Competency and Performance Measures for Organizations in the Construction Industry

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Abstract

Organizations operating in the construction industry seek to understand how to successfully identify and manage competencies, given the significant influence they have on performance. Thus, organizations need to explore new approaches for assessing and enhancing their competencies to improve their performance. This paper presents a review of past studies and identifies the most common organizational competency and performance measures. A focus group was conducted to evaluate and verify the list of identified competency and performance measures. The contributions of this paper are threefold. First, this paper addresses the lack of studies on organizational-level competencies specifically for the construction domain. Second, this paper identifies, categorizes, and ranks organizational competency and performance measures. Third, the categorization of competency and performance measures, verified by the focus group, provides organizations with a systematic method to evaluate their competencies and improve their performance.

Keywords: Construction performance, Competency, Organizational competency, Organizational issues, Organizational performance

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1. Introduction

The construction industry is dynamic, complex, and demands continuous quality, productivity, and performance improvement, due to the emergence of new procurement methods, contracts, and project delivery methods (Kwak et al. 2015; Hanna et al. 2016). The environment within which organizations in the construction industry operate is becoming more complex due to increasing uncertainties present in technology, budgets, and development processes, making it challenging to achieve organizational success and competitive advantage (Acur et al. 2010; Radujković et al. 2010). Several studies (e.g., Beatham et al. 2004; Radujković et al. 2010; Hanna et al. 2016) have criticized the construction industry for its underperformance. For instance, Radujković et al. (2010) argue that the construction industry still suffers from inefficiency and ineffectiveness and lags far behind all other industries in terms of performance. Hanna et al. (2016) concur that the construction industry continues to suffer from declining productivity at a rate of -0.5% per year since 1960, compared to other industries that are growing at a rate of 1.7% annually. Some of the challenges that have long been recognized as inhibiting the performance of the construction industry include problems in its structure (e.g., fragmentation), the dynamic nature of the industry and business environment, the changing nature of the work, and the increasing competition (Beatham et al. 2004; Kwak et al. 2015). Researchers therefore emphasize the importance of adopting effective strategies and performance measurement methods that will improve the performance of organizations in the construction industry (Acur et al. 2010; Horta and Camanho 2014). Loufrani-Fedida and Missonier (2015) argue that recent developments in theory and practice have placed competencies at the center of an organization's success, resulting in a focus on defining critical competencies that must be implemented in the organization's context to ensure better performance. Therefore, in order to achieve better performance and competitiveness, construction organizations

41 (i.e., owners, consultants, and contractors) need to explore new approaches for assessing and
42 enhancing their competencies (Omar and Fayek 2016; Giel and Issa 2016).

43 Many past studies emphasize only select aspects of competency, such as
44 individual/personal or managerial competencies (Salajeghe et al. 2014). Some studies have been
45 conducted at the project level (IPMA 2006, 2015; Salajeghe 2014; Hanna et al. 2016, 2018; Omar
46 and Fayek 2016), but competency studies at the organizational level are few (Escrig-Tena and
47 Bou-Llusar 2005; Edgar and Lockwood 2008). Although organizational competency is a major
48 research focus in many disciplines such as business, human resources, and management, limited
49 research has been conducted in the construction domain. Competency studies at an organizational
50 level need to account for the unique nature of construction, which is widely regarded as complex,
51 full of uncertainties, and contingent on changing environments. As such, there remains a need for
52 a comprehensive analysis of all aspects of organizational competencies that improve performance
53 for construction organizations operating in a highly competitive global market. Thus, this paper
54 has the following objectives: (1) to conduct an extensive review and detailed content analysis on
55 organizational-level competency and performance studies in the construction domain; (2) to
56 identify and systematically categorize organizational competency and performance measures; (3)
57 to evaluate, rank, refine, and validate the list of organizational competency and performance
58 measures and their categorization.

59 The rest of this paper is structured as follows: the first section provides a review of the
60 literature pertaining to organizational competency and performance; the second section discusses
61 the research methodology adopted in this paper and provides the outcomes of the content analysis
62 (i.e., identification and categorization of organizational competency and performance measures
63 and focus group procedures); the third section presents the results and discussion of the focus

group findings, followed by the limitations of the study in the fourth section; and the last section provides conclusions and suggestions for future research.

2. Literature review on organizational competency and performance

2.1 Organizational competency

The concept of "competency" was first proposed in McClelland's (1973) seminal paper, which argues that traditional intelligence tests do not predict future life success. Boyatzis (1982) coined the definition of competency as "an underlying characteristic of a person, which results in effective and/or superior performance in a job." Succar et al. (2013) view competency in terms capability (i.e., the ability to perform a task) and/or maturity (i.e., the degree of excellence in performing a task). The term competency reflects a generic set of abilities suitable for implementing a task and assessing the capability and/or maturity to perform a task (Succar et al. 2013). Competency is a combination of knowledge, skills, and abilities as well as experience to accomplish a specific task (IPMA 2015; Succar et al. 2013). To successfully perform assigned roles, individuals need to accumulate enough experience to complement their competencies (IPMA 2015). In general, competencies are defined as combinations of (1) motives, (2) traits, (3) self-concepts, (4) attitudes or values, (5) content knowledge or cognitive behavioral skills, and (6) any individual characteristic that can be reliably measured or counted and that can be shown to differentiate superior from average performers (Chouhan and Srivastava 2014; Hanna et al. 2018).

The literature indicates a widespread misconception of organizational competencies, which are often perceived narrowly as individual employee skills and capabilities, rather than overall cross-company core competencies that drive integrated business execution (Edgar and Lockwood 2008). Past studies (e.g., Succar et al. 2013; Loufrani-Fedida and Missonier 2015; Loufrani-Fedida and Saglietto 2016) attempt to capture organizational competency using a multi-level approach at

an individual, team/collective, and organizational level. Some studies differentiate between capabilities and competencies (Succar et al. 2013, Walsh and Linton 2001). For instance, Succar et al. (2013) view organizational competency as multi-level, consisting of competency (i.e., an individual's ability) and capability (i.e., a team or organization's ability) to perform a specific task, as well as maturity (i.e., a team or organization's excellence) in performing a task. Their study argues that organizational competency is an aggregation of individual and/or team/group competencies. According to Crawford (2015), the concept of maturity is used to describe the state of an organization's effectiveness at performing certain tasks. The competency versus maturity approach perceives organizational competency (i.e., capability and/or maturity) as an aggregation of individual and/or team capability/maturity. This approach enables performance assessment and improvement that teams and/or organizations aspire to achieve (Succar et al. 2013; Walsh and Linton 2001). However, the competency versus maturity approach fails to capture the overall aspect of an organization that goes beyond simply aggregating individual competency and/or team capability or maturity. Escrig-Tena and Bou-Llusar (2005) assert that the concept of competencies consists of individual/personal competency (e.g., experience, technical knowledge, skills, and abilities) and corporate competencies (i.e., a combination of skills and knowledge that belong to the organization itself. They argue that organizational competencies are a combination of skills and knowledge, not only possessed by individual members, but also embedded in company processes and systems; thus, these skills and knowledge remain in the organization even when individuals leave the company. Accordingly, Loufrani-Fedida and Missonier (2015) view competency in a broad sense as "the ability of an individual, a team, or a company to mobilize and combine resources in order to implement an activity." Acur et al. (2010) consider the development of organizational competencies as antecedents of performance. For example, Rosas et al. (2011)

maintain that organizational competency is the ability of an organization to perform activities, tasks, or processes aimed at achieving a specified number of outcomes (i.e., performance). Accordingly, many companies define required competencies based on the goals that are identified within the context of their strategic plan. Thus, organizational competencies are a set of processes and practices that form the organization's main system for storing knowledge and that determine the regular operation of organizational functions (Escrig-Tena and Bou-Llusar 2005). For this paper, Tiruneh and Fayek's (2018) working definition of organizational competency as "an integrated combination of resources, particular sets of skills, necessary information, technologies, and the right corporate culture that enable an organization to achieve its corporate goals, competitive advantage, and superior performance" will be used.

2.2 Organizational performance

Performance is of particular interest to the construction industry, where organizations focus on improving their performance (Rathore and Elwakil 2015). Predicting construction organizational performance helps identify weak organizational processes and practices, which can then be enhanced, improving efficiency and profitability (Rathore and Elwakil 2015). However, Poveda and Fayek (2009) argue that performance is such a complex process that no single factor can be used to predict or evaluate it. It is a major challenge to predict performance in measurable terms such that it can be used for budgeting and control activities (Georgy et al. 2005; Lin and Shen 2007). Yun et al. (2016) stress the need for effective and flexible performance measurement methods for organizations so they can be successful in a dynamic business environment such as the construction industry. An organization's performance depends greatly on its people and their competencies (Chung and Wu 2011). Practitioners in construction companies always strive to measure performance, compare planned performance to actual performance, and take corrective action in order to improve performance (Georgy et al. 2005; Lin and Shen 2007). Therefore,

research in the construction domain has largely been focused on establishing performance measurement frameworks for construction companies (Deng and Smyth 2014; Horta and Camanho 2014).

2.3 Categorization methods for organizational competencies

A wide range of competency models and frameworks were reviewed in order to identify and categorize organizational competencies. Some of the reviewed studies include the International Project Management Association (IPMA) individual competence baseline (ICB) models (i.e., IPMA Competence Baseline, Version 3.0 (IPMA 2006) and Individual Competence Baseline Version 4.0 (IPMA 2015)), and the fuzzy hybrid model (Omar and Fayek 2016), competency frameworks (Janjua 2012; Salajeghe et al. 2014). These competency models and frameworks are reviewed and summarized below.

Past competency models categorize competencies in various ways. For instance, IPMA (2006) identified 46 project management competencies and classified them into three major categories: technical, behavioral, and contextual. Omar and Fayek (2016) categorized 41 construction project competencies into two groups as functional and behavioral. IPMA (2015) developed 28 competencies categorized as practice, people, and perspective competencies, which are analogous to the technical, behavioral, and contextual competencies of IPMA (2006). Janjua et al. (2012) derived five competency classes: functional, generic management, social skills, cognitive skills, and personal characteristics. Salajeghe et al. (2014) developed a framework for competency assessment with five categories of competencies: knowledge, performance, personal, industry, and organizational competencies. Takey and Carvalho (2015) classified project management competencies into the four categories of project management processes, personal, technical, and context and business. Loufrani-Fedida and Missonier (2015) grouped competencies into three categories: functional, integrative, and collective. The variety of and approaches to

158 competency categorization indicate that organizations define their competencies and categorize
159 them on the basis of their needs and strategic goals. Escrig-Tena and Bou-Llusar (2005) developed
160 a model to evaluate organizational competency, which grouped nine competencies into four
161 categories: managerial, input-based, transformation-based, and output-based. Walsh and Linton
162 (2001) differentiated between competencies and capabilities: competencies refer to firm-specific
163 technologies and production-related skills (i.e., technical competencies), while capabilities refer
164 to firm-specific business practices, processes, and culture (i.e., managerial capabilities). Walsh and
165 Linton (2001) proposed an organizational competencies pyramid that defines organizational
166 competencies as an aggregation of both technical competencies and managerial capabilities. Giel
167 and Issa (2016) developed a framework for evaluating BIM competencies in three categories:
168 strategic, administrative, and operational. Their framework provides an assessment of BIM
169 maturity for owner organizations to evaluate their technical knowledge, improve their BIM
170 requirements during design and construction, and improve the efficiency of their postconstruction
171 operations (Giel and Issa 2016). Loufrani-Fedida and Saglietto (2016) proposed an integrative
172 approach to map multi-level competencies to the knowledge management, human resource
173 management, and strategy of the organization. However, their study does not link these
174 competencies to organizational performance and lacks external validity to apply it broadly. The
175 framework proposed by Salajeghe et al. (2014) may be applicable at an organizational level, given
176 the multi-level approach of the categories developed, although it was developed for measuring
177 project manager effectiveness (i.e., an individual level). The model developed by Omar and Fayek
178 (2016) can be extended to the organizational level, since it captures behavioral and functional
179 competencies at the project level and links those competencies to project performance.

180 Relating organizational competency to performance is essential for identifying target areas
181 where performance can be improved. Previous studies do not capture overall organizational
182 competency and performance and the dynamic and complex nature of organizations. Such studies
183 consider either individual (Janjua et al. 2012; IPMA 2015; Salajeghe et al. 2014; Takey and
184 Carvalho 2015) and/or project-level competencies (IPMA 2006; Loufrani-Fedida and Missonier
185 2015; Omar and Fayek 2016), but fail to frame them at the organizational level. Other studies that
186 model organizational competencies focus only on one specific aspect of the organization, such as
187 quality management competency (Walsh and Linton 2001, Escrig-Tena and Bou-Llusar 2005),
188 BIM competency (Succar et al. 2013; Giel and Issa 2016), and software project management
189 (Loufrani-Fedida and Saglietto 2016). To address these gaps, this study proposes a more
190 comprehensive categorization of organizational competencies that can be applied at different
191 levels within an organization; it also proposes a model to relate competencies to organizational
192 performance measures. The proposed categorization of organizational competency and
193 performance measures, identified through a thorough literature review and detailed content
194 analysis, will help to capture organizational practices as a whole for companies involved in the
195 construction industry.

196 ***2.4 Categorization methods for organizational performance measures***

197 The highly competitive environment of the construction industry creates pressure on organizations
198 to implement systematic performance measurement methods so they can continuously improve
199 their performance (Horta and Camanho 2014). The use of key performance indicators (KPIs)
200 dominates the practice of performance measurement in construction (Deng and Smyth 2014). Many
201 performance measurement frameworks exist for organizations in the construction industry, such as
202 those developed by Beatham et al. (2004), Horta and Camanho (2014), Radujković et al. (2010),
203 and Yun et al. (2016). However, the literature indicates that along with KPIs, key performance

outcomes (KPOs) and perception measures (PerMs) can also be used effectively in the construction industry to measure performance (Beatham et al. 2004; Radujković et al. 2010). KPIs are leading indicators that can predict future trends in organizational operations, thus helping to identify problems at early stages and providing opportunities for change. In contrast, KPOs are results of completed tasks, activities, or processes; hence, KPOs are lagging indicators and do not provide opportunities for change perception measures (PerMs) can be either leading or lagging, depending on the time at which they are measured. PerMs are subjective in nature and are often measured through surveys and interviews (Radujković et al. 2010).

3. Research methodology

The research methodology for this study had three major stages. First, relevant articles from highly regarded journals mostly in construction research were selected. Then, a comprehensive literature review and detailed content analysis was conducted to identify and categorize organizational competency and performance measures. Finally, a focus group study was carried out to evaluate and rank identified competency and performance measures and validate their categorization. The detailed procedures of the research methodology are presented below.

3.1 Selection of journals and relevant articles

In stage 1, journals that are highly-ranked in the construction engineering and management research community were selected. Scopus, a powerful search engine that includes most research publications in construction, engineering, management, and business, was initially used. However, most of the competency studies—including those published earliest—were from business, human resources, and management studies; therefore, journals outside the construction domain were also considered for selection. Thus, to maximize the coverage of journal coverage focusing on competency studies, databases that provide highly-ranked and relevant research work were also

227 used, such as the American Society of Civil Engineers (ASCE) library, the *International Journal*
228 *of Project Management* (IJPM) database, Elsevier, Emerald, Taylor & Francis Online, the Wiley
229 Online Library, and Scopus. Journals that have a CiteScore of 0.90 and above according to 2017
230 Scopus journal metrics were considered.

231 The search for relevant articles was restricted to articles published between 1985 and 2018
232 and conducted using the title, abstract, and keywords (T/A/K) field of the above bibliographical
233 sources. Then, articles relevant to the study were selected using appropriate search terms, including
234 "competency", "performance measurement", "organizational competency", "organizational
235 performance", "competency and performance measures", and "organizational competency and
236 performance measures". As a result, 354 articles focusing on competency and performance from
237 50 journals were initially identified. The contents of the articles were further examined, and the
238 number of articles was reduced to 125 from 33 journals as shown in Table S1 [see end of this post-
239 print document]. Articles were selected based on the following criteria: (1) the article should focus
240 on competency and performance in general and on construction in particular; (2) the article should
241 mention, discuss, or list competency and performance measures; and (3) the article should use a
242 specific classification and categorization technique of competency and performance measures.
243 Once the bibliographical sources were identified, the relevant articles were selected using content
244 analysis, following the approach of Siraj and Fayek (2019). The 354 articles were considered to
245 have met the initial requirement for further analysis since the search terms appeared in the titles,
246 abstracts, or keywords. Due to widespread use of the search terms used for this paper in CEM
247 research, the abstract of each article was used to filter out irrelevant papers. Therefore, articles that
248 included any of the search terms in their titles, abstracts, or keywords but that did not focus on
249 topics related to discussing, classifying, and categorizing competency and performance measures

were excluded. Thus, the 354 articles were reduced to 125. Of the 125 articles considered, 108 (86%) of the articles were from 16 journals that each include at least three articles. The largest number of articles selected were from the following journals: *Construction Management and Economics* (17 articles), *Expert Systems with Applications* (8 articles), *International Journal of Project Management* (10 articles), *Journal of Construction Engineering and Management* (9 articles), *and Journal of Management in Engineering* (7 articles). The remaining 17 articles from 17 journals listed in Table S1 were included because of their relevance to the objectives of this paper based on the article selection criteria.

3.2 Content analysis

A comprehensive review of articles selected in stage 1 was conducted to identify relevant articles that focus on competency and performance for content analysis. Content analysis is a robust technique for collecting and organizing information in order to examine trends and patterns and determine major facets of and valid inferences from analyzed documents (Siraj and Fayek 2019). Content analysis can be qualitative or quantitative. Qualitative content analysis focuses on grouping data into categories based on the contents. Quantitative content analysis determines the numerical values of categorized data (i.e., frequencies, ratings, and rankings) by counting the number of times a topic is mentioned (Chan et al. 2009; Siraj and Fayek 2019). In this paper, a combination of qualitative and quantitative content analysis was adopted in order to (1) review recent advances in competency and performance studies applicable to the construction domain, (2) develop a comprehensive list of competency and performance measures; (3) identify and examine common competency and performance measures and their categorization methods, and (4) systematically identify and categorize the most commonly used organizational competency and performance measures. As a result, a comprehensive list of organizational competency and performance measures was identified and the measures were categorized, as presented in the following section.

3.3 Identification and categorization of organizational competency and performance measures

3.3.1 Identification and categorization of organizational competency

According to Campion et al. (2011), competencies can be hierarchically arranged into categories and subcategories to simplify their presentation for the user, especially if there are a large number of competencies. By performing content analysis and conducting a comprehensive review of the literature, 18 commonly used competency categories were identified. These competency categories were further reduced to 12 by merging categories to avoid redundancy and similarity. In addition, the content analysis indicated that competencies have been viewed from two different perspectives: (1) as assets, skills, or resources belonging to the company that allow an activity to be performed systematically; and (2) as the activities themselves, that is, the operations that the firm is able to carry out by integrating a series of assets, emphasizing what the company does as opposed to what the company has (Walsh and Linton 2001; Escrig-Tena and Bou-Llusar 2005; Succar et al. 2013; Omar and Fayek 2016). The first perspective identifies the cognitive aspect, which is related to the knowledge and skills the firm possesses (i.e., behavioral competencies); the second perspective identifies the processes and practices of implementing the activities, functions, and/or operations the firm undertakes (i.e., functional competencies). Accordingly, 157 competencies were identified and grouped into two sets of organizational competencies: functional (how the organization operates and functions) and behavioral (individual/organizational attributes). The list of competencies was further refined to avoid redundancy and similarity. For instance, competencies described as strategic thinking, strategic planning, strategic policy, and strategic management were merged into one competency. As a result, a total of 101 competencies (i.e., 58 functional and 43 behavioral competencies) were selected and grouped under 12 categories, as shown in Table 1. The competency categories that already exist in the literature are limited to a select few aspects of

298 **Table 1.** Organizational competencies.

Group	Competency category	No. of competencies	Competencies (No. of articles that cite the competency)
Functional	General administration	5	Staff development/training (22); Human resources/personnel (22); Results orientation (5); Goal orientation (5); Managing and support of diversity (8)
	Technical	9	Quality of work (22); Technical/job knowledge (19); Commitment to safety (6); Planning and organizing (10); Strategic planning and management (20); Attention to detail (3); Business acumen/business management skills (13); Market management (12); Finance management (13)
	Cross-functional	5	Cooperation and coordination (collaboration) (13); Stakeholder focus (26); Communications management (16); Delegation (3); Public and government relations (5)
	Production/operation	6	Construction technology/integration management (9); Operations and maintenance (5); Process engineering management (17); Construction, production, and manufacturing (8); Materials management (5); Product engineering (7)
	Construction and engineering research and development	4	Business, legal, and public policy (3); Construction law and regulation (3); Management information systems/technology (22); New technology/product development (17)
	Project management	24	Safety, health, security, and environment (13); Quality management (15); Schedule (time) management (15); Scope management (5); Change management (11); Managing performance (4); Cost management (8); Commissioning and start-up (3); Project monitoring and controlling (3); Project resource management (5); Risk management (15); Design development (3); Integration management (7); Project materials management (5); Stakeholder management (5); Contract administration (4); Project communications management (6); Environmental management (3); Team building (12); Procurement management (8); Project human resource management (9); Program management (3); Conflict management (6); Commitment to sustainability (3)
	Supervisory/managerial	5	Values and ethics (3); Engagement (5); Management excellence (3); Resource management (5); Strategic thinking (3)
	Subtotal	**58**	

Group	Competency category	No. of competencies	Competencies (No. of articles that cite the competency)
Behavioral	Organizational attributes	7	Ability to build trust (5); Competitiveness (3); Adaptability/flexibility (27); Achievement drive (27); Innovation (30); Organizational awareness, culture, and values (9); Risk-taking (5)
	Top management	4	Leadership (26); Strategic thinking (9); Judgement (5); Analytical ability (14)
	Middle management	7	Interpersonal skills (15); Decision-making (15); Consultation (4); Negotiation (8); Reasoning (3); Conflict and crisis resolution/issue management (13); Assertiveness (6)
	First-line management	8	Problem-solving (6); Integrity/high standards (4); Planning and organizing (8); Results orientation; Responsiveness (3); Influence (12); Communication (20); Incisiveness (3)
	Individual/personal	17	Reliability/dependability (8); Teamwork (17); Ethics (4); Initiative (14); Commitment (5); Effectiveness (8); Self-regulation/control (16); Motivation (10); Resourcefulness (3); Perseverance (3); Attention to detail (4); Professionalism (9); Cognitive skills (6); Self-confidence (10); Creativity (11); Sales mindset/selling skills (3); Enthusiasm (3)
	Subtotal	**43**	
	Total	**101**	

competency, such as individual/personal, managerial, and cost estimation competencies. In contrast, the categorizations of organizational competencies proposed in this paper capture an overall view of organizational processes and practices. Therefore, this paper categorizes organizational competencies hierarchically that considers how the organization operate their functions and organize their resources especially human resources.

Functional competencies are the technologies, abilities, and knowledge necessary to perform work-related tasks effectively and to produce specific desired outcomes within the functional domains of the organization (McDermott 2003; Loufrani-Fedida and Missonier 2015). In line with past studies and taking into account construction organizational operations, a total of 58 identified functional competencies are organized into seven categories based on specialized functional areas or departments (e.g., general administration, production/operations, project management, and construction and engineering research and development) and those spanning intra-organization or interdisciplinary functional domains (i.e., cross-functional, technical, and supervisory/managerial competencies).

Behavioral competencies are the individual or organizational attributes that enable the effective and consistent execution of organizational functions, thereby ensuring market competitiveness (IPMA 2006; Rosas et al. 2011). Forty-three behavioral competencies are arranged in five categories according to organizational hierarchy and managerial levels. The first competency category deals with the overall organizational attributes that identify a given construction organization as a single entity. The managerial attribute competencies are grouped into top, middle, and first-line management competencies. Individual/personal attributes make up the fifth behavioral competency category, which encompass competencies that are important for all sets of individuals in the organization.

3.3.2 Identification and categorization of organizational performance measures

This paper identified a total of 44 organizational performance measures and classified them as KPIs, KPOs, and PerMs. Performance measures can be either leading indicators (KPIs), lagging indicators (KPOs), or both (PerMs). KPIs are made up of five categories (i.e., cash flow, quality of work, market shares, safety, and financial stability). The performance measures under the KPI categories are leading indicators that enable the prediction of future trends and identify problems in the early stages of organizational operations and/or projects, which provides the opportunity for intervention to improve performance. KPOs are made up of four categories (i.e., profitability, growth, business efficiency, and effectiveness of planning). The performance measures under the KPO categories are lagging indicators, which are measured as a result of an outcome and which do not enable change. PerMs are categorized as internal customer satisfaction, external customer satisfaction, or competitiveness, dependent on the manager's/individual's perception and/or focus. PerMs can be either leading or lagging indicators, depending on when they are measured. The full list of identified organizational performance measures and their categories is shown in Table 2.

Table 2. Organizational performance measures.

Group	Category	No. of performance measures	Performance Measures (No. of articles that cite the performance measure)
KPIs	Cash flow	1	Cash flow (5)
	Quality of work	2	Rework factor (4); Prevention, appraisal, and failure (PAF) model (3)
	Market share	2	Market returns (3); Market share (11)
	Safety	5	Incident rate (4); Time lost (4); Safety performance (4); Accident frequency rate (5); Accident cost (3)
	Financial stability	2	Debt ratio (4); Liquidity (3)
	Subtotal	**12**	
KPOs	Profitability	10	Profitability (13); Return on investment (5); Return on capital (3); Return on assets (8); Net income (3); Return on equity (3); Economic value added (3); Return on sales

			(5); Financial autonomy (3); Hanging invoice (3)
	Growth	3	Revenue growth (9); Sales growth (9); Volume of works growth (7)
	Business efficiency	2	Net profit margin (3); Efficiency ratio (2)
	Effectiveness of planning	5	Cost predictability (5); Time predictability (5); Change cost factor (3); Cost growth/increase (4); Time growth/increase (4)
	Subtotal	**20**	
PerMs	Internal customer satisfaction	5	Employee satisfaction (8); Employee turnover rate (2); Average remuneration per employee (2); Profit per employee (2); Turnover/revenue per employee (2)
	External customer satisfaction	4	Customer satisfaction (13); Customer retention/loyalty (3); Percentage of repeat customers (2); Number of complaints (3)
	Competitiveness	3	Company image/reputation; (6) Competitive advantage (3); Market advantage (2)
	Subtotal	**12**	
	Total	**44**	

3.4 Focus group

In stage 3, a focus group study was conducted to evaluate, rank, refine, and validate the list of organizational competency and performance measures and their categorization, which were identified through extensive literature review and detailed content analysis. A focus group consists of a group discussion with a moderator prompting the participants to exchange ideas and explore expert opinions based on the participants' experiences (Leung et al. 2014).

The focus group study, approved by the University of Alberta Human Research Ethics Board, was conducted in two phases: the focus group survey and the focus group discussion. The first phase consists of a focus group survey, where participants evaluate the list of organizational competency and performance measures based on their importance with respect to their respective categories. A five-point importance scale was used for evaluation (i.e., extremely unimportant, unimportant, neither unimportant nor important, important and extremely important). The second phase was the focus group discussion session with five discussion points. An interactive semi-

structured focus group discussion led by two moderators/facilitators was conducted. The moderators encouraged the participants to exchange ideas and describe their experiences pertaining to identifying, measuring, and evaluating competency and performance in their organizations.

3.4.1 Size of the focus group

An invitation to participate in the focus group study was sent out via email to individuals working in the construction industry, through eight member organizations of an industry-based research partnership program involving a wide range of company types operating in the construction industry, such as owners, contractors, consultants, trades. Some of these members organizations are associations, who sent out the invitation to their members. A purposive sampling was adopted, in which participants had to fulfill at least the following criteria: (1) they all had either a managerial or senior position and had experience and knowledge of how organizations operate in the construction industry so they could effectively evaluate the competency and performance measures at the organizational level and (2) they were still actively working and had at least five years of practical experience in organizations and/or projects in the construction industry. The purposive sampling that was adopted helped to ensure both the quality of data collected and a mix of wide-ranging interdisciplinary participants (Leung et al. 2014).

There were 13 participants in the focus group study representing eight organizations operating in the construction industry. The North America Industry Classification System (NAICS) – Canada published by Statistics Canada (2017) was used to determine the construction industry sector categories. The participants' demographic information is presented in Table 3. The participants of the focus group were highly experienced professionals (the majority are 40 years old and above with an average work experience of 20 years or more) who hold a management position in their respective organizations. As practitioners working in the construction industry, participants

374 provided their expert opinion in the focus group discussion on issues applicable to their specific
375 organizations. The participants represented eight companies, the majority of which (five) are owner
376 companies involved in heavy and civil engineering construction, specifically in the energy (i.e., oil
377 and gas and power) sector. Of the three remaining companies, one of them is a general contractor
378 and two are specialty subcontractors. Of the eight companies represented, seven of them are large
379 organizations with more than 300 employees and one is small with less than 50 employees.

380 **Table 3.** Focus group participants' demographic information.

Background information	Categories	Number of participants
Age	18–30	0
	31–40	3
	41–50	6
	51–60	4
Company type	Owner	9
	General contractor	1
	Specialty/Subcontractor	3
Position	Senior management	5
	Project management	4
	Engineering management	1
	Project controls	1
	Product manager	1
	Construction manager	1
Overall years of work experience	<10	2
	11–20	5
	21–30	3
	31–40	3
Gender	Male	11
	Female	2

381 ***3.4.2 Focus group session procedures***

382 The focus group consisted of three parts: (1) introduction and presentation, (2) focus group survey
383 evaluation, and (3) focus group discussion. At the beginning of the focus group, participants
384 introduced themselves and stated their position and organization. The moderators described the
385 purpose of the study and the function of the focus group (i.e., processes, procedures, and

anticipated outcomes), the focus group rules (i.e., equal status and voice of each participant to provide suggestions), and confidentiality of the discussions. In addition, the moderators briefly presented the definitions of organizational competency and performance measures, the categories of competency and performance measures, and a planned framework to relate competencies to performance.

Participants were provided with two sets of documents. The first document was a focus group survey consisting of a list of organizational competencies classified as functional or behavioral and grouped under seven and five categories, respectively. This document also included organizational performance measures classified as KPIs, KPOs, and PerMs. Participants were asked to review the list and categorization of each competency and performance measure and evaluate it within its respective category, using a 5-point importance scale (1 = extremely unimportant and 5 = extremely important). As a reference, a second document consisting of the definitions of each organizational competency and performance measure was also provided to help participants understand and evaluate them effectively and validate their categorization.

Following the focus group survey, a semi-structured participative discussion was conducted. For the discussion session, the moderators provided five semi-structured open-ended questions to explore participants' experiences and opinions pertaining to identifying, evaluating, and validating the categorization of organizational competency and performance. The moderators made notes during the focus group discussion to capture participants' opinions and feedback. The moderators also facilitated the discussion by elaborating on and further explaining the suggestions and questions posed by participants. The explanations allowed the moderators and participants to cross-check their respective understandings of the ideas and opinions provided during the course of the discussion, thus helping to minimize data distortion and misrepresentation.

3.4.3 Focus group survey data analysis

All 13 focus group participants completed the survey. The Relative Importance Index (*RII*) for each of the competency and performance measures is calculated using Equation 1 to identify the importance of each competency or performance measure relative to the other competency or performance measures in a given category and to rank them accordingly (Gündüz et al. 2013).

$$RII = \frac{\sum_{i=1}^{5} a_i n_i}{AN}, \quad (1)$$

where $a_i, i = 1, \ldots, 5,$ is a constant representing importance scales 1 to 5 (i.e., extremely unimportant, unimportant, neither unimportant nor important, important and extremely important respectively); $n_i,$ is the number of respondents who selected importance scales of a_i; A is the highest score of the importance scale (i.e., 5); and N is the total number of respondents (i.e., 13) who participated in the focus group.

The *RII* value has a range of 0 to 1, where the higher the *RII*, the more important the competency and/or performance measure relative to the other competency or performance measures in the same category. *RII* helps to identify the most important competency and performance measures based on their values of *RII* and their ranking.

3.4.4 Focus group discussion data analysis

A participative discussion was conducted after the focus group survey was completed. The moderators posed a set of semi-structured questions to initiate full participation and interaction from all participants. First, participants were asked for their opinions on the categorization of competency and performance measures. Second, participants were asked about gaps in the proposed competency and performance measures. Third, participants were asked for recommendations for improving categories and/or individual competency and performance

431 measures, and they provided qualitative suggestions for improving the focus group survey. Fourth,
432 participants were asked about the feasibility of collecting data on competency and performance
433 measures from various organizations. Fifth, participants were asked whether the proposed
434 approach mirrors each participant's organization's approach to defining and measuring
435 organizational competency and performance. The data collected from the discussion were encoded
436 and analyzed in conjunction with the focus group survey data.

437 The purpose of the focus group was to evaluate and identify important competency and
438 performance measures at the organizational level and refine the full list of competency and
439 performance measures for future data collection and modeling. The relative importance of
440 competency and performance measures was quantified using the *RII* and ranked accordingly within
441 each respective category. To refine the list of competency and performance measures, 60 percent
442 of the top-ranked competencies were selected for categories having ten or fewer competencies and
443 40 percent of the top-ranked competencies were considered for categories with more than ten
444 competency or performance measures. If a category had fewer than five competencies or
445 performance measures, all of them were selected. The rationale for applying these refining criteria
446 was to provide a balanced number of competencies within each competency category.

447 ## 4. Results and discussion

448 ### *4.1 Focus group survey results*

449 #### *4.1.1 Organizational competencies*

450 Following the approach presented in Gündüz et al. (2013), Tables S2 and S3 show the rankings of
451 organizational competencies. The mean *RIIs* and the competency category rankings are discussed
452 below. The three top-ranked competencies in each of the competency categories from Tables S2

453 and S3 are discussed in the following sections, based on the mean *RII* and the ranking order of the
454 competency categories.

455 ***4.1.1.1 Functional competencies***

456 Among the seven functional competency categories (Table S2), the three top-ranked functional
457 competency categories are supervisory/managerial competencies (*RII* = 0.874),
458 production/operation competencies (*RII* = 0.867), and project management competencies (*RII* =
459 0.853), respectively. Cross-functional competencies (*RII* = 0.852) are the fourth-ranked
460 competency category. The three lowest-ranked competency categories are construction and
461 engineering research and development competencies (*RII* = 0.849), technical competencies (*RII* =
462 0.836), and general administration competencies (*RII* = 0.785), respectively.

463 **i. *Supervisory/managerial competencies (RII = 0.874)***

464 The supervisory/managerial category is the top ranked functional competency category. *Values*
465 *and ethics* (*RII* = 0.923) is the top ranked competency in this category. Values and ethics encourage
466 adherence to the appropriate and effective core values, culture, and work ethic of the organization.
467 *Engagement* and *management excellence* are the two second ranked competencies in this category,
468 each with an *RII* of 0.877. Engagement helps supervisors and managers lead across organizational
469 boundaries in order to unite a broad-based group of stakeholders, partners, and clients/customers
470 in a shared agenda and strategy. Management excellence is critical for ensuring that people have
471 the support and tools they need and that the workforce as a whole has the capacity and diversity to
472 meet current and long-term organizational objectives.

473 **ii. *Production/operation competencies (RII = 0.867)***

474 Production/operation is the second ranked competency category. In this category, *construction*
475 *technology/integration management* and *operations and maintenance* are the two top ranked
476 competencies, each with an *RII* of 0.908, followed by *process engineering management* (*RII* =

0.862). Construction technology/integration management helps to optimize specific activities and coordinate the diverse components of production, operation, and/or construction works through the application of current technology available in the industry. Operations and maintenance ensure awareness of procedures/systems and safety considerations for setup, process/procedures, control, maintenance, and improvement of technologies that support production, operations, and maintenance in order to meet stakeholder requirements. Process engineering management enables the planning and coordination of process development and improvement across the organization, by identifying and analyzing the strengths and weaknesses of each process relative to acceptable standards.

iii. *Project management competencies (RII = 0.853)*

Project management is the third ranked competency category. *Safety, health, security, and environment* (*RII* = 0.954) is the top ranked project management competency. *Quality management*, *schedule (time) management*, and *scope management* are the three second ranked project management competencies, each with an *RII* of 0.923. Organizations in the construction industry are largely project-based companies (Kwak et al. 2015; Deng and Smyth 2013; Lin and Shen 2007); thus, project management competencies play a critical role in organizational success and performance.

iv. *Cross-functional competencies (RII = 0.852)*

The fourth ranked category is cross-functional competencies. *Cooperation and coordination* (*RII* = 0.933) is the top ranked cross-functional competency; it enables the integration of various interdisciplinary functional domains that span an organization. *Stakeholder focus* (*RII* = 0.877) and *communication management* (*RII* = 0.867) are the second and third ranked competencies, respectively, in this category.

v. *Construction and engineering research and development competencies (RII = 0.849)*

Construction and engineering research and development is the fifth ranked competency category. The three top ranked competencies in this category are *business, legal, and public policy* (*RII* = 0.883), *construction law and regulation* (*RII* = 0.877), and *management information systems/technology* (*RII* = 0.850). Construction and engineering research and development competencies are vital for ensuring organizational work processes remain effective, and they help create innovative processes and products that give the company a short-term and long-term competitive advantage.

vi. *Technical competencies (RII = 0.849)*

The sixth ranked competency category is technical competencies. The first and second ranked competencies in this category are *quality of work* (*RII* = 0.969) and *technical/job knowledge* (*RII* = 0.954), respectively, which indicate the ability of an organization to execute its operations and projects with the desired quality and appropriate expertise. *Commitment to safety* (*RII* = 0.938) is ranked third in this category.

vii. *General administration competencies (RII = 0.849)*

The general administration competency category is the lowest ranked functional competency category. In this category, *staff development/training* and *results orientation* are the two top ranked competencies, each with an *RII* of 0.831. The third ranked competency in this category is *goal orientation* (*RII* = 0.800) . Staff development/training addresses knowledge gaps by providing coaching, training, and continuous learning to help staff develop professionally and to support organizational improvement. Results orientation enables an organization to achieve expected results through successful and timely completion of organizational operations. Goal orientation

helps identify short- and long-term organizational objectives and strategies, as well as how to use resources effectively and efficiently to achieve these goals.

4.1.1.2 Behavioral competencies

Based on the mean *RII* and ranking shown in Table S3, the three top ranked behavioral competency categories are top management competencies (*RII* = 0.900), organizational attributes (*RII* = 0.882), and first-line management competencies (*RII* = 0.877), respectively. Middle management (*RII* = 0.855) and individual/personal competencies (*RII* = 0.835) are the fourth and fifth ranked behavioral competency categories, respectively.

i. Top Management competencies (RII = 0.900)

The top ranked behavioral competency category is top management competencies. The three top ranked competencies in this category are *leadership* (*RII* = 0.969), *strategic thinking* (*RII* = 0.954), and *judgment* (*RII* = 0.846), respectively.

ii. *Organizational attribute competencies (RII = 0.882)*

The second ranked behavioral competency category is organizational attributes. The two top ranked competencies in this category are *ability to build trust* (*RII* = 0.933) and *competitiveness* (*RII* = 0.908), respectively. *Adaptability/flexibility* and *achievement drive* are both ranked third, each with and *RII* of 0.908.

iii. *First-line management competencies (RII = 0.877)*

The third ranked behavioral competency category is first-line management competencies. *Problem-solving* (*RII* = 0.938), *integrity/high standards* (*RII* = 0.908), and *planning and organizing* (*RII* = 0.892) are the three top ranked competencies, respectively.

iv. Middle management competencies (RII = 0.855)

Middle management competencies is the fourth ranked behavioral competency category. *Interpersonal skills* and *decision-making*, each with an *RII* of 0.923, are the two top ranked

competencies in the category. *Consultation*, *negotiation*, *and reasoning* ranked third, with an *RII* of 0.923.

v. *Individual/personal competencies (RII = 0.835)*

Individual/personal competencies is the fifth ranked behavioral competency category. *Reliability/dependability*, with an *RII* of 0.938, is the top ranked competency in this category. The two second ranked competencies in this category are *teamwork* and *ethics*, each with an *RII* of 0.908.

4.1.1.3 Top ten ranked organizational competencies

This section presents the top ten ranked functional and behavioral competencies shown in Tables 4 and 5, based on their *RII* values and irrespective of their competency category. Based on the ranking in Table 4, quality of work is the top ranked competency (*RII* = 0.969). The second top ranked competencies are technical/job knowledge and safety, health and environment, both with *RII* = 0.954. Commitment to safety (*RII* = 0.969) and cooperation and coordination (*RII* = 0.969) are ranked fourth and fifth respectively. The sixth ranked competencies include quality management, schedule management, scope management, and values and ethics, each with *RII* = 0.923. Construction technology/integration management and operations and maintenance are ranked tenth with RII = 0.908. Competencies from the technical and project management competency categories dominate the ten to-ranked competencies (Table 4), which reflects the priorities of organizations in the construction industry.

Table 4. Ten top-ranked functional competencies.

No.	Competency	Competency category	*RII*	Overall rank
1	Quality of work	Technical	0.969	1
2	Technical/job knowledge	Technical	0.954	2
3	Safety, health, security and environment	Project management	0.954	2

4	Commitment to safety	Technical	0.938	4
5	Cooperation and coordination	Cross-functional	0.933	5
6	Quality management	Project management	0.923	6
7	Schedule/time management	Project management	0.923	6
8	Scope management	Project management	0.923	6
9	Values and ethics (integrity and respect)	Supervisory/managerial	0.923	6
10	Construction technology/ integration management	Production/operation	0.908	10
11	Operations and maintenance	Production/operation	0.908	10

Table 5. Ten top-ranked behavioral competencies.

No.	Competency	Competency category	*RII*	Overall rank
1	Leadership	Top management	0.969	1
2	Strategic thinking	Top management	0.954	2
3	Problem solving	First-line management	0.938	3
4	Reliability/dependability	Individual/personal	0.938	3
5	Ability to build trust	Organizational attributes	0.933	5
6	Interpersonal skills	Middle management	0.923	6
7	Decision-making	Middle management	0.923	6
8	Competitiveness	Organizational attributes	0.917	8
9	Adaptability/flexibility	Organizational attributes	0.908	9
10	Achievement drive	Organizational attributes	0.908	9

Based on the rankings in Table 5, the first and second top ranked behavioral competencies are *leadership* (*RII* = 0.969) and *strategic thinking* (*RII* = 0.954), respectively. *Problem solving* and *reliability/dependability*, each with *RII* = 0.938, are ranked third, followed by *ability to build trust* (*RII* = 0.933) in fifth place. The sixth ranked competencies include *interpersonal skills* and *decision-making*, both with *RII* = 0.923. Competitiveness (*RII* = 0.917) is ranked eighth, followed by *adaptability/flexibility* and *achievement drive*, each with *RII* = 0.908 ranked ninth.

The proposed classification of organizational competencies, which was validated through the focus group, helps organizations to identify, classify, categorize, and prioritize their

575 competencies based on their contexts (i.e., the size and type of organization as well as the
576 construction industry sector in which they operate).

577 ***4.1.2 Organizational performance measures***

578 Based on the rankings in Table S4, among the ten top-ranked performance measures are,
579 *Profitability* (*RII* = 0.967) is the top ranked performance measure. The second ranked performance
580 measures include *return on investment*, *incident rate*, *time lost*, and *company image/reputation*,
581 each with *RII* = 0.938. *Cash flow* (*RII* = 0.933) and *cost predictability* (*RII* = 0.933) are ranked
582 sixth, followed by *return on capital* (*RII* = 0.923) and *safety performance* (*RII* = 0.917), ranked
583 eighth and ninth, respectively. *Return on assets* and *competitive advantage* are the tenth most
584 important performance measures, with *RII* = 0.908.

585 The top-ranked performance measures in their respective categories are as follows. *Cash*
586 *flow* (*RII* = 0.933), *rework factor* (*RII* = 0.892), and *market returns* (*RII* = 0.800) are the top ranked
587 performance measures in the KPI categories of cash flow, quality of work, and market share
588 performance measures, respectively. *Revenue growth* (*RII* = 0.862), *net profit margin* (*RII* = 0.846),
589 and *cost predictability* (*RII* = 0.933) are the top ranked performance measures in the KPO categories
590 of growth, business efficiency, and effectiveness of planning, respectively. *Employee satisfaction*
591 (*RII* = 0.908), *customer satisfaction* (*RII* = 0.877) and *company image/reputation* (*RII* = 0.938)
592 were the top ranked performance measures in the PerM categories of internal customer satisfaction,
593 external customer satisfaction, and competitiveness, respectively.

594 Quantitative analysis also enables the prioritization of organizational performance measures
595 by ranking them based on their *RII* values in each category. For example, *market returns,* which
596 shows an organization's sales as a percentage of an industry's total revenue over a fiscal year, is the
597 top-ranked performance measure in the market share category. *Revenue growth*, which measures
598 an organization's growth over time compared to the previous reporting period's performance, is the

599 top-ranked performance measure in the growth category. *Company image/reputation*, which
600 indicates how an organization is perceived by people when the organization's name is mentioned,
601 is the top-ranked performance measure in the competitiveness category.

602 ***4.2 Focus group discussion results***

603 ***4.2.1 Categorization of organizational competency and performance measures***

604 The majority of participants agreed that the categorization of both competency and performance
605 measures is good, but one participant questioned the need for categorization. The moderators
606 explained the rationale behind categorizing the long list of competency and performance measures
607 in order to systematically group them to capture and depict the functional domains of a given
608 organization (e.g., planning, design, construction etc.) in the construction industry. Categorization
609 also helps the development of a technique for measuring and mapping competency to performance
610 measures. A participant questioned why safety is included in some competency and performance
611 categories given that it is an industry requirement. The majority of participants maintained that
612 even if safety is a requirement, it is greatly important to evaluate it given the differences in
613 implementation between organizations and between various construction industry sectors (i.e.,
614 safety requirements in the commercial construction sector are different than those in the heavy
615 industrial construction sector). Two participants maintained that the behavioral competencies
616 category is clearly defined, especially in terms of organizational attributes and managerial
617 competencies. However, they argued that the items included under individual/personal
618 competency category appear to be "characteristics" instead of competencies. The moderators cited
619 past studies (e.g., Omar and Fayek 2016; IPMA 2015; Takey and Carvalho 2015; Salajeghe et al.
620 2014) to explain the basis for developing those individual competencies. In addition to individual
621 cognitive abilities and traits, individual/personal competencies also include the knowledge, skill,
622 ability (known as KSA) and experience that characterize a particular individual; hence, they are

considered competencies. After a thorough discussion, the focus group reached consensus, agreeing that the categorization of organizational competency and performance measures is suitable and appropriate for use in construction organizations. Thus, the focus group validated the categorization of organizational competency and performance.

4.2.2 Gaps in organizational competency and performance measures

One of the issues participants highlighted is the overlap and repetition of competencies, such as *human resource management* and *resource management,* across different categories. The moderators explained that the competencies that are repeated in different categories have different levels of detail (e.g., they exist at the project and/or organizational level). It was also pointed out that some of the competencies (e.g., *human resources/personnel*) are at a higher (i.e., macro) level than some other competencies (e.g., *project human resource management*), which are at the micro level. The moderators explained that similar competencies in different categories were designed to capture organizational competency measures at different levels (e.g., project, business, and/or corporate levels). Such an approach is supported by the majority of participants.

A participant suggested that safety measures need to be grouped under KPOs instead of KPIs. The moderators explained that safety measures were grouped under KPIs because this categorization is supported by the literature, although some of the measures can also be considered KPOs. Another participant suggested that safety measures can be both KPIs and KPOs, stating, for instance, that the occurrence of a safety incident is an indicator that something serious might happen.

A participant raised the issue that some performance measures that are applicable to a certain organization type may not be appropriate for another organization type, such as owner versus contractor/service provider. For instance, performance measures that include return on assets and return on investment capture owners' perspectives. On the other hand, measures such as *market*

growth and *sales growth* are more appropriate from the service perspective (i.e., for contractors and consultants). The moderators explained that the purpose of developing a comprehensive list of performance measures is to account for the context variables of organization type, organization size, and construction sector type, so that individual organizations can select the most appropriate performance measures.

4.2.3 Improvements suggested by the focus group

These suggestions were also discussed during the focus group discussion. In order to address the presence of similar or repetitious competencies in different categories, participants recommended making more distinction between repeated competencies. The moderators explained that the competencies are distinguished by the definition of each individual competency and performance measure. Improvements to overall categorization and specific categories were suggested. Feedback from both the focus group survey and the discussion helped to capture practitioners' experiences in order to improve the list of competency and performance measures and their categorizations at an organizational level. The competency and performance measures that were recommended for inclusion or removal from the list were thoroughly analyzed, and those that were determined to exist and/or effectively capture competency or performance at the organizational level and that were supported by literature are included in order to meet the study objectives.

Competencies incorporated in the functional competency categories based on participants' feedback include: *interdisciplinary alignment* (general administration), *technical innovation* (technical), and *interface management* (cross-functional). Few competencies were suggested to be moved from their original category to a different category. *Delegation* is moved to the managerial/supervisory category from the cross-functional category, while *strategic planning and management* and *financial management* are taken out of the technical category and included under the cross-functional and project management categories, respectively.

Suggested additions to the list of performance measures include *revenue diversification* (cash flow), *near misses* (safety), and *work force growth* and *asset growth* (growth). *Cash flow* is moved to the financial stability category under KPIs based on focus group feedback. In addition, a new performance metric category, community relationships, which includes performance measures such as *equity*, *diversity*, *charitable institutions*, and *indigenous involvement* (aboriginal engagement targets), was suggested for addition. However, equity and diversity are elements of *manage and support diversity* under the general administration competency category, whereas charitable institutions and indigenous involvement needed to be added.

4.2.4 Suitability of competency and performance measures for collecting data

Almost all participants agreed that the competency and performance measures provided were suitable for data collection. Furthermore, participants agreed that the presented approach mirrors most of their organizations' approaches to defining and measuring competency and performance. However, one participant felt strongly that measuring competency and performance is contingent on what the top management needs and also depends on where these priorities fit in the hierarchies of the organization. The moderators explained that the differences in organization type (i.e., owner, consultant, and contractor) and the construction sector in which these companies operate were taken into consideration when developing the categorization. For instance, site priorities include schedule and cost, while corporate priorities will include profit. Performance measures should be put on a spectrum that accounts for the perspective (i.e., owners, contractors, consultants, etc.) from which they are being considered. As a result, the competencies required by an owner organization may differ from those required by contractors or consultants. Therefore, the comprehensive list of organizational competency and performance measures was developed to help different types of organizations to select the appropriate competencies and performance

694 measures based on the nature of their organization and the construction sector in which they
695 operate.

696 ***4.2.5 Verified list of organizational competency and performance measures***

697 All participants agreed that the list of competency and performance measures and their categories
698 were appropriate for use in their respective organizations, thus verifying the list of competency and
699 performance measures and validating their categorization.

700 In addition to competency and performance measures that were based on *RII* values, those
701 recommended by the focus group were incorporated based on their relevance to the assessment of
702 organizational-level competencies and based on supporting literature. Accordingly, the following
703 competencies *i.e., interdisciplinary alignment* (Brassler and Dettmers 2017), *technical innovation*
704 (Ozorhon et al. 2016), and *interface management* (Ahn et al. 2016) were included. In addition,
705 performance measures such as *revenue diversification* (Sung et al. 2017) and *near misses* (Pereira
706 et al. 2017) were included. Based on quantitative and qualitative analyses of the focus group
707 discussion, the final refined list of organizational competency and performance measures is
708 presented in Tables 6 and 7, respectively.

709 **Table 6.** Final list of organizational competencies.

Group	Competency category	Competencies
Functional	General administration	Staff development/training; Results orientation; Goal orientation; Human resources/personnel; interdisciplinary alignment*
	Technical	Quality of work; Technical/job knowledge; Commitment to safety; Planning and organizing; Technical innovation*
	Cross-functional	Cooperation and coordination (collaboration); Strategic planning and management;** Stakeholder focus; Communications management; Interface management*
	Production/operation	Construction technology/integration management; Operations and maintenance; Process engineering management; Construction, production, and manufacturing; Materials management

	Construction and engineering research and development	Business, legal, and public policy; Construction law and regulation; Information management systems/technology
	Project management competencies	Safety, health, security, and environment; Quality management; Schedule (time) management; Scope management; Change management; Managing performance; Cost management; Commissioning and start-up; Project monitoring and controlling; Project resource management
	Supervisory/managerial	Values and ethics; Engagement; Management excellence; Resource management; Delegation***
Behavioral	Organizational attributes	Ability to build trust; Competitiveness; Adaptability/flexibility; Achievement drive; Innovation; Organizational awareness, culture, and values
	Top management	Leadership; Strategic thinking; Judgement; Analytical ability
	Middle management	Interpersonal skills; Decision-making; Consultation; Negotiation; Reasoning; Conflict and crisis resolution/issue management
	First-line management	Problem-solving; Integrity/high standards; Planning and organizing; Results orientation; Responsiveness
	Individual/personal	Reliability/dependability; Teamwork; Ethics; Initiative; Commitment; Effectiveness; Self-regulation/control; Motivation

710 * *Incorporated based on focus group feedback*

711 ** *Moved from technical competency category*

712 *** *Moved from cross-functional competency category*

713 **Table 7.** Final list of organizational performance measures.

Metrics group	Category	Performance measures
KPIs	Quality of work	Rework factor, Prevention, appraisal, and failure (PAF) model
	Market share	Market returns, Market share
	Safety	Incident rate, Time lost, Safety performance, near misses*
	Financial stability	Cash flow, Debt ratio, Liquidity, Revenue diversification,* Credit availability*
KPOs	Profitability	Profitability, Return on investment, Return on capital, Return on assets, Net income, Return on equity
	Growth	Revenue growth, Sales growth, Volume of works growth, Workforce growth*, Asset (equipment and facility) growth*
	Business efficiency	Net profit margin, Efficiency ratio
	Effectiveness of planning	Cost predictability, Time predictability, Change cost factor
PerMs	Internal customer satisfaction	Employee satisfaction, Employee turnover rate, Average remuneration per employee

External customer satisfaction	Customer satisfaction, Customer retention/loyalty, Percentage of repeat customers
Competitiveness	Company image/reputation, Competitive advantage, Market advantage
Community relationship*	Indigenous involvement, charitable institutions, local community project spending

**Incorporated based on focus group feedback*

5. Limitations of the study

Focus groups usually consist of six to eight preselected participants who have similar backgrounds or shared experiences related to the research topic being studied (Liamputtong 2011; Hennink 2014). The relatively small number of participants in a focus group may affect the representativeness of the study results. However, a large sample size for a focus group is not necessarily beneficial, as it does not facilitate sharing deep and intimate experiences and insights among participants (Millward 2006). The number of focus group participants (i.e., n = 13) was sufficient for the focus group discussion; however, this number of participants may have been a limitation when calculating the *RII* and -ranking competency and performance measures. Established credible data collection and analysis procedures were followed to ensure the validity and reliability of the results: (1) purposive sampling was adopted to ensure participants were qualified and had the required experience; (2) multiple sources of evidence, such as participants' written suggestions in the focus group survey and notes taken during the focus group discussion, were collected to ensure data reliability; and (3) the focus group discussion was summarized and reproduced in this paper to enhance the reliability of the results. The extensive and detailed content analysis conducted prior to the focus group as well as the participants' expertise in evaluating and verifying the list of organizational competency and performance measures was helpful for generalizing the results.

The ranking order of competency categories using the mean *RII* may have been impacted by the number of competencies in each category and the focus group size. Furthermore, the

735 importance of each competency and/or performance measure may be dependent on the
736 organizational and operational context of the company. Therefore, considering the broad nature of
737 the construction industry, the ranking of competency and/or performance measures was done based
738 on the context of the companies represented in the focus group.

739 **6. Conclusions and recommendations for future work**

740 This paper presents a review of competency and performance studies focusing on competency and
741 performance measures at the organizational level in the construction industry. Common
742 approaches to competency and performance identification and classification were explored.
743 Organizational competencies are classified into two broad groups: functional and behavioral
744 competencies. After a detailed content analysis, a total of 101 competencies (58 functional and 43
745 behavioral competencies) were identified and organized into seven and five categories,
746 respectively. In addition, 44 organizational performance measures were grouped into three
747 categories. A focus group study was conducted to rank and verify the list and validate the
748 categorization of organizational competency and performances measures, evaluate the importance
749 of these measures in a given category based on their *RII* values and rankings, and refine the list of
750 competency and performance measures.

751 After conducting the focus group, a total of 35 functional and 27 behavioral competencies
752 were selected based on their *RII* values and ranking for future data collection purposes. The ten
753 most important organizational competency and performance measures were also identified. In
754 addition, a total of three functional competencies were incorporated in the list based on feedback
755 from the focus group. Likewise, 33 performance measures were selected based on their rankings
756 using *RII* values and eight measures were added from focus group feedback and recommendations
757 for further data collection. Furthermore, the focus group verified the list of competency and

758 performance measures and validated their categorizations in that they can be used to collect data
759 for measuring competency and performance at an organizational level.

760 The contributions of this paper are threefold. First, this paper presents a critical review of
761 past studies and shows that competency studies at the organizational level for the construction
762 domain are limited. Most competency and performance studies are conducted in disciplines outside
763 the construction domain, such as business and human resource management. Existing competency
764 and performance studies are focused either on individual or project-level competencies rather than
765 organizational-level competencies. This paper contributes by addressing the gap in the research on
766 organizational-level competency and performance studies specifically for the construction domain.
767 Second, the paper identifies, categorizes, and ranks a comprehensive list of organizational
768 competency and performance measures. Third, the proposed competency and performance measure
769 classification method was validated through a focus group, helping organizations in the construction
770 industry to identify and categorize their competency and performance measures according to their
771 context and construction industry sector. Additionally, the competency and performance measures
772 and categorization can serve as a reference for identifying common organizational competency and
773 performance measures for different organizations.

774 Future research will focus on exploring systematic approaches for measuring organizational
775 competency and performance measures. The refined list of competency and performance measures
776 will be used for future data collection from different organizations working in the construction
777 industry in various contexts and for modeling the relationship between competency and
778 performance measures. The results of this study serve as the foundation to design and develop a
779 questionnaire survey for a further study that enables the collection of both quantitative and
780 qualitative data on competencies and performance. Furthermore, competency and performance

781 measures will be mapped to a generic organizational chart of a company operating in the
782 construction industry to determine at which level each of the competency and performance is being
783 measured. Finally, fuzzy hybrid modeling techniques will be developed to enable the assessment
784 of organizational competencies and their mapping to organizational performance for the prediction
785 and improvement of performance. Use of this model will allow organizations to determine the
786 competencies that most significantly affect their performance and determine the extent to which an
787 improvement in these competencies will affect improvements in their performance measures.

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Table S1. Articles selected for content analysis

No.	Journal name	Author(s)	Year	Article title
1	AC	Chao, L., and Hsiao, C.	2012	Fuzzy model for predicting project performance based on procurement experiences
2	AC	Cheung, S. O., Suen, H. C. H., and Cheung K. K. W.	2004	PPMS: A web-based construction project performance monitoring system
3	AC	Omar, M. N. and Fayek, A. Robinson	2016	Modeling and evaluating construction project competencies and their relationship to project performance
4	AC	Succar, B., Sher, W., and Williams, A.	2013	An integrated approach to BIM competency assessment, acquisition and application
5	AC	Uhm, M., Lee, G., and Jeon, B.	2017	An analysis of BIM jobs and competencies based on the use of terms in the industry
6	CiI	Boucher, X., Bonjour, E., and Grabot, B.	2007	Formalization and use of competencies for industrial performance optimization: A survey
7	CiI	Harzallah, M., and Vernadat, F.	2002	IT-based competency modeling and management: From theory to practice in enterprise engineering and operations
8	CiI	Nudurupati, S., Arshad, N., and Turner, T.	2007	Performance measurement in the construction industry: An action case investigating manufacturing methodologies
9	CiI	Rauffet, P., Da Cunha, C., and Bernard, A.	2012	Conceptual model and IT system for organizational capability management
10	CiI	Worley, J. H., Chatha, K. A., Weston, R. H., Aguirre, O., and Grabot, B.	2005	Implementation and optimization of ERP systems: A better integration of processes, roles, knowledge and user competencies
11	CJCE	Esmaili, D., and El-Diraby, T. E.	2017	Organizational competency in urban water infrastructure asset management
12	CJCE	Hanna, A. S., Iskandar, K. A., Lotfallah, W., Ibrahim, M. W., and Russell, J. S.	2018	A data-driven approach for identifying project manager competency weights
13	CJCE	Rankin, J., Fayek, A. Robinson, Meade, G., Haas, C., and Manseau, A.	2008	Initial metrics and pilot program results for measuring the performance of Canadian construction industry
14	CME	Ahadzie, D. K., Proverbs, D. G., Olomolaiye, P. O., and Ankrah, N.	2009	Towards developing competency-based measures for project managers in mass house building projects in developing countries
15	CME	Arditi, D., Gluch, P., and Holmdahl, M.	2013	Managerial competencies of female and male managers in the Swedish construction industry
16	CME	Brown, A. D., and Phua, F. T. T.	2011	Subjectively construed identities and discourse: Towards a research agenda for construction management
17	CME	Chan, T. K.	2009	Measuring performance of the Malaysian construction industry

No.	Journal name	Author(s)	Year	Article title
18	CME	Cheah, C. Y. J., Kang, J., and Chew, D. A. S.	2007	Strategic analysis of large local construction firms in China
19	CME	Dainty, A. R. J., Cheng, M., and Moore, D. R.	2003	Redefining performance measures for construction project managers: An empirical evaluation
20	CME	Dainty, A. R. J., Cheng, M., and Moore, D. R.	2004	A competency-based performance model for construction project managers
21	CME	Egbu, C. O.	1999	Skills, knowledge and competencies for managing construction refurbishment works
22	CME	Kim, A., and Arditi, D.	2010	Performance of minority firms providing construction management services in the US transportation sector
23	CME	Konanahalli, A., and Oyedele L. O.	2016	Emotional intelligence and British expatriates' cross-cultural adjustment in international construction projects
24	CME	Luu, T., Kim, S., Cao, H., and Park, Y.	2008	Performance measurement of construction firms in developing countries
25	CME	Nkado, R., and Meyer, T.	2001	Competencies of professional quantity surveyors: A South African perspective
26	CME	Ruddock, L., and Ruddock, S.	2009	Reassessing productivity in the construction sector to reflect hidden innovation and the knowledge economy
27	CME	Rwelamila, P. M. D.	2007	Project management competence in public sector infrastructure organisations
28	CME	Santoso, J., and Loosemore, M.	2013	Expatriate management in Australian multinational enterprises
29	CME	Xia, B., Chan, A. P. C., and Yeung, J. F.Y.	2009	Identification of key competences of design-builders in the construction market of the People's Republic of China (PRC)
30	CME	Yasamis, F., Arditi, D., and Mohammadi, J.	2002	Assessing contractor quality performance
31	DS	Cleveland, G., Schroeder, R. G., and Anderson, J. C.	1989	A theory of production competence
32	DS	Hitt, M. A., and Ireland, R. D.	1985	Corporate distinctive competence and performance: Effects of perceived environmental uncertainty (PEU), size, and technology
33	DS	Stratman, J. K., and Roth, A. V.	2005	Enterprise resource planning (ERP) competence constructs: Ibo-stage multi-item scale development and validation
34	DS	Vickery, S. K., Droge, C., and Markland, R. E.	1993	Production competence and business strategy: Do they affect business performance?
35	DS	Vickery, S. K.	1991	A theory of production competence revised

No.	Journal name	Author(s)	Year	Article title
36	EMJ	Bartel-Radic, A., and Giannelloni, J.	2017	A renewed perspective on the measurement of cross-cultural competence: An approach through personality traits and cross-cultural knowledge
37	EMJ	Harvey, M., and Lusch, R.	1997	Protecting the core competencies of a company: Intangible asset security
38	EMJ	Lokshin, B., Van Gils, A., and Bauer, E.	2009	Crafting firm competencies to improve innovative performance
39	EMJ	Mothe, C., and Quelin, B.	2000	Creating competencies through collaboration: The case of EUREKA R&D Consortia
40	ESA	Bohlouli, M., Mittas, N., Kakarontzas, G., Theodosiou, T., Angelis, L., and Fathi, M.	2017	Competence assessment as an expert system for human resource management: A mathematical approach
41	ESA	Chin, K., Punb, K., and Lau, H.	2003	Development of a knowledge-based self-assessment system for measuring organizational performance
42	ESA	Horta, I. M., and Camanho, A. S.	2014	Competitive positioning and performance assessment in the construction industry
43	ESA	Hsu, I.	2008	Knowledge sharing practices as a facilitating factor for improving organizational performance through human capital: A preliminary test
44	ESA	Lee, Y.	2010	Exploring high-performers' required competencies
45	ESA	Sun, C.	2010	A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods
46	ESA	Wu, W.	2009	Exploring core competencies for R&D technical professionals
47	ESA	Wu, W., and Lee, Y.	2007	Developing global managers' competencies using the fuzzy DEMATEL method
48	HRMR	Cohen, D. J.	2015	HR past, present and future: A call for consistent practices and a focus on competencies
49	HRMR	Riggio, R. E., and Lee, J.	2007	Emotional and interpersonal competencies and leader development
50	HRMR	Russell, Z. A., Steffensen, D. S., Ellen III, B. P., Zhang, L., Bishoff, J. D., and Ferris, G. R.	2018	High performance work practice implementation and employee impressions of line manager leadership
51	HRMR	Sanchez, J. I., and Levine, E. L.	2009	What is (or should be) the difference between competency modeling and traditional job analysis?

No.	Journal name	Author(s)	Year	Article title
52	IJCRB	Anari, R. Y., and Rezaei, S.	2013	Supply chain management competence and performance: An entrepreneurial approach in Iranian IT SMEs
53	IJCRB	Gholipur, R. A., Mahmoodi, S. M., Jandaghi, G., and Fardmanesh, H.	2012	Presentation model of managerial competency approach in management development
54	IJCRB	Janjua, S. Y., Naeem, M. A., and Kayani, F. N.	2012	The competence classification framework a classification model for employee development
55	IJPE	Khanchanapong, T., Prajogo, D., Sohal, A. S., Cooper, B. K., Yeung, A. C. L., and Cheng, T. C. E.	2014	The unique and complementary effects of manufacturing technologies and lean practices on manufacturing operational performance
56	IJPE	Barnes, J. and Liao, Y.	2012	The effect of individual, network, and collaborative competencies on the supply chain management system
57	IJPE	Chavez, R., Yu, W., Jacobs, M. A., and Feng, M.	2017	Manufacturing capability and organizational performance: The role of entrepreneurial orientation
58	IJPE	Horta, I. M., Camanho, A. S., and Da Costa, J. M.	2012	Performance assessment of construction companies: A study of factors promoting financial soundness and innovation in the industry
59	IJPE	Yang, J.	2010	The knowledge management strategy and its effect on firm performance: A contingency analysis
60	IJPM	Adler, T. R., Pittz, T. G., and Meredith, J.	2016	An analysis of risk sharing in strategic R&D and new product development projects
61	IJPM	Ahadzie, D. K., Proverbs, D. G., and Olomolaiye, P.	2008	Towards developing competency-based measures for construction project managers: Should contextual behaviors be distinguished from task behaviors?
62	IJPM	Ahadzie, D. K., Proverbs, D. G., and Sarkodie-Poku, I.	2014	Competencies required of project managers at the design phase of mass house building projects
63	IJPM	Crawford, L., and Nahmias, A. H.	2010	Competencies for managing change
64	IJPM	Edum-Fotwe, F. T., and McCaffer, R.	2000	Developing project management competency: Perspectives from the construction industry
65	IJPM	Ekrot, B., Kock, A., and Gemünden, H. G.	2016	Retaining project management competence – Antecedents and consequences
66	IJPM	Engelbrecht, J., Johnston, K. A., and Hooper V.	2017	The influence of business managers' IT competence on IT project success

No.	Journal name	Author(s)	Year	Article title
67	IJPM	Medina, R., and Medina, A.	2014	The project manager and the organization's long-term competence goal
68	IJPM	Palacios-Marqués, D., Cortés-Grao, R., and Carral, C. L.	2013	Outstanding knowledge competences and web 2.0 practices for developing successful e-learning project management
69	IJPM	Shao, J.	2017	The moderating effect of program context on the relationship between program managers' leadership competences and program success
70	IJHRM	Apospori, E., Nikandrou, I., Brewster, C. and Papalexandris, N.	2008	HRM and organizational performance in northern and southern Europe
71	IJHRM	Carstens, J. G., and De Kock, F. S.	2017	Firm level diversity management competencies: Development and initial validation of a measure
72	IJHRM	Chao M., and Shih, C.	2016	Customer service-focused HRM systems and firm performance: Evidence from the service industry in Taiwan
73	IJHRM	De Vos, A., De Hauw, S., and Willemse, I.	2015	An integrative model for competency development in organizations: the Flemish case
74	IJHRM	Díaz-Fernández, M., López-Cabrales, A., and Valle-Cabrera, R.	2013	In search of demanded competencies: Designing superior compensation systems
75	IJHRM	Graf, A.	2004	Screening and training inter-cultural competencies: Evaluating the impact of national culture on inter-cultural competencies
76	IJHRM	Gray, L.	1999	New Zealand HRD practitioner competencies: Application of the ASTD competency model
77	IJHRM	Lo, K., Macky, K., and Pio, E.	2015	The HR competency requirements for strategic and functional HR practitioners
78	IJHRM	Long, C. S., and Ismail, W. K. W.	2011	An analysis of the relationship between HR professionals' competencies and firms' performance in Malaysia
79	IJHRM	Long, C. S., Ismail, W. K. W., and Amin, S. M.	2013	The role of change agent as mediator in the relationship between HR competencies and organizational performance
80	IJHRM	Wickramasinghe, V., and De Zoyza, N.	2011	Managerial competency requirements that enhance organisational competences: A study of a Sri Lankan telecom organisation
81	IJHRM	Wickramasinghe, V., and De Zoyza, N.	2009	An assessment of managerial competency needs: Empirical evidence from a Sri Lankan telecommunication service provider
82	JCEM	Deng, F., and Smyth, H.	2014	Nature of firm performance in construction

No.	Journal name	Author(s)	Year	Article title
83	JCEM	Deng, F., and Smyth, H.	2013	Contingency-based approach to firm performance in construction: Critical review of empirical research
84	JCEM	Guo, B. H. W., Yiu, T. W., González, V. A., and Goh, Y. M.	2016	Using a pressure-state-practice model to develop safety leading indicators for construction projects
85	JCEM	Hanna, A. S., Ibrahim, M. W., Lotfallah, W., Iskandar, K. A., and Russell, J. S.	2016	Modeling project manager competency: An integrated mathematical approach
86	JCEM	Horta, I. M., Camanho, A. S., and Da Costa, J. M.	2010	Performance assessment of construction companies integrating key performance indicators and data envelopment analysis
87	JCEM	Jin, Z., Deng, F., Li, H., and Skitmore, M.	2013	Practical framework for measuring performance of international construction firms
88	JCEM	Karakhan, A. A., Rajendran, S., Gambatese, J., and Nnaji, C.	2018	Measuring and evaluating safety maturity of construction contractors: Multicriteria decision-making approach
89	JCEM	Kim, A., and Arditi, D.	2010	Performance of MBE/DBE/WBE construction firms in transportation projects
90	JCEM	Pereira, E., Han, S., AbouRizk, S. and Hermann, U.	2017	Empirical testing for use of safety related measures at the organizational level to assess and control the on-site risk level
91	JETM	Akgun, A. E., Keskin, H., and Byrne, J.	2009	Organizational emotional capability, product and process innovation, and firm performance: An empirical analysis
92	JETM	Bolivar-Ramos, M. T., Garcia-Morales, V. J., and Garcia-Sanchez, E.	2012	Technological distinctive competencies and organizational learning: Effects on organizational innovation to improve firm performance
93	JETM	Chaudhuri, A., and Boer, H.	2016	The impact of product-process complexity and new product development order winners on new product development performance: The mediating role of collaborative competence
94	JETM	Fowler, S. W., King, A. W., Marsh, S. J., and Victor, B.	2000	Beyond products: new strategic imperatives for developing competencies in dynamic environments
95	JETM	Hwang, D., Yang, M. G., and Hong, P.	2015	Mediating effect of IT-enabled capabilities on competitive performance outcomes: An empirical investigation of ERP implementation
96	JETM	Kilic, K., Ulusoy, G., Gunday, G., and Alpkan, L.	2015	Innovativeness, operations priorities and corporate performance: An analysis based on a taxonomy of innovativeness

No.	Journal name	Author(s)	Year	Article title
97	JETM	Wang, Y., Lo, H., and Yang, Y.	2004	The constituents of core competencies and firm performance: Evidence from high-technology firms in china
98	JME	Dainty, A. R. J., Cheng, M., and Moore, D. R.	2005	Competency-based model for predicting construction project managers' performance
99	JME	Isik, Z., Arditi, D., Dikmen, I. and Birgonul, M. T.	2010	Impact of resources and strategies on construction company performance
100	JME	Lee, C., Chong, H., Liao, P., and Wang, X.	2017	Critical review of social network analysis applications in complex project management
101	JME	Lee, S., Yu, J., and Jeong, D.	2014	BIM acceptance model in construction organizations
102	JME	Rojas, E. M.	2013	Identifying, recruiting, and retaining quality field supervisors and project managers in the electrical construction industry
103	JME	Tripathi, K. K., and Jha, K. N.	2017	Determining success factors for a construction organization: A structural equation modeling approach
104	JME	Yu, I., Kim, K., Jung, Y., and Chin, S.	2007	Comparable performance measurement system for construction companies
105	SMJ	Arrfelt, M., Wiseman, R. M., McNamara, R., and Hult, G. T. M.	2015	Examining a key corporate role: the influence of capital allocation competency on business unit performance
106	SMJ	Hitt, M. A., and Ireland, R. D.	1985	Corporate distinctive competence, strategy, industry and performance
107	SMJ	King, A. W., and Zeithaml, C. P.	2001	Competencies and firm performance: Examining the causal ambiguity paradox
108	SMJ	Tippins, M. J., and Sohi, R. S.	2003	IT competency and firm performance: Is organizational learning a missing link?
109	AACE IT	Hollmann, J. K. and Elliott, B. G.	2006	Core competencies, expectations and career path for an estimating professional
110	ACAJ	Zingheim, P. K.; Ledford Jr., G. L., and Schuster, J. R.	1996	Competencies and competency models: Does one size fit all?
111	BRIS JST	Salajeghe, S., Sayadi, S., and Mirkamali, K. S.	2014	The relationship between competencies of project managers and effectiveness in project management: A competency model
112	CI	Murphy, M. E.	2014	Implementing innovation: A stakeholder competency-based approach for BIM
113	IAMAC	Brophy, M., and Kiely, T.	2001	Competencies; A new sector; Developing a competency model for three star hotels
114	IBERJ	Rambe, P., and Makhalemele, N.	2015	Relationship between managerial competencies of owners/managers of emerging technology firms and business performance: A conceptual

No.	Journal name	Author(s)	Year	Article title
				framework of internet cafés performance in South Africa
115	ICCI	Mahmood, A., Hamidaddin, A., and Shafiei, M.	2006	What competencies do project managers need?
116	IJAEC	Omar, M. N. and Fayek, A. Robinsons	2016b	Organizational Competencies and Project Performance Tool (OCPPT©): Evaluating construction project competencies and performance
117	IRBRP	Shirazi, A., and Mortazavi, S.	2009	Effective management performance: A competency-based perspective
118	JATM	Liang, C., Lin, Y., and Huang, H.	2013	Effect of core competence on organizational performance in an airport shopping center
119	JBI	Edgar, W. B., and Lockwood, C. A.	2008	Organizational competencies: Clarifying the construct
120	JCiEM	Radujkovic, M., Vukomanović, M., and Dunović, I. B.	2010	Application of key performance indicators in south-eastern European construction
121	JKSU-ES	Ali, H. A. E. M.; Al-Sulaihi, I. A., and Al-Gahtani, K. S.	2013	Indicators for measuring performance of building construction companies in Kingdom of Saudi Arabia
122	LODJ	Woodruffe, C.	1993	What is meant by a competency?
123	OS	Grant, R. M.	1996	Prospering in dynamically-competitive environments: Organizational capability as knowledge integration
124	P	Boyatzis, R. E.	2006	Using tipping points of emotional intelligence and cognitive competencies to predict financial performance of leaders
125	V	Mukhopadhyay, K., Sil, J., and Banerjea, N. R.	2011	A competency based management system for sustainable development by innovative organizations: A proposal of method and tool

Note: *AC = Automation in Construction, CJCE = Canadian Journal of Civil Engineering, CiI = Computers in Industry, CME = Construction Management and Economics, DS = Decision Sciences, ESA = Expert Systems with Applications, HRMR = Human Resource Management Review, IJCRB = Interdisciplinary Journal of Contemporary Research in Business, IJPM = International Journal of Project Management, IJHRM = International Journal of Human Resource Management, IJPE = International Journal of Production Economics, JCEM = Journal of Construction Engineering and Management, JETM = Journal of Engineering and Technology Management, JME = Journal of Management in Engineering, SMJ = Strategic Management Journal, AACE IT = Association for the Advancement of Cost Engineering International Transactions, ACAJ = American Compensation Association Journal, BRIS JST = BRIS Journal of Science and Technology (MAGNT Research Report), CI = Construction Innovation, EMJ = European Management Journal, IAMAC = The Irish Academy of Management Annual*

Conference, IJCRB = Interdisciplinary Journal of Contemporary Research in Business, IBERJ = International Business and Economics Research Journal, ICCI = International Conference on Construction Industry, IJAEC = International Journal of Architecture, Engineering and Construction, IRBRP = International Review of Business Research Papers, JATM = Journal of Air Transport Management, JBI = Journal of Business Inquiry, JCiEM = Journal of Civil Engineering and Management, JKSU-ES = Journal of King Saud University – Engineering Sciences, LODJ = Leadership & Organization Development Journal, OS = Organization Science, P = Psicothema, V = Vision.

Table S2. *RII* and ranking of functional competencies

No.	Competency category and competencies	*RII*	Rank in category	Overall rank	No.	Competency category and competencies	*RII*	Rank in category	Overall rank
	General Administration Competencies				28	Management information systems/technology	0.850	3	29
1	Staff development/training	0.831	1	35	29	New technology/product development	0.785	4	48
2	Results orientation	0.831	1	35		**Project Management Competencies**			
3	Goal orientation	0.800	3	46	30	Safety, health, security, and environment	0.954	1	2
4	Human resources/personnel	0.738	4	53	31	Quality management	0.923	2	6
5	Managing and support of diversity	0.723	5	55	32	Schedule (time) management	0.923	2	6
	Technical Competencies				33	Scope management	0.923	2	6
6	Quality of work	0.969	1	1	34	Change management	0.908	5	10
7	Technical/job knowledge	0.954	2	2	35	Managing performance	0.908	5	10
8	Commitment to safety	0.938	3	4	36	Cost management	0.892	7	15
9	Planning and organizing (tasks/activities)	0.908	4	10	37	Commissioning and start-up	0.892	7	15
10	Strategic planning and management	0.818	5	43	38	Project monitoring & controlling	0.892	7	15
11	Attention to detail (work processes and procedures)	0.800	6	46	39	Project resource management	0.877	10	19
12	Business acumen/ business management skills	0.785	7	48	40	Risk management	0.862	11	25
13	Market management	0.700	8	57	41	Design development	0.862	11	25
14	Finance management	0.650	9	58	42	Integration management	0.862	11	25
	Cross-Functional Competencies				43	Project materials management	0.846	14	31
15	Cooperation and coordination	0.933	1	5	44	Stakeholder management	0.831	15	35
16	Stakeholder focus	0.877	2	19	45	Contract administration	0.831	15	35
17	Communication management	0.867	3	24	46	Project communications management	0.831	15	35
18	Delegation	0.831	4	35	47	Environmental management	0.831	15	35
19	Public and government relations	0.754	5	51	48	Team building	0.815	19	44
	Production/Operations Competencies				49	Procurement management	0.815	19	44
20	Construction technology/ integration management	0.908	1	10	50	Project human resource management	0.769	21	50
21	Operations and maintenance	0.908	1	10	51	Program management	0.754	22	51
22	Process engineering management	0.862	3	25	52	Conflict management	0.738	23	53

No.	Competency category and competencies	*RII*	Rank in category	Overall rank	No.	Competency category and competencies	*RII*	Rank in category	Overall rank
23	Construction, production, and manufacturing	0.850	4	29	53	Commitment to sustainability	0.723	24	55
24	Materials management	0.846	5	31		**Supervisory/Managerial competencies**			
25	Product engineering	0.831	6	35	54	Values and ethics	0.923	1	6
	Construction and Engineering Research and Development Competencies				55	Engagement	0.877	2	19
26	Business, legal, and public policy	0.883	1	18	56	Management excellence	0.877	2	19
27	Construction law and regulation	0.877	2	19	57	Resource management	0.846	4	31
					58	Strategic thinking	0.846	4	31

Table S3. *RII* and ranking of behavioral competencies

No.	Competency category and competencies	*RII*	Rank in category	Overall rank	No.	Competency category and competencies	*RII*	Rank in category	Overall rank
	Organizational Attributes				20	Planning and organizing	0.892	3	14
1	Ability to build trust	0.933	1	5	21	Results orientation	0.877	4	15
2	Competitiveness	0.917	2	8	22	Responsiveness	0.877	4	15
3	Adaptability/flexibility	0.908	3	9	23	Influence	0.846	6	24
4	Achievement drive	0.908	3	9	24	Communication	0.846	6	24
5	Innovation	0.862	5	20	25	Incisiveness	0.831	8	32
6	Organizational awareness, culture, and values	0.862	5	20		**Individual/Personal Competencies**			
7	Risk-taking	0.785	7	38	27	Reliability/dependability	0.938	1	3
	Top Management Competencies					Teamwork	0.908	2	9
8	Leadership	0.969	1	1	29	Ethics	0.908	2	9
9	Strategic thinking	0.954	2	2	30	Initiative	0.877	4	15
10	Judgement	0.846	3	24	31	Commitment	0.877	4	15
11	Analytical ability	0.831	4	32	32	Effectiveness	0.877	4	15
	Middle Management Competencies					Self-regulation/control	0.862	7	20
12	Interpersonal skills	0.923	1	6	34	Motivation	0.862	7	20
13	Decision-making	0.923	1	6	35	Resourcefulness	0.846	9	24
14	Consultation	0.846	3	24	36	Perseverance	0.840	10	31
15	Negotiation	0.846	3	24	37	Attention to detail	0.831	11	32
16	Reasoning	0.846	3	24	38	Professionalism	0.831	11	32
17	Conflict and crisis resolution/issue management	0.831	6	32	39	Cognitive skills	0.815	13	37
18	Assertiveness	0.767	7	40	40	Self-confidence	0.769	14	39
	First-line Management Competencies					Creativity	0.754	41	41
19	Problem-solving	0.938	1	3	42	Sales mindset/selling skills	0.708	16	42
20	Integrity/high standards	0.908	2	9	43	Enthusiasm	0.692	17	43

Table S4. *RII* and ranking of performance measures

No.	Performance measure category and metrics	*RII*	Rank in category	Overall rank	No.	Performance measure category and metrics	*RII*	Rank in category	Overall rank
	KPIs					**Growth**			
	Cash flow				23	Revenue growth	0.862	1	17
1	Cash flow	0.933	1	6	24	Sales growth	0.785	2	29
	Quality of work				25	Volume of works growth	0.723	3	38
2	Rework factor,	0.892	1	13		**Business efficiency**			
3	Prevention, appraisal, and failure (PAF) model	0.846	2	21	26	Net profit margin	0.846	1	21
	Market Share				27	Efficiency ratio	0.767	2	34
4	Market share	0.800	1	28		**Effectiveness of planning**			
5	Market returns	0.708	2	40	28	Cost predictability	0.933	1	6
	Safety				29	Time predictability	0.900	2	12
6	Incident rate	0.938	1	2	30	Change cost factor	0.867	3	15
7	Time lost	0.938	1	2	31	Cost growth/increase	0.867	3	15
8	Safety performance	0.917	3	9	32	Time growth/increase	0.833	5	25
9	Accident frequency rate	0.862	4	17		**PerMs**			
10	Accident cost	0.817	5	27		**Internal customer satisfaction**			
	Financial stability				33	Employee satisfaction	0.908	1	10
11	Debt ratio	0.769	1	31	34	Employee turnover rate	0.846	2	21
12	Liquidity	0.754	2	35	35	Average remuneration per employee	0.769	3	31
	KPOs				36	Profit per employee	0.738	4	37
	Profitability				37	Turnover/revenue per employee	0.723	5	38
13	Profitability	0.967	1	1		**External customer satisfaction**			
14	Return on assets	0.938	2	2	38	Customer satisfaction	0.877	1	14
15	Return on investment	0.923	3	8	39	Customer retention/loyalty	0.846	2	21
16	Net income	0.908	4	10	40	Percentage of repeat customers	0.785	3	29
17	Return on capital	0.862	5	17	41	Number of complaints	0.769	4	31
18	Return on equity	0.862	5	17		**Competitiveness**			
19	Economic value added	0.831	7	26	42	Company image/reputation	0.938	1	2
20	Return on sales	0.750	8	36	43	Competitive advantage	0.908	2	10
21	Financial autonomy	0.700	9	41	44	Market advantage	0.877	3	14
22	Hanging invoice	0.677	10	42					