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CAPABILITIES-BASED FORECASTING MODEL FOR INNOVATION DEVELOPMENT IN SMALL-AND-MEDIUM CONSTRUCTION FIRMS (SMCFS)

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Abstract. Triggering innovation among Small-and-Medium Construction Firms (SMCFs) is of paramount importance to gear up the growth of construction firms. Thus, this study aims to develop a Capability-Based forecasting model for innovation development in SMCFs. Built on 157 questionnaires, the model was tested using partial least squares (PLS) technique of structural equation modelling (SEM). The practicality and robustness of this model was then validated by 12 experts. Findings affirm SMCFs making use of multiple Capability-Based approaches would be able to secure their performance via innovation activities. For academia, the new model contributes to the stream of construction innovation management by integrating both technological and organizational innovations in a single framework. For practitioners and policymakers, the model offers valuable input for continuing growth of SMCFs via innovation.

Keywords: capability-based model, innovation development, construction SME, forecasting model.

Introduction

Within the complex system of construction, innovation is known as a key to the long-term success in firms of different sizes (Zubizarreta *et al.* 2017; Turk 2016). Innovation may engender the fourth pillar to be integrated with the golden triangle of cost, time and quality (Nyström *et al.* 2016). Unlike manufacturing orthodoxies where business is an in-firm operation, the construction is characterised with several distinct features, such co-creation of outputs around one-off projects, a temporary coalition with varying business actors, and business deliveries upon complex in-situ sites (Gann, Salter 2000). Substantial evidence have indicated that the technologies and new practices engaged by construction firms can lead to improved project performance (Winch 1998; Russell *et al.* 2006), enhanced functionality and sustainable market share (El-Mashaleh *et al.* 2006), as well as organizational competitive advantage (Salunke *et al.* 2011). According to Utterback (1974), in mature industries, such as textiles, machine tools, and construction, innovation is more likely to come from smaller, newer firms than from older, larger firms. Paradoxically, Betts and Ofori (1992) and Reichstein *et al.* (2005) argue that small firms are likely to find more factors hampering innovation than the larger counterparts. The capacity of these firms to hinge on costly investment, such as R&D-related spending (Cohen, Klepper 1996) and introduction of new products or processes (ABS 2006), often increase with firm size. Accordingly, a typical shortage of resources in the small construction firms may restrict them from pursuing the desired innovation (Barrett, Sexton 2006). Set against a preexistent competitive background, some resource-poor construction firms present conflicting evidence regarding their capability to innovate successfully over time (Iliescu, Ciocan 2017). Success in this regards lies on the small firms to inwardly capitalise on specific capabilities to pursue continuous growth over innovation (Sexton, Barrett 2003; Barrett, Sexton 2006; Lu, Sexton 2006; Manley 2008). However, to what extent these concepts are interrelated to each other and how innovation could be achieved within a small and medium setting remain unclear (Xue *et al.* 2018). It is also worth

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mentioning that construction researchers remain silent on exploring the degree to which capabilities affect innovation activities, and thereby fail to assist the resource-poor small and medium construction firms (SMCFs) in predicting their likely performance goals within innovation framework (Martínez-Román *et al.* 2017). Underpinned by the theoretical resource-based view (RBV), this study aims to examine the potential effect of innovation activities with regards to capability-based antecedents and firm-based performance of SMCFs and to develop a forecasting model of innovation for SMCFs based on the research output. To this end, structural equation modelling technique was applied to investigate the impact of five hypothesised latent variables on the capabilities of SMCFs to support their innovation activities, which potentially lead to higher performance. Construction experts then validated the model for its practicality and robustness. The model is expected to contribute to a better appreciation of SMCFs through the stimulation of innovation activities within and among the small and medium enterprises.

1. Research model and hypotheses

This study proposes a research model of innovation (see Figure 1) based on RBV to explain innovation and performance in SMCFs. The model's hypothesises is that innovation activities mediate the relationship between organizational capabilities and firm performance.

According to RBV (Wernerfelt 1984; Barney 1991), direct relationships between various Capability-Based approaches and innovation activities are assumed to be positive. Direct relationships between innovation activities and firm performance are expected to be positive as well. Capabilities are influenced by five factors: inter-organizational network (IN), organizational learning (OL), entrepreneurship (EO), integrated market orientation (IMO) and human resource practice (HRP) (Iliescu, Ciocan 2017). Financial and non-financial dimensions measure firm performance (FP). Lastly, innovation activities are pivoting on two different types of innovations, namely: technological innovation (TI) and organizational innovation (OI) (Martínez-Román *et al.* 2017).

1.1. Resource-based view (RBV)

As remarked by Gann and Salter (2000), to understand the management of technology and innovation in construction firms, the resource-based approach seems the most promising because it focuses on systematic differences across firms in their ability to mobilise resources for implementing competitive strategies. Following this line of reasoning, the present study hinged on the RBV for understanding innovation in construction SMCFs. According to RBV, each firm could be regarded as owning a unique bundle of resources and capabilities, both of which, being tangible and intangible (Wernerfelt 1984). Synergistically, the ability to enhance its distinctive resources and capabilities was what ultimately explained the competitive advantage between a firm and its peer competitors in the same business environment. As aforementioned, the RBV contended that firms with an ability to develop distinct resources and capabilities were harnessed with competitive advantages that were strategically relevant to foster innovation. Attributed to the potential lack of resources, however, small firms were traditionally related to efficacy problem. Put differently, innovation activities undertaken by these firms were typically pushed forward under constrained environment, scilicet, finite resources (Sexton, Barrett 2003). This led scholarly efforts towards an emphasis on new values creation through "capabilities" to neutralise the innate resource-disadvantages and external environment-constraints (Sexton, Barrett 2003; Barrett, Sexton 2006; Sexton *et al.* 2006; Lu, Sexton 2006; Manley 2008). Likewise, Gronum *et al.* (2012) remarked that such scarce resources manifest as organizational capabilities or competencies leading to the creation of competitive advantages for SMEs.

1.2. Framework of innovation

When firms executed existing activities in a new approach, this was often regarded as an innovation. In a general sense, innovation encompassed a "change in routine" (Nelson, Winter 1982) as well as the "carrying out of new combinations" (Schumpeter 1934). Further, it rested on practices so new that the set pattern of accepted processes

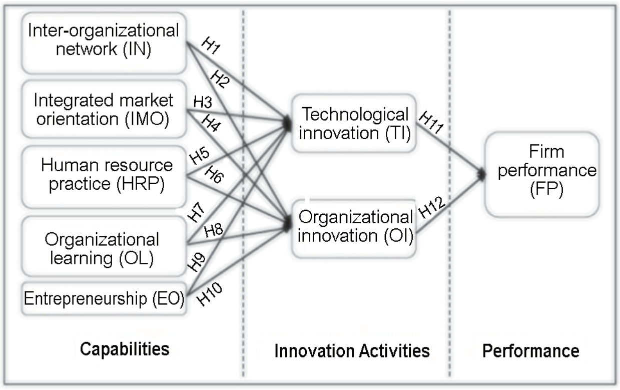

Figure 1. Research model on innovation development for SMCFs

Table 1. A summary of studies on innovation in SMCFs

Author(s), year	Innovation		Conceptualization/ measurement of innovation	Approach/ method
	Associate with capabilities	Associate with performance		
Sexton and Barrett (2003)	✓	✓	Technical and administrative	Conceptual/ Synthesizing of literature
Barrett and Sexton (2006)	✓	✓	Technical and administrative	Mixed/ Case studies
Sexton *et al.* (2006)	✓	×	Technological and organizational	Quali./ Case studies
Lu and Sexton (2006)	✓	✓	Explorative and exploitative	Quali./ Single case study
Manley (2008)	✓	✓	Technological product	Quali./ Case studies
Hardie and Manley (2008)	×	✓	Technological and organizational	Quali./ Case studies
Thorpe *et al.* (2009)	×	✓	Product, process and organizational	Quali./ Interviews
Rezgui and Miles (2010)	×	✓	Technical ICT	Quali./ Case studies
Hardie *et al.* (2013)	×	×	Technical products	Quali./Interviews

or products is developed or replaced (Langford, Dimitrijevic 2002). Pedersen (1996) termed innovation as "the first use of a technology within a construction firm either in the process or in the product" (p. 884). In general, there was a consensus that innovation represents something new. In other words, it was the "newness" of the idea itself that underpinned the starting point of organizational innovation. Thus far, empirical findings addressing construction innovation in SMCFs observed that innovation is somewhat relating to capabilities and performance (see Table 1). With this in mind, it is sensible for this study to explore the influence of capabilities on innovation that impact firm's performance.

1.2.1. Technological innovations

As noted by Manley (2008), product or process innovations were closely linked to the concept of technological advancement that had a technical character. Product innovation was related to new changes in end products or services (Dibrell *et al.* 2008; Nasution *et al.* 2011), or the process of bringing new technology into practical use (Lukas, Ferrell 2000). According to Damanpour (1991), product innovation was embraced to satisfy the external user or market demands. On the other hand, process innovation reflected changes in the way an organization produces products or services (Dibrell *et al.* 2008) such as new or significantly improved techniques, equipment and software (Gunday *et al.* 2011). According to Chang *et al.* (2012), process innovation was intended to safeguard and increase quality and decrease costs of production.

In reviewing the SME literature, it was important to note that the works on innovation had mainly rooted on technological products or process innovations (Manley 2008; Rezgui, Miles 2010; Hardie *et al.* 2013). This might be attributed to the increasing complexity of construction projects and globalised competition among firms in the industry (Tatum, Funke 1988). Accordingly, the present study contended that SMCFs would engage in technological types of innovation activities (see Table 2) as a mean to improve their business deliveries. Based on the above rationales, the hypothesis regarding linking technological innovation and firm performance is stated as below.

H11: Technological innovation is positively related to firm performance.

1.2.2. Organizational innovations

Compared with the technological product and process advancements, the scholars of both general and SME fields of construction have scarcely addressed the "more than technological" types of innovations. Even though some SME scholars viewed innovation as an approach that went beyond technologies – administrative innovations (Sexton, Barrett 2003; Barrett, Sexton 2006) or organizational innovations (Sexton *et al.* 2006; Hardie, Manley 2008; Thorpe *et al.* 2009). The understanding on these types of innovations remained unclear. One notable exception was the work by Hardie and Manley (2008) who observed that both the technological and organizational innovations could be hardly isolated from each other and small construction business needed to undertake the two types of innovations concurrently and synergistically to succeed. Such finding was meritorious in revealing the potential complementary effect of both technological and organizational types of new deliveries. In a recent study by Brochner (2010), more works have been called for a better understanding of construction innovation going beyond the typical technological classification. Accordingly, this led the present study to integrate another typology which led to changes that were not directly related to product or process means, but to marketing and management practices, scilicet, organizational innovation as classified by Manley (2008). Marketing innovation was strongly attributed to the four P's of marketing, i.e., pricing strategies, product design or packaging, product placement and product promotion (Kotler, Armstrong 1991). Marketing embraces the creation, delivery and communication of customer value to the target market more effectively in compared with competitors (Kotler, Armstrong 1991).

Table 2. Indicators of innovation

Indicators	References
Indicators of technological innovation	Nasution *et al.* (2011); Gunday *et al.* (2011); Chang *et al.* (2012)
Product innovation (good and service) & process innovation (production or delivery method)	
Indicators of organizational innovation	Arditi *et al.* (2008); Nasution *et al.* (2011)
Marketing innovation (packaging, promotion, pricing, place and people) & managerial innovation (internal business strategies)	
Indicators of inter-organizational network	
Breadth (to indicate heterogeneity) and depth (indicated by importance) of networks	Gronum *et al.* (2012)
External partners: customers/clients, suppliers, competitors, experts/consultants, research centres/labs, universities/ education providers, industry associations, regulators & government business assistance providers etc.	Manley (2008); Oerlemans and Knoben (2010)
Indicators of integrated market orientation	Narver and Slater (1990); Narver *et al.* (2004); Nasution and Mavondo (2008)
Reactive market orientation (i.e., customer orientation, competitor orientation and inter-functional coordination) Proactive market orientation (i.e., latent need fulfilment)	
Indicators of organizational learning	Jerez-Gomez *et al.* (2005)
Managerial commitment to recognize and ensure employees understands importance of learning; Systems perspective in having a common objective; Openness and experimentation as ways of improving the work process; Knowledge transfer among the members in firm	
Indicators of human resource practice	Nasution *et al.* (2011)
Job-related (match employees to specific job, employees as the most valuable resources, training programs, the importance of having satisfied employees, clear career paths for employees, job security for employees, high motivation); Reward related (benefits and bonuses for outstanding performance, receive feedback on the employees' performance)	
Indicators of entrepreneurship	
Autonomy (employees take responsibility on work, minimum supervision on employees, employees prioritize the work); Risk taking (uncertainty is treated as challenge, venture to unexplored territories, management acceptance on failure, emphasize success rather than failure, failure is viewed as learning); Proactiveness (seek new opportunities, introduce new services, constantly look out for business, seek opportunities to improve business, always ahead of competitors to respond to market)	Nasution and Mavondo (2008)
Indicators of firm performance	Slaughter (2000); Matear *et al.* (2002)
Financial measures (profitability, annual sales growth, market share) and non-financial measures (labour productivity, customer satisfaction, repeat business, reputation impacts)	

In considering the service-oriented nature of construction firms, Arditi *et al.* (2008) discussed marketing practice in construction organizations within five parameters, namely, product, price, promotion, place and people. On the other hand, managerial or administrative innovation included changes in the administrative processes and firm structures linking to the fundamental work activities of a firm and its management (Damanpour 1991). Examples were the changes introduced in organizational structure, policies, work methods and procedures (Hine, Ryan 1999). Following the above line of enquiries, it was essential to introduce and stress different types of innovations in understanding their implications towards the small or medium construction firms. Importantly, the literature remained silent in investigating whether the two distinct innovations exerted equal, or different, impacts on firms considering them simultaneously. Hence, the present study contended that being highly innovative in the conduct of technological sense did not constitute competitive strength; but coupled with organizational mode (see Table 2) it does. Accordingly, this study focused on the two different types of innovation activities (i.e., technological and organizational innovations) to appropriately capture their impacts on SMCFs. Based on the above discussions about organizational innovations and firm performance, the hypothesis can be described as below.

H12: Organizational innovation is positively related to firm performance.

1.3. Framework of organizational capabilities

1.3.1. Inter-organizational network

Firms' networks with external organizations had been demonstrated as an essential factor in numerous SME studies of innovation. SMEs had little access to critical innovation resources (Mohannak 2007). As remarked by Chetty and Holm (2000), networks can help firms expose themselves to new opportunities, obtain knowledge, learn from experiences and benefit from the synergistic effect of pooled resources. Through external networks, SMEs could efficiently outsource for resources they did not currently own and acquired size-related advantages of larger firms. In particular, the established external relationships could aid small construction firms in compensating the riskiness of being small and uncertainties associated with innovation activities (Manley 2008). In dealing with timely completed projects, the small firms did not operate in isolation; instead, they were, along with all construction firms, located in a wide variety of fluctuating inter-organizational linkages of varying intricacy (Betts, Wood-Harper 1994). In spite of the rich resources embedded in the networks, firms must have the necessary capability to exploit and turn the resources out into innovation (Lu, Sexton 2006). Networks enhanced small construction firms' access to social resources necessary to engender innovation activities (Hardie *et al.* 2013). According to work of Gronum *et al.* (2012), both the breadth and depth of inter-organizational networks could lead to innovation outcomes. The notion of "breadth" referred to number of external connections whereas "depth" referred to the structure of external connections (Laursen, Salter 2006). Likewise, Manley (2008) found that small construction companies having network ties with both value chain partners and general industrial actors, including the R&D centres, were more likely to introduce new technologies on projects. The implementation of technological innovation by small firms not necessarily needed any on-going relationships with universities or research bodies (Hardie, Manley 2008). Furthermore, it was evident that the reports identifying the effect of network capability were subject to the biased preference towards qualitative-based analysis of innovative offerings (Sexton *et al.* 2006; Hardie, Manley 2008; Hardie *et al.* 2013). Hence, the present study conjectured that inter-organizational networks permit SMCFs to draw on resources beyond the firms' boundaries to innovate across a wider range of activities. Table 2 lists the two components of inter-organizational network. In summary, the hypotheses are developed and described as below.

H1: Inter-organizational network is positively related to technological innovation; and

H2: Inter-organizational network is positively related to organizational innovation.

1.3.2. Integrated market orientation

Underlined as one of the core-value creating capabilities (Slater, Narver 1994), market orientation included knowing and understanding customers and competitors (Deshpande *et al.* 1993; Narver, Slater 1990). Market orientation was an essential contributor to long-term organizational success throughout the small business domain. As highlighted by Pelham (1999), smaller businesses could leverage their potential advantages of flexibility, adaptability, and closeness to their customer base into superior, individualized service. Accordingly, the proficiency to integrate the market-oriented attitude with innovation focus would harness small firms with service advantages. Firms being active in developing a strong client focus tended to be more successful in delivering their innovation and service delivery (Sexton *et al.* 2006). Additionally, research by Thorpe *et al.* (2009) found that the desire of construction SMEs to differentiate itself from its competitors influenced their ability to engage in innovation. The small construction businesses would closely use their competitors as a frame of reference to adopt innovation (Sexton *et al.* 2006; Hardie, Manley 2008). According to Narver and Slater (1990), market orientation was a three-dimensional construct that included customer orientation, competitor orientation, and inter-functional coordination. Alternatively, Kohli and Jaworski (1990) defined market orientation as generation and dissemination of organization-wide information, and appropriate response to present and future customers' needs. Building on prior studies, the present study posited that market orientation was important in complementing the innovation stance of construction SMEs. In particular, both the reactive (Narver, Slater 1990) and proactive (Narver *et al.* 2004) notions of market orientation, i.e. integrated market orientation (Nasution, Mavondo 2008) were adopted to capture their effects on innovation in SMCFs, as summarised in Table 2. Consequently, the hypotheses between technological and organizational innovations and integrated market orientation are stated below.

H3: Integrated market orientation is positively related to technological innovation; and

H4: Integrated market orientation is positively related to organizational innovation.

1.3.3. Human resource practice

Over the years, issue of human resource and its management and/or practices had been, theoretical and empirically, evolved as a focus of research in SME literature. According to Wright *et al.* (2001), a firm's human resource was different from human resource practices. The former referred to human capital pool (i.e. a stock of employees) while the latter related to systems (i.e. multiple practices) that were used to manage the human capital pool. In opposed to other resources those were easy-to-imitate, Barney and Wright (1998) suggested that the management of human resources, was intricate, ambiguous and dynamic, and consequently was a possible origin of significant competitive advantage. Even if competitors realised the value generated by human resource practices, they could not replicate them at once, particularly in resource-constrained environments common within SMEs (Razouk 2011). For small construction firms, human resource or human resource practice had appeared to be a possible input for innovation. Sexton *et al.* (2006) observed that the small construction firms' adoption of technologies was supported by employees being sent on formal training courses. Meanwhile, Lu and Sexton (2006) noted that the project-based innovation activity is heavily depending upon the capacity, ability and motivation of staff members at the operational level. However, the small firms tend to take an informal approach to nurture a highly motivating business culture between the owners and employees, and this provided them with an advantage over larger firms to support creativity and innovation without formal structure of organization (Manley 2008). Such practices were important to the success of the firm regarding the employees' mastery of the technical problem being confronted (Hardie, Manley 2008). However, the current understanding of the human resource practice in the construction SMEs literature remained inconclusive. Specifically, the preceding works had vaguely addressed the impact of human resource practice in relation to innovation. Therefore, the present study intended to capture the essence of prior work in SMCFs. Table 2 exhibits the two components of human resource practice. Based on the above justifications, the hypotheses can be summarised as below:

H5: Human resource practice is positively related to technological innovation; and

H6: Human resource practice is positively related to organizational innovation.

1.3.4. Organizational learning

Regarded as one of the core capabilities of firm, organizational learning was a significant index of competitiveness of businesses (Chaston *et al.* 2001). According to Polanyi (1967), the knowledge contained both explicit (or codified) and tacit (or uncodified) types, and additionally, people obtained knowledge, of explicit and tacit distinction, via experiential learning (Kolb 1984). Accordingly, organizational learning referred to the capability of an organization to process knowledge – in other words, to create, acquire, transfer and integrate knowledge – and to modify its behaviour to reflect new cognitive situations with a view to improving its performance (Jerez-Gomez *et al.* 2005). Organizational learning could be regarded as a firm's capability to maintain or enhance firm performance based on experience (Garcia-Morales *et al.* 2007). Hence, any organization might end with dysfunction without relentless pursuit of learning. In multiple case studies, Salunke *et al.* (2011) deciphered the dynamic mode of different learning activities in connection with the occurrence of project-oriented innovation. As Nonaka (1994) addressed, innovation occurred when the shared knowledge generated novel and common insight within the organizational members. Hence, innovation requires that individual employees share the acquired knowledge, such as ideas, experiences and mistakes, among each other within the organization (Hardie, Manley 2008). However, the roles of knowledge-based strategy in nurturing small construction innovators' capability to achieve enhanced innovation performance warranted further examination (Manley 2008). Responsing to this need, the present study postulated that organizational learning was positively related to innovation in SMCFs. Table 2 exhibits the four components of organizational learning. Based on the above rationale, the hypotheses can be summarised as below:

H7: Organizational learning is positively related to technological innovation; and

H8: Organizational learning is positively related to organizational innovation.

1.3.5. Entrepreneurship

Entrepreneurship is manifested as the firm's behaviour entailing decision-making, methods, and practices (Wiklund, Shepherd 2005). Entrepreneurs are those with willingness to innovate, search for risks, take self-directed actions, and more proactive and aggressive than the rivals in seising new marketplace opportunities (Wiklund 1999). In this connection, small firms having a high degree of entrepreneurial orientation, would be able to discover and capitalise on new opportunities to differentiate them from their rivals (Wiklund, Shepherd 2005). Accordingly, small entrepreneurial firms could underpin a greater competitive advantage. Barrett and Sexton (2006) observed that small construction firms would persistently display entrepreneurial behaviour to pursue market-based innovation. Meanwhile, Salunke *et al.* (2011) assert that an entrepreneurial persistence would support the project-oriented service firms, including the small-sized businesses, in seising a greater innovation-based competitive advantage. The entrepreneurial project-based firms would, even with limited access to capital, pursued innovation by strategically utilising scarce resource at hand (Salunke *et al.* 2011). Despite the significant association between entrepreneurship and project-based practice, limited studies have addressed their impact within the context of innovation. As summarised in Table 2, the present study contended that SMCFs with entrepreneurial orientation would have the capabilities to engage in offering innovation in their business deliveries. Based on the above discussions about entrepreneurship and innovations, the hypotheses can be described as below:

H9: Entrepreneurship is positively related to technological innovation; and

H10: Entrepreneurship is positively related to organizational innovation.

1.4. Framework of firm performance

For small businesses, superior business performance was primarily an outcome of intense innovation-oriented approach (Laforet 2013). Within the complex system of construction, innovation was found to contribute to the enhancement of project performance as well as firm performance. Winch (1998) and Slaughter (2000) note that firms usually undertook the consideration on innovation, and subsequently, implemented on construction projects. Therefore, firms, not projects, were the only fulcrum credible for evaluating changes in the construction domain (Sexton *et al.* 2006). For this reason, the decisions to adopt and implement an innovation (either on projects or firms) originated from the business entity itself. In other words, the "firm" should be taken as unit of analysis (Salunke *et al.* 2011). Consistent with prior works (Sexton *et al.* 2006; Salunke *et al.* 2011), the present study first placed findings on the "firm" as opposed to the "project" to investigate the outcome of innovation. Next, positing construction innovation as robust predictor to positive firm performance, the notion of financial and non-financial measures (see Table 2) was taken to evaluate the firm-based consequence of innovation within SMCFs.

2. Research methods and procedures

Further to the comprehensive literature review, a questionnaire was developed to determine the capabilities used by SMCFs to achieve innovation activities and superior performance. A pilot survey was firstly conducted with 31 respondents associated with SMCFs (i.e., 3 architects, 4 QS consultants, 9 engineers and 15 contractors) to pre-test the measures developed for this questionnaire form. This is consistent with Yap and Skitmore's (2017) approach to confirm the aptness, clarity and unambiguousness of the survey instrument. The final questionnaire contained four main sections. The first section was designed to collect general information concerning the respondents, such as work position and the nature of the construction firm that they are currently attached. The second and third sections involved rating of the various types of innovation activities and commitment on five capabilities respectively. The final section solicited rating the firm's performance, as compared to their major competitors. A five-point Likert scale was adopted to measure the innovation activities, organizational capabilities and firm performance. The population consisted of all contracting firms headquartered within the Klang Valley region where the capital city of Kuala Lumpur is located. According to the National SME Development Council (2005), a service firm (including the construction-based) having 5 to 19 full-time employees is regarded as small-size whereas a service firm having 20 to 50 full-time employees is considered as medium-size. A sample of contracting firms was drawn from the Malaysian Construction Industry Development Board (CIDB)'s listings. A cover letter was enclosed together with the questionnaire to give an introduction to the topic together with the purpose of the survey, and definition of terms. To increase the response rate and minimise non-response bias, follow-up calls were made to the non-responsive firms after three weeks. In the main survey, a total of 750 questionnaire forms were distributed to the targeted firms, out of which 157 valid responses were returned, representing a response rate of 26.8%. Table 3 depicts the general information of the respondents and their associated firms. The respondents are homogenous samples of managing director/owners, senior managers and others. The sample varies between firms that based on business upon main-contracting or specialist-contracting basis. Nearly 52% of the firms are small (5–19 employees) while about 43% are medium-sized (20–50 employees). Almost 80% of the firms have been operating more than 10 years now. A vast majority of the firms currently operates in the domestic market while only 3.2% have operation overseas.

Table 3. Characteristics of respondents and their firms

Description	Frequency	%
Designation of respondents		
Managing director/owner	86	54.8%
Senior manager	64	40.8%
Other	7	4.5%
Firm type (Main activities)		
General contracting	75	48.4%
Specialist contracting	70	45.2%
Mix (General & specialist contracting)	10	6.5%
Firm age		
≤ 5 years	6	3.9%
> 5 ≤ 10 years	26	16.9%
> 10 ≤ 20 years	87	56.5%
> 20 ≤ 30 years	31	20.1%
> 30 years	4	2.6%
Firm's largest market		
Domestic	152	96.8%
International	5	3.2%
Number of full-time employees		
5–19	87	57.2%
20–50	65	42.8%

Note: When total number is ≠ 157, it is because not all respondents provided the data.

3. Data interpretation and analysis

Partial least squares-path modelling (PLS-PM) as one of the most widely applied second-generation multivariate analysis technique was chosen as the analytical approach because: (i) it is well suited for exploratory study when the purpose was to determine the relative relationship among latent variables (Hulland *et al.* 2010); (ii) it works efficiently for a small sample with too many variables and data with non-normal or unknown distribution (Chin, Dibbern 2010). Similarly, Liao and Teo (2017) employed PLS-PM basing on the above reasons in their study concerning critical success factors for building information modelling implementation in building projects. The sample size of non-probability sampling design did not appear to follow a rigorous procedure as the purpose of sampling was not to ensure a representative of the sample to the entire population. According to Hair *et al.* (2006), a sample size of minimum 1:5 (variables to respondents) but not less than 100 is required for multivariate analysis, particularly the factor analysis. As such, 157 cases were considered

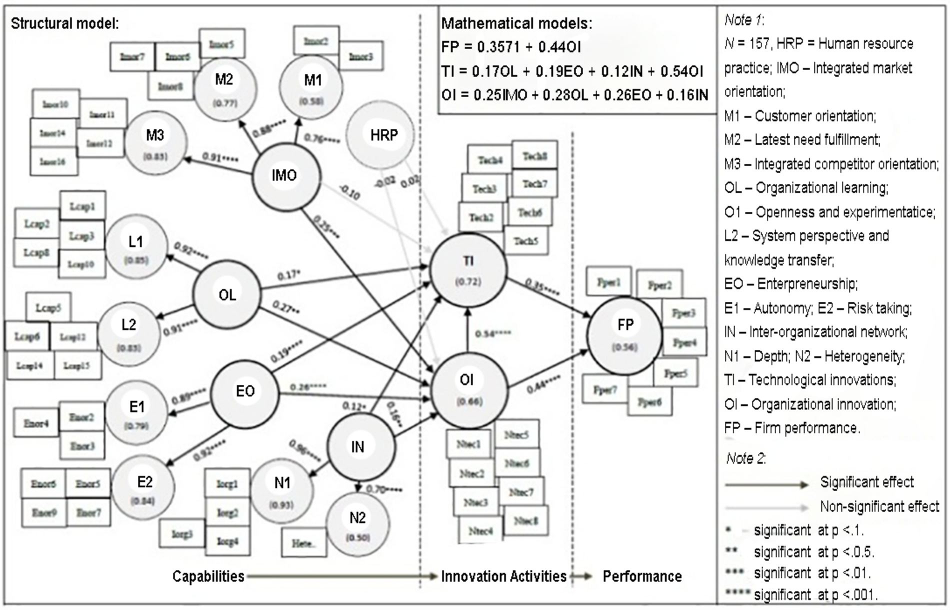

Figure 2. Final capability-based forecasting approaches for innovation development in SMCFs

adequate for PLS-PM analysis – consistent with the rationale adopted by Alashwal and Fong (2015) in their empirical study to determine fragmentation of construction projects using PLS approach. To check the possibility of non-response bias, several characteristics of the early and late respondents were compared. The independent t-test and Chi-squared test results are statistically insignificant, suggesting that non-response bias does not exist (Armstrong, Overton 1977). To address common method bias (CMB), this study adopted the Harman Single Factor test as suggested by Podsakoff *et al.* (2003) by employing an unrotated factor analysis (Eigen value > 1) criterion. The test revealed the 24 distinct factors accounted for 75.01% of the variance. The first factor captured only 29.75% (less than 50%) of the variance in the data to confirm that a single dominant factor did not emerge and therefore CMB was not a significant issue in this study. According to Hair *et al.* (2013), two stages are essential in applying PLS-PM, viz. assessment of measurement and structural models. Firstly, to determine the quality of measurement models, the fitting index of PLS-PM can be built on various tests to assess the reliability and validity of the construct measures (Hair *et al.* 2013). The specific tests include indicator reliability, internal consistency (composite reliability), convergent validity [average variance extracted (AVE)] and discriminant validity. Indicators with low loading (less than 0.55) will be eliminated from the constructs to yield a better model quality, called scale purification (Chin 1998). Meanwhile, the construct reliability is examined using a threshold value of 0.70 (Nunnally 1978) and the average variance extracted (AVE) value is recommended to be greater than 0.50 (Fornell, Larcker 1981). For discriminated validity to exist, the square root of AVE for each construct must be greater than its correlations with any other construct (Hair *et al.* 2006). Measurement items that did not pass the tests were eliminated to ensure the robustness of the measurement models. The result is shown in Table 4. Further to confirming that the measurement items have good reliability and validity, the second stage of PLS-PM proceeds by the formation of structural model. To this end, both squared multiple correlations (R2) values and path coefficients are computed for this purpose. As indicated in Figure 2, the squared multiple correlations (R2) value of the structural model reveals a very satisfactory level of predictability for the framework. The R2 value for the intermediate endogenous constructs (i.e., technological innovation = 0.72; organizational innovation = 0.66) and the endogenous latent constructs (i.e., firm performance= 0.56) can be considered as moderate.

Also, path coefficients were computed to ascertain the prescribed structural relationships between constructs. Table 4 shows that most of the hypothesised paths have values higher than the theoretical t value of 1.65. For example, the effect of IN on technological innovation ($\beta = 0.12$, $t = 1.740$) and organizational innovation ($\beta = 0.16$, $t = 2.143$) are statistically significant, supporting H1 and H2. Similarly, IMO is observed to exert a significant positive effect on organizational innovation ($\beta = 0.26$, $t = 2.961$), therefore supporting H4. Likewise, OL has a significant positive effect on technological innovation ($\beta = 0.16$, $t = 1.740$) and organizational innovation ($\beta = 0.27$, $t = 2.143$), supporting H6 and H7. Next, EO has also found to significantly relate to both technological innovation ($\beta = 0.19$, $t = 3.354$) and organizational innovation ($\beta = 0.26$, $t = 3.891$), supporting H9 and H10. The effect of technological innovation ($\beta = 0.35$, $t = 3.615$) and organizational innovation ($\beta = 0.43$, $t = 4.511$) on firm performance are also significant, giving support to H11 and H12. Contrary to prediction, however, no support is indicated for the hypothesized path of HRP with both technological innovation (H7) and organizational innovation (H8), as well as IMO and technological innovation (H3). Nevertheless, a significant effect is

Table 4. Result for all reflective measurement models

Construct	Items	Factor loadings	t-Statistic
(1)	(2)	(3)	(4)
Capability-Based approaches			
Inter-organizational network (IN) CR = 0.8462 AVE = 0.5252			
Depth (N_1) CR = 0.8395 AVE = 0.5697	Iorg1: Network with customers	0.8252	31.4256
	Iorg2: Network with suppliers of components, equipment and software	0.8318	32.1226
	Iorg3: Network with competitors	0.6281	10.6424
	Iorg4: Network with experts and consultancy firms	0.7152	16.2622
Heterogeneity (N_2) CR = 1.0000 AVE = 1.0000	Hete: Breadth (diverse number) of networks	1.0000	0.0000
Integrated market orientation (IMO) CR = 0.9181 AVE = 0.5051			
Customer orientation (M_1) CR = 0.8993 AVE = 0.8171	Imor2: Monitor on firm's commitment toward customers' needs	0.8980	42.9646
	Imor3: firm's strategies driven by the need to create value for customers	0.9098	65.1695
Latent need fulfilment (M_2) CR = 0.8888 AVE = 0.6665	Imor5: Understand unexpressed customers' needs	0.7922	27.1011
	Imor6: Seek on uncovering new customers' needs	0.8107	24.6045
	Imor7: Develop solutions to unexpressed customers' needs	0.835	28.7589
	Imor8: Firm's techniques to discover unexpressed customer needs	0.8269	27.6552
Integrated competitor orientation (M_3) CR = 0.8873 AVE = 0.6118	Imor10: Share information about competitors' strategies	0.7938	24.2685
	Imor11: Rapid respond to thread	0.7671	22.9227
	Imor12: Discussion on competitors' strategies by top management	0.8248	33.0459
	Imor14: Integrated functions	0.7625	18.0236
	Imor16: Management understands how everyone can contribute to firm	0.7607	20.0124
Human resource practice (HRP) CR = 0.9119 AVE = 0.5364			
(H1) CR = 0.8949 AVE = 0.7397	Hrep1: Employees as the most valuable resources	0.6655	9.978
	Hrep2: Specific job requirements	0.8058	20.923
	Hrep4: Satisfied employees	0.7946	23.1109
	Hrep5: Clear career paths	0.7999	27.349
	Hrep6: Job security	0.7528	15.101
	Hrep7: Maintain high level of employee motivation	0.8393	30.4311
(H2) CR = 0.9017 AVE = 0.6058	Hrep8: Benefits for performance	0.8996	55.8827
	Hrep9: Bonuses for outstanding performance	0.8452	26.309
	Hrep10: Feedback on performance	0.834	31.2381
Organizational learning (OL) CR = 0.9170 AVE = 0.5021			
Openness and experimentation (L_1) CR = 0.8909 AVE = 0.6208	Lcap1: Involve staff in important decision making	0.7481	17.5405
	Lcap2: Management favourably in carrying out changes to adapt to and/or keep ahead of new situation	0.8393	33.1138
	Lcap3: Employees' learning capability	0.7855	22.3254
	Lcap8: Promotion on experimentation and innovation	0.8125	28.5257
	Lcap10: External experiences and ideas as useful instruments for firm's learning	0.7502	16.8762
System perspective and knowledge transfer (L_2) CR = 0.8692 AVE = 0.5708	Lcap5: Employees' generalized knowledge on firm's objectives	0.7622	22.9571
	Lcap6: Contribution of all parts of the firm to achieve overall objectives	0.786	24.4965
	Lcap12: Discussion and analysis on errors and failures	0.7739	24.2595
	Lcap14: Open discussion	0.7243	18.729
	Lcap15: Instruments to record down the past situation	0.7292	14.339

End of Table 4

Construct	Items	Factor loadings	t-Statistic
(1)	(2)	(3)	(4)
Autonomy (E_1) CR = 0.8644 AVE = 0.6806	Enor2: Minimum supervision	0.8452	27.9224
	Enor3: Work prioritization	0.8633	36.5201
	Enor4: Uncertainty as challenge	0.763	18.8468
Risk taking (E_2) CR = 0.8346 AVE = 0.5581	Enor5:Venture into unexplored territories	0.7149	14.9271
	Enor6: Acceptance on failure	0.7559	15.9994
	Enor7: Emphasis on success rather than failure	0.7816	26.0376
	Enor9: Seek for new opportunities for present operations	0.7342	14.5255
Innovation activities			
Technological innovation (TI) CR = 0.8864 AVE = 0.5287	Tech2: Improve existing goods/services	0.6477	12.0799
	Tech3: Seek on new goods/services	0.7093	17.6004
	Tech4: Offer new goods/services	0.6451	12.714
	Tech5: Updated production to increase productivity	0.7713	21.8475
	Tech6: Use of technologies	0.7836	19.6529
	Tech7: New production to improve quality and/or decrease cost	0.7881	22.4204
	Tech8: Removal of non-value added activities	0.7292	16.0832
Organizational innovation (OI) CR = 0.9224 AVE = 0.5980	Ntec1: New management approaches	0.8153	35.32
	Ntec2: Investment in updating management procedures	0.7514	21.2933
	Ntec3: Seek to improve management	0.7490	19.2364
	Ntec4: Renew organizational structure	0.7572	21.5186
	Ntec5: Extended/customized service	0.7756	21.3058
	Ntec6: New market	0.7689	23.1054
	Ntec7: New promotion techniques	0.8237	31.4828
	Ntec8: Renew pricing strategies	0.7410	17.5643
Performance			
Firm performance (FP) CR = 0.9130 AVE = 0.6010	Fper1: Profitability	0.6634	11.3206
	Fper2: Annual sales growth	0.8221	31.4033
	Fper3: Market share	0.7942	24.387
	Fper4: Labour productivity	0.7553	19.633
	Fper5: Customer satisfaction	0.788	27.8728
	Fper6: Repeat business	0.7754	26.4574
	Fper7: Reputation	0.8172	34.5564

Note: CR = composite reliability; AVE = average variance extracted.

detected between technological innovation and organizational innovation ($\beta = 0.54$, $t = 8.043$). From the PLS-PM, mathematical equations (Ling *et al.* 2012) depicting the relationships between variables/constructs are derived accordingly in Eqns (1) to (7).

$$FP = 0.35TI + 0.44OI; \quad (1)$$

$$TI = 0.17OL + 0.19EO + 0.12IN + 0.54OI; \quad (2)$$

$$OI = 0.25IMO + 0.28OL + 0.26EO + 0.16IN, \quad (3)$$

where: OL construct score of a firm's learning capability:

$$OL = 0.93L_1 + 0.91L_2. \quad (4)$$

EO construct score of a firm's entrepreneurial capability:

$$EO = 0.89E_1 + 0.92E_2. \quad (5)$$

IN construct score of a firm's inter-organizational network capability:

$$IN = 0.97N_1 + 0.71N_2. \quad (6)$$

IMO construct score of a firm's integrated market orientation capability:

$$IMO = 0.91M_1 + 0.88M_2 + 0.76M_3. \quad (7)$$

The coefficients in Eqn (1) explain the path relationship between dependent construct/firm performance (FP) and constructs/innovations (TI and OI). Likewise, the coefficients in Eqns (2) and (3) explain the path relationship between constructs/innovations (TI and OI) and independent constructs (IMO, IN, OL and EO). Positive coefficients denote more application of a construct leads to higher innovation activities or performance within the SMCFs. Also, coefficients in Eqns (4) to (7) depict the information on the different types of capabilities for each innovation activities. For each construct, the observed first-order constructs and coefficient are used to calculate a construct's score (Fornell, Lacker 1981). Practically, the mathematical equations can be used as a self-assessment tool (Ling *et al.* 2012) by SMCFs to predict their level of firm performance, via innovations. For instance, to calculate FP, a SMCF should rate the extent to which it commits (or will commit) each Capability-Based approach shown in Eqns (4) to (7) on a 5-point scale, where 1 = does not commit and 5 = commit to a great extent. Using Eqns (4) to (7), construct scores can be calculated and input into Eqns (1), (2), and (3), so that the innovation activities (TI/OI) and performance (FP) of a SMCF can be determined. If the SMCF found a low level of performance, the mathematical models will suggest ways to improve their overall success based on the innovation practices and Capability-Based approaches they committed.

3.1. Model validation

According to Abdul-Rahman *et al.* (2013), a validation process of the developed model is essential to determine whether it is of an application value for evaluation in construction practice. The validation of the innovation model (including both the structural relationships and mathematical equations) is conducted with 12 experienced construction practitioners. Since they have sufficient construction experience (i.e., at least 15 years) and designation (of managerial position) (Ling *et al.* 2012), and are currently associated with SMCFs, the practitioners are therefore in position to validate the predictive ability of the model within construction framework. To this end, the experts are requested to fill in an evaluation form that based scores on the value of completeness, reliability, user-friendliness, and value-addedness in decision-making, with each parameter has a 10-scale evaluation. Overall, the result indicates the robustness and practicality of the new innovation model within SMCFs setting. The experts generally agreed that the structure of capabilities-innovation-performance could systematically help them to self-assess their orientation towards innovation more objectively and fairly. Accordingly, they could make use of the model to re-orientate their commitment on Capability-Based approaches whichever they think inadequate to obtain a higher level of performance, via a range of innovation practices.

3.2. Discussion on findings

Unlike previous studies that have ubiquitously elucidated the large firms' connection with innovation, the present research is underpinned by RBV (Wernerfelt 1984; Barney 1991) to gain more profound insights of the implication of innovation activities on smaller construction firms (Barrett, Sexton 2006; Hillebrandt 2006).

To this end, Eqns (1) to (3) suggest that innovative SMCFs could attain superior performance along two different innovation activities (TI and OI), which are supported by four Capability-Based approaches (IN, IMO, OL and EO). Built on the literature and the empirical findings of the study, it is first identified that the innovation activities engaged by SMCFs mainly associate with technological innovations (TI) and organizational innovations (OI). Instead of R&D-based innovations (Bygballe, Ingemansson 2014), the innovations being pursued by the SMCFs are identified to include non-R&D-related activities, such as adoption of new products, renewed production processes, updated managerial practices and marketing strategies. As revealed in Table 5, both technological and organizational types of innovation activities mutually complement each other as shown in their significant and positive interrelationship ($\beta = 0.54$, $t = 8.043$). Practically, they often need to be undertaken concurrently to result in a synergistic impact to the firms (Hardie, Manley 2008). The 12 experts further echo this observation that the adoption of technological innovation frequently requires a simultaneous change in the organizational practices, and vice versa. In pursuing innovation, capabilities have been seen as important approaches for the SMCFs as to continuously secure themselves in the marketplace. Table 5 affirms that four approaches under RBV's capabilities affect innovation activities of firms. Given that SMCFs generally work under resource-constrained environment, the depth (N1) and breadth (N2) of external networks with other firms (see Eqn (3)) ensure that a SMCF will expose to a pool of resources required for innovation activities (Manley 2008; Gronum *et al.* 2012). Further, a majority of the experts point out that their firms prefer networking with their clients and value-chain partners for the innovations they pursued are mostly out-in adoptions, rather than in-out inventions that require technical expertise from industrial actors like universities or research bodies. Besides, Eqn (4) suggests that three sub-construct (M1, M2 and M3) loading on integrated market orientation (IMO) are significantly important to support organizational innovations; however, they have no effect on technological innovations. The highest loading carries by integrated competitor orientation (M3) (Sexton *et al.* 2006) suggest that firms should respond quickly towards the innovation-related threads posed by their rivals. Meanwhile, the insignificant path of "Integrated market orientation" to "Technological innovation", as depicted in Table 5, is agreed by all the experts. They explain that too much emphasis on the product or process innovations could result in a negative impact when the clients are risk-averse towards innovations or when the

Table 5. Structural effects among all latent constructs

	Path coefficient	t-Statistic	Significance	Conclusion
Hypothesized links				
Inter-organizational network → Technological innovation	0.1208	1.740	*	H1 supported
Inter-organizational network → Organizational innovation	0.1644	2.143	**	H2 supported
Integrated market orientation →Technological innovation	–0.1039	1.487	NS	H3 not supported
Integrated market orientation → Organizational innovation	0.2594	2.961	***	H4 supported
Human resource practice →Technological innovation	0.0209	0.477	NS	H5 not supported
Human resource practice → Organizational innovation	–0.0257	0.536	NS	H6 not supported
Organizational learning → Technological innovation	0.1698	1.740	*	H7 supported
Organizational learning → Organizational innovation	0.2745	2.143	**	H8 supported
Entrepreneurship → Technological innovation	0.1941	3.3547	****	H9 supported
Entrepreneurship → Organizational innovation	0.2597	3.8910	****	H10 supported
Technological innovation → Firm performance	0.3494	3.615	****	H11 supported
Organizational innovation → Firm performance	0.4361	4.511	****	H12 supported
Non-hypothesized links				
Organizational innovation → Technological innovation	0.5446	8.043	****	

Note: NS = not significant.* [t] = 1:65, at p .1 level.
** [t] = 1:96, at p .05 level.*** [t] = 2:58, at p .01 level.
**** [t] = 3:29, at p .001 level.

margin of tenders is barely enough for firms' survival. Additionally, organizational learning (OL) stands out to be another capability that enables SMCFs to work innovatively. As depicted in Eqn (5), the positive coefficients of the sub-constructs indicate that more openness and experimentation (L1), as well as system perspective and knowledge transfer (L2), would lead to the higher capability of firms to pursue two different types of innovation activities. For firms of small size, their known liabilities of smallness could turn into a positive feature during the knowledge transposal processes, which are relatively easier due to the small scale of activities undertaken (Manley 2008). Last but not least, autonomy (E1) and risk-taking (E2) loaded on entrepreneurship (EO) have appeared to play a favouring role in spurring both the technological and organizational innovation activities of SMCFs. Some of the experts emphasise that they often need to act as risk-takers in pursuing innovations, which might present a chance of failure upon implementation. The entrepreneurial orientation of the firms, however, is mainly established according to the vision of the owner (Barrett, Sexton 2006). After all, the four Capability-Based approaches turn out as a function of two different innovation activities, which is in combination a function of the performance of SMCFs. Particularly, Eqn. (1) shows that the engagement in both technological innovations (TI) and organizational innovations (OI) makes it important for SMCFs to achieve superior performance. This finding extends the essence of prior works that ubiquitously centre on the technological enhancements (Sexton *et al.* 2006; Manley 2008; Hardie *et al.* 2013). Table 5 shows that the new offerings engaged by SMCFs do not base solely on a product-and-process viewpoint, but also from a managerial-and-marketing prospect. However, the greater impact organizational innovation found on firm performance, as compared to that of technological innovation, contradicts the work of Thorpe *et al.* (2009) that assert that small builders would focus largely on improving their product or daily tasks rather than marketing their products and services per se. Nonetheless, the majority of the experts provide a neutral point of view that the two innovation activities are equally important in ensuring the success and continuity of their businesses. The experts were in consensus that their employees were one of the most valuable resources within the company. However, the construction practitioners stated that their firms did not provide any reward for employees' contribution to new ideas or solutions attributed to firm improvement. The reward system mainly accounted for the promotion of the employees' performance, rather than their contribution towards innovation. As such, HRP is not an antecedent to construction innovations (H5 and H6). It is also interesting to note that IMO does not affect TI (H3). According to the experts interviewed, they could hardly recommend the use of innovation, such as new products that they got to know in past projects. This was due to the decision to use building materials, whether conventional or improved ones, on a project, largely depended on the contract specification, which was formulated according to the clients' requirements. Hence, being customer-oriented did not necessarily lead the SMCFs better realisation of technological innovation.

Conclusion and recommendations

The present study adds valuable insights to the preceding research streams by developing and validating a new model of innovation (including both the structural and mathematical models) for the SMCFs. Notably, the model rests its originality along two aspects. First, it establishes the causal relationships between capabilities, innovation activities and performance. More particularly, the model unlocks interesting extension to the body of knowledge that a couple of Capability-Based approaches, such as entrepreneurship, integrated market orientation, interorganizational networks and organizational learning, are significant in spurring a range of technological and organizational innovation activities that eventually enable the SMCFs to acquire beneficial consequences about their firms. Second, the new model is distinguishing from any other models established earlier in such a way that it is moving a track further to consolidate on two different innovation activities. As noted earlier, the past literature is biasedly focused on the technological products and processes enhancements. To highlight a broader paradigm and contribution of construction innovation, the model integrates both technological and organizational innovations in a single framework. As such, it contributes to knowledge in construction innovation management that the two different, yet, complementing innovation activities should be included simultaneously for conducting innovation- related studies of SMCFs nature. Finally, given that the innovation model has been validated for its industrial practicality and robustness, it contributes to practice by proposing ways for the SMCFs' practitioners to predict the likely level of performance (Eqns (1) to (7)). If performance is found to be low, the practitioners could adjust their commitment to innovation activities and Capability-Based approaches based on those identified in the innovation model. Subsequently, they could improve and secure their performance where appropriate. For policymakers, the new model presents evidence on the use of Capability-Based approaches by innovative SMCFs, and consequently, offers input for scheming out an SME-focused innovation policy for those with finite resources. That is, the policymakers should strive to nurture the internal development of capabilities of SMCFs to appropriately aid them to sustain beneficial impacts of innovation despite stiff economic rents. This study presents several limitations that, nevertheless, hold great opportunity for future research. First, the design of cross-sectional analysis impedes a full consideration of the causality nature between the variables. Future research should apply longitudinal research to enable a higher accuracy in interpreting the causal relationships. Second, the empirical setting is placed within a contracting context (i.e., general and specialist contracting services only). In assessing the applicability of the findings to other construction-based SMEs, future research is recommended to help in generalising the result in other professional service firms such as architectural firms, engineering firms, quantity surveying firms, etc. Third, this study does not consider all factors influencing innovation activities in SMCFs. Further research should also consider the external factors, such as regulatory environment, that could majorly leverage SMCFs' innovative competence and competitiveness in the marketplace. Finally, this study does not include large organizations, and therefore, could not explain the potential difference of innovation patterns between large, medium and small companies. Future studies should examine the innovative behaviour of firms, with regards to their size, upon construction-based scientific investigation.

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