the project level as construction projects are their main sources of revenue and profit. However, overemphasis on project risk management (PRM) tends to engender some problems, such as lack of a holistic view of project risks, lack of transparency across projects, inappropriate resource allocation among projects, and difficulties in achieving the corporate strategic objectives (Zhao *et al.*, 2012). The recent trend has been to regard risk management as an enterprise-wide process that collectively considers the risks that various projects face and links these events to the corporate strategy (Gordon *et al.*, 2009; Zhao *et al.*, 2013). The 2000s have witnessed the proliferation of enterprise risk management (ERM) in the financial, manufacturing, insurance and energy industries. As ERM allows common risks that are traditionally addressed at the project level to be more efficiently and consistently managed across a company (Hallowell *et al.*, 2013), ERM was forecast to grow in the construction industry and construction companies have been seen as prime candidates for ERM (Zhao *et al.*, 2013).

According to the Committee of Sponsoring Organizations of the Treadway Commission (2004), ERM is defined as:

> a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable

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> assurance regarding the achievement of entity objectives. (p. 2)

Despite resources invested, successful ERM programmes can generate a number of benefits. For example, in construction companies, ERM can positively contribute to performance indicators, improve decision making and control on projects, and reduce losses caused by risks (Liu *et al.*, 2011; Low *et al.*, 2013). In reality, companies carry out ERM for these potential benefits (Pagach and Warr, 2011) and ensure that these benefits far outweigh the costs related to ERM initiation (Hallowell *et al.*, 2013). To ensure ERM success and the subsequent benefits, the management should identify the critical success factors (CSFs), and thus take measures to ensure the effective implementation of these key areas of ERM.

In 2006, the State-owned Assets Supervision and Administration Commission of the State Council of China (2006) issued the *Guidance to Enterprise Risk Management for Central Enterprises* to drive ERM implementation in central enterprises. Central enterprises are those entities owned by China's central government. As some of the leading Chinese construction companies (CCCs) are among the central enterprises, it can be inferred that ERM has been initiated and practised by them. The CCCs that are state-owned but not central enterprises may also initiate ERM.

The objectives of this study are to identify the CSFs for ERM and investigate the interrelationships among these CSFs in CCCs. Despite studies on the ERM implementation in the banking (Wu and Olson, 2008), insurance (Hoyt and Liebenberg, 2011), and energy industries (Muralidhar, 2010), few have been focused on ERM in the construction industry. Thus, this study expands the existing literature relating to ERM through identifying a list of CSFs for ERM in construction companies. By identifying the CSFs, the management may better predict the probability of success and the necessary steps to avoid failure and identify problematic areas to undertake necessary corrective actions (Hwang and Lim, 2013). In addition, although this study focuses on ERM in CCCs, the implication of this study is not limited to them. The management and operation of CCCs have a wider range of implications and tend to affect the international construction market because CCCs have ventured into over 180 countries (National Bureau of Statistics of China, 2012). Hence, the identification of the CSFs allows other construction companies to prepare their customized lists of CSFs for ERM and to better understand the key areas that are worth paying attention to for ERM success. Therefore, this study can significantly contribute to the body of knowledge relating to ERM.

Background

Enterprise risk management

Traditionally, risk management is segmented and conducted in separate business units or departments (i.e. silos) within a company. Silo-based risk management fails to consider the interactions between risks (Chapman, 2006; Cendrowski and Mair, 2009), creates inefficient coordination between silos and duplication of risk management expenditure (Meulbroek, 2002; Hoyt and Liebenberg, 2011), and may overlook the most significant risk (Collier, 2009). Different from the silo-based approach, ERM treats each risk as part of the entire risk portfolio of an enterprise rather than as a discrete risk (Cumming and Hirtle, 2001; Liebenberg and Hoyt, 2003), and concerns understanding the risk interactions and how risk response measures can deal with multiple risks across multiple business areas (Chapman, 2006). In addition, ERM attempts to consolidate a risk management process across all the levels within the organization, and concerns not only an enterprise's view of risks, but also the degree of coordination and consolidation with which the enterprise manages the risks (Culp, 2002). Furthermore, ERM is viewed as a top-down approach to risk management as it needs the sponsorship of top management and is related to the corporate strategy (Olson and Wu, 2008).

Both ERM and PRM are approaches to dealing with risks that a company faces, but at different levels (Liu *et al.*, 2011, 2013). Hence, ERM and PRM do not contradict each other. They share a similar management process, in which risk identification, analysis and response are critical steps. However, ERM and PRM have different goals due to their different levels of focus. ERM deals with risks at the enterprise level, focusing on the strategic, operations, reporting and compliance objectives of a company (Cendrowski and Mair, 2009), while PRM addresses risks at the project level and focuses on project objectives, such as time, cost, quality and safety objectives. In addition, PRM is still necessary and should not be considered as a hindrance to implementing ERM in a construction company. PRM has been considered as one of the nine project management knowledge areas (Project Management Institute, 2008), and is critical to the success of projects and the survival of construction companies. PRM can be regarded as an integral part of ERM because project risks are within the entire risk profile of a construction company and ERM should be implemented at all levels of a company, including the project level. Effective PRM practices, which properly deal with project risks, can contribute to ERM effectiveness throughout a company. In turn, ERM provides a new way to improve

PRM in construction companies (Liu *et al.*, 2013) because ERM implementation involves better communication of project risk information, thus helping management to make better informed decisions and deal with project risks more effectively and efficiently.

An ERM framework is described as a specific set of functional activities and the associated definitions that define the ERM system in an organization and its relationship with the organizational system (Dafikpaku, 2011). To facilitate ERM implementation in various industries, the Committee of Sponsoring Organizations of the Treadway Commission (2004) developed a three-dimensional ERM conceptual framework. This framework specifies how the people from the four organizational levels (i.e. entity-level, division, business unit, and subsidiary) across an enterprise implement the eight interrelated ERM components in order to achieve strategic, operations, reporting and compliance objectives. The eight components consist of internal environment, objective setting, event identification, risk assessment, risk response, control activities, information and communication, as well as monitoring. However, Liu *et al.* (2011) found that no CCCs had adopted this framework, indicating that CCCs may need a framework specifically for themselves. Thus, it is necessary to identify the key activities of ERM in CCCs, and these activities, which are represented by the CSFs for ERM, could constitute a new framework specifically for CCCs.

Critical success factors

CSFs describe those few key activities in which favourable results are absolutely necessary for a manager to reach his or her goals (Rockart, 1982). This approach has been widely applied to identify the key activities in construction management. For instance, Tabish and Jha (2011) evaluated the CSFs for public construction projects; Tang *et al.* (2012) investigated the CSFs for international market entry; and Hwang *et al.* (2013) explored the CSFs for public–private partnership (PPP) projects. To gain an in-depth understanding of ERM in CCCs and ensure ERM success, it is necessary to make explicit the key areas of activities that are essential for ERM success. Thus, the CSF method is adopted in this study to identify the key activities of a successful ERM programme. The identification of the CSFs allows the management staff to take measures to ensure the effective implementation of the key areas of ERM.

A literature review was conducted to identify the CSFs for ERM. As there have been few studies on ERM in construction companies, the analysed

Table 1 CSFs for ERM

		References															
Code	CSFs for ERM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Sum
CSF01	Commitment of the board and senior management		×	×				×	×	×	×				×	×	8
CSF02	ERM ownership	×	×	×	×						×	×			×	×	8
CSF03	Risk appetite and tolerance	×		×				×	×								4
CSF04	Risk-aware culture		×	×	×		×		×	×		×			×	×	9
CSF05	Sufficient resources	×				×	×		×	×			×				6
CSF06	Risk identification, analysis and response	×	×	×		×								×		×	6
CSF07	Iterative and dynamic ERM process steps	×	×	×			×				×				×	×	7
CSF08	Leveraging risks as opportunities	×	×											×		×	4
CSF09	Risk communication		×				×		×							×	4
CSF10	A common risk language							×								×	2
CSF11	A risk management information system (RMIS)			×	×		×	×			×						5
CSF12	Training programmes						×		×	×	×						4
CSF13	Formalized key risk indicators (KRIs)							×									1
CSF14	Integration of ERM into business processes		×	×	×									×		×	5
CSF15	Objective setting					×							×				2
CSF16	Monitoring, review and improvement of ERM framework				×												1

Notes: References are as follows:
1. Aabo *et al.* (2005); 2. AON (2010); 3. Barton *et al.* (2002); 4. Cendrowski and Mair (2009); 5. Bowling and Rieger (2005); 6. Dafikpaku (2011); 7. Duckert (2011); 8. Economist Intelligence Unit (2007); 9. Professional Risk Managers' International Association (2008); 10. Garvey (2008); 11. Muralidhar (2010); 12. Gupta (2011); 13. Segal (2011); 14. Stroh (2005); 15. Hallowell *et al.* (2013).

literatures were related to ERM in various industries. Some literatures presented successful ERM case studies, while others explored the critical factors contributing to successful ERM programmes. Thus, as Table 1 indicates, a total of 16 CSFs for ERM are identified. Table 1 also shows how many times the literatures mentioned each CSF to indicate the attention it has attracted. These CSFs can describe the key activities of an ERM programme, and are therefore hypothesized to be critical to ERM success in CCCs. The implementation levels of these key areas can be used to measure ERM maturity (Zhao *et al.*, 2013). The section on data analysis and discussion presents the detailed descriptions of these CSFs.

Method and data presentation

As a systematic method of collecting data based on a sample, the questionnaire survey technique has been widely used to collect professional views on the CSFs in construction management research (e.g. Li *et al.*, 2005; Kulatunga *et al.*, 2009; Tabish and Jha, 2011; Tang *et al.*, 2012; Hwang and Lim, 2013). Thus, a questionnaire survey was undertaken to collect the professional views on the CSFs for ERM in CCCs. The population consisted of all the industry practitioners with extensive experience in risk management in CCCs, and all the academics who have gained in-depth knowledge of risk management in CCCs through research. As there was no sampling frame in this survey, the sample was a non-probability sample. The non-probability sampling plan can be used to obtain a representative sample (Patton, 2001), and has been recognized as appropriate when the respondents were not randomly selected from the entire population, but were rather selected based on whether they were willing to participate in the study (Wilkins, 2011). A list of senior and middle management staff of CCCs in Mainland China and the overseas subsidiaries and a list of academics from the universities located in Mainland China and Hong Kong were obtained. From April to June 2012, survey questionnaires were sent to all the 390 practitioners and academics on the two lists.

In addition to the literature review that supported the development of the survey questionnaire, face-to-face interviews were conducted with four professionals to solicit comments on the readability, comprehensiveness and accuracy of the preliminary questionnaire (see Figure 1). One of them was from academia while the other three were from CCCs based in Singapore. Based on their comments, the authors made revisions to improve the readability and accuracy of the description of the CSFs, and added footnotes to explain the terminologies used. The final questionnaire presented the

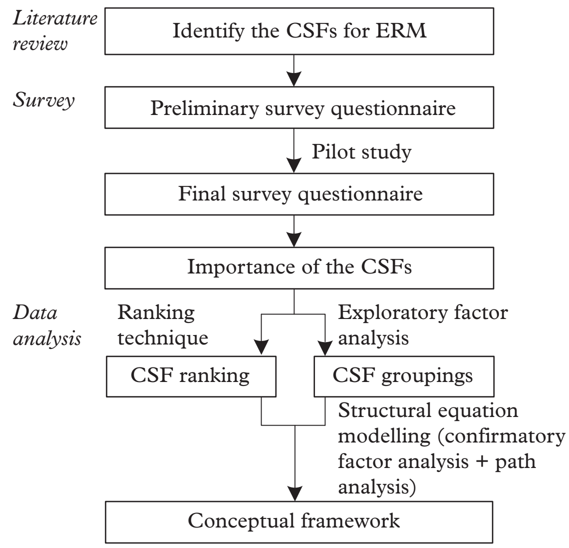

Figure 1 Research method

ERM definition and research objectives to the respondents and collected their general information, including their organizations, work and/or research experience, and designations. In addition, the questionnaire presented the 16 CSFs with the respective descriptions and requested the respondents to rate the importance of each CSF according to a five-point scale (1 = very low, 2 = low, 3 = medium, 4 = high, and 5 = very high) (see Appendix). Measuring the relative importance of CSFs has also been used in other previous studies that explored CSFs in the construction management area (e.g. Li *et al.*, 2005; Chen and Chen, 2007; Yang *et al.*, 2009; Chan *et al.*, 2010).

It should be clarified that the findings presented in this current paper form Phase I of a much larger research project. Because of the word limit, this paper is only able to present the CSFs for ERM in CCCs. For this Phase I, only the ranking and grouping of the CSFs for ERM are presented in this paper to provide a fundamental understanding of the key areas of ERM activities. In Phase II of the aforementioned larger study, another survey was conducted (but not presented here) to assess the implementation level of each CSF for ERM in the CCCs operating overseas.

A total of 89 completed questionnaires were received, representing a response rate of 23%. The 89 responses were adequate compared with the past studies relating to CCCs (e.g. 31 in Low and Jiang (2006) and 45 in Ling *et al.* (2012)). Out of the 89 respondents, 25 were academics and 64 were practitioners (see Table 2). Among the 64 industry respondents, 37 were from China while 12, 11, 2 and 2 were from the overseas divisions of CCCs in Asia, Africa, Europe and Latin America, respectively. Some of the 37

Table 2 Profile of respondents

		Industry (N = 64)		Academia (N = 25)		Overall (N = 89)	
Characteristics	Categorization	N	%	N	%	N	%
Work experience	5–10 years	40	63	3	12	43	48
	11–15 years	8	13	6	24	14	16
	16–20 years	7	11	9	36	16	18
	21–25 years	4	6	4	16	8	9
	Over 25 years	5	8	3	12	8	9
Title	Prof.	–	–	11	44	11	12
	Associate Prof.	–	–	14	56	14	16
	Senior mgmt.	14	22	–	–	14	16
	Department mgmt.	12	19	–	–	12	14
	Project mgmt.	38	59	–	–	38	43
Location	China	37	58	25	100	62	70
	Asia (w/o China)	12	19	–	–	12	14
	Africa	11	17	–	–	11	12
	Europe	2	3	–	–	2	2
	Latin America	2	3	–	–	2	2

domestic practitioners also had overseas work experience. Thus, the data probably reflected the opinions on CSFs for ERM from CCCs in the global construction market. Moreover, 52% of the respondents had more than 10 years' experience in the industry or academia, which further ensured the response quality.

Data analysis and discussion

Ranking of the CSFs for ERM

The Cronbach's alpha coefficient was 0.920, which was much higher than the threshold of 0.70 (Nunnally, 1978) and showed high data reliability. The ranking technique has been widely used in previous studies completed by others to rank the relative importance of the CSFs in the construction management domain (e.g. Yang *et al.*, 2009; Chan *et al.*, 2010; Hwang and Lim, 2013). In this study, the 16 CSFs for ERM were ranked based on their relative importance mean scores. As Table 3 indicates, the importance mean scores of the CSFs range from 3.40 to 4.55. To test whether each CSF was significantly important to ERM success in CCCs, the one-sample t-test was conducted. The *p*-values of all the CSFs were 0, suggesting that all the CSFs had significant importance. In addition, the Spearman rank correlation coefficient was 0.849 with statistical significance at the 0.05 level. This implied that the practitioners and academics agreed on the overall importance ranking of the 16 CSFs despite the differences in mean scores. A total of six CSFs obtained overall importance mean scores over 4.00. The ranking of the CSFs would enable the practitioners to understand which areas of activities of ERM implementation are worthwhile to pay more attention to and to prioritize for resource investments.

'Commitment of the board and senior management' received the top rating, suggesting that the tone at the top was perceived as the most important. As ERM is a top-down approach, support, encouragement and commitment at the senior level are of great importance to ERM implementation. Also, commitment of the board and senior management was found to be an internal force that drives ERM implementation within companies in various industries (Kleffner *et al.*, 2003; Gates, 2006). Thus, the board and senior management in construction companies should be committed to ERM implementation. Such commitment should be visible to make employees perceive ERM as a priority for the leadership, and more importantly, should not be interrupted by changes in the ERM champion because ERM implementation is a long-term journey spanning many years (Bowling and Rieger, 2005).

'Risk identification, analysis and response' occupied the second position, implying that CCCs attached great importance to the actual execution of ERM as this CSF describes the critical steps of a generic risk management process. To implement ERM, a company should adopt a formalized ERM process. Specifically, the management needs to identify all categories of potential risks from internal and external sources, and then prioritize them using risk analysis techniques. Thus, the management can develop a list of top risks or a risk map, which has been used in successful ERM cases (Aabo *et al.*, 2005), and appropriate risk response measures to deal with the critical risks.

The third ranked CSF was 'objective setting', indicating that clearly identified objectives at various levels

Table 3 Ranking of the CSFs for ERM

Code	ERM maturity criteria	Industry		Academia		Overall		
		Mean	Rank	Mean	Rank	Mean	Rank	p-value
CSF01	Commitment of the board and senior management	4.47	1	4.76	1	4.55	1	0[a]
CSF02	ERM ownership	4.13	4	4.24	5	4.16	4	0[a]
CSF03	Risk appetite and tolerance	3.56	15	3.36	15	3.51	15	0[a]
CSF04	Risk-aware culture	3.78	13	3.92	10	3.82	12	0[a]
CSF05	Sufficient resources	3.95	6	4.16	6	4.01	6	0[a]
CSF06	Risk identification, analysis and response	4.17	3	4.56	2	4.28	2	0[a]
CSF07	Iterative and dynamic ERM process steps	3.95	6	4.00	8	3.97	7	0[a]
CSF08	Leveraging risks as opportunities	3.63	14	3.56	14	3.61	14	0[a]
CSF09	Risk communication	3.92	9	3.84	11	3.90	10	0[a]
CSF10	A common risk language	3.48	16	3.20	16	3.40	16	0[a]
CSF11	A risk management information system	3.83	12	3.60	13	3.76	13	0[a]
CSF12	Training programmes	3.95	6	3.84	11	3.92	9	0[a]
CSF13	Formalized key risk indicators	3.88	11	3.92	10	3.89	11	0[a]
CSF14	Integration of ERM into business processes	3.92	9	4.48	3	4.08	5	0[a]
CSF15	Objective setting	4.20	2	4.40	4	4.26	3	0[a]
CSF16	Monitoring, review and improvement of ERM framework	3.92	9	4.08	7	3.97	7	0[a]

Notes:

[a]The one-sample t-test result is significant at the 0.05 level (two-tailed).The Spearman rank correlation coefficient is 0.849 and significant (p-value = 0) at the 0.05 level (two-tailed).

were highly important to ERM success in CCCs. As ISO 31000:2009 defines risk as the effect of uncertainty on objectives (International Organization for Standardization, 2009a), risk is closely associated with objective setting. Also, the Committee of Sponsoring Organizations of the Treadway Commission (2004) recognized objective setting as the precondition to risk identification, assessment and response. Thus, the management of construction companies should clearly identify and express their objectives at all levels, and regularly assess deviations from plans against the objectives (Hopkinson, 2011). More importantly, as ERM should be applied in strategy setting, the management should attach more importance to strategic objectives.

'ERM ownership' was ranked fourth, suggesting that successful ERM implementation in CCCs needed an owner to centralize risk management and take charge of risk oversight. This result was consistent with the ERM practices in other industries (Banham, 2004). An ERM owner can be a dedicated senior executive, a stand-alone department, a board-level risk committee, or even a chief risk officer (CRO). In addition, the creation of the ERM owner can signal the corporate emphasis on risk management to its employees and investors (Cendrowski and Mair, 2009). Who the ERM owner is should also be openly communicated to all the staff. Zhao *et al.* (2012) investigated the ERM implementation in a CCC based in Singapore and found that the ERM responsibility was included in the function of the managing director while the board served as a risk committee.

The fifth ranked CSF was 'integration of ERM into business processes'. This result echoed the guidance issued by the State-owned Assets Supervision and Administration Commission of the State Council of China (2006). This guidance stipulates that ERM should be fully integrated into the management and business processes of an enterprise. These processes include, but are not limited to decision making and strategic planning. In all decision-making processes, especially in strategic decision making, the management should consistently consider the risk identified and anticipate the emerging risks. In addition, the management should incorporate ERM at organizational planning and strategy stages (Sharman, 2002) and integrate ERM with other initiatives (Chitakornkijsil, 2010). However, full integration of ERM is not easy and can be time consuming, and it would take from three to five years for this to materialize in large companies once ERM is initiated. This is because of the delays in moving level by level in the company and the need for change management to overcome inertia (Shortreed, 2010).

Another highly ranked CSF was 'sufficient resources', implying that sufficient resources, such as funds, qualified staff, time, knowledge and expertise, were inevitable and necessary for ERM implementation in CCCs. Thus, to advance ERM implementation, the management should consistently allocate resources for improving the risk management process, tools, techniques and personnel skills. On the other hand, insufficient inputs of time, funds and staff, lack of internal knowledge and expertise, and lack of risk management techniques and tools would greatly hinder ERM implementation and success (Gates, 2006; Muralidhar, 2010).

Underlying CSF groupings

Exploratory factor analysis (EFA) identifies a relatively small and manageable set of underlying (i.e. latent) factor groupings that can be used to represent the correlations among a large set of interrelated variables. EFA requires two essential stages: (1) factor extraction, which determines the initial number of the groupings underlying a set of variables; and (2) factor rotation, which makes the groupings more interpretable and determines the final number of the underlying groupings (Norusis, 1992). Factor rotation can be orthogonal or oblique. EFA has been widely used in the previous studies that investigated CSFs in the construction management domain (e.g. Li *et al.*, 2005; Chen and Chen, 2007; Chan *et al.*, 2010; Ika *et al.*, 2012), and can be used as a precursor to latent variable modelling or confirmatory factor analysis (CFA) (DiStefano *et al.*, 2009). This method was therefore adopted to explore the underlying groupings among the 16 CSFs for ERM.

The ratio of sample size to the number of variables in this study was 5.56, which was higher than the ratio of 5.00 recommended by Gorsuch (1983). Thus, the sample size was large enough for factor analysis. In addition, the appropriateness of the factor analysis for the factor extraction was assessed in various ways. The Kaiser-Meyer-Olkin (KMO) value was 0.892, indicating a high degree of common variance among the CSFs. The value of the test statistic for Bartlett's sphericity was large (chi-square = 741.312) and the p-value was 0, suggesting that the population correlation matrix was not an identity matrix. Hence, it can be concluded that the data collected were appropriate for EFA.

The principal components analysis was used to identify the underlying grouped factors and obtained a three-factor solution with eigenvalues over 1.000. The three factor groupings explained approximately 62% of the variance, higher than the guideline of 60% recommended by Malhotra (2006).

The varimax rotation (i.e. orthogonal) method, which has been widely used in previous CSF studies (e.g. Chan *et al.*, 2004; Li *et al.*, 2005; Yang *et al.*, 2010), is actually problematic (Hetzel, 1996; Pett *et al.*, 2003; Matsunaga, 2010). First, the orthogonality of factors is often an unrealistic assumption. In almost all fields of social science, any factor is to some extent related to other factors, and thus, arbitrarily forcing the factors to be orthogonal may result in biasing the reality. In addition, even if the factors are indeed uncorrelated, the orthogonality should be empirically verified and revealed via EFA with an oblique rotation method (Matsunaga, 2010). Therefore, the promax rotation method, which is an oblique rotation method that provides solutions with correlated components, was adopted in this study. This method was also adopted in past construction management studies using EFA (e.g. Lam *et al.*, 2008; Lee and Chan, 2008; Chan *et al.*, 2010). Table 4 indicates the CSF groupings based on the promax rotation.

Table 4 Results of the EFA on CSFs for ERM

	CSF grouping		
CSF code	1	2	3
CSF06	0.802		
CSF15	0.747		
CSF13	0.744		
CSF16	0.582		
CSF05	0.558		
CSF14	0.470		
CSF07	0.424		
CSF10		0.853	
CSF09		0.844	
CSF04		0.682	
CSF11		0.600	
CSF12		0.548	
CSF08		0.463	
CSF01			0.779
CSF02			0.676
CSF03			0.664
Eigenvalue	7.410	1.316	1.122
Variance (%)	46	8	7
Cumulative variance (%)	46	54	62

Notes: Grouping 1: Execution and integration. Grouping 2: Communication and understanding. Grouping 3: Commitment and involvement of top management.

The factor loading value reflects the degree of contribution of individual CSFs to each underlying grouping. Most CSFs obtained the factor loading above the threshold of 0.45 (Comrey, 1973). 'Iterative and dynamic ERM process steps' obtained the lowest factor loading, which was slightly lower than the threshold of 0.45 recommended by Comrey (1973), but it was still above the lowest acceptable level of 0.40 (Matsunaga, 2010). Thus, the 16 CSFs were classified into three groupings: execution and integration, communication and understanding, and commitment and involvement of top management. Each grouping was labelled by considering the CSFs with high loadings in the grouping and what these CSFs had in common.

Execution and integration

This grouping accounted for 46% of the total variance and consisted of seven CSFs, which were all associated with the execution and integration of ERM. The CSF with highest factor loading was 'risk identification, analysis and response', which described the three critical steps in the PRM process. PRM can be seen as an integral part of ERM because project risks are within the entire risk profile of a construction company and ERM should be implemented at all levels, including the project level. Thus, executing the three risk management steps included in this CSF can be seen as executing an ERM process.

The CSF with the second highest factor loading was 'objective setting'. Clearly identified objectives are closely related to the ERM process execution because they are the preconditions to risk identification, risk assessment and risk response (Committee of Sponsoring Organizations of the Treadway Commission, 2004).

Another high-loading CSF was 'formalized key risk indicators'. A key risk indicator (KRI) is 'a measure to indicate the potential, presence, level, or trend of a risk' (Hwang, 2010, p. 126). KRIs help monitor risks and involve predetermined thresholds that will trigger actions by management to adjust its strategies proactively to manage the risks accordingly (Beasley *et al.*, 2010). Duckert (2011) argued that well-defined KRIs were critical to ERM success and that a data-centric approach to ERM with KRIs would be the only sensible way to establish it in the twenty-first century. Thus, KRIs should be identified for all the critical risks that a company faces and need to be periodically analysed and revisited by risk owners (Risk and Insurance Management Society, 2008).

In addition, the effective ERM process execution could be guaranteed by 'monitoring, review and improvement of ERM framework' and 'sufficient resources'. According to ISO 31000:2009, the management should periodically measure progress against the risk management plan, and review whether the risk management framework is still appropriate (International Organization for Standardization, 2009b). Considering the results of monitoring and reviews, the management can make decisions on how to improve the ERM framework. All the steps of an ERM process need resources, including not only time, money and people, but also knowledge and expertise.

This CSF grouping also contained 'integration of ERM into business processes'. To make risks effectively managed across an enterprise, ERM should be fully integrated into the business and management processes of an enterprise although it is time consuming (Shortreed, 2010). Thus, integration and execution of ERM are closely related.

The last CSF in this grouping was 'iterative and dynamic ERM process steps'. An ERM process should be iterative and dynamic, and thus can comprise a continuous improvement cycle. Also, such an ERM process allows the management to monitor, identify and analyse new risks that may emerge following changes in the environment (Garvey, 2008; AON, 2010; Dafikpaku, 2011).

Communication and understanding

This CSF grouping explained 8% of the total variance and included six CSFs for ERM. The CSF with the highest factor loading was 'a common risk language', indicating that the CSF greatly contributed to communication and understanding related to ERM. A common risk language, which can explain the terminologies and methodologies and contribute to a common understanding of their meanings and context throughout an enterprise, was viewed as a key quality of an effective ERM programme (Duckert, 2011) and an imperative for successful ERM deployment (Institute of Management Accountants, 2006). In addition to contributing to the understanding of risk management terminologies and methodologies, such a risk language would underpin risk culture, facilitate risk communication, cut through the layers and break down the silos (Espersen, 2007). Also, the common risk language should be used consistently in all communications to become a part of mainstream dialogue (Duckert, 2011). To facilitate the acceptance of a risk language, a glossary of risk terms, which provides risk management practitioners with a common reference resource for risk terminologies (Espersen, 2007), can be created and distributed within the enterprise. However, common risk languages have not been widely used in CCCs (Liu *et al.*, 2011).

'Risk communication' obtained the second highest factor loading. To be successful, ERM should have proper communication flow between management and the risk management function (Kleffner *et al.*, 2003). Relevant and reliable risk information obtained from various sources should be communicated transparently across multiple projects and departments of a company. Transparent risk communication should encourage individual comments and expert views during the development of cross-functional understanding of risks and risk management strategies (AON, 2010). Also, there should be a communication mechanism to ensure that critical risk information is reported to the board and senior management in a periodic or timely manner (Dafikpaku, 2011), and meanwhile, to ensure that line managers, project managers and staff are promptly notified of critical information and decisions from the top management (Barton *et al.*, 2002).

Another CSF with a high factor loading was 'risk-aware culture'. Nothing is more crucial to ERM success in an organization than a supportive culture (Cendrowski and Mair, 2009; Brooks, 2010), which can be called either a risk-aware culture (Protiviti, 2006; Brooks, 2010) or a risk culture (Collier, 2009; Sanchez *et al.*, 2009) in the existing literature about ERM. A risk-aware culture has been seen as a success factor for ERM implementation (Stroh, 2005; Ward, 2006; KPMG, 2010) and requires the buy-in of organizational individuals at all levels (Hopkin, 2010) and the embedment into the corporate culture (AON, 2010). In addition, a risk-aware culture enables employees to speak up and then be listened to by decision makers, and thus allows decision makers to understand the importance of identifying and assessing risks in current and potential business activities and the importance of risk communication (Brooks, 2010). Thus, a risk-aware culture can contribute to risk communication and understanding of ERM.

Also, communication and understanding can be facilitated by the application of 'a risk management information system (RMIS)'. It was suggested that information and communication technology should play a key role in enabling information flow across an enterprise (Dafikpaku, 2011). Thus, a RMIS can serve as a platform for risk communication and reporting, record risk management activities, or even undertake risk identification and analysis and provide response plans.

Moreover, 'training programmes', which involve communicating the ideas and perceptions regarding ERM implementation, can be used to reduce misunderstanding and anxiety about ERM among employees and help them clearly understand the ERM philosophy and policy, the ERM process, and the value of ERM. Such programmes also enable employees to understand that ERM is not a quick process but a multi-year journey.

The last CSF in this grouping was 'leveraging risks as opportunities'. To clearly understand ERM, management needs to first understand the nature of risk. Risks are double-edged (Zou *et al.*, 2007) and encompass both threats and opportunities (Ward and Chapman, 2003). In addition to dealing with downside risks (threats), ERM also involves leveraging and exploiting the upside risks (opportunities) for competitive advantage (Banham, 2004; Pagach and Warr, 2010; Dafikpaku, 2011). Thus, this CSF is associated with the understanding of ERM.

Commitment and involvement of top management

This CSF grouping was responsible for 7% of the total variance and consisted of three CSFs. In this grouping, the highest factor loading was achieved by 'commitment of the board and senior management'. It is worth iterating that such commitment has been recognized as an internal driver for ERM implementation (Kleffner *et al.*, 2003; Gates, 2006) and should be visible and continual because it is essential for organizational buy-in, aligning risk strategy with organizational objectives, and incorporating a risk-based approach at the planning and strategy stages (Sharman, 2002).

Another CSF that belonged to this grouping was 'ERM ownership'. In a CCC, the ERM responsibility could be included in the function of a senior executive and a board-level risk committee could be set up specifically for ERM implementation (Zhao *et al.*, 2012). Thus, the top management can be involved in ERM implementation. However, ERM ownership may be influenced by the company size because previous studies indicated that the size was associated with ERM adoption (Beasley *et al.*, 2005; Hoyt and Liebenberg, 2011). For example, in a large CCC, both a board risk committee and a stand-alone department could be set up for ERM implementation.

'Risk appetite and tolerance' was the last CSF in this grouping. Risk appetite is the 'amount and type of risk that an organization is willing to pursue and retain', while risk tolerance is an 'organization's or stakeholder's readiness to bear the risk after risk response in order to achieve its objectives' (International Organization for Standardization, 2009a, p. 9). Risk appetite, established by management with oversight by the board of directors, relates primarily to the business model and is a guidepost in strategy setting, while risk tolerance relates primarily to the organization's objectives and is tactical (Protiviti, 2006). Thus, operating within the risk tolerance provides the management with greater assurance that the company is within the risk appetite, which produces a higher degree of comfort that the company will achieve its objectives. According to the guidance issued by the State-owned Assets Supervision and Administration Commission of the State Council of China (2006), risk appetite and tolerance should be determined by the board of directors. Thus, this CSF can be closely associated with the involvement of top management.

Conceptual framework and validation

Based on the EFA results, a conceptual framework was developed to describe the key activities of ERM as well

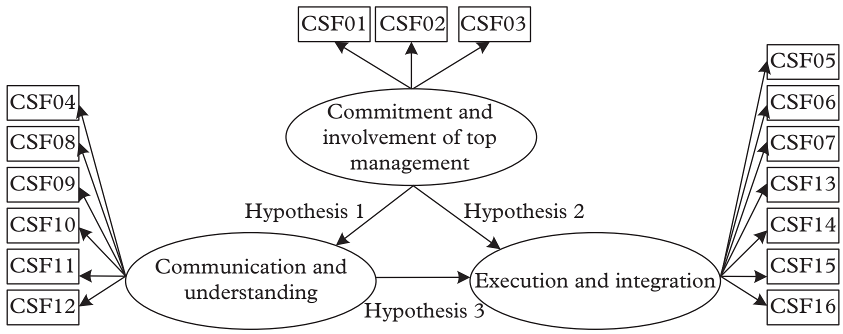

Figure 2 Conceptual framework for ERM

as the hypothetical relationships among the three CSF groupings (see Figure 2). This framework involves three hypotheses as follows:

Hypothesis 1: The commitment and involvement of top management positively influences the communication and understanding relating to ERM.

Hypothesis 2: The commitment and involvement of top management positively influences the execution and integration of ERM.

Hypothesis 3: The communication and understanding relating to ERM positively influences the execution and integration of ERM.

The structural equation modelling (SEM) method has been seen as one of the most suitable techniques for analysing the possible relationships among variables (Eybpoosh *et al.*, 2011). Observable variables and latent variables are used in SEM. The former can be directly measured, while the latter are hypothetical or theoretical constructs inferred from the observable variables. SEM consists of measurement and structural models. In this study, the measurement model provides the relationships between each CSF (the observable variable) and its respective grouping (the latent variable), while the structural model presents the relationships among the CSF groupings (the latent variables). This present study is aligned with the reflective model because the CSFs denote the effects of the CSF grouping that they belong to.

As a second-generation multivariate statistical technique, SEM combines both econometric and psychometric perspectives in the statistical modelling and enables a maximally efficient fit between data and a structural model because both CFA and path analysis can be executed simultaneously in a single structural equation model (Lim *et al.*, 2011). Thus, SEM is chosen in this study.

In addition, there are two types of SEM: covariance-based SEM (CB-SEM) and partial least squares structural equation modelling (PLS-SEM). Although CB-SEM has been used in construction management studies (e.g. Eybpoosh *et al.*, 2011; Doloi *et al.*, 2012), PLS-SEM has some advantages over it. For instance, PLS-SEM can analyse complex problems without requiring a large sample size and normal distribution of data, and estimate latent constructs as linear combinations of observable variables through weight relations (Fornell and Bookstein, 1982; Chin, 1998; Hair *et al.*, 2012; Lim *et al.*, 2012). Thus, PLS-SEM has gradually been adopted in construction management research in recent years. For example, Aibinu *et al.* (2011) adopted PLS-SEM to analyse the organizational justice and cooperative behaviour in the construction project claims process while Lim *et al.* (2012) used PLS-SEM to develop and validate mathematical models for predicting organizational flexibility of construction companies in Singapore. Because the number of the questionnaire responses was not large, PLS-SEM was adopted to validate the conceptual framework. The three CSF groupings produced by the EFA served as the latent variables in the structural and measurement models.

CFA is to test the hypothesis that the relationship between the observable variables and their underlying latent variable exists. The hypothesized model is based on theory and/or previous analytic research. In addition, CFA usually serves as the first step to assess the proposed measurement model. Most of the rules regarding assessment of model fit and model modification in SEM apply equally to CFA. In this study, CFA was conducted to test whether the data fitted the measurement model, i.e. to confirm the CSF groupings produced by the previous EFA. This hybrid approach combining EFA and CFA was recommended by Thompson (2003) and Matsunaga (2010). As the latent factors in CFA are usually specified to be interrelated, the promax rotation used in the EFA helped maintain conceptual consistency across EFA and CFA.

The reliability and validity of the CSFs should be assessed. Specifically, the factor loadings should be at least 0.45 (Comrey, 1973); Cronbach's alpha coefficient should be at least 0.70 (Nunnally, 1978); the composite reliability (CR) score should be at least 0.70 (Hair *et al.*, 1998); the average variance extracted (AVE) value should be at least 0.50 (Fornell and Larcker, 1981); and for adequate discriminant validity, the square root of the AVE score of each construct should exceed the inter-construct correlation (Fornell and Larcker, 1981; Chin, 1998). In addition, with respect to the indicator reliability, indicators with factor loadings below 0.70 should only be removed if deleting this indicator leads to an increase in CR above the suggested threshold value (Hair *et al.*, 2011). Nevertheless, the indicators with loadings below 0.70 could be retained because of their contributions to content validity (Hair *et al.*, 2011).

The results indicated that the CFA factor loadings ranged from 0.596 to 0.878 and that the AVE, CR and Cronbach's alpha values were above their respective thresholds (see Table 5). In addition, no correlation between any two CSF groupings was larger than the square root of the AVEs of them (see Table 6), which provided the evidence of discriminant validity and suggested that the three groupings were different from each other. Thus, the measurement model was reliable and valid for the structural path modelling.

Then, the bootstrapping technique (Efron, 1987; Davison and Hinkley, 1997) was applied to estimate the significance of path coefficients and test the hypotheses. In this study, the number of bootstrap samples was 5000, as recommended by Hair *et al.* (2011), and the number of cases was equal to the number of responses (i.e. 89). The critical t-value for a two-tailed test was 1.96 (significance level = 0.05). The bootstrapping results showed that the three path coefficients were positive and significant at the 0.05 level (see Table 7), implying that the three hypotheses were supported and that the structural model was validated.

Table 5 The reliability and validity of the CSFs

Grouping	CSF code	Factor loading	AVE	CR	Cronbach's alpha
CITM	CSF01	0.827	0.636	0.840	0.713
	CSF02	0.795			
	CSF03	0.769			
CU	CSF04	0.795	0.588	0.849	0.857
	CSF08	0.596			
	CSF09	0.878			
	CSF10	0.739			
	CSF11	0.792			
	CSF12	0.773			
EI	CSF05	0.707	0.599	0.899	0.868
	CSF06	0.726			
	CSF07	0.722			
	CSF13	0.745			
	CSF14	0.723			
	CSF15	0.791			
	CSF16	0.815			

Notes: CITM = commitment and involvement of top management; CU = communication and understanding; and EI = execution and integration.

Table 6 Discriminant validity of CSF groupings

Grouping	CITM	CU	EI
CITM	0.797[a]		
CU	0.537	0.767[a]	
EI	0.637	0.736	0.748[a]

Notes: [a]The square root of AVE of each grouping.
CITM = commitment and involvement of top management; CU = communication and understanding; and EI = execution and integration.

Therefore, the conceptual framework was validated. The rationale behind this framework is discussed as follows. The commitment of top management tends to drive ERM implementation (Kleffner *et al.*, 2003; Gates, 2006) and the leadership and involvement of top management signal the emphasis on ERM to employees. First, the commitment and involvement of top management can guarantee the sponsorship of training programmes, and ensure the creation of risk communication mechanisms as well as the use of the common risk language and RMIS. Also, the tone at the top could help reduce the influence of unsupportive culture and encourage the creation of a risk-aware culture. Thus, the commitment and involvement of top management can facilitate the communication and understanding relating to ERM.

Secondly, the commitment and involvement of top management can ensure that sufficient resources are invested in ERM execution, objectives at all levels are clearly identified and expressed, and that KRIs are identified for all the critical risks of a company. Additionally, it would take several years to fully integrate ERM into business and management processes, during which there may be changes in senior management roles. Thus, continual commitment and involvement of top management ensures that execution and integration would not be disrupted by changes within top management.

Furthermore, effective risk communication across a company provides reliable risk information to management and helps them execute the ERM process while a risk-aware culture contributes to the identification of emerging risks. Meanwhile, the understanding of ERM would help reduce the resistance to ERM practices resulting from a biased perception or misunderstanding, and facilitate the integration of ERM into

Table 7 Path coefficients and significance

Hypothetical path	Path coefficient	t-value	Interpretation
Hypothesis 1: CITM → CU	0.537	5.873	Supported
Hypothesis 2: CITM → EI	0.324	3.612	Supported
Hypothesis 3: CU → EI	0.582	7.610	Supported

Notes: CITM = commitment and involvement of top management; CU = communication and understanding; and EI = execution and integration.

business and management processes. Therefore, communication and understanding can positively contribute to the execution and integration of ERM.

Conclusions and recommendations

The objectives are to identify the CSFs for ERM and investigate the interrelationships among these CSFs in CCCs. The analysis results implied that all the 16 CSFs identified from the literature review were significantly important to ERM success in CCCs, which was consistent with the findings from the literature review relating to CSFs for ERM in various other industries outside construction. The top-ranked CSFs represented the most important areas of a successful ERM programme. Given the resource constraints, the management would allocate resources for the most important areas rather than all the key areas.

In addition, the EFA results showed three underlying CSF groupings: execution and integration, communication and understanding, and commitment and involvement of top management. The commitment and involvement of top management positively contributed to the communication and understanding as well as the execution and integration of ERM, while the communication and understanding facilitated the execution and integration of ERM. The three CSF groupings and the inherent interrelationships constituted a conceptual framework that described the key areas of ERM activities in CCCs. Compared with the frameworks that had rarely been used in CCCs (Liu *et al.*, 2011), this proposed framework indicates the groupings of key ERM activities as well as the inter-grouping relationships that are specifically for CCCs, thus providing for the first time a better understanding of ERM in CCCs.

The managerial implications that can be drawn from this study include the following:

(1) Top management should have a visible and continual commitment to ERM implementation and be involved in ERM implementation, which is critical to other key areas of ERM.
(2) The management should adopt and consistently execute a formalized ERM process throughout the company.
(3) The management should clearly identify and express objectives at all levels, and regularly assess deviations from plans against the objectives.
(4) The company should appoint a dedicated senior executive, or set up either a stand-alone department or a board-level committee as the ERM owner to take charge of ERM implementation.
(5) The management should integrate ERM into all daily management processes and consistently consider risk information, risk tolerance and appetite, and risk response strategies in all decision-making activities, especially in strategic decision making.
(6) The management should allocate sufficient resources for the implementation of the key areas of an ERM programme.

Although the objectives are achieved, there are limitations to conclusions that may be drawn from the results. First, the CSFs identified in this study may not be exhaustive with the passage of time. Second, because of the difficulty in constructing a sampling frame, this study used the non-probability sample. Despite the inherent limitation of this sampling method, it can still be used to obtain a representative sample (Patton, 2001), and has been recognized as being appropriate when the respondents were not randomly selected from the entire population, but were rather selected based on whether they were willing to participate in the study (Wilkins, 2011). Also, as the data were collected from the professionals with experience and knowledge relating to ERM in CCCs, caution is warranted when the analysis results are interpreted and generalized.

Nonetheless, the implications of this study are not limited to CCCs because the management in other companies could use the CSFs identified from the literature review and follow the research method adopted in this study to prepare the customized list of CSFs for ERM, according to the characteristics and real-world circumstances faced by them. Also, the findings of this study provide valuable information for future studies related to ERM in the global construction industry. Hence, this study contributes to the body of knowledge relating to ERM in the broader global community.

Future research is recommended to focus on the theoretical nexus between the CSFs and ERM based on an appropriately chosen quantitative and/or qualitative analysis. In addition, as the CSFs describe the key areas that should be linked to the performance indicators (Hwang and Lim, 2013), future research should develop a set of metrics to measure ERM performance, based on the identification of the CSFs.

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APPENDIX

The survey questionnaire

No.	ERM maturity criteria	Rating the Importance (1 = very low, 3 = medium, 5 = very high)				
		1	2	3	4	5
1	Commitment of the board and senior management	☐	☐	☐	☐	☐
2	ERM ownership	☐	☐	☐	☐	☐
3	Risk appetite and tolerance	☐	☐	☐	☐	☐
4	Risk-aware culture	☐	☐	☐	☐	☐
5	Sufficient resources	☐	☐	☐	☐	☐
6	Risk identification, analysis and prioritization	☐	☐	☐	☐	☐
7	Iterative and dynamic ERM process steps	☐	☐	☐	☐	☐
8	Leveraging risks as opportunities	☐	☐	☐	☐	☐
9	Risk communication	☐	☐	☐	☐	☐
10	A common risk language	☐	☐	☐	☐	☐
11	A risk management information system	☐	☐	☐	☐	☐
12	Training programmes	☐	☐	☐	☐	☐
13	Formalized key risk indicators	☐	☐	☐	☐	☐
14	Integration of ERM into business processes	☐	☐	☐	☐	☐
15	Objective setting	☐	☐	☐	☐	☐
16	Monitoring, review and improvement of ERM framework	☐	☐	☐	☐	☐