MODELLING OF ORGANIZATIONAL CAPABILITIES, INNOVATION ACTIVITIES AND PERFORMANCE OF SMALL AND MEDIUM SIZED CONSTRUCTION FIRMS

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ABSTRACT

The relevance of innovation in service industries has been addressed within a project-based construction setting. Adopting innovative technologies and practices is important in accruing beneficial outcomes related to improved project delivery and performance as well as sustained competitive advantage of construction firms. However, little empirical emphasis has been paid to small and medium scale firms that constituted the bulk structure of the industry. The present study aims to develop an innovation framework, together with its mathematical equations, that considers organizational capabilities as a distinguishing character of superior firm performance in small and medium contracting firms (SMCFs). Construction innovation is defined as two different types of innovation activities, that is, technological and organizational innovations. Organizational capabilities involve several dimensions, such as entrepreneurship, organizational learning, integrated market orientation, human resource practice and inter-organizational network. The present study proposes an innovation framework, based on resource-based view (RBV) of firm, which assumes a positive effect of organizational capabilities on innovation, which in turns exerts a positive effect on firm performance. To date, to what extent these concepts are interrelated to each other and how innovation can be achieved within a small and medium (SME) setting remain unclear. Draw upon a mixed method, the proposed innovation framework and its mathematical equations are sequentially developed and validated with 157 empirical surveys and 12 in-depth interviews. Both the quantitative and qualitative studies are sampled on SMCFs (of general and specialist types) located in Kuala Lumpur, Malaysia.

The purpose of the quantitative surveys was to gauge the strength of relationship between capabilities, innovation and firm performance. To this end, partial least square (PLS) approach of structural equation modelling (SEM) is utilized to produce quantitative results, which are then validated with a qualitative study that involves 12 experts specifically associated with SMCFs. The findings affirmed that capabilities can positively spur the effectuation of the two different, yet, complementing types of innovation desired by SMCFs. In turn, both the technological and organizational innovations are found to spur the development of superior performance of SMCFs. Further analysis indicated a partial mediating effect of the two distinct types of construction innovation. The results are expected to contribute to the academics in two main areas. First, the new innovation framework considers both capabilities-based antecedents and firm-based consequence to understand the nature of innovation in SMCFs. It provided an advanced explanation of how SMCFs innovate to accrue competent market position. Second, the conceptualization of innovation is consolidated on two different types of construction innovation, therefore advancing the understanding of innovation in SMCFs setting. Finally, the mathematical equations provide practical guidance for both practitioners and policymakers as to promote new value creation among SMCFs.

ABSTRAK

Kaitan inovasi dengan industri-industri perkhidmatan telah dibicarakan dalam latar belakang industri pembinaan yang berasaskan projek. Aplikasi teknologi and amalan inovatif adalah penting untuk menghasilkan faedah-faedah berkaitan dengan penambahbaikan penyampaian dan prestasi projek serta kemampanan kelebihan daya saing firma pembinaan. Walau bagaimanapun, kurangnya penyelidikan empirikal yang diberikan kepada perusahaan kecil dan sederhana (PKS) yang membentuk sebahagian besar struktur industri pembinaan. Kajian ini bertujuan untuk membangunkan satu rangka kerja inovasi, bersama dengan persamaan matematiknya, yang mempertimbangkan keupayaan dalaman sebagai satu ciri pembezaan dari segi keunggulan prestasi kontraktor PKS. Inovasi pembinaan ditakrifkan sebagai dua berlainan jenis aktiviti inovasi, iaitu, inovasi teknologi and inovasi organisasi. Keupayaan organisasi melibatkan beberapa dimensi, seperti keusahawanan, pembelajaran organisasi, orientasi pasaran bersepadu, amalan sumber manusia dan perangkaian antara organisasi. Kajian ini mencadangkan satu rangka kerja inovasi, berdasarkan pandangan berasaskan sumber firma (RBV), yang menganggap pengaruh positif keupayaan organisasi terhadap inovasi, yang seterusnya mengenakan kesan positif terhadap prestasi kontraktor PKS. Setakat ini, sejauh mana konsep-konsep ini saling berkaitan antara satu sama lain dan bagaimana inovasi boleh dicapai di kalangan kontraktor PKS masih lagi kabur. Dengan menggunakan kajian kaedah campuran, rangka kerja inovasi dan persamaan matematiknya telah berurutan dibangunkan dan disahkan dengan 157 soal selidik dan 12 temubual mendalam. Kedua-dua pendekatan kuantitatif dan kualitatif melibatkan firma kontraktor PKS (jenis umum dan pakar) yang terletak di Kuala Lumpur, Malaysia. Kajian kuantitatif bertujuan untuk menolok kekuatan hubungan antara keupayaan, inovasi dan prestasi kontraktor PKS. Oleh itu, pemodelan persamaan struktural (SEM) dengan *partial least square* (PLS) telah digunakan untuk memperolehi keputusan quantitatif, yang seterusnya disahkan dengan kajian qualitatif temubual yang melibatkan 12 orang pakar-pakar yang sedang berkerja di firma kontraktor PKS. Penemuan kajian telah mengesahkan bahawa keupayaan organisasi boleh merangsangkan kedua-dua jenis inovasi yang berbeza, namum, saling melengkapi satu sama lain. Seterusnya, kedua-dua inovasi teknologi and inovasi organisasi akan merangsangkan pertambahbaikan prestasi di kalangan kontraktor PKS. Analisis selanjutnya menunjukkan kesan perantara secara separa inovasi pembinaan. Keputusan tersebut dijangka menyumbang kepada kemajuan akademik menerusi dua bidang utama. Pertama, pembangunan rangka kerja baru inovasi tersebut mempertimbangkan kedua-dua keupayaan dan prestasi untuk memahami kepribadian inovasi di kalangan kontraktor PKS. Ianya mejelaskan bagaimana kontraktor PKS menginovasi diri untuk mencapai kedudukan pasaran yang cekap. Kedua, konsep inovasi telah dikukuhkan di atas dua jenis inovasi pembinaan yang berbeza, oleh itu memajukan pemahaman inovasi di kalangan kontraktor PKS. Akhirnya, persamaan matematik menyediakan panduan kepada para pengamal industri dan pembuat dasar dalam menggalakkan penciptaan nilai baharu di kalangan kontraktor PKS.

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
AVE	Average variance extracted
B2P	Business-to-project
BIM	Building Information Modelling
BRC	British reinforced concrete
CB-SEM	Covariance-based structural equation modelling
CFA	Confirmatory factor analysis
CFI	Comparative Fit Indices
CIDB	Construction Industry Development Board
CRISP	Construction Research and Innovation Strategy Panel
DSS	Decision support system
ECI	Early contractor involvement
EO	Entrepreneurship
FP	Firm performance
GC	General Contractor
GoF	Goodness-of-fit
HRP	Human resource practice
IBS	Industrialized Building System
IDP	Integrated design process
ISO	International Organization for Standardization
IMO	Integrated market orientation
IN	Inter-organizational network
IT	Information technology
KMO	Kaiser–Meyer–Olkin
LISREL	Linear structural relations
MIIT	Ministry of Industry and Information Technology
NESTA	National Endowment for Science, Technology and the Arts
NSW	New South Wales
OI	Organizational innovation

OL	Organizational learning
OECD	The Organization for Economic Co-operation and Development
P2B	Project-to-business
P2P	Project-to-project exchange
PCA	Principal Component Analysis
PKS	Perusahaan kecil dan sederhana
PLS	Partial least square
PLS-PM	Partial least square path modeling
PLS-SEM	Partial least square of structural equation modeling
PM	Project manager
PR	Public relations
R^2	Square multiple correlations
R&D	Research and Development
RBV	Resource-based view
RMSEA	Root Mean Square Error Approximation
SBS	Small Business Service
SC	Specialist Contractor
SEM	Structural equation modeling
SCKIPSFs	Small construction knowledge-intensive professional service firms
SMCFs	Small and medium contracting firms
SMEs	Small and medium enterprises
TFI	Tucker-Lewis Fit Indices
TI	Technological innovation
VIF	Variance inflation factor
VO	Variation order

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CHAPTER 1

INTRODUCTION

1.0 Research overview

This chapter provides an overview of the present study and the research method used. It begins with a background that introduces the topics, followed by problem statement of the study. Some related works are reviewed to highlight the gaps in literature. Then, several research questions and objectives are presented to navigate the research study through the development of a conceptual framework of innovation. The last section outlines the method used as well as the contribution and scope of the present study.

1.1 Background of the study

As Newton (1999) remarks, 'innovation' may turn into the fourth pillar to be united with the extant dimensions of cost, quality and time. In line with the assertion, the construction industry in Malaysia is compelled to move in this direction. By year 2015, it is set to transform into a world-class, innovative and knowledgeable global solution provider (Construction Industry Development Board [CIDB], 2007). Being confronted with continuing challenges related to dynamic business environment, amplified demands for renewal of the built environment of greater sophistication is clearly present in the industry. Securing competitiveness, via innovation, is therefore of high priority in the agenda of most businesses (Howell & Higgins, 1990; Damanpour & Schneider, 2006).

Unlike manufacturing orthodoxies where business is an in-firm operation, the construction is characterized with several distinct features, such co-creation of outputs around one-off projects, temporary coalition with varying business actors, and business deliveries upon complex in-situ sites (Gann & Salter, 2000; Manley, 2008). For construction-based service firms, every project is regarded as a new prototype due to the one-off delivery (Manseau & Seaden, 2001). In this view, the portfolio of on-site projects they engaged offers a rich source of motivation toward new ideas and innovation. Along with achieving performance improvement of the design-construction process and the physical structure (Winch, 1998), innovation is essential for reducing costs, increasing functionality and maintaining market share (Seaden, Guolla, Doutriaux, & Nash, 2003; Thomas, Lee, Spencer, Tucker, & Chapman, 2004; El-Mashaleh, O'Brien, & Minchin, 2006).

Introducing innovation into construction, of intricate and fragmented setting, however, is more difficult than in other industries (Tatum, 1986; Winch, 1998). Known to include a number of intricate processes related to the on-site fabrication of products with complex, unique, durable, fixed, costly and risky nature (Nam & Tatum, 1988), the production of every single project require extensive regulation to secure quality and safety of its products and services (Gann, 2000). Additionally, the construction is fragmented with gigantic amount of small-scaled firms (Oragne, Onions, Burke, & Colledge, 2005; Australian Bureau of Statistics [ABS], 2006; SME Corporation Malaysia, 2011), which often complement the large high profile players in undertaking construction projects (Manley, 2008). To trigger a stronger innovation culture across the entire industrial system, an understanding on multi-facet nature of innovation, in connection with the two diametrically opposite entities (i.e., large and small firms), is of paramount importance.

As noted by Schumpeter (1942), only large organizations could afford research and development (R&D) based investments, and consequently, the establishment of R&D-capabilities; large, diversified organizations could tolerated and absorb the loss of innovating across wide technological fronts; and firms require certain degree of market control to acquire the rewards of innovation. For these reasons, larger organizations are more likely to be the impetus of technical progress (Schumpeter, 1950). In assessing organizational features those are thought to explain innovativeness of small firms, some scholars concur with the Schumpeter’s (1950) reasoning that small firms are typically burdened with the “liability of smallness” (Aldrich & Auster, 1986), and for new ventures, the “liability of newness” (Stinchcombe, 1965).

Notwithstanding the above arguments, Rothwell (1985) adversely remarks that large players tend to display an innovative advantage mostly in material or resources while small businesses are conferred with behavioural advantages. Such view has been mirrored in the innovation literature of construction. Scholars suggest that larger organizations have sufficient capacity to hinge on costly investment, such as R&D-related spending (Gann & Salter, 2000; Miozzo & Dewick, 2002, 2004; Acha, Gann & Salter, 2005; Brochner, 2010) while smaller firms differentiate themselves by certain internal capabilities to offset their size disadvantages (see Sexton & Barrett, 2003a, b; Barrett & Sexton, 2006; Lu & Sexton, 2006; Manley, 2008). Obviously, both large and small firms conceivably innovate in different ways (Yap & Souder, 1994). Instead of one-size-fit-all means, research addressing innovation in the large or the small businesses need to take particular consideration of the diverse peculiarities.

1.2 Problem of the study

In construction, innovation is known as a key to long-term success in firms of dissimilar size. The industry, however, is overwhelmed with heterogeneous of firms of varying competing and collaborating relationships that are to cohere well together in a temporary coalition to deliver one bespoke project prior moving on to next projects. Against this context, the industry is increasingly challenged to satisfy the needs and aspirations of clients (Boyd & Chinyio, 2006), in terms of improved building performance (both functionally and aesthetically), and reduced initial capital and on-going operational and maintenance costs (Barrett, Sexton, & Lee, 2008). The construction firms are under pressure to innovate, that is, to develop and/or adopt new technologies and practices as a mean to attempt to satisfy these demands (Hartmann, 2006a).

Yet, the industry as a whole has been accused of being poor in its innovation performance. The firms in construction are often characterized with adversarial behaviour, dissentious orientation, lacking of communication and coordination, deficient customer focus and low R&D investment (Egan, 1998; Fairclough, 2002). In an academic comparison of innovation activities across several sectors of the economy, the construction is found to underperformance significantly compared to that of manufacturing (Reichstein, Salter, & Gann, 2005). Furthermore, it is pointed out that the capacity 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. For small construction firms, having sufficient time, cost and technical expertise in acquiring available technologies and innovations is particularly crucial to support the resource-intensive innovation activities. In this view, a shortage of resources in typical small firms may restrict the resource-constrained firms from pursuing innovation (Barrett & Sexton, 2006).

Set against an already competitive background, some small construction firms, however, present conflicting evidences in that they are capable to innovate successfully over time. Success in this regard lies on the small firms to develop internal capabilities to pursue long run growth over innovation activities (Sexton & Barrett, 2003b; Barrett & Sexton, 2006; Lu & Sexton, 2006; Manley, 2008). In a similar effort, Gann (2000) remarks that the construction firms need to increase their capabilities in managing innovation if they are to "build reputations for technical excellence that set them apart from more traditional players" (p. 220). However, to what extent these concepts are interrelated to each other and how innovation can be achieved within a small and medium setting remain unclear. In spite of their significance in occupying the bulk structure of construction (Oragne et al., 2005; SME Corporation Malaysia, 2011), it has been extended that "…it has not been sufficiently envisioned, embedded and evaluated in the context of small, project-based firms to form a robust, grounded body of innovation knowledge in its own right” (Barrett & Sexton, 2006, p. 344). In a similar effort, Hillebrandt (2006) highlights the need and call for more works on the smaller firms, “it is time attention was directed to the rest of the industry” (p. 670). Put differently, the construction research remains silent on exploring the degree to which capabilities affect innovation activities, and thereby fails to assist the resource-poor small and medium construction firms (SMCFs) in predicting their likely performance goals within the innovation framework.

To capture the essence of prior works, the present study investigates the capabilities that small and medium contracting firms (SMCFs) use to support their innovation activities, which potentially lead to higher performance in the firms. Within the line of theoretical resource-based view (RBV) (Penrose, 1959; Wernerfelt 1984; Barney, 1991), this study conjectures that the innovative SMCFs will purposefully develop and deploy certain capabilities to which superior performance has been found. The purpose of conducting the study is to develop and validate a framework of innovation that can be used by the innovative SMCFs to predict their likely performance level. This final outcome is expected to contribute to a better appreciation of SMCFs through the stimulation of a higher level of innovation activities within and among the small and medium economies that are based on construction.

1.3 Research questions

To address the aforementioned research problems, the present study states several questions to direct the research work toward the appropriate methodology, as follows:

- What is the nature of innovation in construction industry? Is there any difference between practice of innovation in large organizations and small firms?
- For small construction firms, what are the related capabilities-based antecedents and firm-based consequences pertaining to their innovation activities? To what extent do they interrelate with each other?
- How do different types of organizational capabilities affect innovation activities, which in turn have a potential effect on firm performance? Do technological and organizational innovations, similarly, or differently, mediate the relationship?
- What is the framework that can be built up to motivate a higher level of innovation among the resource-poor SMCFs?

1.4 Objectives of the study

To answer the research problem, the present study formulates four research objectives as follows:

1. To identify the types of innovation activities among the SMCFs;
2. To identify the potential effect of innovation activities with regards to capability-based antecedents and firm-based performance of SMCFs;
3. To develop a framework of innovation, together with its mathematical equations, for SMCFs based on the research output; and
4. To validate the framework that was developed.

1.5 Conceptual framework of innovation

Using SMCFs as the focal point of analysis, the present study aims to extend the prior works (Sexton & Barrett, 2003a, b; Manley, 2008; Thorpe, Ryan & Charles, 2009). As illustrated in Figure 1.1, a path diagram establishes the interconnection of three types of variables in ovals. Specifically, the theoretical RBV (Penrose, 1959; Wernerfelt 1984; Barney, 1991) is utilized to support the assumption that organizational capabilities, innovation activities and firm performance are interrelated in a single framework. On the far left, 'organizational capabilities' is posited as independent (exogenous) variables that predict innovation activities. 'Innovation activities' is posited as an endogenous variable that has both independent and dependent features. In one hand, it is a dependent variable that is predicted by 'organizational capabilities'; in the other hand, it is an independent variable because it predicts 'firm performance'. On the far right, 'firm performance' operates as dependent (endogenous) variable predicted by 'innovation activities'. As seen in Figure 1.1, the weighting of each path is represented by coefficients *a* and *b*, where '*a'* denotes the weighting of the path of organizational capabilities and innovation activities; '*b'* denotes the weighting of the path of innovation activities and firm performance.

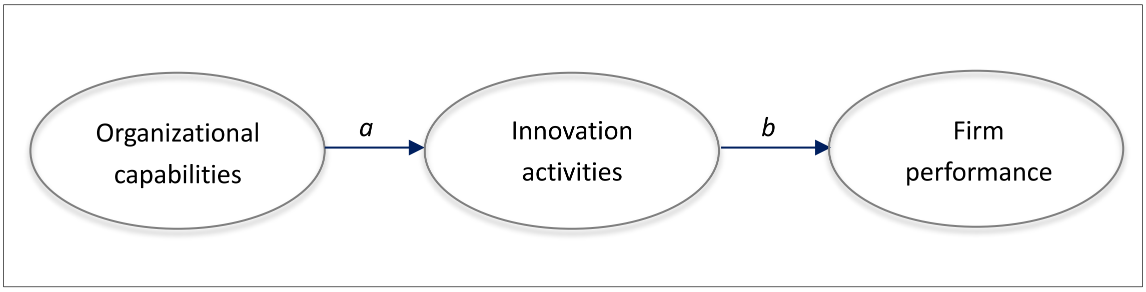


Figure 1.1: Proposed conceptual framework and types of variables

According to Ling, Li, Low and Ofori (2012), the relationships between variables in the path diagram can be then translated into mathematical equations as presented below.

Firm performance = *b* x Innovation activities (1)

Innovation activities = *a* x Organizational capabilities (2)

Further, it is important to note that the relationships discussed above are of direct effects (i.e., linkage of organizational capabilities and innovation activities; and linkage of innovation activities and firm performance). Also, the present study is interested in testing models that are more complicated, i.e., mediation analysis. In specific, ‘innovation activities’ is posited as a mediator variable that receives ‘organizational capabilities’ and translating them into ‘firm performance’. All these are presented in detail in Chapters 3 and 4.

1.6 Research methodology: An overview

As summarised in Figure 1.2, the research problem is first identified in the research process, and subsequently, the research questions are set out. Next, a review of innovation literature, in general construction as well as small and medium enterprises (SMEs) in particular, is carried out. The main aim of literature review is to identify 1) the appropriate ‘innovation’ concept associated with construction, especially the small and medium firms, and 2) the unsolved research problem pertaining to challenges of managing innovation in small and medium construction firms. Based on the literature review and RBV (Penrose, 1959; Wernerfelt 1984; Barney, 1991), several hypothesized relationships are modelled into a testable conceptual framework of innovation. Further, a mixed method is used to collect primary data among the SMCFs. A quantitative survey is first conducted, and followed by qualitative interviews and validation.

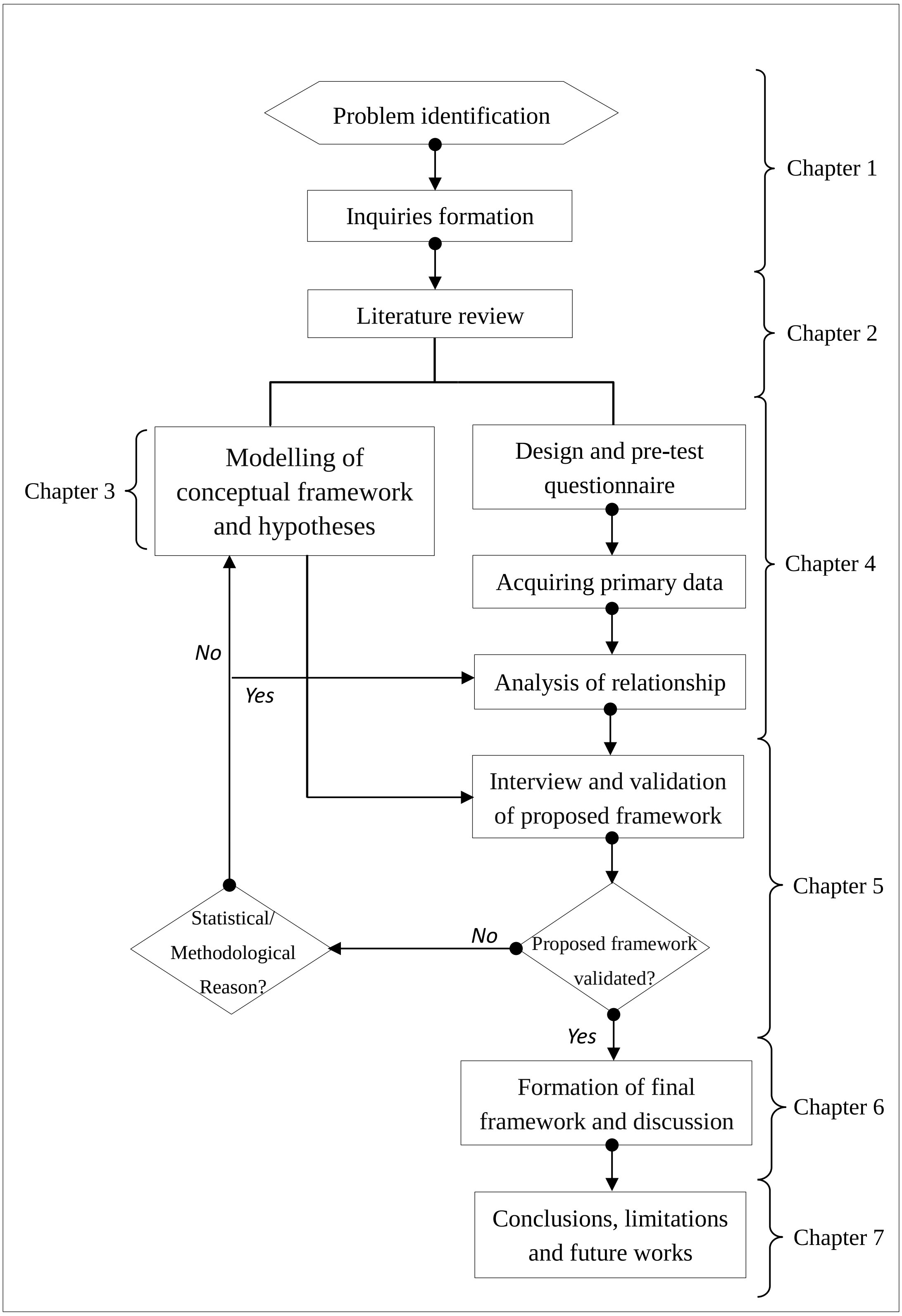


Figure 1.2: Research procedure

For the collected quantitative data, one of the most widely applied second-generation multivariate analysis techniques—structural equation modeling (SEM)—is performed using partial least square path (PLS-PM) approach to test the innovation framework. Next, qualitative interviews are used to further explore the statistical findings derived from prior quantitative survey approach. The analysis of qualitative data can be done using manual analysis of the interviews to explore themes and codes of the phenomenon (Creswell, 2008). Also, the framework is validated by construction experts for its practicality and robustness towards the practice of innovation in the industry. From this, a new framework of innovation, together with its mathematical equations, are developed as the final outcome of the study.

1.6.1 Research design: Approaches and strategies

Research strategy hinges on three elements: research question(s), control over behavioural events and degree of focus on contemporary events (Yin, 2009). In this connection, there are three types of research procedures, i.e., quantitative method, qualitative method and mixed method (Creswell, 2009). In specific, the mixed method design can be further categorized into six major designs: convergent, explanatory, exploratory, embedded, transformative and multiphase (Creswell & Clark, 2011). To answer the research problem (see Section 1.2) and research questions (see Section 1.3), the present study adopts the sequential explanatory design, where a quantitative study is first conducted, and followed by a qualitative study (see Table 1.1).

1.6.2 Justification of using mixed method: Sequential explanatory design

In its most basic sense, the mixed method of sequential explanatory design encompasses two distinct phases, i.e., a quantitative phase and a qualitative phase (Creswell, Clark, Gutmann & Hanson, 2003). In this design, the researcher first collects and analyses the quantitative data and follows up by the collection and analysis of the qualitative data in the sequence. The purpose of the second, qualitative phase is to explain, or elaborate on, the quantitative findings acquired in the first phase. Finally, the two phases are connected in the intermediate stage, i.e., discussions (see Chapter 6), in the research study. The rationale of using this design approach is that the initial quantitative results offer a general understanding on the research problem. From this, a subsequent qualitative research refines and explains those quantitative results by exploring participants' views in more depth (Creswell et al., 2003; Tashakkori & Teddlie, 1998).

As in the current study, two types of questions arise. To first identify the linkage between innovation activities and the associated capabilities-based antecedents and firm-based consequence, it involves hypotheses testing and answering the question "What?", which implies a quantitative approach (Yin, 2009). To further elaborate the nature of the linkage, it involves answering the question "How?" (i.e., how are innovation activities, first, affected by capabilities, and second, affecting performance of SMCFs), which requires a qualitative approach. Accordingly, a quantitative study is firstly conducted to establish the linkage between the dependent variable (organizational capabilities), mediating variable (innovation activities) and independent variable (firm performance) as identified in the literature. Secondly, a qualitative study, which builds on the first quantitative study, is conducted to elaborate and validate the quantitative results. Eventually, a new framework of innovation is developed for the SMCFs.

Table 1.1: Research methods and approaches according to the research questions

Research questions	Research paradigm	Method of data collection (analysis)	Purpose
What is the nature of innovation in construction industry? Is there any difference between practice of innovation in large and small firms?	-	Literature review (synthesizing)	-Identify the relevancy of innovation with respect to large and small construction firms
For small construction firms, what are the related capabilities-based antecedents and firm-based consequences pertaining to innovation in small firms? To what extent they interrelate with each other?	Quantitative	Questionnaire survey (hypothesis testing via PLS-PM)	-Develop and test a framework of innovation that links organizational capabilities, innovation activities and firm performance together
How do organizational capabilities affect innovation activities, which in turn have a potential effect on firm performance? Do technological and organizational innovations, similarly, or differently, mediate this relationship?	Qualitative	In-depth interviews (elaborate statistical findings), validation (validate the innovation framework)	-Elaborate the statistical linkages between organizational capabilities, innovation activities and firm performance -Validate the practicality and comprehensiveness of the developed innovation framework
What is the framework that can be built up to motivate a higher level of innovation among the resource-poor SMCFs?	-	Discussion (interpreting the results)	-Integrate both the quantitative and qualitative results to establish a final framework of innovation (together with its mathematical equations) for the SMCFs

1.7 Significance of the study

Fundamentally, the small or medium businesses have been known as the vital origin of economic growth and employment in both district and national levels. Besides accounting for over 95% of businesses, SMEs have contributed to approximately 50% of total value added worldwide (The Organization for Economic Co-operation and Development [OECD], 1997; United Nations, 1993). Furthermore, depending on the country, the SMEs could generate between 60% and 90% of all new jobs (OECD, 1997). Clearly, the SMEs have constituted the bulk structure of most industries, and therefore, played a significant role in most nations. As in construction, the huge proportion of number and contribution of SMEs is similarly reported globally, such as Australia (ABS, 2006), UK (Department of the Environment, Transport and the Regions [DETR], 2000, Table 3.3), Malaysia (SME Corporation Malaysia, 2011) and etc. Seen in this light, how to trigger innovation among the small and medium construction firms has been a major theme in political and academia debates.

As aforementioned, the scholarly negligence on firms of smaller size—"there is a dearth of research investigating innovation from the perspective of the small construction firm" (Sexton & Barrett, 2003b, p. 623)—is indicative of both the inconclusiveness and importance of the matter. Given that the industry, other than few big players, is abundantly congested with SMEs, insufficient understanding of the issue may result in less practical and less appropriate managing paradigms of innovation from the small and/or medium firms' perspective. Further, this is problematic in terms of national policies geared toward enhancing innovation performance of individual firms with dissimilar size and features. The present study attempts to contribute to this aspect, in which a new framework of innovation is developed and validated.

Academically, the innovation framework, together with its mathematical equations, attempt to fill the literature gaps by integrating a number of research priorities to advance the understanding on the implication of construction innovation in an SME setting, which has as yet scarce in attention (Sexton & Barrett, 2003b; Barrett & Sexton, 2006). Practically, where over 80% of construction-based firms are of small or medium size (SME Corporation Malaysia, 2011), the innovation framework and its mathematical equations are expected to benefit the innovative SMCFs' practitioners by assisting them to predict their likely level of performance. Also, they could serve as a guideline for policy makers to establish creative and supportive policies in order to trigger continuous improvement within and among SMCFs, via innovation.

1.8 Research scope

For every research, there will be some reasonable limits to maintain the scope of study. Various parties in the construction process such as, contractors, consultants, manufacturers and suppliers can contribute to the level of innovation in the industry. This study specifically places the empirical setting on small and medium firms operating on contracting basis (i.e., general and specialist/trade contractors) in developing countries (i.e., the case of Malaysia). According to National SME Development Council (2005), a service firm, including those of construction nature, with 5 to 19 employees is regarded as a small firm whereas a service firm with 20 to 50 employees is regarded as a medium firm. Moreover, this study is limited to include only firms locating within advanced territories, i.e., Kuala Lumpur, where the firms are likely to operate under competitive environment during the course of the research. The influence of other location (e.g., rural area) on innovation activities is not considered.

1.9 Outlines of the remaining chapters

Including the current chapter, this thesis comprises altogether seven chapters. The content of the subsequent chapters is briefly outlined below.

Chapter 2: Literature review

Draws on the general literature of construction research, the chapter first reviews the features of innovation at project, firm and industry levels. It is argued that they are all related to favour or hinder innovation in the construction firms. Next, the chapter presents the connection of innovation with firm size. Specifically, relating works are reviewed to understand the applicability of the findings those derived from large firms on the small or medium firms. Focusing on small or medium firms, the chapter then presents an overview of the fundamental works on these firms' innovation approaches to highlight the research gaps. The outcome of the chapter is a discovery of new directions toward a better understanding of innovation in small and medium construction firms.

Chapter 3: Framework development and research design

Within the RBV line of reasoning, the chapter posits that capabilities, instead of resources, are the input factors that can result in innovative forms of firm performance in SMCFs. From this, a conceptual framework of innovation is proposed for the SMCFs in which the linkages of organizational capabilities, innovation activities and firm performance are established. Based on the concepts and theories discussed, the chapter highlights specific indicators of organizational capabilities, innovation activities and firm performance that are respectively used to develop the measurement scales of independent, mediating and dependent variables. Also, a research design is presented to depict the logical sequence of data collection in view of the research proposition.

Chapter 4: Quantitative study

The purpose of the chapter is to quantitatively test and develop the conceptual framework proposed in Chapter 3. To this end, PLS-SEM is applied to investigate the impact of five hypothesized latent variables on the capabilities of SMCFs to support their innovation activities, which potentially lead to higher performance in the firms. Steps for the development of questionnaire survey are formulated via conceptualization, operationalization and measurement of variables. Also, pre-test of the questionnaire survey, i.e., content validation, face validation and pilot study, is conducted. In the same chapter, steps for the collection and analysis of data, together with the statistical results, are presented as well. The outcome of the chapter—mathematical equations and related statistical results—is essential for subsequent phase of qualitative exploration.

Chapter 5: Qualitative study and validation

The chapter intends to elaborate and validate the results of the prior quantitative study (in chapter 4) and to bring the results to the specifics of Malaysia. Via in-depth interviews with experts those specifically associated with SMCFs, a summary of the responses from interviewees are presented. The same experts are included in the validation of the innovation framework.

Chapter 6: Discussion

The chapter first highlights the main findings of the quantitative and qualitative studies. These findings are then compared with the prior works to seek both conflicting and similar results. Overall, this chapter intends to interpret to what extent and in what ways the qualitative results explain and add insight into the quantitative results in relation to the study's purpose.

Chapter 7: Conclusion and recommendation

The chapter underscores the achievement of the research objectives in the present study. The contributions and implications of the study are presented as well. Importantly, limitations and recommendations for future work in the similar area are made.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter specifically brought together the advancement of innovation issue in a construction setting. First, studies concerning innovation in different level of arena were drawn to understand its occurrence behind the peculiar project-based industry. Second, a variety of perspectives that implicated how innovative behaviours of small firms would be differing from that of large organization was presented. Taking into account the arguments of innovation and firm size, the prior works specifically focused on the role of small construction firms in driving innovation were then formulated. Finally, the existing research gaps, including the overlooked innovation issues as well as the bias conceptualization and methodological measurement of innovation, were uncovered as new directions toward a better understanding of innovation in small and medium construction firms.

2.1 Innovation: Its connection with the Construction Industry

Over decades, the term ‘innovation’ had rooted its significance across different streams of research, i.e., manufacturing and service. The theoretical and empirical works on innovation were spawned by the wide array of focus by government bodies, industrial practitioners and academic societies on the role of innovation as the basis of global economic growth. According to Schumpeter (1942), innovation, by an extensively shared definition, implied the commercialization of invention. Further, Howell and Higgins (1990) observed that the persistence to engage in innovation enabling firms to be more likely to prosper or survive in competitive environment. As such, firms, of all industry types, were hardly competing with each other to differentiate themselves in the rival marketplace via innovation (Nijssen, Hillebrand, Vermeulen, & Kemp, 2006). Joining this line of argument, a burgeoning group of scholars had specifically directed their works towards project-based industry of construction nature (Gann, 1994; Nam & Tatum, 1989; Slaughter, 2000; Winch, 2003; Barrett & Sexton, 2006; Manley, 2008; Brochner, 2010; Pellicer, Yepes, Correa, & Alarcon, 2012; Salunke, Weerawardena, & McColl-Kennedy, 2011, 2012; Ozorhon, Abbott, & Aouad, 2013). Specifically, construction had been understood to display several characteristics unique to all industries. Understanding its peculiarity of business provisioning would have a strong impact on triggering; from a micro view, the innovative performance of the individual firms and, from a macro view, the innovative improvement of the industry as a whole.

2.2 Level of Innovation

As remarked by Winch (1998), the construction industry itself carries some distinguishing features that potentially fostered or impeded the practice of innovation (see Figure 2.1). In particular, innovation could be viewed from two levels—micro (i.e., project and firm) and macro (i.e., industry) levels. The micro level concerned with unique arena of projects, where the creation of new knowledge relied on localized management of the project-specific features for successful innovation, as well as organizational features of the companies, those associated with resources, culture, people, and learning processes conducive to innovation. On the other hand, the macro level looked at the entire industry and concerns the contextual features of construction that greatly shaped the innovativeness of the bulk of individual construction companies. The next section brought together a selection of literature specifically focusing on the different features of the construction industry in relation to the practice of innovation at project, firm and industry levels.

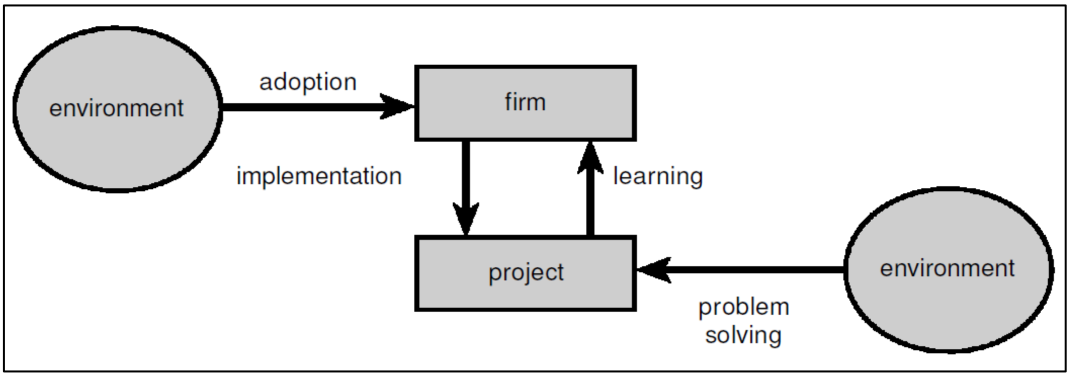


Figure 2.1: A model of construction innovation process (Winch, 1998, p. 273)

2.2.1 Features at the project level

In investigating the "why" behind the push for innovation, scholars had since long recognized project-based problems as major source of new solutions (Slaughter, 1993b; Dulaimi, Nepal & Park, 2005; Hartmann; 2006b; Ozorhon, Abbott, & Aouad, 2009; Pellicer, Yepes, Correa, & Alarcon, 2014). Given that construction was an on-site assembly industry, the fabrication of final product was routinely associated with high levels of unanticipated challenges (Toole, 1998). Whenever new project objectives could not be achieved with known means, search activities were initiated amongst the group of people involving in a project to identify new solutions (Slaughter, 2000). As Grabher (2002) observed, "through their trans-disciplinarily and transience, projects thus indeed appear as a most pertinent form for creating knowledge in the context of application" (p. 1492). Further, new initiatives were often delivered via bricolage, that was, combination of ostensibly identical resources in a creative way (Salunke et al., 2012).

Besides that, clients' demands and requirements were another factor that triggers innovation in construction project (Gambatese & Hallowell, 2011a; Thorpe et al., 2009; Pellicer et al. 2014). To meet the changing needs of individual clients, every completed project involved a creation of highly bespoke end-products (Reichstein et al., 2005). Accordingly, the project owners (i.e., clients) could act as both an inhibitor and driver of an innovative environment (Dulaimi, Ling, Ofori, & De Silva, 2002; Blayse & Manley, 2004; Dulaimi et al., 2005). This had turned every one-off delivery into a new prototype (Manseau & Seaden, 2001). However in every project, the final product was large, heavy, long-lived, expensive, primarily custom-made and weather-dependant (Liebing, 2001). An introduction of new solutions in the complex environment could create unexpected effects, and therefore, must be managed appropriately.

For construction projects were obliged to sub-contracting nature (Winch, 1998), the negotiation of new solution with one or more parties within the project was particularly important (Dulaimi, Ling, & Bajracharya, 2003). Given the different interests and perceptions among the involved parties, the innovation process needed to engage a range of actors with varying economic logics (Bygballe & Jahre, 2009). Most often, it was likely that the introduction of some solutions beneficial for one party or a group of the involved firms might counteract the others (Bygballe & Ingemansson, 2014). Hence, project-based innovations were more likely to be favourable with close partnering and collaborative effort between the diverse parties (Winch, 2003). Importantly, the incentives or benefits derived from project innovations must be divided between the clients and the project participants engaged in the coalition (Winch, 1998).

2.2.2 Features at the firm level

Much research had been devoted to understand the key factors that influenced innovation at the organizational level. These included culture, learning, collaboration, customer focus and resources (Toole, Hallowell, & Chinowsky, 2013). A number of researcher had addressed the importance of organizational culture, in terms of openness to new ideas (Dikmen, Birgonul, & Dikmen, 2005; Ling, Hartmann, Kumaraswamy, & Dulaimi, 2007) and management's commitment to innovation (Nam & Tatum, 1997; Bossink, 2004). Meanwhile, learning and knowledge management had also proved to greatly support the innovative capacity of construction firms (Miozzo & Dewick, 2002; Harty, 2005). Essentially, the new knowledge gained from problem-solving in portfolio of project processes, once being captured by firms, could be used in new projects (Winch, 1998). Nevertheless, capturing knowledge generated in single project into firm was difficult (Brady & Davies, 2004). Also, there was little time for project participants, who were engaged to new projects, to recognize the usefulness of the experiences made in the former completed project (Grabher 2002).

Given the complexity of construction, linkages within and across firm boundaries must be created to favour collaboration and trust, both of which, crucial to innovation activities (Ling, 2003; Hamel, 2006; Ling et al., 2007). In particular, the new ideas must be outsourced externally from both researchers and consultants (Bossink, 2004). Hence, innovation networks were essential to access to non-sensitive information (Drejer & Vinding, 2006). Moreover, the focus of construction companies on customer needs and the possession of close ties with the customers had shown to promote innovation (Seaden and Manseau, 2001; Dikmen et al., 2005). At the same time, some researchers identified that the pursuit of innovation depended on slack resources of firms (Sexton & Barrett, 2003). For instance, employees should be given a slack in their workload to enable the development and experimentation of new ideas (Dulaimi et al., 2002). In sum, the control and capitalisation of these particular set of factors was within the remit of firm, and consequently, central to the management of construction innovation.

2.2.3 Features at the industry level

The industry itself had been criticized for the impediments it placed in the growth of innovation (Winch, 1998). Particularly, it was fragmented by a multiplicity of small firms and few large organizations. In the UK, SMEs accounted for over 95% of the construction industry (Oragne et al., 2005). Similarly in Malaysia, over 80% of the firms registered as “construction-based” were categorized as SMEs (SME Corporation Malaysia, 2011). Such a fragmented feature had structurally restricted innovation, given the capacity of SMEs to innovate was rather limited (Miozzo & Ivory, 1998; Miozzo & Dewick, 2004). Further, the fragmentation was exacerbated by the separated responsibilities of designers and contractors (Winch, 1998), where design was usually isolated from production that in turn isolated from maintenance (Reichstein et al., 2005). Such divergence of knowledge expertise explained the inability of the project actors to work together efficiently (Dulaimi et al., 2002), and the slow progress of innovation activities in the industry (Gann, 2000).

Nevertheless, the scholars had attempted to solve the impeding issues in order to enable innovation throughout the industry. For instance, some researchers suggested the role of existing procurement system in shaping an innovative macro-environment within the temporary micro-environment surrounding each project (Barlow, 2000; Blayse & Manley, 2004). In this view, the use of traditional lump-sum contracts tended to trigger stiff competition based on price rather than interaction between construction players (Dubois & Gadde, 2000). On contrary, the promotion of relationship contracting, such as design-and-build (D&B) contracts, could substantially favour the project teams in undertaking innovation (Dulaimi et al., 2003). Different types of procurement methods and their associated characteristics and impact on innovation had been summarised by Saad and Jones (2003) (see Table 2.1).

More recently, some scholars had studied on some advanced procurement systems to identify their beneficial impacts on innovation practice in construction. For instance, Lenferink, Arts, Tillema, van Vaklenburg and Nijsten (2012) found that the procurement strategy of early contractor involvement (ECI) could add value to construction projects in terms of time gains, improved project control and more innovative solutions. Similarly, Natural Resources Canada (2015) reported that the use of integrated design process (IDP) would foster open-mindedness and creativity that led to innovation and synthesis, which allow the team to achieve the complex requirements of a high performance building. Meanwhile, Costa and Grilo (2015) presented how the operations, transaction relationship and collaboration within supply chain could be innovatively improved using a BIM-based e-procurement prototype.

Table 2.1: Procurement methods and innovation (Saad & Jones, 2003, p. 37)

Procurement method	Key characteristics	Impact on innovation
Traditional single-stage	▪ Design and construction separated ▪ Cost-orientated through competitive, fixed-price tendering ▪ Clear lines of accountability	▪ Encourages fragmentation, hierarchy and division of work ▪ Encourages short-term relationships ▪ Slow decision making ▪ Limited opportunity for contractor to engage in design
Two-stage tendering	▪ Integration between design and construction through earlier involvement of contractor	▪ Opportunity for contractor to add value and manage risk at design stage ▪ Potential for greater integration, often countered by sub-contracting strategies ▪ More client involvement
Fast-track: Management contracting	▪ Overlapping design and construction stages ▪ Popular for large or complex projects ▪ Complex approach requiring the management of a large number of contractors	▪ Allows greater flexibility for change ▪ Scope for value management and engineering ▪ Complex contractual relations and assignment of liability often leads to adversarial relationships
Fast-track: Construction management	▪ Contractor acts as an impartial client agent controlling all aspects of the project ▪ Requires experienced client	▪ Allows considerable flexibility ▪ Scope for value management ▪ Promotes long-term relationships ▪ Allows full involvement of client
Design and build	▪ Single point of responsibility for design and build	▪ Encourages the use of tried and tested solutions ▪ Competition of product as well as price ▪ Expensive tender process ▪ Potential for long-term relationships

Furthermore, the regulatory environment had been pointed to direct the way in favouring or hindering patterns of innovation in a nation (Gann, Wang, & Hawkins, 1998; Blayse & Manley, 2004). Specifically, a prescriptive specification had been recognized to hamper the innovation offered by contractor (Gann et al., 1998), whereas a performance-based specification could promote the adoption of new solution (Winch, 1998). If national policy recognizes that innovation was stimulated by and stimulating price competition rather than interaction, then it would counteract with the promotion of innovation in the country (Bygballe & Ingemansson, 2011). Given the clients' tendency to award projects based on low bid (Miozzo & Dewick, 2002), reducing design and construction-related costs became the main focus of most innovation activities (Duke, 1988; Seaden, 1996). This was echoed by Nam and Tatum (1992) that, "Material suppliers develop new materials, equipment suppliers develop new equipment and construction professionals are rarely aware of these developments; their focus is usually on reducing the material and labour requirements for a project" (p. 520). Within a public policy for promoting innovation, Havenvid (2015) concluded that a fundamental issue could arise if construction firms continued to pursue mainly competitive strategies at the expense of addressing its interactional problems.

Moreover, the collaboration between universities and the industry was increasingly perceived as a vehicle to enhance innovation through knowledge exchange (Ankrah & AL-Tabbaa, 2015). To this end, the government could act as a broker to promote linkage between contractors and institutional parties such as universities as well as specialist sub-contractors (Miozzo & Dewick, 2002). In this role, the government could ensure the spill over impacts of innovation among the contractors or weaker organizations by providing financial support to pilot projects or encouraging collaborations in the networks. In adverse, a bias in allocation of governmental assistance would greatly impact the innovation in construction firms, especially the small ones (Manley, 2008). More recently, Chang, Chen and Fong (2015) extended the earlier notion of university-industry collaboration by focusing on a more comprehensive technology transfer process, scilicet, from faculty to firm. The research revealed that faculty's share of licensing revenue and non-economic benefit would have a positive impact on invention disclosure and the amount of effort expended by faculty, while increasing licensing price, decreasing the invention disclosure rate, and not necessarily increasing the investment by the firm.

The above review of different features of the construction industry in connection to three distinctive levels of innovation clearly illustrated the opportunities and difficulties confronted by construction companies. In particular, the difference in a firm's capacity to innovate was supposed to be influenced by both macro industrial structure, as well as micro organizational condition of firms which based business operation on project deliveries. It was against this setting that project-based construction firms, of dissimilar size, operate.

2.3 Definition: Innovation in Construction

When firms executed existing activities in a new approach, this was often regarded as innovation. In a general sense, innovation encompassed a "change in routine" (Nelson & Winter, 1982, p. 128) as well as the "carrying out of new combinations" (Schumpeter, 1934, p. 65). Further, it rested on "practices so new that the set pattern of accepted processes or products is developed or replaced" (Langford & Dimitrijevic, 2002, p.17). In construction specific, Slaughter (1988) related innovation to "actual use of a non-trivial change and improvement in a process, product or system that is novel to the institution developing the change" (p. 1). In a broader view, the European Commission (1995) described innovation as "the renewal and enlargement of the range of products and services and the associated markets; the establishment of new methods of production, supply, and distribution; the introduction of changes in management, work organization, and the working conditions and skills of the workforce" (p. 688). Meanwhile, 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).

Deemed innovation to be "more than technology related" (p. 5), the Construction Research and Innovation Strategy Panel (CRISP) (1997), on the other hand, viewed innovation as "the successful exploitation of new ideas, where ideas are new to a particular enterprise, and are more than technology related – new ideas can relate to process, market or management" (p. 5). Counteracting this view, Toole (1998) defined innovation as the "application of technology that is new to an organization and that significantly improves the design and construction of a living space by decreasing installed cost, increasing installed performance and/or improving the business process" (p. 323). Likewise, the Civil Engineering Research Foundation (CERF, 2000) referred innovation to "the act of introducing and using new ideas, technologies, products and/or processes aimed at solving problems, viewing things differently, improving efficiency and effectiveness, or enhancing standards of living" (p. 3).

In general, there was consensus that innovation represents something new. In other words, it was the 'newness' of the idea itself that underpinned the starting point of innovation. Accordingly, an innovative firm would be an enterprise that invented or adopted innovation (Attewell, 1992; Knowles et al., 2008). This suggested that one of the minimum requirements for a firm to be regarded as innovative was its decision to 'adopt' the established innovation; even the firm was not participating in the process to 'develop' innovation (i.e., invention). Further, as noted by Sexton and Barrett (2003b), "the idea only has to be new to a given firm, rather than new to the world" (p. 626). It was the exploitation of an idea, which was perceived as new to the particular unit of enterprise, for innovation to be deemed to have occurred (Manseau & Sedean, 2001; OECD, 1997).

2.4 Innovation and firm size

Traditionally, one of the research priorities had been the relationship between innovation activities and firm performance. Following Schumpeter's works that initially viewed SMEs as the source of most innovation (Schumpeter, 1934), and later posited large established organizations as the genuine innovators (Schumpeter, 1950), much efforts had been given to test hypotheses regarding the specific effect of 'size' on innovation (see Rothwell, 1985, 1989; Rothwell & Dodgson, 1991; Nooteboom, 1994; Barnett & Storey, 2000; Edwards, Delbridge, & Munday, 2005; Freel, 2005; Hausman, 2005; Radas & Bozic, 2009; Rosenbusch, Brinckmann, & Bausch, 2011; Vahter, Love & Roper, 2014; Sarooghi, Libaers, & Burkemper, 2015). Such issue had received considerable attention given that the small firms' innovation was significant and distinct from that of large-firms' innovation (Acs & Audretsh, 1990). As the present study paid a special focus on SMEs, it was important to first clarify the definition of small or medium firms, as presented in the next section.

2.4.1 The definition of small or medium firms

It was widely known that the large majority of businesses within the construction industry worldwide fall into the category of SMEs. Nevertheless, extraordinary variation existed for the definition of 'SMEs'. In this view, it was important to note that the definition of an SME altered from country to country. In general, whether a firm was regarded as SME could be determined based on the firm's assets, its number of employees or its annual turnover. International and national bodies, for example, defined micro companies as employing fewer than 10 staffs; small as employing fewer than 50 staffs; medium as employing between 50 and 250 staffs; and, large as employing more than 250 staffs (e.g. European Commission, 2003; Small Business Service [SBS], 2003). In comparison, the threshold set in the USA was much higher than in a smaller economy, such as that of Australia. In this regards, the qualifying definition for a small business of construction category was $31million in annual receipts (US Small Business Administration, 2007). For Australia, the NSW government defined a 'small business' as a company having 20 employees maximum (N.S.W. Government, 2004). Similarly, Hall (1995) stated that, for Australia, an SME could be regarded as having less than 100 employees in the manufacturing sector and having less than 20 employees in the services sector. Meanwhile, the ABS (2006) generally defined firm having less than 20 employees as a small business and firm having less than 200 as a medium business. Additionally, a 'micro-business' was defined to be less than five employees. As compared to European Union, the definition of SMEs in China was generally larger in size and varies by industry. For the construction industry, a small firm was defined as business having RMB 3 to 60 million of assets while a medium firm was defined as business having RMB 60 to 800 million of assets (Ministry of Industry and Information Technology [MIIT], 2011). As in Malaysia, service businesses employing not more than 50 full-time employee or annual sales turnover not exceeding RM5 million were regarded as SMEs (National SME Development Council, 2005). In the present study, the definition of SMEs given by National SME Development Council (2005) was adopted because it comprised the jurisdiction of the research undertaken.

2.4.2 The distinctiveness of small businesses (or SMEs)

Throughout the innovation literature, it was important to note that firms being categorized as small businesses (or SMEs) innovated differently from those large organizations. This was due to their dissimilar features in a variety of aspects. With innate weakness, such as "liability of smallness" (Aldrich & Auster, 1986), or "liability of newness” in start-ups (Stinchcombe, 1965), small firms were noticeably differ from their larger counterparts in the case of resources. Limited degree of financial capacity, which was common in small businesses, suggested their inability to capitalize on innovative opportunities that could be very risky and costly (Davis, Hills, & LaForge, 1985; Sivades & Dwyer 2000). However, small firms demonstrated an efficient undertaken of innovation of more ad-hoc and informal nature (Nooteboom, 1994), such as the focus on incremental innovations and engagement of more than one type of innovation (Comacchio & Bonesso, 2007). They tended to act as development-oriented innovators as opposed to larger innovators that were more research-minded (Santarelli & Sterlacchini, 1990).

Also, small businesses had indicated a better responsive ability to adapt to rapidly changing environmental needs, and therefore, known to compete effectively with larger firms (Raju, Lonial, & Crum, 2011). From a market-oriented perspective, the small businesses owners usually had more operational expertise, which, integrated with great customer knowledge, could become impetus of innovative solutions over time (Dahl & Moreau, 2002). As such, small firms could outsource the resources required for innovation via their external networks (Nooteboom, 1994; Olson, Walker, & Reukert, 1995; Sivades & Dwyer, 2000; Gronum, Verreynne, & Kastelle, 2012). Such networks were often established in the forms of collaborations, joint venture, alliances (Comacchio & Bonesso, 2007), and also partnering in international value chains (Gassmann & Keupp, 2007). Yet, such ability of exploiting external contacts was regarded as weak by some other authors due to the parochial nature of small firms

(Hausman & Fontenot, 1999; Srinivasan, Lilian, & Rangaswamy, 2002).

For less innovative firms, often the larger firms, the most notable impediment to innovation was bureaucratic rigidity that concerning with top management isolation, intolerance of fanatics, short time horizons, excessive rationalism, excessive bureaucracy and inappropriate incentives (Quinn, 1985). In adverse, the less bureaucracy and clannish structures (Sivades & Dwyer, 2000) explained a greater agility and flexibility in firms of smaller size (Chen & Hambrick, 1995). Accordingly, some scholars had associated the motivator/barrier to small firms' innovativeness with characteristics of owner/manager, in that the entrepreneurial personality was of paramount. As decision-making were closely held by owner/manager (Dyer & Handler, 1994), the manager/owners had the necessary power to assure quick decision-making and undertaking of innovation activity in response to marketplace conditions (Sexton & Barrett, 2003b). On contrary, manager/owners with risk-averse and conservative attitude (Donckels & Frohlich, 1991; File & Prince, 1996) would reject the advice and suggestions of others and unwilling to delegate authority to employees, which attributed to reduced innovativeness in SMEs (Dyer & Handler, 1994).

In reviewing the preceding literature, small businesses characterized with family-owned nature were also associated with high tendency of risk aversion (Sethi, Smith, & Park, 2001). Most often, family business tended to have a focus of dreams, plans and fears for the future (Dodd, Anderson, & Jack, 2013). As strategic decisions were often underpinned by family and individual goals, rather than maximization of firm potential, these firms tended to reject changes to avoid any concomitant conflict (Davis et al., 1985; Donckels & Frohlich, 1991; Dyer & Handler, 1994). Other characteristic features, such as less developed education and training (Romano, 1990), unwillingness to delegate authority to others (Dyer & Handler, 1994), limited capacity to conduct in-house R&D (Hausman, 2005), supported the controversy that small firms were having difficulty to pursue innovation. Accordingly, they were often less adapted to changes in the economic, technological, or competitive markets (Drozdow & Carroll, 1997; Gallo & Sween, 1991).

In sum, the small businesses (or SMEs) and large organizations were noted as diametrically opposite entities with regard to their wide variations of firm characteristics. Given the lack of internal resources, the small or medium firms were frequently perceived to have weaker capacity to undertake innovation activities that required substantial investment. Further, they often had little market influence and entirely different governance structure as opposed to major corporations. Among the plethora of innovation studies, Rothwell (1985) asserted that the large players tended to display an innovative advantage mostly in material or resources while the small businesses were conferred with behavioural advantages. Likewise, Lennerfors (2013) championed the role of small, appropriate technologies in empowering people, in contrast to the phrase of "bigger is better". Accordingly, different views on innovation, in relation to firm size, were relatively abundant in the literature. While some scholars argued that small firms were as innovative as larger organizations despite their scale disadvantages (see Rothwell & Zegveld, 1982; Pavitt, Robson, & Townsend, 1987; Oakley, Rothwell, & Cooper, 1988; Acs & Audretsch, 1990), other studies refuted this claim by questioning the true value of their innovations (Tether, 1998; Tether, Smith, & Thwaites, 1997). After all, all these contentions implied a need to consider the firm size to appropriately advance the understanding on innovation in any industry context.

2.4.3 The effect of firm size on construction innovation

In construction field, research had demonstrated that there was unlikely one best way to manage innovation. To this end, the management of construction innovation would encompass all activities that aimed to exploit ideas successfully (Drejer, 2002). As such, varying processes and outcomes of innovation necessitated different ways of management (Slaughter, 1998; Tidd, 2001; Winch, 1998). Furthermore, it entailed the reinforcement of the capability as well as willingness of a firm to innovate (Hartmann, 2006a). Beyond these lines of analyses, it had been noted that the management of construction innovation varied considerably in firms of dissimilar size (Pries & Doree, 2005). For both the small and large firms were fundamentally different, yet, important entities (Sexton, Barrett & Aouad, 2006), an understanding on their innovative patterns was important for better legitimization of government initiatives and corporate guidance as to stimulate innovation across the industry. The next section presented a selection of literature that particularly drawn on different scale of firm size, either large or small, to explore the logic of innovation in the construction.

2.4.3.1 Some studies on construction innovation and the large organizations

Various scholars had depicted the nature of innovative practices on large players and iconic projects with systemic innovation. For instance, Slaughter (1993a) observed that large-scaled contracting firms were important source of innovation to a large extent than originally recognized. As noted by Cleff and Rudolph-Cleff (2001), contractors employing 200 or more staffs were largely innovative in either product or process developments. Additionally, these parties were mediators in the interface between those that developed new products and processes (i.e., materials and components suppliers, specialist consultants and trade contractors) and those that adopted these new ideas (i.e., clients, regulators and professional institutions) (Winch, 1998).

Across five groups of largest contractors located at Germany, Sweden, Denmark, France and UK, Miozzo and Dewick (2002) indicated that diverse types of innovation activities in firms were strategically related to the corporate governance. In specific, the divergence in corporate governance structures, such as ownership, finance, organizational and management structures, and mechanisms of knowledge diffusion, gave rise to a function of differences in the innovation pattern of the firms. In integration with R&D investment, specific structure of corporate governance would secure optimal condition for developing new construction process and final products. In line with the works of Gann (Gann et al., 1998; Gann & Salter, 2000), the authors also observed the pivotal role of government as significant in encouraging the large contractors to nurture long-term linkages with external knowledge sources, therefore resulting in their active engagement in innovative projects.

Via a matrix of R&D strategies, Acha et al. (2005) indicated that the management of technological development was only workable when firms adapted to episodic learning. For project-based organizations, episodic learning was referred to the routine of integrating lessons from episodes of projects into longer-term establishment of firms (Davies & Brady, 2000). Such mode of learning came in three types—project-to-project exchange (P2P), project-to-business (P2B) and business-to-project (B2P). Given that R&D activities were embedded inside firms and project teams, how firms develop meta-routines to effectively tap their leaning capabilities were strongly related to the businesses as a whole. Developing and integrating capabilities in staffs, establishing a dual career structure, winning complex projects, using high profile projects, integrating diverse parts of firm via networks, offering incentive for communities had all been suggested to favour the management of R&D as well (see Figure 2.2).

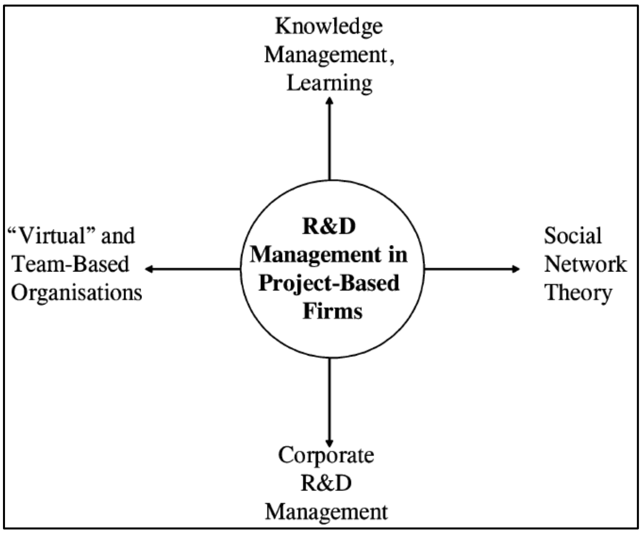


Figure 2.2: At a convergence in the literature (Acha et al., 2005, p. 259)

Using "project" as unit of analysis, Dulaimi, Nepal and Park (2005) specifically explored the champion behaviour of project manager (PM) in relation to level of innovation and project-based performance. The proposed hierarchical structural model ascertained that in large- or medium-sized projects, the PM was playing a multi-faceted role in championing the innovative practices on site. In this regards, the PM must possess some competency and professionalism, sufficient resource supply and delegation of autonomy and decision authority. Adequate resources and support from senior management would aid in creating conducive environment for construction projects (Ling, 2003; Dulaimi, Ling & Bajracharya, 2003). The finding also suggested that innovative practices could improve the organizational effectiveness and lead to long-term benefits for the firms.

With respect to large contracting firm, Hartmann (2006a) developed a managing framework (see Figure 2.3) that structuring the most relevant context variables of innovation. Based on a typical contracting firm that employed approximately 1,000 staffs, the framework suggested that both environmental and instrumental variables as crucial to depict innovation performance of contracting firms. The environmental configuration included both external and internal context. Variables of the external environment encompassed procurement form, client's acceptance on innovation and regulation degree. Variables of the internal environment included service offer, knowledge strength, cooperative behaviour, financial strength and time need. Based on that, the innovation management was instrumentally fostered by the culture (explicitly advocating innovative ideas), strategy (concerning the direction of innovation), structure and processes (providing methodological and hierarchical supports) and specific measures (having well-established service units and portfolio-based project checkpoints) in the firm. Firm could assess whether an innovation had performed well by evaluating these context-related variables with attractiveness and strength of the innovation (Hartmann, 2006a).

In another vein, Brochner (2010) reported a need to study innovation in a mix of technological and non-technological trajectories (see Figure 2.4). The author observed that the intensity of material, informational, methodological, contractual or relational innovations was influenced by various types of activities undertaken by the large-scaled contractors. Similar to earlier works (Ball, 1996; Gann & Salter, 2000; Lim & Ofori, 2007), most of the large firms had been found to engage in R&D, and additionally, cultivating a higher intensity of innovation via collaboration with peer competitors. On the other hand, recruitment of employees with high degree of education was found to spur the non-technological innovation, particularly the relational variety. Notably, the author criticized the earlier studies that narrowly focused on the technological innovation; a broader perspective was needed to completely reveal the innovative trajectories in the construction industry.

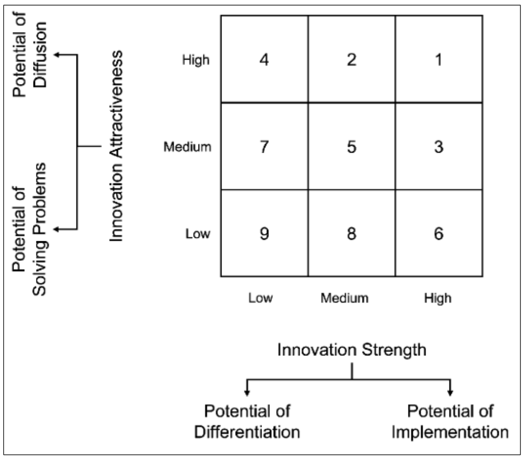


Figure 2.3: Portfolio used to evaluate innovation performance (Hartmann, 2006a, p. 576)

More recently, Davies and Harty (2013) probed into a specific type of project-based innovation, that was, Building Information Modelling (BIM) on a large hospital construction project. In the case study, the main contractor had developed various BIM-enabled tools to permit an innovative use of the technology. For instance, site workers used mobile tablet personal computers to gain access to design information as well as to capture work quality and progress data on-site. Accordingly, the potential benefit of the on-site use of BIM tools was accrued further by the actively supporting users. The findings also suggested that technical IT skills were transferred to the project via personal relationships and arrangements rather than formal processes. Instead of the corporate IT function, the technology transfer was pushed forward by construction project employees (Davies & Harty, 2013).

Level of R&D and innovation	Trajectory			
	Material	Informational	Methodological	Contractual or Relational
R&D	19	19	28	17
Innovation new to the firm	15	13	16	10
Innovation new to the country	8	4	6	4

Figure 2.4: Level of R&D and innovation among surveyed contractors by trajectory (Brochner, 2010, p. 242)

In general, it was beyond dispute that the burgeoning researches on large construction firms, like the manufacturing literature on most large corporations, shown a proclivity to concatenate the innovation with structured approach of management. Further, the role of R&D had also seen as important for these firms to develop competitive advantage. Importantly, these research studies had offered paramount contributions to advance the understanding on innovation in the construction field. Nonetheless, the research models which were designed specifically for large-scale organizations might have different meanings in an SME context. In this view, the next section presented the prior works on innovation engaged by the small construction firms in particular.

2.4.3.2 Some studies on construction innovation and the small firms

According to Lim and Ofori (2005), a vast portion of small businesses presented in an industry might result in stronger competition, which potentially drove firms to be more vigilant with regard to innovation. As Utterback (1974) observed, "in mature industries, such as textiles, machine tools, and construction, innovation is more likely to come from smaller, new firms than from older, larger firms, as well as from firms in other industries" (p. 659). Paradoxically, others (Betts & Ofori, 1992; Reichstein et al., 2005) argued that the small firms were likely to find more factors hampering innovation than the larger counterparts. In order to shed more lights on the controversies, a few groups of authors had specifically focused on the small construction firms that managed to overcome their scale disadvantages in order to pursue innovation.

One of the earlier innovation studies on small construction firms were the qualitative works conducted by Sexton and co-authors (Sexton & Barrett, 2003a, b; Barrett & Sexton, 2006; Sexton et al., 2006; Lu & Sexton, 2006). By synthesizing the innovation literature of small business context, Sexton and Barrett (2003a) proposed a generic innovation model (see Figure 2.5) for small firms those characterized with project-based construction nature. In specific, any successful innovation outcome (enhanced performance) was realized through the firms' appropriate focus on innovation

(innovation focus), possession of though and action capabilities (organizational capabilities for innovation), and strategic exploitation of market opportunities using internal resources (context of innovation), all of which shape the innovation process that eventually generated the final outcomes. Altogether, the authors set out several research questions that served as important basis for further investigation.

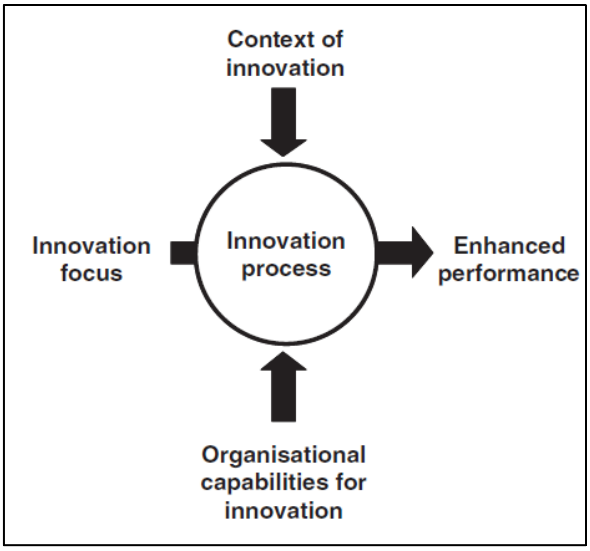


Figure 2.5: Generic innovation model (Sexton & Barrett, 2003a, p. 614)

Extending the earlier work (Sexton & Barrett, 2003a), the same authors (Sexton & Barrett 2003b; Barrett & Sexton, 2006) remarked that the capabilities of small firms to undertake innovation lie in the firms' given environment, interaction environment, business strategy/market positioning, technology, people and organization of work. Given their comparative deficiency of market and resource buffers, the innovation activities of firms dynamically steered across three stages: survival, stability and development (Sexton & Barrett, 2003b). Further, the progression of the stages was not rigidly linear, but cyclical in nature (Barrett & Sexton, 2006). Accordingly, the owners needed to emphasize innovation based on a balance context of market-led and resource-based conditions. Such an observation endorsed the general literature that small firms were more agile and responsive to the external environment, as opposed to the larger firms (Rothwell, 1989; Nooteboom, 1994; Rothwell & Dodgson, 1994).

In a single case study, Lu and Sexton (2006) had also extended the earlier work (Sexton & Barrett, 2003b) to provide insight for small construction knowledge-intensive professional service firms (SCKIPSFs). A knowledge-based innovation model (see Figure 2.6) was devised to urge the senior management in building, linking and energising diverse form of capitals (i.e., relationship, human and structure) to form knowledge capital, from which successful business and project innovation will flow. To sustain both ‘project pull’ and ‘project push’ activities, a strategic and systemic investment and management of all the capitals was required to create an equilibrium innovative approach. Similar to Sexton et al. (2006), the authors addressed the need to recognize both small and large firms as different species of entities. Governmental intervention to promote innovation in both types of firms was challenged by the different emphasis of firms; the large firms tended to cohere with codification strategies (e.g. IT-based knowledge systems) while the small firms were more attuned to personalisation strategies (e.g. interaction practice) (Lu & Sexton 2006).

Another group of researchers were Thorpe and co-authors (Thorpe & Ryan, 2007; Thorpe et al., 2009). Among the SME residential builders who adopted innovative products and sustainable construction methods, Thorpe et al. (2009) observed that most of the innovations adopted were regarded as new to the ‘firm’ rather than the ‘industry’.

Further, SME builders' value-chain networks (such as business partners, clients, universities, government, industry association and others) acted as a knowledge repository for firms to draw knowledge about innovations. A similar finding was also reported by Manley (2008) that the implementation of innovation by small construction firms was more feasible with the use of external relationship-building strategies to access to complementary resources required for innovation. In effect, beneficial project outcomes were resulted from the project-based innovations in the small environment.

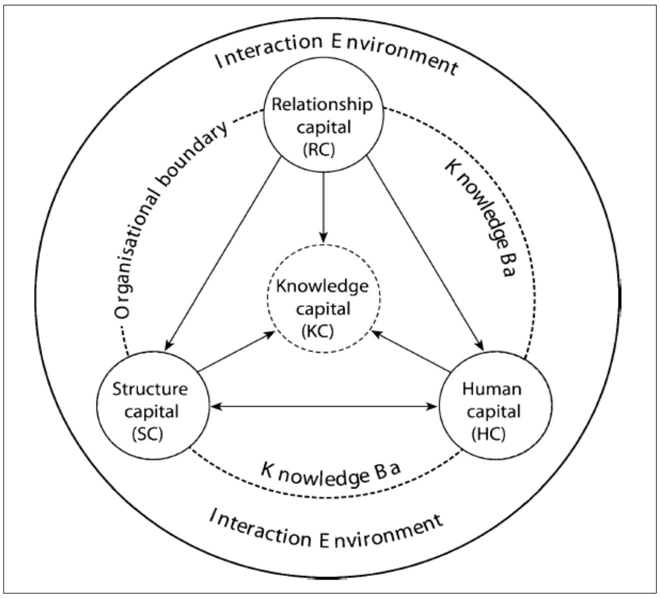


Figure 2.6: Knowledge-based innovation concept model for SCKIPSFs (Lu & Sexton, 2006, p. 1275)

Also, research works by Hardie and co-authors (Hardie & Manley, 2008; Hardie, Allen & Newell, 2013) identified on how SMEs performed as non-R&D-based innovators. For instance, Hardie and Manley (2008) observed the complementary role of organizational innovation and advanced business practices with regard to the implementation of technical innovation in construction SMEs. Further, the small firms needed to compensate for their liability of smallness by establishing diverse and extensive linkages with their peers. This view was similarly echoed by other SME scholars in the construction literature (Thorpe & Ryan, 2007; Manley, 2008; Thorpe et al., 2009; Rezgui & Miles, 2010). Meanwhile, Hardie et al. (2013) suggested that SMEs could deliver various types of technical innovations under supportive regulatory climate (e.g. performance-based building standards, subsidies, sponsored programs, etc.).

2.4.3.3 Construction innovation: Large vs. small firms

As aforementioned, it was supposed that the success of firms to capitalize innovation was explained by the size of the companies. In reviewing the construction literature, it was obvious that both the large and small construction firms innovated differently. Larger organizations often had sufficient resources and structured management systems, both of which, constituted the capacity to invest on R&D to develop innovations. The smaller firms (or SMEs), on the other hand, tended to hinge on distinctive capabilities to offset their resource restrictions towards innovation. As such, it was important to note that these studies had suggested the impact of firm size on the understanding of innovation in the context of project-based construction industry as well. The extant works on innovation had, as yet, paid very limited attention to construction firms of small size, as opposed to the large firms (Manley, 2008). The implication of innovation remained neglected within the small and/or medium construction businesses. Meanwhile, majority of the scholarly works had not distinguished between small, medium and large organizations and at large had simply controlled for firm size. A summary of management studies on construction innovation was presented in Table 2.2.

Table 2.2: A review on construction innovation (with respect to firm size)

Author(s), year	Firm size/ parties	Approach/ method	Location	Study's contributions and some highlights
Nam & Tatum, 1997	All size/ Client, consultants, contractors	Quali./ Case studies	US	Found that three factors—effective leadership (or entrepreneurship), technological competence, and delegation of slack resources and power—as essential for implementation of technological innovation. Surrounded the three factors, the study also suggested how design and construction firms could practically increase their technological innovation.
Winch, 1998	All size/-	Conceptual/ Synthesizing of literature	-	Proposed two management frameworks of innovation that addressing the impeding problem of innovation at two levels: institutional and firm. As in institutional level, the role of infrastructure, superstructure and system integrators were discussed. As in firm level, the study presented a two-moment model of innovation that comprised top-down and bottom-up approaches that were of equal importance in the trajectories of innovation process.
Slaughter, 2000	All size/-	Conceptual/ Synthesizing of literature	-	Captured the implementation of innovation in six stages: identification, evaluation, commitment, preparation, use and post-use evaluation. The study had also discussed the innovation types (i.e., incremental, architectural, modular, system and radical) and the associated managing strategies.
Miozzo & Dewick, 2002	Large/ Contractors	Quali./ Case studies	Five European countries	Observed the nature of certain characteristics of corporate governance (i.e., ownership, finance, management structures, organizational knowledge diffusion, and long-term linkage with external knowledge sources) in shaping strategic control over the incentives and abilities to undertake innovation and R&D activities.
Dulaimi et al., 2003	-/ Clients, consultants, contractors	Quanti./ Survey	Singapore	Theorized on organizational motivation and inter-organizational relationships, the study suggested that an innovative implementation occurs when there were effort, high expected goals, favourable results and high commitment in the projects. Incentives and participation of upstream and downstream parties were important to ensure the successful implementation of innovation.
Seaden et al., 2003	All size/ General and trade contractors	Quanti./ Survey	Canada	Developed a conceptual model that replicated the strategic decision-making of innovation around four variables: business environment, business strategy, innovative practices and business outcomes. Certain business environment and strategies were strongly linked to firm innovativeness, as observed in new approaches applied in ICT and advanced business practices.

Table 2.2, continued

Author(s), year	Firm size/ parties	Approach/ method	Location	Study's contributions and some highlights
Sexton & Barrett, 2003a	Small/ -	Conceptual/ Synthesizing of literature	-	Proposed a generic model to structure a holistic understanding as to improve innovation performance of small firms. Eight gaps were identified around five aspects of theme: innovation focus, innovation process, context of innovation, organizational capabilities for innovation, and innovation outcomes.
Sexton & Barrett, 2003b	Small/ Contractors & Consultants	Mixed/ Case studies & action research	UK	Underlined the motivation to innovate went after a fluid hierarchy of survival, stability and development. Firms could nurture their capabilities via integration of firms' business strategy, organization of work, technology and people. With appropriate focus between market-based or resource-based innovation, the owners could trigger innovation activities.
Whyte, 2003	Large/ All actors	Quali./ Case studies	US & UK	Investigated how project size and extent of innovation reuse across projects affected the innovation adoption within the construction sector. The framework of different types of projects influenced the adoption of an innovation; large unique projects and/or on many small projects with design reuse favoured the use of innovation.
Ling, 2003	All size/ Client, consult. & contractor	Quanti./ Survey	Singapore	Suggested four enabling factors of innovation: the level of interest of project team members, working environment, formation of task groups and capabilities of people involved in the innovation.
Dulaimi et al., 2005	Large and medium/ General contractors	Quanti./ Survey	Singapore	Proposed a hierarchical structural model to investigate the role of project manager (PM) in influencing the level of innovation and project performance. It was highlighted that the championing role of PM were complemented with competency and professionalism, tactical use of influence tactics and decision authority. Adequate resources and support from senior management would aid in creating conducive environment for projects.
Pries & Doree, 2005	All size/ actors, except clients	Conceptual/ Meta-analysis of past studies	Dutch	Tracked the changes of level of innovation, the study found that incremental and process-oriented innovations dominated the type of innovation used in practice. Innovation was observed to be an inter-organizational approach, and in this regard, the small and large firms innovated differently.

Table 2.2, continued

Author(s), year	Firm size/ parties	Approach/ method	Location	Study's contributions and some highlights
Reichstein et al., 2005	All size/ Manufac., services, construct.	Quanti./ Survey	UK	Contrasted the attitude of firms of different sectors on innovation. It was found that the liabilities of immobility and unexpected demand were the two key distinguishing features that explain the innovative behaviour in construction. The study revealed that innovation of construction was underperforming compared to manufacturing.
Acha et al., 2005	Large/ Engineer. consultants	Quali./ Case studies	-	Developed a matrix of R&D models to aid in the assessment of choices to organize R&D for the establishment of organizational memory and capability. It was argued that new models of decentralized R&D were conducive for project-based environment to combine flexibility and integration of meta-routines long-term.
Hartmann, 2006a	Large/ Contractors	Quali./ Case studies	Swiss	Devised a framework of innovation management to reveal the impact of instrumental, external and internal environment on innovation performance. Successful management of innovation need to consider interrelated reactions and interactions of firm's environment.
Barrett & Sexton, 2006	Small/ Contractors & Consultants	Mixed/ grounded theory and case studies	UK	Observed that typical innovations were closely tied to firms' operations that deal with very scarce of resources. Firms took up established technologies by 'learning on the job' and the degree of innovativeness depended on the stability of the firms. The role of owner, the emphasis on niche markets and the limited slack resources would influence the innovation activities which were to be in parallel with normal business.
Manley & Mcfallan, 2006	- / All actors	Quanti./ Survey	Australia	Developed a model of firm-level innovation process that comprised of three components: business environment, innovation and business strategies. Through a range of strategies (i.e., human resource, technical and marketing), firms in road industry could capitalize on opportunities of environmental disadvantages and successful in adopting technologies.
Sexton et al., 2006	Small/ General & specialist contractors	Quali./ case study	UK	Stressed the transfer of technology occurs if only it could fit into business in a quick and tangible way. The large and small firms, with difference in organizational capabilities, innovated differently. Small firms could only manage new technologies that involved low financial investment and low degree of risks.

Table 2.2, continued

Author(s), year	Firm size/ parties	Approach/ method	Location	Study's contributions and some highlights
Manley, 2006	-/ All actors	Mixed/ Survey and case studies	Australia	Suggested two major drivers of product- or process-related innovation: client needs and crises during project. Further, innovation was maximized via enhanced links with leading-edge clients and value-based tender. Related businesses and employees would complement in-house knowledge of innovation.
Lu & Sexton, 2006	Small/ Architecture firm	Quali./ 22-month single case study	UK	Proposed a knowledge-based innovation concept model, the study identified four variables distinctive for explorative and exploitative innovations: human, structure, relationship and knowledge capital. Exploitative innovation (i.e., new refinement and efficiency activities) was the principal source that generates sustainable competitive advantage as opposed to explorative innovation (i.e., new search, variation, experimentation, flexibility and discovery).
Habets, Van Der Sijde & Voordijk, 2007	All size/ All actors	Quanti./ Survey	Netherlands	Proposed an entrepreneurship in networks model to investigate the adoption of new production technologies in four dimensions: strategic, economic, cultural and social capital. The characteristic of perceived innovation and features of adopter were found to affect the technology adoption.
Thorpe & Ryan, 2007	SMEs/ Residential builders	Quali./ Case studies	Australia	Identified that the small builders were quite innovative in order to respond to clients' requirement and to achieve an outcome of industry leadership. The groups of firms viewed positively on the sustainable practices of design and construction processes, which mean they had committed to innovation for long-term gains. Government assistances were required to aid them in shaping environment conducive to innovation.
Hardie & Manley, 2008	SMEs/ Contrac-tors	Quali./ Case studies	Australia	Observed some network-based factors to underpin high level of innovation: close relationship with industry and professional bodies, as well as active networking with the general industry, research bodies and regulators. Notably, the study found that organizational innovation would support and enable the implementation of technical innovation.
Manley, 2008	Small/ Contra. & Consult.	Quali./ Case studies	Australia	Investigated the enablers of project-based innovation: work with advanced client, build up relationship with external partners and acquire patent for innovation. Understanding the typology context of innovation was important for building up the appropriate managing strategies. The government inefficient assistance and regulation had largely hindered innovation.

Table 2.2, continued

Author(s), year	Firm size/ parties	Approach/ method	Location	Study's contributions and some highlights
Thorpe et al., 2009	SMEs/ Residen-tial builders	Quali./ Interviews	Australia	Investigated the type of innovation, as well as drivers and results of adopting innovations in small residential builders to ascertain how innovations were developed or adopted by these firms. Both technical and non-technical innovations were used to bring beneficial outcomes to the firms in various terms. Rather than exogenous R&D, firms used their external supply-chain relationship and broader industry association to outsource for knowledge required in innovation.
Brochner, 2010	Large/ Contrac-tors	Quanti./ Survey	Sweden	Observed 17 types of activities for influencing the intensity of four innovation trajectories: material, informational, methodological, contractual or relational. The most dominating innovation was the material trajectory that was "new to the country"; the less implemented innovation was the methodological trajectory. Firms involved in R&D to cultivate a higher intensity of innovation via collaboration with peer competitors.
Salunke et al., 2011	Large & medium/ project firms	Quali./ Case studies	Australia	Developed an innovation-based competitive advantage model to identify how entrepreneurial firms pursued innovation-based performance. Organizational capabilities (i.e., episodic learning, relational learning, client-focused learning and combinative capability) impacted on how firms create, extend and modify processes for greater innovation and sustained competitive advantage.
Gambatese & Hallowell, 2011a	All size/ All actors	Quali./ Case studies	US	Identified factors that affecting innovation on projects: owner influence, presence of innovation champion, upper management support, knowledge management, R&D, organizational climate and structure. These factors were to be optimized with three components of innovation: idea generation, opportunity and diffusion to successfully achieve cost, quality, schedule and safety goals.
Pellicer et al., 2012	Medium/ Contractor	Quali./ Single case study	Spain	Proposed a standardized innovation model to identify the drives, success factors, benefits and barriers of achieving innovation. The study suggested that through systematic process, both technical and non-technical innovation could be managed and lead to organizational improvement, better organizational problem-solving, increased technical capabilities, knowledge management, business profit and client satisfaction.

Table 2.2, continued

Author(s), year	**Firm size/ parties**	**Approach/ method**	**Location**	**Study's contributions and some highlights**
Salunke et al., 2012	Medium/ Project-oriented firms	Mixed/ Interview & survey	UK & Australia	Proposed a service innovation-based conceptual model to demonstrate how firms with entrepreneurial spirit strategically used bricolage to innovate and gain sustained competitive advantage. The study specifically suggested that both interactive and supportive innovation activities as relevant to the project-oriented firms.
Toole et al., 2013	-/Engineering -procurement-construction firms	Mixed/ Survey and case studies	Austin	Developed a maturity model tool to aid in the evaluation of the innovation achievement of firms using eight criteria of strength and weakness: culture, resources, risk, customer, learning, collaboration, leadership and processes. To increase innovation, organizational leaders needed to shift toward an innovation-based perspective. Firms also needed to commit to repeatable processes and resource allocations.
Hakansson & Ingemansson, 2013	All size/ General contractors	Mixed/ Interviews and Survey	Sweden	In an inter-organizational setting, it was argued the problematic issue of using "innovation" to define the concept of changes, and propose "renewal" to identify enabling and impeding factors to construction renewal. The strong project focus, and lack of knowledge transfer between individual project and actors were key hindrances to renewal activities.
Hardie et al., 2013	SMEs/ Building contractors	Quanti./ Survey	Sydney	Focused on construction firms with an environmental focus, the study developed a value tree to examine factors (i.e., company resources, client and end-user influences, project-based conditions, industry networks and regulatory climate) significant for these innovators. Through analytic hierarchy process, the findings shown that the regulatory environment was the most crucial factors to enable a technical-based innovation delivery by SMEs.
Bygballe & Ingemansson, 2014	All size/ All types of actors	Mixed/ Survey and structured interviews	Norwegian and Swedish	Drawn on an industrial network perspective, the study proposed an analytic model to address the logic of innovation in construction. The findings showed that new solutions need to be transferred between project, company and industry levels for the realization of innovation. A balance was needed for the innovation behaviour in terms of inter-organizational relationship and exploration- exploitation orientation.

2.5 Innovation in small construction firms: Highlighting certain gaps

Continuing Sexton and Barrett's (2003b) reasoning that "small construction firms have their own distinctive characteristics which are profoundly different from those of large construction firms" (p. 623), this section aimed to provide a new direction toward better understanding of SMEs out of the existing literature. Thus far, empirical findings addressing construction innovation in the small and/or medium environment had been fragmented and ambiguous (see Table 2.3). It was fragmented to the extent that they were falling short of exploring the interacting effects between some important factors, such as capabilities, innovation and performance. It was ambiguous in the emphasis on technological (also known as technical) innovations, without regard to other types of innovations that were deemed to be important to the small and/or medium businesses.

Nonetheless, the unsolved issues had inspired new insights that in turn directing the research work in the present study. First, most studies suggested that organizational capabilities could trigger innovation activities that in turn lead to some beneficial outcomes in the small and/or medium construction firms. However, no studies had investigated the extent of the interacting effects within the structure of capabilities-innovation-performance. Second, the existing works reflected a bias on the use of technological-based metrics to measure innovation in construction firms, including the small and medium ones. Accordingly, studies that either addressing on 'organizational' innovations or integrating both technological and organizational innovations in a single model were rather limited. Also, it was observed that the research methods used dominates on qualitative-centred approaches, such as case studies and interviews. Based on the above notions, the literature remained relatively immature toward both the understanding of, and therefore, the approach to manage innovation in the small and medium construction firms. In this view, the present study contended that advances could be made in the above mentioned issues.

Table 2.3: A summary of studies on innovation in the small construction firms

Author(s), year	**Innovation**		**Conceptualization/ measurement of innovation**	**Approach/ method**
	Associate with capabilities	**Associate with outcome/ performance**		
Sexton & Barrett, 2003a	✓	✓	Technical and administrative	Conceptual/ Synthesizing of literature
Sexton & Barrett, 2003b	✓	✓	Technical and administrative	Mixed/ Case studies
Barrett & Sexton, 2006	✓	✓	Technical and administrative	Mixed/ Case studies
Sexton et al., 2006	✓	×	Technological and organizational	Quali./ Case studies
Lu & Sexton, 2006	✓	✓	Explorative and exploitative	Quali./ Single case study
Thorpe & Ryan, 2007	×	✓	Technical product and process	Quali./ Interviews
Manley, 2008	✓	✓	Technological product	Quali./ Case studies
Hardie & Manley, 2008	×	✓	Technological and organizational	Quali./ Case studies
Thorpe et al., 2009	×	✓	Product, process and organizational	Quali./ Interviews
Rezgui & Miles, 2010	×	✓	Technical ICT	Quali./ Case studies
Hardie et al., 2013	×	×	Technical products	Quali./Interviews

2.5.1 Association of innovation with capabilities and performance

In the context of small and/or medium firms, it was generally regarded that internal capabilities of firms would potentially lead to a final success of innovation. In this connection, it was important to note that there were three key terms used in these earlier works—1) organizational capabilities, 2) innovation and 3) performance—as uncovered in the forthcoming sections.

2.5.1.1 Some studies on innovation and its antecedent capabilities

According to Prahalad and Hamel (1990), capabilities referred to the capacity of a firm to, in a combinative manner, deploy and coordinate different resources through employing its organizational processes as to affect a desired end. Similarly, Amit and Shoemaker (1993) regarded capabilities as organizational processes that were developed over time upon complex interactions among the firm's resources, and therefore, were firm-specific. Accordingly, capabilities were often equated to core competencies of firms (Prahalad & Hamel, 1990). In specific, they were valuable, rare, inimitable and non-substitutable (Barney, Wright, & Ketchen, 2001). In connection to innovation, Burgelman, Maidique and Wheelwright (1996) defined capabilities as "the comprehensive set of characteristics of an organization that facilitate and support innovation strategies", (p. 8). In consensus, Sexton et al. (2006) pointed out that capabilities, which came from the company itself, serve as a motivating platform to innovation. To ensure the effective implementation of an innovation, firms needed to minimize the constraint conditions while maximizing their organizational capabilities (Gann, 2000; Dulaimi et al., 2002).

According to Sexton and Barrett (2003a), two key capabilities, namely thought capabilities and action capabilities, underpinned effective implementation of innovation by small construction firms. The former referred to the ability to keep balance between concentrating on short-term efficiency and being receptive to changes needed for long-term improvement while the latter supported and translated the cognitive intent into organizational action. To fuel both the capabilities, Chaston, Badger and Sadler-Smith (1999) further viewed learning as important to encourage a firm to innovate. A learning-based capability would strengthen SMEs with an ability to better and quicker respond to market cues than their competitors (Prieto & Revilla, 2006). Moreover, such capability allowed SMEs to recognize new strategies and channels to work tighter with their customers (Sok & O'Cass, 2011), and constituted critical source for superior performance (Chaston, 2012). A similar notion was endorsed by Barnett and Storey (2000) who asserted that small innovative firms had a proactive approach to learning, and took the holistic standpoint that learning was a vital element of their long-term evolution and competitiveness.

Research by Sexton and Barrett (2003b) highlighted five types of capabilities as critical to make up successful innovation in small consultancy and contracting firms. They were business strategy (overall purpose and direction of firm; financial viability), market positioning (orientation towards desired target markets), people (staff members' possessing knowledge, skills and motivation), technology (machines, tools and work routines to transform inputs into outputs) and organization of work (creation and co-ordination of project teams, and intra- and inter-organizational networks). Due to their smallness, firms were more agile to respond to their external business environment by stressing the ‘soft-focused’ capabilities to create, manage and exploit innovation (Sexton & Barrett, 2003b). A similar notion was also suggested by Sexton et al. (2006) that the strategic direction and external business context of firms needed to be coupled with organizational capabilities to ensure a transfer of new technology in small construction firms.

In line with Schumpeter’s notion, Barrett and Sexton (2006) noted the persistence in entrepreneurship as a prerequisite for innovation in small consulting and contracting firms. According to Schumpeter (1950), innovation was regarded as an outcome of “entrepreneurial behaviour”. The managerial strength exercised by the principals of firm substantiated the direction and implementation of strategy in small businesses (see Storey, 1986; Dodgson & Rothwell, 1991). In particular, the process through which a construction company decided to adopt an innovation frequently depending on the action of a ‘champion’ (Quinn, 1985; Nam & Tatum, 1997; Slaughter, 2000) to lead the innovation along. Especially when the firm was small in size, the final success of innovation was proportionally greater when the owner was close to the innovation process (Manley, 2008; Thorpe et al., 2009). However, the lack of vision in the owner, who possesses the power to ensure quick decision-making, might stimulate adverse impact that inhibiting innovation activities of small firms (Barrett & Sexton, 2006).

Drawn on architectural practice, Lu and Sexton (2006) differentiated two types of capabilities—explorative and exploitative capabilities—to understand, connect and manage knowledge-based resources required for successful innovation. In line with the work of March (1991), exploitative capabilities were referred to resources that could be used to enhance organizational efficiency and acquire short-term competitive advantage whereas explorative capabilities involved the creation and utilization of novel resources and capabilities to enhance organizational effectiveness and acquire sustainable competitive advantage. Hence, different resources of a firm, such as relationship capital, human capital and structure capital, were highlighted to make up dynamic knowledge capital, altogether as essential to successful innovations (Lu & Sexton, 2006). Nonetheless, the empirical finding was qualitatively derived from a single case study of professional firm, and consequently, inconclusive to understand innovation nature in project-based firms featured with constructing basis.

According to the work of Manley (2008), small firms needed to examine their internal capabilities in terms of relationship, technology, marketing, knowledge and employee to practically success in introducing innovation on projects. Amongst all, it was indicated that the final innovation success, at large, relied on small firms' capability to establish linkage with their supply-chain partners and research actors. This was unsurprising finding given the similar research works founded in the literature (Hewitt-Dundas, 2006; Gronum et al., 2012; Lasagni, 2012). In this view, research by Liao and Welsch (2002) provided that the close proximity between the issues of network relations and SMEs was primarily a consequence of the resource deficiencies associated with the small size of the businesses. Likewise, Sexton et al. (2006) identified that the need to appropriately engage in network relations was crucial for small firms because they often lacked of resources and knowledge as to develop innovations on their own. However, it was observed that SMEs primarily engage in external links with the value chain partners and scarcely ever interacted with research organizations, universities, technology centres or any similar links (Toole, 1998; Sexton et al., 2006; Hardie & Manley, 2008; Hardie et al., 2013).

Clearly, the importance of capabilities had been long attested in the innovation literature. However, the SME scholars had not explored the potential impact capabilities had on innovation. This might be due to the ubiquitous use of qualitative approaches in the prior research works that limited the investigation from unlocking the causal linkage. Consequently, all these arguments called for further empirical analysis to explain the effect of organizational capabilities on innovation in construction SMEs setting. The next section presented the preceding literature those associated with the analysis on innovation and its outcome/performance.

2.5.1.2 Some studies on innovation and its consequent performance

Research stream on classical economics (Schumpeter, 1942; Schmookler, 1966; Freeman, 1989) had established a positive linkage between innovation and performance. In construction field, various scholars had similarly regarded innovation as a function to positive outcomes in construction projects and business firms. According to Sexton and Barrett (2003b), innovation was "the effective generation and implementation of a new idea, which enhances overall organizational performance" (p. 626). Later, Stewart and Fenn (2006) observed that innovation acted as a profitable exploitation of ideas that importantly contributing to competitive advantage of firms. In most cases, innovation was known to go along with the aim of achieving some sort of business advantage as to outperform the rivals (Salunke et al., 2011).

Over the years, substantial evidences indicated that innovation adopted by construction firms could lead to improved project performance (Madewell, 1986; Slaughter, 1998), reduced costs, enhanced functionality and sustainable market share (Seaden et al., 2003; Thomas et al., 2004; El-Mashaleh et al., 2006), as well as organizational competitive advantage (Salunke, Weerawardena, & McColl-Kennedy, 2011). For small construction companies, innovation was found to bring about better project performance (Hardie & Manley, 2008; Thorpe & Ryan, 2007) or organizational operations (Sexton & Barrett, 2003b; Barrett & Sexton, 2006). Overall, Slaughter (2000) observed that innovation in construction was seen to manifest its beneficial impact in two aspects: project criteria and company criteria (see Figure 2.7).

Project criteria	Company criteria
Cost	Reputation impacts
Long-term facility performance	Unique capability
Construction performance	New market
Duration (design, planning and construction)	Compatibility with and utilization of existing capabilities
Technical feasibility	Improvement of existing capabilities
Worker safety	Appropriability of benefits
Environmental impacts	Effective use of innovation
Risk of failure	Size of initial commitment
Implementation complexity	

Figure 2.7: Project and company criteria to evaluate innovation alternatives (Slaughter, 2000, p. 5)

In terms of project criteria, project-specific innovation was observed to enable small firms to be effective and efficient in delivering their services to meet current and/or future project needs (Lu & Sexton, 2006). Along with cost and time saving (Hardie & Manley, 2008), the innovation driven by small firms also provided significant project-based benefits in both safety and quality improvements (Manley, 2008). With regard to environmental impact and worker safety, Hardie and Manley (2008) revealed that innovation led to reduced use of scaffolding and less likelihood of worker injury on site. The increased performance in building facility, such as greater efficiency resulted from the use of lighter weight of new material and enhanced construction method, and improved liveability of housing, was observed by Thorpe and Ryan (2007).

In terms of company criteria, the works of Sexton and co-authors (Sexton & Barrett, 2003b; Barrett & Sexton, 2006; Lu & Sexton, 2006) identified the major outcomes of innovation activities within two aspects, namely, improved effectiveness and efficiency of firm. Additionally, Manley (2008) asserted that innovation could lead to good reputation and repeat business opportunities with same and related clients. Meanwhile, Thorpe et al. (2009) reported a number of positive consequences (see Figure 2.8), such as repeat use of innovation, increased external knowledge, spillover benefits of innovation to other firms, positive clients' response, improved business operation, competitive advantage, profitability, decreased organizational risk, exerted by innovation implemented by the small construction innovators. In another study, Rezgui and Miles (2010) noted that innovation could harness the firms with financial capability that enabled them move forward in an SME alliance.

Result of innovation	Number of firms
Need to make change in business operation	7
Helped firm gain competitive advantage	10
Positive effect on profitability	12
Positive response by clients	16
Decreased organizational risk	11
Benefited other firms or clients with which firm deals	16
Gaining increased knowledge to advantage of firm	20
Repeat use of selected innovation	20

Figure 2.8: Result of using innovation (Thorpe et al., 2009, p. 193)

Even if an innovation was effectively implemented, it was not guaranteed that the innovation would accrue positive returns to the firm (Dulaimi et al., 2002). On the contrary, the decision to innovate might even forcefully jeopardize the firm (Capaldo, Corti, & Greco, 1997). Hence, firms must be able to select the most appropriate technologies available to them, and having selected them, to fully make use of them (United Nations Centre for Human Settlements, 1995). Based on the above review, it was clear that exploring the linkage of capabilities with regard to innovation, as well as assessing the potential benefits from the innovation, might be a rich area to pursue. To do so, it was important to clarify the conceptualization of the term ‘construction innovation”, which was presented in the forthcoming sections.

2.5.2 The conceptualization of innovation: From manufacturing to construction

Anecdotally, the need to gear up the rate of innovation was evident in the construction industry. For many years, however, construction was accused as low-innovator (Bowley, 1960; Gann, 1994; Winch, 1998; Koskela & Vrijhoef, 2001), an industry of the old type (Landes, 1969) and extremely conservative (Rosenberg, 1982). In a meta-analysis, Reichstein et al. (2005) reported that construction had significantly underperformed in innovation, as compared to that of manufacturing. As such, it was often assumed that innovation happened more in high tech industries and less in low tech industries (Muscio, 2007). Importantly, questions aroused as to whether there were sector-based obstacles for promoting innovative culture in the construction industry? Or whether a less-innovative approach by construction companies was continuously biased by the measurement error?

Joining this line of argument, Toole et al. (2013) highlighted that the metrics used to measure the consequences and impacts of innovation were dominating the construction literature, yet, their practical application was limited. Often, the output variables synonymous with firms' innovation activities were the traditional science-based indicators such as R&D expenditures, number of R&D personnel or patentable products (Bygballe & Ingemansson, 2014). For instance, in several countries, the deficiency of new ideas and innovation in the construction had been accused to be rooted in its low rate of R&D activities (Egan, 1998; Building for Growth, 1999; Fairclough, 2002). The traditional metrics, however, had been recognized as inappropriate in explaining the nature of innovation in the construction industry (Winch, 2003). In other words, the applicability of the manufacturing-based theories to construction was doubtful. In the next section, some related issues were drawn to depict a clearer picture on how innovation was first originated from the manufacturing regimes, and being extended to the construction sector.

2.5.2.1 The manufacturing-based innovations

For more than half century (1930s to nearly 1990s), scholarly efforts had been unprecedentedly paid to the science-like knowledge to theoretically and empirically understand firm-level innovation. This was reflected in early model of innovation, which suggested the path of innovation as a linear sequence, initiated with invention and ends with diffusion (Herbig, 1994). Accordingly, it had been recognised that all firms' innovation activities as proxied by technological inputs, such as formal R&D effort, to result in final innovation (Cohen & Levinthal, 1990; Triguero & Corcoles, 2013). Basically, R&D referred to "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD, 1993, p. 29). In this view, much of the empirical investigations on innovation were drawn on information taken from large firms and R&D-intensive sectors (Cockburn & Henderson, 1998; Lane & Lubatkin, 1998; Narula, 2001; Rosenkopf & Almeida, 2003). Consequently, the research works tended to rely heavily on R&D-based strategies (e.g. Escribano, Fosfuri, & Tribo, 2009). Argued as the original source of innovation, the dominance of R&D in innovation literature had predominantly led policy-makers to equate innovation policy with R&D policy (Dosi, 1988; Freeman & Soete, 1997).

While science-like knowledge had continuously used to illuminate the practice of innovation in firms, the technological R&D efforts, however, had been challenged from different perspectives. For instance, research by Triguero and Corcoles (2013) refuted that R&D does not necessarily guarantee the final occurrence of innovations; the investment in R&D primarily relied on firm-level decisions, yet the final outcomes (i.e., successful innovations) were affected by other external factors (e.g. market dynamism). Likewise, Capaldo and Petruzzelli (2011) argued that firms involved in R&D depended on their inter-organizational relational capability to balance the needs of value creation and appropriability. More particularly, some recent studies had casted doubt on the inappropriateness in linking R&D variables with SMEs (Ortega-Argiles, Vivarelli, & Voigt, 2009; Raymond & St-Pierre, 2010). As noted by Rubalcaba (2006), R&D might be an indicator of innovativeness for all firms, including the SMEs, in sectors associated with intensive technological activities but worked limitedly in service firms. Similarly, Hervas-Oliver, Sempere-Ripoll and Boronat-Moll (2014) revealed that the SMEs' innovation strategy depending much on the external acquisition of knowledge source in that their pattern of innovation, and therefore, exhibiting a clear-cut discrepancy from that of R&D-based innovation strategies.

Stressing the shortcoming of the linear model, Albaladejo and Romijn (2000, p. 4—5) posited that "a substantial part of the learning may not take the form of well-defined R&D programmes and other formalized technological effort. Informal and incremental problem solving and experimentation take place on the shop floor and are closely associated with production. This is a fortiori the case in small companies that do not have the resources and organization to mount large R&D and human resource development programmes”. Moreover, for firms with low technology activities, there could be innovation without R&D (Dosi, 1988; OECD, 1997; Hervas-Oliver, Garrigos, & Gil-Pechuan, 2011). Generally, they utilized non-R&D-based activities—marketing, design and engineering capabilities, training and learning, development of new production facilities, and organizational investment and change—to perform as innovators (Dosi, 1988; OECD, 1997). As such, R&D effort was only one of the activities relating to innovation (Hervas-Oliver et al., 2011).

After all, it was important to note that sectors differing in terms of sources, pace, and rates of innovation as attested in Pavitt’s (1991) work on manufacturing, and Evangelista’s (2000) work on services. More precisely, the well-established conclusions derived from goods-centred sectors could be very much differed from those found in service-specific market settings (Damanpour, 1996). However, the scholarly and governmental efforts gave too much weight to the innovation processes connected to that of R&D and overlooked other ways that firms use to innovate (Arundel, 2007), despite that firms could innovate using a number of non-R&D-based approaches (Hervas-Oliver et al., 2011). The traditional concept of innovation was intended to be designed as manufacturing-specific, and controversially still applied a ‘manufacturing mind-set’ to innovation. As such, it might be problematic for studying industry, such as construction, and construction innovation.

2.5.2.2 Toward a better understanding of construction innovation

Innovation, as the theme of vigorous debate, had triggered a wide extent of, sometimes, conflicting definitions and measurements. While some scholars highlighted that innovation in construction was bound to technology developments that entailed investments in R&D activities (Nam & Tatum, 1992; Toole, 1998), conflicting views had been proposed in the sense that R&D measures could be misleading for they were only a small subset of innovation activities in the industry (Seaden & Manseau, 2001). Despite governmental and scholarly promotion of the role of R&D as crucial to construction innovation, a practical observation in several countries was that the industry generally scored low on R&D activities and that little firms took advantage of R&D-based programs provided by governments (Seaden & Manseau, 2001; Miozzo & Dewick, 2004). For instance, the Rethinking Construction report (Egan, 1998) in the UK and the Building for Growth report (1999) in Australia attributed the slow performance improvements of the construction to its low investment in R&D. Similarly, The Construct for Excellence report (Construction Industry Review Committee, 2001) in Hong Kong and Construction 21 report (Construction 21 Steering Committee, 1999) in Singapore urged the need for more R&D efforts to bring about advances in construction processes and technologies.

Notwithstanding these views, Nam and Tatum (1992) contended that even if the key resources essential for R&D were given, construction practitioners would not pursue technical leadership via R&D activities as the yielded new knowledge and technology could not be monopolized. According to Winch (1998), innovation could be developed from various sources of activities, like learning-by-doing that encompasses product and process improvements which aroused from the shop floor or the site, and thus, did not invariably require experts. Supporting this view, Gann and Salter (2000) asserted that innovation was often constituted by on site problem-solving, rather than exclusive deliveries of formal R&D and technical support functions. Much of the design and engineering works, undertaken by separate organizations, involved ‘R&D-like’ activities, i.e., creation of new knowledge, seeking of components and prototyping, as well as searching of new combinations from extant technologies (Reichstein, Slater & Gann, 2008). Yet, almost none of these activities were counted in the R&D statistics of construction industry (Reichstein et al., 2008).

Undoubtedly, the innovation paradigm originating from manufacturing industries was inherently valuable to the construction field. However, many aspects of construction varied from manufacturing (Nam & Tatum, 1997). Unlike the functionally organized firms where innovation was largely an in-firm problem, the construction companies had exclusively depends on the on-site production of temporal nature and highly dynamic project-based environment. Specifically, the firms in construction were endowed with a peculiar business background, i.e., the organizing of tasks around one-off projects, deliveries of specific services upon adaptable and flexible mechanism, and co-creation of outputs within a temporary coalition of varying business organizations. Altogether, these assertions suggested a hint to the unique feature of innovation processes in construction (Stewart & Tatum, 1988; Tatum, Bauer, & Meade, 1989).

After all, in traditional industries such as construction, there had been an increasing shift in managerial focus of innovation from an R&D-based effort to a more broadly innovative approach. As enlightened by NESTA's (2007) report, the practice of innovation in construction sector was, in many aspects, 'hidden' from the typical metrics applied to technology-driven industries. In a similar view, Manley (2008) observed that, for SMEs in construction sectors, the external interaction with established firms were more important for the final occurrence of innovation, rather than the ability to patent technologies. Considering these perspectives might assist in elaborating how innovation occurs across numerous boundaries and also why or why not it occurs. This was particular essential to appropriately advance the understanding on the logic of innovation in the construction industry (Bygballe & Ingemansson, 2014). In the next section, some related studies were presented to appropriately underpin the measure of innovation in the project-based setting of construction.

2.5.2.3 Some general studies on construction innovation

Following the work of Bowley (1960) who pioneered in noticing the two major types of innovations—those that changed the product and those that affected processes—the construction research on innovation had, since then, largely endorsed on technical advancement. For instance, five major technological innovations had been observed to lead substantial progress in construction projects and processes, and the industrial structure as a whole (Gann, 1994). These innovations were 1) Information technology (IT) in the construction process; 2) IT in building such as '"intelligent buildings"; 3) Mechanization of construction activities; 4) Prefabrication; and 5) New materials.

Also, Slaughter (1998) captured a series of product-based innovations with different radicalness (i.e., incremental, modular, architectural, system and radical innovations). The most predominant innovations were those of incremental nature (Gann, 1994; Koskela & Vrijhoef, 2001). They involved a marginally departure from existing practices and mainly reinforce the existing capabilities of organizations (Marquis, 1988; Henderson & Clark, 1990). In adverse, innovations of radical nature were the most uncommon as they involved a fundamental change that clearly displaces the existing practices in such way that they rendered the prior solution obsolete (Nelson & Winter, 1977). The former often originated within the company that had control over the relevant components and linkages whereas the latter was more likely to emerge from other industries, often of scientific or engineering research basis (Slaughter, 1998). Understanding the distinct characteristics of innovation could be meaningful in assisting firms to establish appropriate managing approaches and implementing strategies (i.e., special skills, expertise and activities), particularly in dealing with certain contextual factors by the time of engaging in innovation (Blayse & Manley, 2004; Hartmann, 2006a).

In the most recent, Gambatese and Hallowell (2011b) evaluated the initiation, development, implementation and diffusion of product-based innovations from the viewpoint of successful innovation generating organizations. Supporting prior research (Gann, Matthews, Patel, & Simmonds, 1992; Damanpour & Wischnevsky, 2006), the authors revealed that innovation efforts disproportionately relating to the product enhancement as compared to process improvement (see Figure 2.9). Given the increasing technical complexity of projects and globalized competition (Tatum, 1988), the materialization of innovations in building structures and construction processes became vital with the desire to directly reduce project cost and duration, and improve the performance of the completed structure itself (Nam & Tatum, 1989; Toole, 1998; Slaughter, 2000).

Category	Innovative product
Information technologies	Project information management system (1)
	Lessons learned systems (2)
Computer-based electronic devices	Estimating and bidding software (1)
	Project control system (1)
	Leak noise correlator (1)
End products (design and construction)	Material products (5)
	Mechanical products (7)
	Electrical products (2)
Construction means and methods	Concrete formwork/placement (5)
	Task management (2)
	Welding (1)
Construction equipment	Heavy/civil equipment components (5)
	Concrete materials washout (1)

Figure 2.9: Types of innovation (Gambatese & Hallowell, 2011b, p. 510)

While the actualization of innovation conventionally dominated over product or production means, the technological approaches had recently attracted criticism for the risk of disintegrating other relevant metrics (Brochner, 2010). In this view, some scholars tracked on the findings originating from the organizational innovation. Besides technological innovation, Seaden et al. (2003) simultaneously demonstrated how various types of advanced business practices enable the construction firms to attain greater competitive advantage. Similarly, Dikmen, Birgonul and Ozcenk (2005) suggested that the integration of a well-developed marketing function into firms' operations could effectively add value to the overall success of business. Meanwhile, Pellicer et al. (2012) recognized that the restructure of organizational framework could lead to an organizational improvement in term of problem-solving and profitability. In support, Hakansson and Ingemansson (2013) exposed that the construction companies predominantly improving the organizational aspects of operational practices to better organize projects across varying activities, resources, and actors.

According to Van der Aa and Elfring (2002), organizational innovations seemed to play a significant role, especially in the service industry. As Evangelista and Vezzani (2010) remarked, organizational innovation exerted similar beneficial effects as those depicted in cost-reducing process enhancements or customer value-generating product developments. For firms operating on construction basis, the key issues were not merely managing project or business processes per se, but the integration of both elements to come across innovation (Gann & Salter, 2000). Following this line of enquiry, it was contended that the distinction of both technological and organizational innovations was often obscured in practice. Each dimension could act complementarily in aiding the potential success of construction firms. Eventually, the conceptualization of innovation in construction setting should rest on a broader value of innovation (Manseau, 1998; National Research Council of Canada, 2001). Specifically, as remarked by Brochner (2010), it should be rested on both technological and non-technological trajectories of innovations.

2.5.2.4 Some SME studies on construction innovation

In line with the general construction literature, most attempts to conceptualizing innovation in the SMEs based predominantly on technological innovations that centred on the product and process developments. Yet, some scholars viewed innovation as an approach that went beyond technologies. For instance, case studies of Sexton and Barrett (2003b) noted that different types of innovation, such as client relationship development innovation, organizational and managerial innovations at firm and project levels, and technological innovation, had been undertaken by small construction firms. Later, Barrett and Sexton (2006) qualitatively revealed that administrative innovation occurs in the restructuring of organizational process whereas technical innovation occurs in the computerization of operational works in small contracting firms.

Focusing on technology transfer, Sexton et al. (2006) categorized the absorption and use of technologies in small construction firms into three types: enabling technology (necessary for organizational survival), critical technology (differentiating a company over its rivals) and strategic technology (long term technology strategy of company). In another study, Lu and Sexton (2006) distinguished two forms of innovations: explorative and exploitative innovations. The former was project specific, such as the use of new materials, to solve clients' demands that generating short-term competitive advantage. On contrary, the latter was firm specific, such as new system and structures to improve portfolio of operational activities that were embedded in in firms and led to sustainable competitive advantage.

Meanwhile, Thorpe and Ryan (2007) revealed that the 50 examples of innovations being engaged by the small builders were predominated with product or process innovations those related to sustainable design and construction of buildings. Examples were “green smart” design and construction, new engineered products, retrofit of solar passive principle to older buildings, new substitute of materials, and so on. In five case studies, Manley (2008) asserted that small construction firms were able to overcome their size disadvantages and introduce technological product innovations to their clients for better project performance. Examples were twin-coil air-conditioning, permeable road pavement, post-tensioned steel trusses, ground penetrating radar and storage gutters and infiltration. Nevertheless, research by Hardie and Manley (2008) stressed that organizational innovations, such as new management and policies, were important in supporting the development of technological solutions. In other words, both the technological and organizational innovations were inseparable for they need to be undertaken concurrently to produce synergistic effects on the SMEs’ businesses.

In another qualitative study, Thorpe et al. (2009) adopted OECD’s (2005) latest definition on innovations to investigate the motivation, drivers and results of developing or adopting innovation among small contractors. The findings indicated that majority of the firms had committed to product innovation, process innovation, organizational innovation, or a mixture of the innovations. In this connection, almost all the innovations, either developed or adopted, were new to the firm rather than new to the industry. Meanwhile, Rezgui and Miles (2010) investigated the adoption of ICT-enabled alliance modes of operation by SMEs in construction sector. Such business process innovation enabled the SMEs to compete in new ways and gain better reward for their work. In the most recent, Hardie et al. (2013) depicted how construction SME innovators, which associated with an environmentally focus, succeeded in delivering technical innovations in projects. In this regards, the intervention of regulatory system played a major role in assisting the SMEs to develop and deliver the innovative products and practices.

Remarkably, two key themes recurred across the diverse range of innovation studies on small construction firms—innovation was 1) an application of technology, or 2) more than technology related. Further, it was important to note that majority of the studies exclusively focused on technological innovations that centred on the product and process developments. The implication of organizational innovations, including both marketing and managerial advancements (The Organisation for Economic Co-operation and Development [OECD], 2005), remained nearly non-existent. Given that there was an increasing need for new research works and practical guidance, especially from the perspective of small firms (Barrett and Sexton, 2006), it was therefore important to complement the biased measurement using a broader perspective of innovation.

2.5.2.5 The definition of innovation used in the present study

According to Manley (2008), innovation could be grouped differently, from simple distinction to detailed categories, along an expanding set of dimensions (see Table 2.4). Amongst all, the most dominating and widely applied typology was the one authorized by the OECD (2005). The OECD established internationally agreed instruments, decisions and recommendations in domains where multilateral agreement was essential for individual countries to go forward in a globalized economy (OECD, 2006). Moreover, the OECD was well-known for its publications, country surveys and statistics encompassing various economic and social issues, i.e., macroeconomics, trade, education, development, as well as science and innovation. Therefore, it was useful for the present study to apply the definitions provided by the latest OECD (2005) as the basis for defining and investigating innovation.

According to the latest manual of OECD (2005), there were four different types of innovations, where "an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (pg 46). Such a definition of innovation had been taken as the fundamental reference source by some scholars that based research on small construction firms (Manley, 2008; Thorpe et al., 2009). Specifically, Manley (2008) remarked that the product and process innovations could be known as technological innovations while the marketing and managerial innovations could be classified as organizational innovations. Accordingly, the present study adopted such conceptualization, i.e., technological and organizational innovations to describe, identify and analyse innovation activities in the SMCFs setting.

Table 2.4: Key innovation typologies (Manley, 2008, p. 1754)

Author(s)	Typology based on…	Innovation categories
Harty (2005)	Implementer's control	*Bounded*: innovation implementation can be contained within a single sphere of influence *Unbounded*: innovation implementation takes place in more contested domains
OECD (2005)	Output class	*Product*: good or service *Process*: production or delivery method *Marketing*: packaging, placement, pricing *Organizational*: internal business practices
OECD (2005)	Degree of novelty	*New to the firm*: lowest degree of novelty – innovation adopted within the industry *New to the industry*: innovation adopted from another industry *New to the world*: highest degree of novelty – previously unseen innovation – likely to be patented if technological in nature
Gopalakrishnan & Bierly (2001)	Knowledge characteristics	*Tacit/explicit*: extent of codifiability, teachability, observability, articulateness *Systemic/autonomous*: extent to which knowledge components are linked with other components *Complex/simple*: sophistication of knowledge [these dimensions reflect Slaughter, 2000]
Slaughter (2000)	Change in knowledge and change in system linkages (system linkages first addressed by Teece, 1986)	*Incremental*: small change in knowledge and small system impact *Architectural*: small change in knowledge and large system impact *Modular*: large change in knowledge and small system impact *System*: large change in knowledge from a combined set of innovations and large system impact *Radical*: large change in knowledge and new system
Mitropoulos & Tatum (1999)	Decision making (Similar to Winch, 1998)	*Strategic*: continuous monitoring of ideas, thorough evaluation of options, top management participation, seeking to maximise benefits [proactive innovation] *Project*: solution driven innovation, limited evaluation of available options, seeking to minimise consequences of failure [reactive innovation]

Table 2.4, continued

Author(s)	Typology based on…	Innovation categories
Winch (1998)	Source of idea	*Top down*: new idea adopted by firms' managers and implemented on projects [proactive innovation] *Bottom up*: new idea is the result of problem-solving on construction sites, which may be later learned by the firm [reactive innovation]
Rothwell (1994), Powell (1991)	Process	*Linear/firm-based*: innovation process managed by a single firm *Interactive/networked*: innovation process shared between organizations
Teece (1986)	System linkages	*Autonomous*: little system impact *Systemic*: large system impact

It was important to mention that this study was not seeking to overturn the role of R&D-based innovations as the standard of assessing technological advancement in a nation or industry. Rather it was to address innovation analysis of small construction firms within a broader paradigm, in that the hitherto neglected organizational innovation. According to Sexton and Barrett (2003b), the definition sufficiently inclusive to precisely define innovation in small construction firms was:

The effective generation and implementation of a new idea, which enhances overall organizational performance (p. 626)

More specifically, the current research defined innovation in small and medium contracting firms as:

The effective generation and implementation of a new idea of technological and organizational types, which enhances overall organizational performance

2.6 Summary

This chapter reviewed studies on a distinct issue of the construction industry, namely, innovation. Studies on innovation had been centred on three levels: project, firm and industry. The three levels of innovation had specifically depicted the peculiar nature of the project-based industry in influencing the innovativeness of the construction firms, including the SMEs. From this, some definitions on construction innovation were presented. Further, this chapter also reviewed some significant works on the effect of firm size on innovation. The review started with the definition of small or medium business over several countries. An overview of general studies on how the small or medium firms were distinct from larger organizations was then presented. The purpose was to point out the importance of considering the effect of firm size in conducting innovation research. In construction specific, the chapter presented the difference of innovation in construction firms of large or SME size. In particular, innovation in SMEs differed from innovation in the larger organization in several aspects, including lack of slack resources, deficiency of human resources, weak financial strength, and therefore, being more agile and behavioural-oriented. Next, the chapter specifically focused on the small construction firms as a mean to highlight certain gaps in the prior literature. Specifically, the chapter argued that the SME innovation studies fall short of associating innovation with capabilities and performance as well as being inappropriate in measuring and assessing the dynamic of innovation in construction firms, especially SMEs. Several decades of research on the issue of innovation had established a wide range of insights, but the analysis of innovation, especially for construction SMEs, necessitated a broader perspective of measurement, which was defined accordingly.

CHAPTER 3

FRAMEWORK DEVELOPMENT AND RESEARCH DESIGN

3.0 Introduction

Some fundamental explications about the theoretical RBV were drawn as the basis on which a conceptual framework of innovation could develop. The goal of the conceptual framework was to explain the effects of organizational capabilities on innovation activities and, ultimately, firm performance. Next, the chapter drawn on prior discussion related to small firms to identify and specify indicators that determined these notions. A conceptual framework was then coined with its associated hypotheses to establish the presumed relationship among the three constructs. From this, the chapter proceeded to identify the research design most appropriate for testing, developing and validating the framework at the end of the chapter.

3.1 Theoretical background of RBV: Resources and capabilities

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 mobilize resources for implementing competitive strategies” (p. 968). Following this line of reasoning, the present study hinged on the RBV for the purpose of understanding innovation in construction SMEs. According to RBV, each firm could be regarded as owning a unique bundle of resources and capabilities, both of which, being tangible and intangible in nature (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.

According to Maijoor and Van Witteloostuijn (1996), resources lied in assets those tied semi-permanently to the firm. They could be represented as tangible (financial or physical) or intangible (i.e., human, commercial, technological, and organizational assets) assets utilized by firms to exploit, manufacture, and deliver products and services to its customers (Barney, 1991). For each firm, recombining a unique collection of internal resources would bring about synergies in the form of sustained competitive advantage (Penrose, 1959). Accordingly, firm could utilize its internal resources to capitalise on opportunities put forward by business conditions, and consequently, creatively manage the external challenges (Baker & Nelson, 2005). Not concerns with the assets per se, capabilities referred to how firm deployed and reconfigured different resources to acquire improved productivity and achieve strategic goals (Makadok, 2001). According to Schriber and Lowstedt (2015), organizational capabilities consisted of routines that evolved over time by being enacted in the organizational contexts. In its basic sense, capabilities could be either associated with the individuals who own them, i.e., in the form of dispersed knowledge, or with the firm as a whole, i.e., the savoir faire of the firm and its staff members (Grant, 1991). For capabilities associated with a firm, they were referred to information-oriented, internally intangible processes that were developed over time via complex interactions among the resources in the firm (Amit & Shoemaker, 1993).

From the above points of view, there were two key features to make a distinction between a capability and a resource. Firstly, a capability was of firm specific on account of its embedding in the firm and its processes whereas an ordinary resource was not (Makadok, 2001). This implied that a capability would probably vanish with the complete dissolve of an organization; while in contrast, a resource could continue to be extant in the hands of another new firm. Secondly, the major purpose of a capability was to achieve an increased effectiveness and productivity of resources embedded in a firm in order to accomplish its goals, therefore acting as 'intermediate goods' (Amit & Shoemaker, 1993). As remarked by Barney (1991), the position and performance difference of firm was determined by firm's heterogeneous set of resources and capabilities that were valuable, rare, imperfectly imitable and non-substitutable (Barney, 1991). If resources furnish an input, organizational capabilities delineated a firm's capacity to coordinate, put the input in productive use, and transform it into innovative outcome (Collis, 1994). In other words, it was the discipline of effective and efficient managing of resources which were known to influence the capabilities of firms to innovate (Dosi, 1988).

Notably, tangible resources could influence the development of organizational capabilities positively and negatively and with varying strength (Schriber & Lowstedt, 2015). In this connection, Sok, O'Cass and Miles (2015) argued that SMEs must possess both resources and capabilities that were complementary with one another to achieve superior financial performance. Put differently, some SMEs might outperformance others because they created synergy and asset interconnectedness at a superior level. To more adequately address the main prescription of the RBV, new research approach must be considered. In the context of construction industry, the present study intended to examine the effect of innovation and the relative contribution of various resources and capabilities on firm success. More specifically, how did construction SMEs focus, deploy and develop both their tangible resources and intangible capabilities might have consequences for theories of RBV and theories of innovation of firms.

3.1.1 RBV and its connection with construction innovation

The construction literature often framed the driving forces of innovation in the industry as a function (client) demand-pull versus (contractor) technology-push factors (Tatum, 1989; Arditi, Kale, & Tangkar, 1997; Bossink, 2004). In this view, innovation was seen to intertwine within two forces—those external (environment) and internal (organizational characteristics) to the firm (Winch, 1998; Sexton & Barrett, 2003b; Seaden et al., 2003; Manley & McFallan, 2006; Hartmann, 2006a). Respectively, the external and internal forces were aligned with market-based view and RBV of innovation (Barrett & Sexton, 2006). The external factors furnished the macro climate that promoting or constraining the use of innovation while the firm-specific characteristics depicted a systematic difference across different organizations in their ability to alter their internal resources in achieving strategic advantage.

Controversially, researchers had attempted to derive a conclusion to the relative implications of external and internal forces of a firm towards innovation and business performance. A more traditional perspective, on one hand, suggested that “while firms’ resource endowments may determine strategy success, strategy choice is . . . restricted by market structure” (Hewitt-Dundas & Roper, 2000, p. 1). Such a view was consistent with Gann’s (2000) assertion that demand-pull (i.e., clients/market condition) had a stronger impact on innovation. In other words, the focus on the ‘internal’ level of organization was not sufficient when innovation was seen as triggering in a national system that were rather market-led than resource-based in scope (Lim, Ofori & Park, 2005). A more behaviourally perspective, on the other hand, opposed that a firm’s innovation activities and performance lied not only in organizational structure or industry features, but also in its resources and capabilities (Dosi, 1988). In this regards, Sexton, Barrett and Aouad (1999) observed that for construction SMEs, “the sifting of possible [innovation] options was rigorous, with SMEs being close enough to both their markets and their capabilities to instinctively know what will work, and what will not” (p. 17). In like manner, Sexton and Barrett (2003b) underscored that the small construction firms could hardly influence their given environment. As pointed out by Manley (2008), “although the firm can influence the environment in which it operates, it has a more immediate ability to influence its own capabilities” (p. 1753).

The earlier innovation literature had highlighted that forces, those external and those internal to firms, as two distinct determinants of innovation. Interestingly, both the external and internal factors exerted impact on performance of firm independently (Exposito-Langa, Molina-Morales & Tomas-Miquel, 2015). For construction firms (Gann & Salter, 2000), especially those of smaller size (Sexton & Barrett, 2003a, b;

Barrett & Sexton, 2006), a clear analysis had been facilitated between the linkages of innovation with internal characteristics of firms. Such a notion was fundamentally attributed to the theoretical reasoning of RBV (Penrose, 1959; Wernerfelt 1984; Barney, 1991). In line with the prior works (Sexton & Barrett, 2003a, b; Barrett & Sexton, 2006), the RBV was used to offer new insights to the analysis of innovation in the present study.

3.1.2 RBV and small construction firms' innovation

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, 2003b). This had led scholarly efforts towards an emphasis on new values creation through 'capabilities' to neutralize the innate resource-disadvantages and external environment-constraints within small or medium construction firms (Sexton & Barrett, 2003a, b; 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" (p. 263). Such a view found support in the conflicting evidences that revealed that the unique characteristics of SMEs allowed them to develop and deploy certain organizational capabilities (Aragon-Correa, Hurtado-Torres, Sharma & Garcia-Morales, 2008). Consequently, it became a key distinguishing feature of firms (Street & Cameron 2007).

Based on the above contentions, capabilities, instead of resources, were input factors that could result in innovative forms of competitive performance. Within the RBV line of reasoning, the present study similarly conjectured that the resource-restricted, yet, innovative SMEs would purposefully leverage their capabilities to which improved performance had been found. The next section would draw the preceding literature of small firms to provide a key link between capabilities, innovation and performance.

3.2 Theoretical linkage and empirical evidences

This section concentrated on a review of related literatures that addressing on innovation attributed to small or medium businesses to appropriately underpin the hypotheses and framework of the present study.

3.2.1 Framework of organizational capabilities

As the study concerned about the implication of capabilities, factors relating to resources, such as financial capital, human capital, and the like, would not be considered. More specifically, only factors those determined (measured) the capabilities-based antecedents to innovation in small or medium firms were taken. In this view, the extant literature had identified a number of factors that appeared to suit this notion.

3.2.1.1 Inter-organizational network

Firms' networks with external organizations had been demonstrated as an important factor in SME studies of innovation. Generally, SMEs had little access to critical innovation resources (Mohannak 2007). Besides, they inclined to possess insufficient capacity to independently manage the entire innovation process (OECD 2010). Accordingly, they were incited to establish inter-firm linkages with other firms to potentially enable a pooling of resources and information. As remarked by Chetty and Holm (2000, p. 77), "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 effectively outsource for resources they did not currently own (Hitt & Ireland, 2002) and acquired size-related advantages of larger firms (Cumbers, Mackinnon, & Chapman, 2003).

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 (Burt, 1997), 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 required social resources embedded therein that promoted 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 structure of external connections (Laursen & Salter 2006). In this view, Hewitt-Dundas (2006) and Lasagni (2012) revealed that nurturing diverse types of relationships, such as supply chain linkages (with customers and suppliers) and research collaborations (with R&D laboratories and research institutes) played a sizeable role in accelerating innovation among European SMEs. 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.

Yet, it was also noted that the ‘technology’, which was concerned with “the ability to protect patents”, was especially rare in small construction firms (Manley, 2008, p. 1760). Supporting this view, Lu and Sexton (2006) viewed network resources of a firm as a result of interactions between individual, firms, and external supplier chain partners. Put differently, the implementation of technological innovation by small firms not necessarily necessitated 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; Manley, 2008; Hardie et al., 2013). Concluding from the arguments, the present study conjectured that inter-organizational networks permit SMEs to draw on resources beyond the firms' boundaries to innovate across a wider range of activities. Table 3.1 summarized the two components of inter-organizational network.

Table 3.1: Indicators of inter-organizational network

Factors/indicators	**References**
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 and government business assistance providers, etc.	(Manley, 2008; Oerlemans & Knoben, 2010)

3.2.1.2 Integrated market orientation

The extant literature in SMEs had informed extensively on the central role of market orientation. Underlined as one of the core-value creating capabilities (Slater & Narver, 1994), market orientation included knowing and understanding customers and competitors (Deshpande, Farley, & Webster, 1993; Narver & Slater, 1990). In empirical sense, market orientation was an important contributor to long-term organizational success throughout the small business domain (Harris & Watkins, 1998; Pelham, 2000; Bradshaw, Maycock & Oztel, 2008; Salavou, 2002; Akman & Yikmaz, 2008). 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" (p. 34). Accordingly, the proficiency to integrate the market-oriented attitude with innovation focus would harness small firms with service advantages (Salavou, 2002; Akman & Yikmaz, 2008).

In essence, construction-based businesses were characterized by service offerings which were clients-specific as to continuously respond and meet the clients' changing needs through innovation. For instance, the pivotal role of client as a driver of sustainable innovation, along with improved efficiency and productivity, was noted by Thorpe and Ryan (2007). Also, Sexton and Barrett (2003b) identified that the small construction firms' positioning towards desired target markets would amplify the goal of attaining sustainable profitability. Because customers' needs change rapidly, Barrett and Sexton (2006) suggested that the small construction firms needed to develop an in-depth understanding on their typical clients that in turn brought about repeat business and referrals due to the strong dynamic inter-relationships. 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. In extending Narver and Slater's (1990) work, Narver, Slater and MacLachlan (2004) suggested that companies similarly needed to understand and satisfy needs of customers of latent ones. Firms' effort in fulfilling the unexpressed preference of customers was crucial to discern and anticipate potential opportunities by proactive means. 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 construction SMEs, as summarized in Table 3.2.

Table 3.2: Indicators of integrated market orientation

Factors/indicators	**References**
Reactive market orientation (i.e., customer orientation, competitor orientation and inter-functional coordination)	(Narver & Slater, 1990)
Proactive market orientation (i.e., latent need fulfilment)	(Narver et al., 2004; Nasution & Mavondo, 2008).

3.2.1.3 Organizational learning

SME literature had long since acknowledged that the pursuit of learning was important in driving value-creating opportunities in the form of innovation (Chaston et al., 1999; Barnett & Storey 2000; Sok & O'Cass, 2011). Regarded as one of the core capabilities of firm (Chaston, Badger and Sadler-Smith, 2001), organizational learning was a significant index of competitiveness of firm, including that of SMEs (Jerez-Gomez, Cespedes-Lorente & Valle-Cabrera, 2005). According to Polanyi (1967), 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, p. 716). Also, organizational learning could be regarded as a firm’s capability to maintain or enhance firm performance based on experience (Garcia-Morales, Llorens-Montes & Verdu-Jover, 2007). Hence, any organization might end with dysfunction without relentless pursuit of learning (DiBella, 1995).

In this connection, learning also appeared to indicate high potential significance in the construction firms. In project-based productive networks, firms were, generally, entrapped within a discontinuous mode of one-off production which in turn constraint the rapid assimilation of new knowledge across projects (Gann & Salter 2000; Drejer & Vinding 2006). To compete in environments with such broken loops of learning, Lu and Sexton (2006) asserted that tacit, experiential knowledge accumulation and learning to be fundamental to the cycle of project-based innovation. Notably, Manley (2008) suggested that the known liabilities of smallness could turn into positive feature of small firms such that the knowledge transposal processes were relatively easier, and therefore, promoting generation of new ideas. 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 required that individual employees shared the acquire 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). Addressing this need, the present study postulated that organizational learning was positively related to innovation in construction SMEs. Table 3.3 summarized the four components of organizational learning.

Table 3.3: Indicators of organizational learning

Factors/indicators	**Reference**
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.	(Jerez-Gomez et al., 2005)

3.2.1.4 Human resource practice

Over 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 (Williamson, Cable, & Aldrich, 2002; Michie & Sheehan, 2008; Patel & Cardon, 2010; Sheehan, 2014). According to Wright, Dunford and Snell (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 potential origin of significant competitive advantage. Even if competitors realized the value generated by human resource practices, they could not replicate them at once, particularly in resource-constrained environments common within SMEs (Becker & Gerhart, 1996; Razouk, 2011). However, SME owners must invest carefully because the short-run costs of spending on the human resource practices were rather significant (Sheehan, 2014).

For small construction firms, human resource or human resource practice had appeared to be a likely input for innovation. According to the works of Sexton and Barrett (Sexton & Barrett, 2003b; Barrett & Sexton, 2006), an appropriate motivation offered important implications for firms to create, manage and exploit innovation, which was undertaken by the staff members. Likewise, 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 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 success of firm in terms of the employees' mastery of the technical problem being confronted (Hardie & Manley, 2008). However, the extant understanding on 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 the construction SMEs settings. Table 3.4 summarized the two components of human resource practice.

Table 3.4: Indicators of human resource practice

Factors/indicators	**Reference**
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).	(Nasution, Mavondo, Matanda, & Ndubisi, 2011)

3.2.1.5 Entrepreneurship

For years, how entrepreneurship was positively intertwined with SME businesses had been the subject of scholarly investigation (Wiklund & Shepherd 2005; Keh, Nguyen & Ng, 2007; Nybakk & Hansen, 2008; Chaston, 2012; Engelen, Kube, Schmidt, & Flatten, 2014). In its most primary sense, entrepreneurship was manifested as firm behaviour (Lumpkin & Dess 1996) as entailing the decision-making, methods, and practices (Wiklund & Shepherd 2005). Truly entrepreneurs were those with willingness to innovate, search for risks, take self-directed actions, and more proactive and aggressive than the rivals in seizing new marketplace opportunities (Wiklund 1999). In this connection, small firms, having a high degree of entrepreneurial orientation, would be able to discover and capitalize new opportunities as to differentiate them from their rivals (Wiklund & Shepherd, 2005). Accordingly, small entrepreneurial firms could underpin a greater competitive advantage (Engelen et al., 2014).

In reviewing the construction literature, however, the relevancy of entrepreneurship had been limitedly emphasized by SME scholars. Exceptions were the work by Barrett and Sexton (2006), and Salunke et al. (2011) which identified the potential value of entrepreneurship. For instance, Barrett and Sexton (2006) observed that small construction firms would persistently display entrepreneurial behaviour to pursue market-based innovation. Meanwhile, Salunke et al. (2011) asserted that an entrepreneurial persistence would support the project-oriented service firms, including the small-sized businesses, in seizing a greater innovation-based competitive advantage. The entrepreneurial project-based firms would, even with limited access to capital, pursued innovation by strategically utilizing scarce resource at hand (Salunke et al., 2011). In spite of the strong connection between entrepreneurship and project-based practice (Kuura, Blackburn & Lundin, 2014), very limited studies have addressed their impact within the context of innovation. As summarized in Table 3.5, the present study contended that SMEs with entrepreneurial orientation would have the capabilities to engage in offering innovation in their business deliveries.

Table 3.5: Indicators of entrepreneurship

Factors/indicators	**Reference**
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, first to introduce new services, constantly look out for business, seek opportunities to improve business, always ahead of competitors to respond to market).	(Nasution & Mavondo, 2008)

3.2.2 Framework of innovation activities

A framework of innovation activities might aid in elaborating new technologies or practices attributed to construction SMEs and also in developing a conceptual framework of innovation of this notion. In reviewing the preceding literature, scholars had introduced a number of typologies of innovation separating product and process (Bowley 1960), bounded and unbounded (Harty, 2005), incremental and radical (Slaughter, 2000), top down and bottom up (Winch, 1998), strategic and project (Mitropoulos & Tatum, 1999). One commonly studied typology was the one that make a distinction between product and process innovations.

3.2.2.1 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. Basically, product innovation was related to new changes in end products (i.e., goods) or services (OECD, 2005; Dibrell, Davis, & Craig, 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/or software (Gunday, Ulusoy, Kilic, & Alpkan, 2011). According to Chang, Linton and Chen (2012), process innovation was intended to safeguard and increase quality and/or decrease costs of production. In this connection, Simonetti, Archibugi and Evangelista (1995) argued that the goals of product and process innovations were divergent; the former were usually linked with the creation of new markets whereas the latter were introduced for costs saving or improving the flexibility and performance of production processes.

In reviewing the SME literature, it was important to note that the works on innovation had mainly rooted on technological products or process innovations (Thorpe & Ryan, 2007; Manley, 2008; Rezgui & Miles, 2010; Hardie, Allen, & Newell, 2013). This might be attributed to the increasing complexity of construction projects and globalized competition among firms in the industry (Tatum, 1988). Accordingly, the present study contended that small and medium construction firms would engage in technological types of innovation activities (see Table 3.6) as a mean to improve their business deliveries.

Table 3.6: Indicators of technological innovation

Factors/indicators	**References**
Product innovation (good and service) & process innovation (production or delivery method)	(OECD, 2005; Nasution et al., 2011; Gunday et al., 2011; Chang et al., 2012)

3.2.2.2 Organizational innovations

In compared with the technological product and process advancements, the scholars of both general and SME fields of construction had 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, 2003a, b; 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 important 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 in a concurrent and synergistic manner in order to success. 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 had 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, 1991). In considering the service-oriented nature of construction firms, Arditi, Polat and Makinde (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/or 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 3.7) 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 small and medium businesses that anchored on construction-based services.

Table 3.7: Indicators of organizational innovation

Factors/indicators	**References**
Marketing innovation (packaging, promotion, pricing, place and people) & managerial innovation (internal business strategies)	(OECD, 2005; Arditi et al., 2008; Nasution et al., 2011)

3.2.3 Framework of firm performance

For small businesses, superior business performance was essentially an outcome of strong innovation-oriented approach (Freel & Robson, 2004; Laforet, 2013). Within the complex system of construction, innovation was found to contribute to the enhancement of project performance as well as firm performance. In this vein, Winch (1998) and

Slaughter (2000) noted that the consideration on innovation was usually undertaken by the firms, 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).

However, the extant researches offering evidences on the consequences of construction innovation with regard to firm performance remained inconclusive. While some researchers echoed the positive impact of innovation (Sexton & Barrett, 2003b; Barrett & Sexton, 2006; Lu & Sexton, 2006; Manley, 2008; Thorpe et al., 2009), others presented an opposing conclusion (Capaldo et al., 1997; Dulaimi et al., 2002). Further, the past research had employed a variety of measures to indicate firm performance, such as effectiveness and efficiency (Sexton & Barrett, 2003b; Barrett & Sexton, 2006; Lu & Sexton, 2006), reputation and repeat business (Manley, 2008), repeat use of innovation, increased external knowledge, spillover effect, positive clients' response, improved business operation, competitive advantage and profitability (Thorpe et al., 2009), increased financial capability (Rezgui & Miles, 2010), etc. The inconsistency in the use of indicators led to incomparable findings on the impact of innovation on firm performance.

Meanwhile, it was important to note that these performance measures were all subjectively measured in the prior studies. For small firms, Pelham and Wilson (1996) viewed that the subjective measures was used to deal with difficulties with asking managers to provide sensitive information. Supporting this view, Laforet (2013) claimed the difficulty in obtaining financial accounts of small firms for analysis. Hence, the subjective measure was more appropriate to be used to assess the performance of small firms. In this regards, some studies had suggested the use of financial and non-financial measures to provide a more comprehensive assessment on firm performance (Matear, Osborne, Garrett, & Gray, 2002; Haber & Reichel, 2005; Laforet, 2013). As clarified by Ambler and Roberts (2008), the financial measures reflected the past performance of firm while non-financial measures concerned with future performance of firm.

In 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 3.8) was taken to evaluate the firm-based consequence of innovation within the small and medium construction firms.

Table 3.8: Indicators of firm performance

Factors/indicators	**Reference**
Financial measures (profitability, annual sales growth, market share) and non-financial measures (labour productivity, customer satisfaction, repeat business, reputation impacts)	(Slaughter, 2000; Matear et al., 2002)

3.3 Conceptual framework and hypotheses development

Based on the foregoing reviews, the present study proposed a conceptual framework of innovation (see Figure 3.1) to highlight the relationship between organizational capabilities, innovation activities and firm performance. On the basis of RBV, direct relationship between organizational capabilities and innovation activities was assumed to be positive. Direct relationship between innovation activities and firm performance was assumed to be positive as well. In addition, innovation activities were assumed to stimulate performance within capabilities (i.e., mediation). As discussed earlier, organizational capabilities could be affected by five factors: inter-organizational network, organizational learning, entrepreneurship, integrated market orientation and human resource practice. Firm performance was measured by financial and non-financial dimensions. Lastly, innovation activities centred on two different types of innovations, that was, technological and organizational innovations.

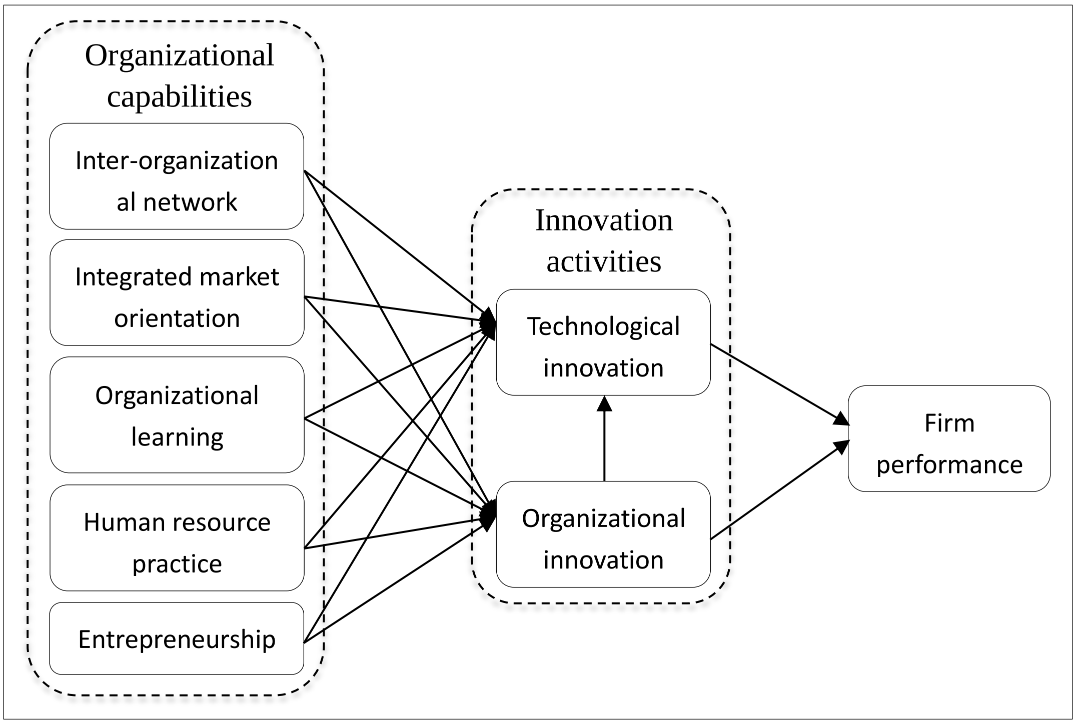


Figure 3.1: Conceptual framework of innovation

To articulate the relationship among organizational capabilities, innovation activities and firm performance, several propositions can be highlighted. It is assumed that there is a positive influence of each of the components of organizational capabilities on the two different types of innovation activities, which in turn have a positive influence on the firm performance. Additionally, it is assumed that the innovation activities would exert mediating influences on these relationships. All the hypotheses will be tested in a quantitative study (Chapter 4) and refined further in a qualitative study (Chapter 5). Based on the proposed framework, research propositions are articulated around the following hypotheses:

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

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

H3: Integrated market orientation is positively related to technological innovation.

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

H5: Organizational learning is positively related to technological innovation.

H6: Organizational learning is positively related to organizational innovation.

H7: Human resource practice is positively related to technological innovation.

H8: Human resource practice is positively related to organizational innovation.

H9: Entrepreneurship is positively related to technological innovation.

H10: Entrepreneurship is positively related to organizational innovation.

H11: Organizational innovation is positively related to technological innovation.

H12: Technological innovation is positively related to firm performance.

H13: Organizational innovation is positively related to firm performance.

3.4 2 Research design for developing and validating the innovation framework

From the discussion of the conceptual framework of innovation in the previous section, this section proceeded to identify the research design most adequate to develop and validate the proposed framework. To this end, it was important to understand the worldview philosophy of research to shape the approach to a particular research. According to Creswell (2008), there are four different worldviews—post-positivism, constructivism, advocacy/participation and pragmatism—within social scientific research. The post-positivism emphasized on determinism, reduction, empirical observation and measurement and theory verification. Next, the constructivism assumed that individuals sought an understanding of the word in which they live and work. Meanwhile, the advocacy/participation focused on the needs of groups and individuals who are "powerless" in society and therefore resulting in feminist perspectives, queer theory, disability theory and critical theory. Finally, the pragmatism emphasized the research problem and used all approaches available to understand the problem, i.e., individual researchers were free to choose the methods, techniques and procedures of research best serve their needs and purposes.

The worldview of pragmatism was chosen as the philosophy stance of the current research, given that the research problem was in the most important position to derive knowledge about the problem. In this worldview, the researcher looked into many approaches to collect and analyse data rather than using only quantitative or qualitative approach (Creswell, 2008). Put differently, the researcher used both quantitative and qualitative data (i.e. a mixed method design) because they worked to provide the best understanding of the research problem. In the present study, the use of a mixed method design was to test, develop and validate the proposed innovation framework.

According to Creswell and Clark (2011), where the research problem called for a mixed methods approach and reflected on the theoretical foundations of the research study, the next step was to choose a particular design that best fit the problem and research questions in the study. In this regards, a research design was important to provide a logical sequence in concatenating research questions and conclusion via data compilation, analysis and interpretation (Yin, 2009). Hence, the selection of research technique(s) would be based on their contribution to the analysis required for testing and validating the framework. Recalled the research problems, purpose and research questions introduced in Chapter 1, the rationale of selecting a mixed method design arouse in many ways, including the need to addresses the questions “What?” and “How?”. First, the questions of “What?” investigated the association between organizational capabilities, innovation activities and firm performance. This implied the use of a quantitative approach for this purpose. Second, the questions of “How?” related to further examination of the quantitative results through the use of a qualitative approach. The theoretical stance needed to be advanced using both quantitative and qualitative approaches, and therefore, called for the use of mixed methods research to obtain a more complete view of the research problem and questions in the present study.

3.4.1 A two-phase explanatory design

As remarked by Creswell and Clark (2011), mixed methods studies were defined as research methods that included at least one quantitative strand and one qualitative strand. According to Teddlie and Tashakkori (2009), a strand was as a component of a study that included the basic procedure of conducting quantitative or qualitative research: posing of question, collection of data, analysis of data and interpretation of results based on the data. Altogether, there were six major types of mixed methods designs that a researcher could choose on, namely, convergent, explanatory, exploratory, embedded, transformative and multiphase (Creswell & Clark, 2011). According to Bradley et al. (2009), the sequential explanatory design was well suited when qualitative data was required to explain quantitative significant (or non-significant) results, positive-performance exemplars, outliers results or surprising results.

In consistent, the sequential explanatory design, i.e., a quantitative strand followed by a qualitative strand, was selected and the selection was based on two initial conditions: construction SMEs' engagement in innovation; the relationship between organizational capabilities, innovation activities and firm performance. Both the conditions had been partially satisfied (in Chapter 2 and 3) through the review on prior literature as the most suitable modelling technique for this study's innovation framework. By empirical means, the present study next followed the principle of mixed method sequential explanatory design to navigate the procedures of collecting, analysing, interpreting, and reporting of data. According to Creswell and Clark (2011), the explanatory sequential design occurred in two distinct interactive phases. The design commenced from the collecting and analysing the quantitative data, which had the first priority for addressing the research questions, i.e., to identify the association between the hypothesized relationships in the innovation framework (in Chapter 4). In investigating the statistical requirement for testing the innovation framework, more comprehensive mathematical modelling techniques should be used. Examples were dynamical system techniques, statistical modelling techniques, differential equation techniques, game theoretic techniques and so on. Amongst all, structural equation modeling (SEM), which was a family of statistical modeling techniques, was chosen. Increasingly, the SEM techniques were well known for being capable of testing multiple factors at the same time. More particular, partial least square approach of SEM (PLS-SEM) was adopted for the quantitative analysis. According to Hair, Hult, Ringle and Sarstedt (2013), several stages were essential in applying PLS-SEM, namely specification of structural model (and its mathematical equations) and measurement models, data collection and examination, assessment of measurement and structural models, and advanced analysis (mediation test). All these stages were discussed in detail in Chapter 4.

Subsequently, the quantitative phase was followed by a qualitative phase of collection and analysis of data. The qualitative phase was designed such that it elaborated the results of the first, quantitative phase in more depth (in Chapter 5). According to Coyle (1977), there were several ways to justify causal links qualitatively, such as direct observation, reliance on accepted theory, hypothesis or assumption and statistical evidence. The present study adopted interviews to enrich the study with a better understanding on: 1) perception and practice of innovation among SMCFs, and 2) causal mechanisms for the proposed effects among organizational capabilities, innovation activities and firm performance. Together, both quantitative and qualitative data were appropriately interpreted to provide a confident empirical justification on the validity of the model (in Chapter 6). Figure 3.2 provided an overview on procedural steps used to implement a mixed method sequential explanatory design.

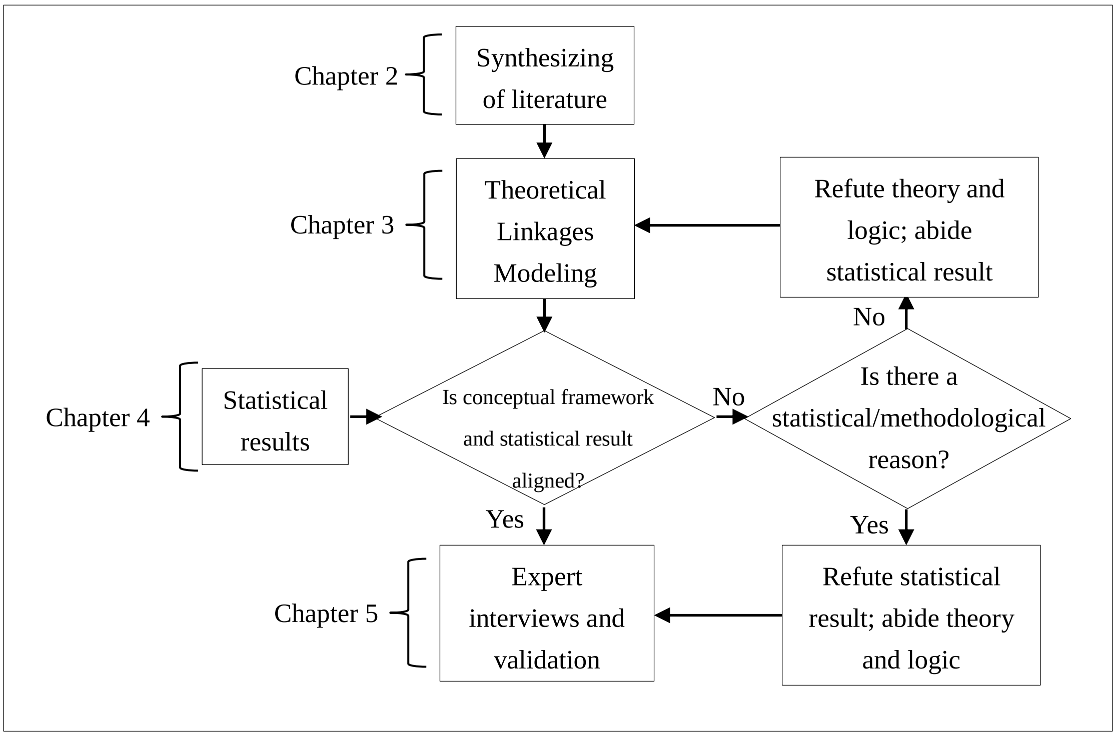


Figure 3.2: Methodology for developing and validating the innovation framework

As shown in Figure 3.2, the literature on construction innovation in smaller firms was synthesized into an innovation framework with the causal relationships being affirmed by the theoretical RBV. Through an initial quantitative study, the framework was first tested. If both statistical results and theoretical concepts of the innovation framework were aligned, the causal path was validated and accepted as one of the links in the innovation framework, and vice versa. Further, the framework was qualitatively investigated through in-depth interviews with construction practitioners to address the nature of causal paths that could not be statistically validated. In particular, the qualitative study sought to elaborate, enhance and clarify the quantitative results from the initial quantitative study with qualitative results. Finally, the framework was validated by its overall practicality and comprehensiveness towards the practice of innovation in the construction industry.

3.5 Summary

This chapter was divided into two sections: framework development and research design. Developing the conceptual framework encompassed the identification of the indicators of organizational capabilities, construction innovation and firm performance. As a latent concept, organizational capabilities comprised entrepreneurship, organizational learning, inter-organizational network, human resource practice and integrated market orientation. Indicators of construction innovation included technological and organizational innovations. Lastly, firm performance was a single construct measured by both financial and non-financial dimensions. The proposed conceptual framework drew on the RBV to concatenate organizational capabilities, construction innovation and firm performance in a single framework. Next, research design summarized the procedure of collecting, analysing and interpreting data through a mixed method sequential explanatory approach. Research design of both quantitative and qualitative strands was presented. The next chapter presented procedures and results of the quantitative strand, which was subsequently elaborated with a qualitative strand to further add insights into the present study. The findings were expected to contribute to the development of final framework of innovation at the end of the research study.

CHAPTER 4

QUANTITATIVE STUDY

4.0 Introduction

To test the innovation framework as proposed in Chapter 3, a quantitative strand was firstly used for the purpose. Specifically, a questionnaire survey was used to answer the research questions and test the hypothesis. In this view, PLS-SEM was used to navigate the procedures in collecting and analysing quantitative data. Foremost, the procedure started with the development of a questionnaire through the specification of structural model, followed by measurement models. Next, data was collected using non-probability sampling design, which was well suited for study that require certain criteria set by the researcher (Cavana, Delahaye, & Sekaran, 2001). Prior to its assessment using PLS approach, the data was examined for its missing data, suspicious response patterns, outliers and data distribution. Meanwhile, some descriptive analyses were conducted as well. From this, principal component analysis (PCA), confirmatory factor analysis (CFA) and partial least squares path modelling (PLS-PM) were used to assess the quality of the measurement and structural models, both of which subsequently, constitute the entire path model. Lastly, advanced analysis, that was, mediation test was used to assess the mediating effect of innovation activities in the final developed innovation framework.

4.1 Structural equation modeling (SEM)

Structural equation modeling (SEM) was an important mathematical tool to estimate a network of causal relationships linking two or more complex concepts. According to Kaplan (2000), SEM could be applied to make more flexible the system of composite indicators (i.e., latent complex concepts) as well as to model causal relationship among the composite indicators. In simple, Hair, Black, Babin, Anderson and Tatham (2006) made clear that SEM was "a family of statistical models that sought to explain the relationship among multiple variable" (p. 711). As a matter of fact, SEM encompassed a number of statistical methodologies that intended to estimate causal relationships (which were built on a theoretical model) between two or more composite indicators, each measured by a range of observable indicators (Trinchera & Russolillo, 2010).

Amongst all, the two major families of SEM techniques were covariance-based SEM (CB-SEM) and partial least square SEM (PLS-SEM) (Hair et al., 2013). Both types of SEM techniques were fundamental different in terms of their objectives (theory testing vs. prediction) and approach (covariance vs. variance) (Chin & Newsted, 1999). In this regards, the most prominent representatives for the CB-SEM and PLS-SEM were, respectively, linear structural relations (LISREL) and partial least squares path modelling (PLS-PM). Importantly, neither of the techniques was commonly superior to the other and both approaches were appropriate for different research context (Hair et al., 2013). The strengths of PLS-SEM were weaknesses of CB-SEM, and vice versa. Accordingly, researcher needed to understand the differences to select the most appropriate method that best suited the research. In the present study, the PLS-PM was applied to analyse the multivariate data due to certain conditions, which were justified in the next section. After this, PLS-PM was indicated as PLS.

4.1.1 Justification of applying PLS-SEM in the present study

As seen in Table 4.1, several rules of thumb could be used to decide whether to use CB-SEM or PLS-SEM. First, the PLS-SEM was a more suitable analysis approach in contrast to CB-SEM in situations where theory was less developed (Hair et al., 2013). This was especially true if the overarching objective of using structural modelling was to predict and explain the target constructs. Hence, the CB-SEM was applied when the research objective was to test a theory while PLS-SEM was useful for predictive applications and theory development (Chin & Newsted, 1999). Moreover, PLS-SEM was well suited for exploratory study when 1) the purpose of study was to determine the relative relationship among latent variables, and 2) the path model was an objective instead of overall model fit (Hulland, Ryan, & Rayner, 2010). As noted by Chin and Dibbern (2010), PLS worked efficiently in studies having small sample, too many variables (as in the case of the present study), and data with non-normal or unknown distribution. Lastly, PLS was preferable when the phenomenon under study was new or changing (i.e., theoretical framework was yet to be fully crystallized) and when the model was relatively complex (having large number of manifest and latent variables) (Wetzels, Odekerken-Schroder, & Van Oppen, 2009).

However, the PLS-SEM had several limitations. According to Hair et al. (2013), PLS-SEM was not applicable when the structural models were non-recursive, i.e., having causal loops or circular relationships between the latent variables. Also, the use of PLS-SEM for theory testing and confirmation was limited for its model evaluation was not based on global goodness-of-model (GoF) fit measure. Further, PLS-SEM parameter estimates were not optimal with regards to bias and consistency (i.e., PLS-SEM bias). Nonetheless, simulation study of Reinartz, Haenlein and Henseler (2009) suggested that the differences between CB-SEM or PLS-SEM estimates were very small. As such, the PLS-SEM bias strongly advocated by CB-SEM researchers was not relevant for most applications (Hair et al., 2013).

Table 4.1: Rules of thumb for choosing between PLS-SEM and CB-SEM (Hair et al., 2013, p. 19)

Use PLS-SEM when ■ The goal is predicting key target constructs or identifying key "driver" constructs. ■ Formative measured constructs are part of the structural model. Note that formative measures can also be used with CB-SEM, but doing so requires construct specification modifications (e.g., the construct must include both formative and reflective indicators to meet identification requirements). ■ The structural model is complex (many constructs and many indicators). ■ The sample size is small and/or the data are non-normally distributed. ■ The plan is to use latent variable scores in subsequent analyses.
Use CB-SEM when ■ The goal is theory testing, theory confirmation, or the comparison of alternative theories. ■ Error terms require additional specification, such as the covariation. ■ The structural model has non-recursive relationships. ■ The research requires a global goodness-of-fit criterion.

In sum, in cases where there was lacking of a priori knowledge on 1) structural model relationships or measurement of the constructs, or 2) the emphasis was more on exploration rather than confirmation, researcher should considered the use of PLS-SEM as an alternative to CB-SEM (Hair et al., 2013). Accordingly, these conditions encouraged the researcher to apply the PLS-SEM approach in the present study. According to Hair et al. (2013), several stages were essential in applying PLS-SEM, namely (1) specification of structural model, (2) specification of measurement model, (3) data collection and examination, (4) assessment of measurement models, (5) assessment of structural model, and (6) advanced analysis (i.e., mediation test). All these stages were followed to collect and analyse the quantitative data, as presented in the forthcoming sections.

4.2 Specification of structural model

In the first stage of applying PLS-SEM, it was important to specify the structural model of a research study (Hair et al., 2013). Recalled in Section 3.3, a conceptual model of innovation connecting various variables/constructs was presented. The innovation model itself was a path model, i.e., a diagram that connected variables/constructs on a basis of theory and logic to visually display the hypotheses that would be tested. According to PLS-SEM, a path model was constituted by two elements: structural model (also called inner model) and measurement models (also called outer models) (Hair et al., 2013). The former described the relationship between the latent variables while the later described the relationship between the latent constructs and their measures (i.e., indicators). This section first discussed structural model and covered measurement models in the next section.

In specifying a structural model, researcher needed to consider two primary issues: the sequence of variables and the relationship between them (Hair et al., 2013). Both issues were paramount to the concept of modelling as they denoted the hypotheses and their relationship to the theory being tested. In the current study, the proposed innovation model had three main conceptual components: (1) the constructs of organizational capabilities, namely, inter-organizational network, integrated market orientation, organizational learning, human resource practice and entrepreneurship, (2) the two innovation dimensions, namely, technological innovation and organizational innovation, and (3) the construct of firm performance. Figure 4.1 showed the constructs and their relationships, which denoted the structural model for the PLS-SEM.

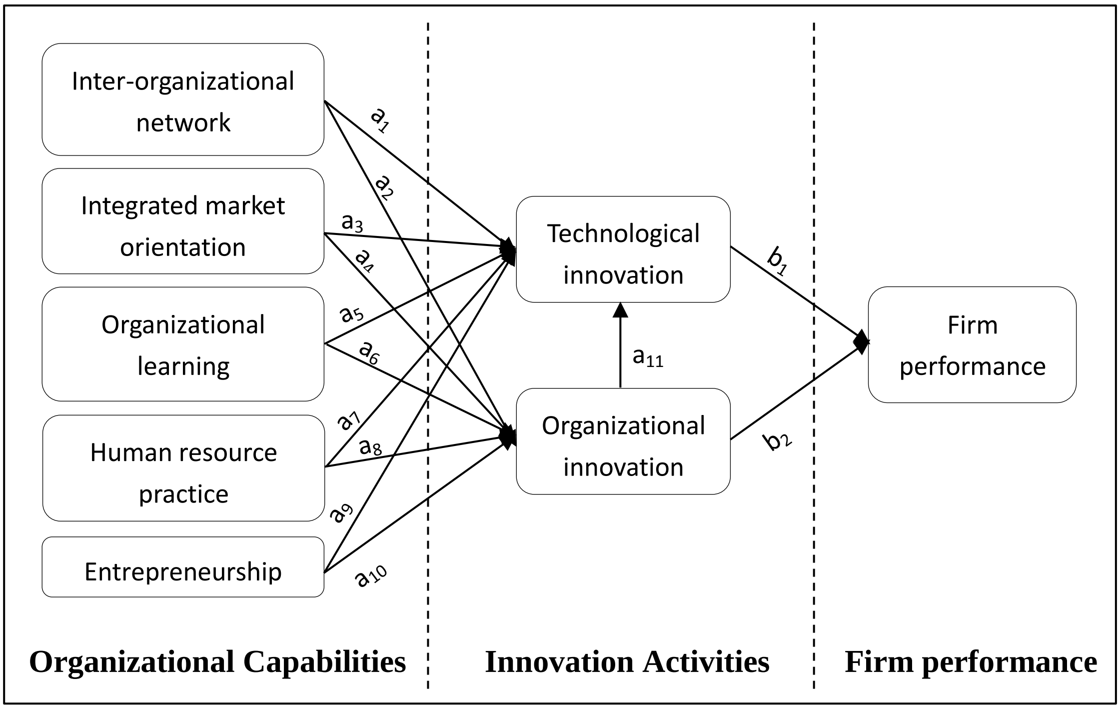


Figure 4.1: Structural model of innovation for SMCFs

As depicted in Chapter 3, the sequence of the constructs in the innovation framework was based on RBV (Penrose, 1959; Wernerfelt 1984; Barney, 1991). According to RBV, it was assumed that the sequence was displayed from organizational capabilities to innovation activities and to firm performance. In specific, on the far left were the five independent (also called exogenous) constructs of organizational capabilities, including inter-organizational network, integrated market orientation, organizational learning, human resource practice and entrepreneurship. Meanwhile, both the technological innovation and organizational innovation were endogenous constructs that acting as both independent and dependent variables. Respectively, they were predicted by the five independent variables, and at the same time, predicting on firm performance. Accordingly, the firm performance on the far right was a dependent (also called endogenous) construct. The arrows between the constructs denoted the sequence and the casual links between them (Hair et al., 2013), which were determined by theoretical RBV. Further, the weighting of each path was depicted by its own coefficient. For instance, a_7 denoted the path coefficient for the path of ‘Human resource practice’ and ‘Technological innovation’; a_{11} denoted the path coefficient for the path of ‘Organizational innovation’ and ‘Technological innovation’; b_1 denoted the path coefficient for the path of ‘Technological innovation’ and ‘Firm performance’, and so forth. Notably, mathematical equations depicting the relationships between variables/constructs could be derived accordingly (Ling et al., 2012) (see Table 4.2).

Table 4.2: Mathematical equations from innovation framework of SMCFs

Technological innovation = a_1 x Inter-organizational network + a_3 x Integrated market orientation+ a_5 x Organizational learning + a_7 x Human resource practice + a_9 x Entrepreneurship + a_{11} x Organizational innovation
Organizational innovation = a_2 x Inter-organizational network + a_4 x Integrated market orientation+ a_6 x Organizational learning + a_8 x Human resource practice + a_{10} x Entrepreneurship
Firm performance = b_1 x Technological innovation + b_2 x Organizational innovation

In addition to examination of the direct relationships between the three types of constructs (organizational capabilities, innovation activities and firm performance), the present study also examined whether the model relationships were more complex, i.e., involving mediation relationships. In particular, both the technological and organizational innovations were conjectured to act as mediators in the hypothesized causal links within the structural innovation model. To this end, the mediation relationship was estimated and interpreted using PLS-SEM in the final part of the quantitative analysis (See Section 4.7).

4.3 Specification of measurement models

After specifying the structural models, the procedure of PLS-SEM proceeded to specify the measurement models (Hair et al., 2013). In contrast to the structural model that depicted the structural relationships among latent variables (i.e., constructs), the measurement models described the relationship between constructs and their corresponding measures (also called items, indicator or manifest variables). To specify the measurement models, however, the constructs, of latent nature, needed to be first conceptualized, operationalized and scaled. According to Babbie (2010), conceptualization gave “definite meaning to a concept by specifying one or more indicators of what we have in mind” (p. 131). On the other hand, operationalization referred to reducing the abstract concepts associated with a construct that it was measureable in a tangible way (Sekaran, 2003). In the present study, all the latent constructs were drawn from past studies that had conceptually defined and operationally developed the measurement scales. To do so, an extensive literature review (see Section 3.2) was performed to identify the adoptable scale items, as summarized in Table 4.3. Apart from this, defining an appropriate scale was important to measure different variables (i.e., constructs). According to Sekaran (2003), there were four basic types of scales, namely, nominal, ordinal, interval and ration. The present study employed an interval scale, which suited the multivariate analysis (Hair et al., 2006).

According to PLS-SEM, each of the latent groups (i.e., constructs and their associated indicators) could be then categorized into two broad types of measurement specification, scilicet, reflective and formative measurement models (Hair et al., 2013). In reflective measurement models (see Figure 4.2), causality was from the construct to its indicators (Diamantopoulos & Winklhofer, 2001), i.e., the arrow went from the construct to the indicators. In other words, it was based on the assumption that all indicator items were caused by the same construct, and the indicators associated with a particular construct should be highly correlated with each other (Hair et al., 2013). Moreover, ‘individual items should be interchangeable, and any single item could generally be left out without changing the meaning of the construct, as long as the construct had sufficient reliability' (Hair et al., 2013, p. 43).

Table 4.3: Operationalization of constructs and scaling

Construct	Measure	(5-point Likert scale)
Inter-organiza-tional network	Gronum et al. (2012) two dimension on breadth (heterogeneity) and depth (importance) to measure external links (8 items) adapted from prior works (Manley, 2008; Oerlemans & Knoben, 2010): clients, competitors, experts/consultants, suppliers, universities, R&D centres, and firms of other industries.	(anchored by 'no importance' and 'very important' at the end points).
Integrated market orientation	Narver and Slater's (1990) three dimensions: customer orientation (4 items), competitor orientation (4 items) and inter-functional coordination (4 items); and Narver et al.'s (2004) latent need fulfilment (4 items).	(anchored by 'never' and 'always' at the end points).
Organiza-tional learning	Jerez-Gomez et al.'s (2005) four dimensions: managerial commitment (4 items), systems perspective (4 items), openness and experimentation (4 items) and knowledge transfer (4 items).	(anchored by 'never' and 'always' at the end points).
Human resource practice	Nasution et al.'s (2011) two dimensions: job-related practices (7 items) and reward-related practices (3 items).	(anchored by 'never' and 'always' at the end points).
Entrepre-neurship	Nasution and Mavondo's (2008) three dimension: risk taking (5 items), proactiveness (5 items), and autonomy (3 items).	(anchored by 'never' and 'always' at the end points).
Technologi-cal innovation	Adapted measure (OECD, 2005; Nasution et al., 2011; Gunday et al., 2011; Chang et al., 2012) focusing on innovative products (4 items) and process deliveries (4 items).	(anchored by 'never' and 'always' at the end points).
Organiza-tional innovation	Adapted measure (OECD, 2005; Arditi et al., 2008; Nasution et al., 2011) focusing on innovative marketing (5 items) and managerial practices (4 items).	(anchored by 'never' and 'always' at the end points).
Firm performance	Adapted measure (7 items) capturing financial and non-financial performances of firm (Slaughter, 2000; Matear et al., 2002)	(anchored by 'much worse' and 'much better' at the end points).

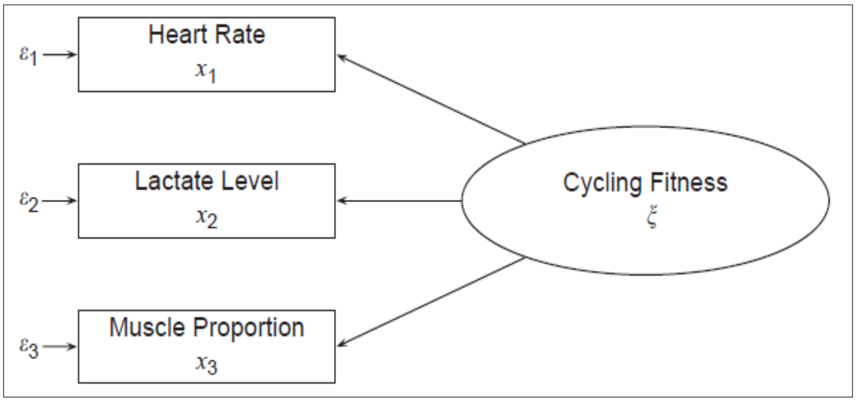


Figure 4.2: Example of a reflective measurement model (Henselar, Ringle & Sinkovics, 2009, p. 289)

In adverse, for formative measurement models (see Figure 4.3), causality was from the indicators to construct (Diamantopoulos & Winklhofer, 2001), i.e., the arrow went from the indicators to the construct. Taken jointly, all the indicator items of a formative construct determined the meaning of the construct itself, which implied that the omission of an indicator potentially changed the nature of the construct (Hair et al., 2013).

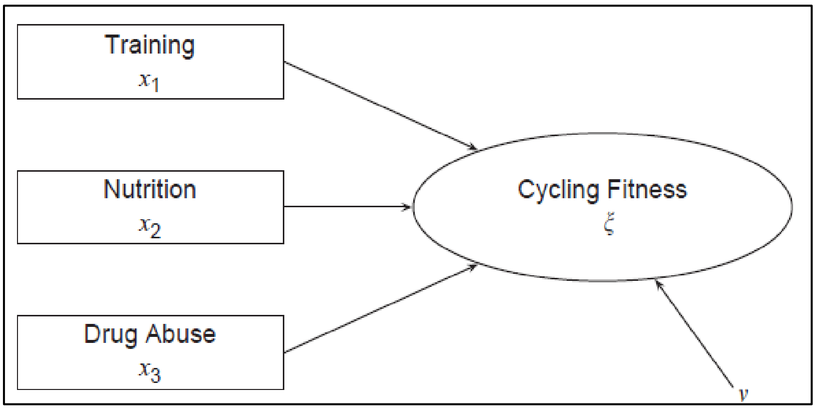


Figure 4.3: Example of a formative measurement model (Henselar et al., 2009, p. 290)

However, the decision as to reflectively or formatively measure a construct remained the subject of considerable argument and had not been fully resolved. As remarked by

Hair et al. (2013, p. 45), “There is not a definite answer to this question since constructs are not inherently reflective or formative. Instead, the specification depends on the construction conceptualization and the objective of the study”. Nevertheless, a number of guidelines had been proposed for researchers to decide on the mode of measurement model (see Table 4.4). Thus far, the measurement models were dealt with first-order components, i.e., a single layer of constructs. Nonetheless, all the exogenous and endogenous variables consisted of another layer of latent dimensions that required certain indicators to measure them. Therefore, the models could be operationalized as higher-order models or hierarchical component models (HCM), as presented in the next section.

Table 4.4: Guidelines for choosing the measurement model mode (Hair et al., 2013, p. 47)

Reflective	Formative	Reference
The causal priority is from the construct to the indicators	The causal priority is from the indicators to the construct	Diamantopoulos & Winklhofer (2001)
The construct is a trait explaining the indicators	The construct is a combination of the indicators	Fornell & Bookstein (1982)
The indicators represent consequences of the construct	The indicators represent causes of the construct	Rossiter (2002)
It is necessarily true that if the assessment of the trait changes, all items will change in a similar manner (assuming they are equally coded)	It is not necessarily true that if the assessment of the trait changes, all items will change in a similar manner (assuming they are equally coded)	Chin (1998)
The items are mutually interchangeable	The items are not mutually interchangeable	Jarvis, MacKenzie & Podsakoff (2003)

4.3.1 Higher-order (or hierarchical component) models

According to Ringle, Sarstedt and Straub (2012), higher-order models or hierarchical component models (HCM) most frequent included testing second-order structures that had two layers of components. Specifying the structural model to involve more than one layer led to the advantage of overcoming the abstract definition of one layer measurement (Wetzels et al., 2009). Although models could be specified to include more than two layers of constructs (Wetzels et al., 2009), the most common type was the second-order, i.e., two layers, constructs (Hair et al., 2013). For example, entrepreneurship could not be measured directly and require certain indicators (i.e., manifest variables). Therefore, entrepreneurship was represented by several first (also called lower) order components that captured separate attributes of entrepreneurship. These included autonomy, proactiveness and risk taking. Construct of autonomy, proactiveness, and risk taking and their indicators (i.e., manifest variables) constituted first-order models, while construct of entrepreneurship with its three indicators constituted a second-order model. This went the same for other constructs in the structural models. Further, where it involved testing hierarchical relationships that containing two layers of constructs, Ringle et al. (2012) and Jarvis et al. (2003) made a distinction between four types of models hinged on the linkages among (1) the first-order latent variables and their manifest variables, and (2) the second-order latent variable(s) and the first-order latent variables (see Figure 4.4). These included reflective-reflective type I model (reflective first-order, reflective second-order), reflective-formative type II model (reflective first-order, formative second-order), formative-reflective type III model (formative first-order, reflective second-order) and formative-formative type IV model (formative first-order, formative second-order). The current study was concerned about the type I model, where the exogenous and endogenous LVs were all specified as type I models.

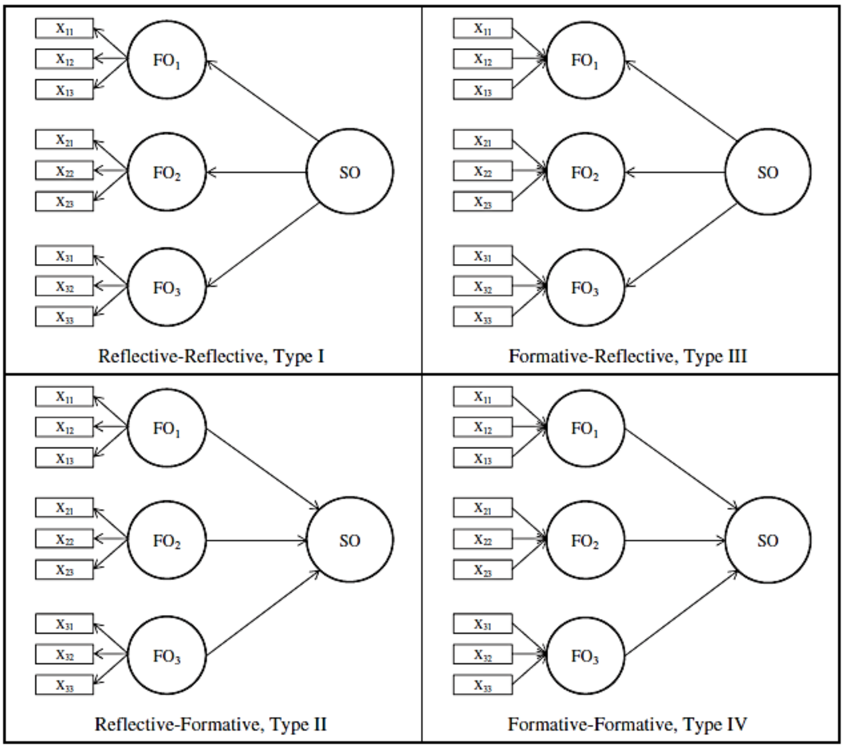


Figure 4.4: The four types of hierarchical latent variable models (Becker, Klein & Wetzels, 2012, p. 363)

In the present study, there were altogether eight measurement models (i.e., inter-organizational network, integrated market orientation, organizational learning, human resource practice, entrepreneurship, technological innovation, organizational innovation and firm performance) measured by multiple sub-constructs and the associated items. All constructs were type I models as indicated by the arrow pointing from the higher-order constructs to their respective lower-order constructs, that in turn pointing to their indicators. The scale items of all the measurement models were drawn from similar reported studies. Figure 4.5 illustrated the measurement model of entrepreneurship (i.e., main construct, sub-constructs and the associated items).

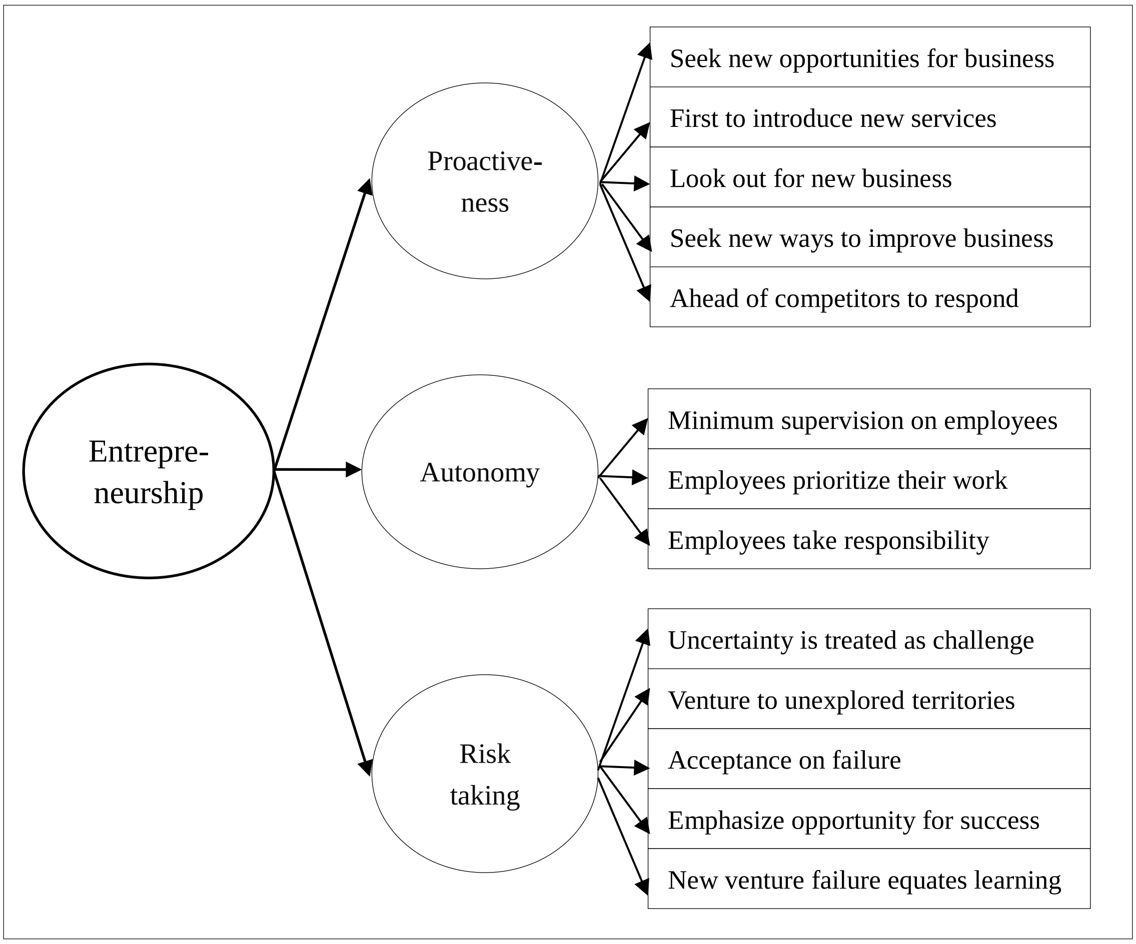


Figure 4.5: Hierarchical measurement model of entrepreneurship (Type I, reflective-reflective)

4.4 Data collection and examination

The third stage of PLS-SEM concerned with survey data collection and examination. The procedure of data collection included developing and pre-testing questionnaire, identifying sampling design, choosing sample and defining data collection method. The collected data was subsequently examined with some tests, prior to analyses, in order to satisfy certain requirement of multivariate data analysis.

4.4.1 Developing and pre-testing the questionnaire

In a thorough review of the preceding literature (as summarized in Table 4.3), a questionnaire consisting of variables with multi-items scales was formulated. Prior to the main distribution of questionnaires, these items were pre-tested. According to Cavana et al. (2001), pre-test of the questionnaire was process of developing the measuring instrument that includes content validity, face validity, and pilot study. The purpose of content validity was to ensure that the instrument sufficiently measure the concept in line with relevant literature or theories, past research and/or judgment of experts (Cavana et al. 2001). Meanwhile, the purpose of face validity was to ensure that items were clear and understandable, as well as to check if the items were measuring the concepts being investigated. Finally, pilot study was performed to make certain that the instrument as a whole functions effectively (Bryman & Bell, 2007).

4.4.1.1 Content validity

Content validity was related to how well the dimensions and elements of a concept had been depicted (Sekaran, 2003). In the present study, all items in the instrument were gathered from previous relevant literature (Cavana et al. 2001). Further, the adequacy of items in measuring the concepts could be validated via judgment of experts (Cavana et al. 2001). As illustrated in Appendix B, the researcher sought the opinion of four academics in the field to validate the adequacy of each item that were assigned to the constructs of the study. Also, the academics were asked to suggest any missing item in the questionnaire that they deem relevant and important. Based on the results of the content validity, some items were deleted.

4.4.1.2 Face validity

According to Cavana et al. (2001), face validity might be carried out in line with pilot study. The questionnaire survey of the pilot study was self-administered (i.e., distributed and collected by the researcher). This allowed the researcher to ask respondents about clarity and accuracy of each item. According to the proposed suggestion, some changes were made on the wording of questions or the deletion/replacement of redundant items.

4.4.1.3 Pilot study

Pilot study was important to test whether respondents were capable of completing the questionnaire and understand the questions (Creswell, 2008). In this connection, Bryman and Bell (2007) suggested that the respondents participated in the pilot study should be those who were not part of the sample. Instead, they should be a subset of comparable members of the population to avoid the effect of sample representativeness (Bryman & Bell 2007). To this end, a sample of SMEs was assembled from the "construction" category of the Malaysian SMEs Corporation listing. Subsequently, the instrument was pretested on a range of construction-based SMEs (i.e., architects, QS consultants, engineers and contractors), which locate in Klang valley. 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. The researcher distributed the questionnaire surveys on June 10, 2013. Exactly one month later, 31 valid questionnaires were collected. Table 4.5 illustrated the characteristics of the sample of pilot study.

Table 4.5: Information of the sampled respondents and their associated firms

Respondent	Position in firm	Exp. Construction	Firm age	Firm size	Firm type	Firm location	Firm's largest market
R01	MD/Owner	Between 11-15 years	3	Between 5-9	Architecture	Klang valley	Domestic
R02	MD/Owner	Between 21-25 years	13	Between 20-49	Engineering	Klang valley	Domestic
R03	Senior Management	Between 11-15 years	20	Between 20-49	Engineering	Klang valley	Domestic
R04	Senior Management	Between 11-15 years	7	Between 10-19	Quantity Surveying	Klang valley	Domestic
R05	Senior Management	Between 5-10 years	8	-[no answer]	Specialist/Trade Contracting	Klang valley	Domestic
R06	Senior Management	Between 21-25 years	6	-	Engineering	Klang valley	Domestic
R07	Other	Less than 5 years	23	Between 20-49	Engineering	Klang valley	Domestic
R08	MD/Owner	Between 21-25 years	20	Between 5-9	Specialist/Trade Contracting	Klang valley	Domestic
R09	Other	Between 16-20 years	14	Between 10-19	Engineering	Klang valley	Domestic
R10	Senior Management	Between 5-10 years	19	Between 5-9	Specialist/Trade Contracting	Klang valley	Domestic
R11	Senior Management	Between 11-15 years	10	Between 5-9	Specialist/Trade Contracting	Klang valley	Domestic
R12	MD/Owner	Between 21-25 years	21	Between 5-9	Specialist/Trade Contractor	Klang valley	Domestic

Table 4.5, continued

Respondent	Position in firm	Exp. Construction	Firm age	Firm size	Firm type	Firm location	Firm's largest market
R13	MD/Owner	Between 21-25 years	-	Between 10-19	Quantity Surveying	Klang valley	Domestic
R14	-	Between 16-20 years	13	Between 20-49	Specialist/Trade Contracting	Klang valley	Domestic
R15	MD/Owner	Between 11-15 years	5	-	General contracting	Klang valley	Domestic
R16	MD/Owner	Between 26-30 years	14	Between 10-19	General contracting	Klang valley	Domestic
R17	-	Between 5-10 years	20	Between 20-49	Quantity Surveying	Klang valley	Domestic
R18	MD/Owner	Between 26-30 years	14	Between 10-19	Architecture	Klang valley	Domestic
R19	MD/Owner	Between 16-20 years	10	Between 5-9	General contracting	Klang valley	Domestic
R20	Senior Management	Between 16-20 years	14	Between 20-49	Engineering	Klang valley	Domestic
R21	MD/Owner	Between 26-30 years	21	Between 20-49	Architecture	Klang valley	Domestic
R22	Senior Management	Between 21-25 years	10	-	Quantity Surveying	Klang valley	Domestic
R23	MD/Owner	Between 21-25 years	7	Between 5-9	Engineering	Klang valley	Domestic
R24	MD/Owner	Between 5-10 years	23	Between 20-49	General contracting	Klang valley	Domestic
R25	Senior Management	Between 5-10 years	16	Between 10-19	Engineering	Klang valley	Domestic
R26	Senior Management	Between 5-10 years	14	Between 10-19	Specialist/Trade Contracting	Klang valley	Domestic
R27	MD/Owner	Between 26-30 years	18	-	Specialist/Trade Contracting	Klang valley	Domestic
R28	-	Between 16-20 years	19	Between 10-19	General contracting	Klang valley	Domestic
R29	Senior Management	Between 5-10 years	13	Between 5-9	Specialist/Trade Contracting	Klang valley	Domestic
R30	Senior Management	Between 26-30 years	20	Between 20-49	Specialist/Trade Contracting	Klang valley	Domestic
R31	Senior Management	Between 26-30 years	22	Between 10-19	Engineering	Klang valley	Domestic

4.4.1.4 Reliability of pilot study

Test of reliability was performed to check the internal consistency and stability of the instrument (Cavana et al., 2001). By using Cronbach's alpha available in the SPSS Statistics (version 16), the instrument was tested on their consistency in yielding the same answers when repeated. Based on Table 4.6, it was revealed that the scores for all scales ranging from .738 to .923, which were above the threshold of .60 that indicated good reliabilities (Sekaran, 2003).

Table 4.6: Reliability of questionnaire survey in the pilot study

Construct	N of items	Cronbach's Alpha if Item Deleted
OL	15	0.909
EO	13	0.853
HRP	10	0.901
IMO	16	0.923
IN	9	0.825
TI	8	0.738
OI	8	0.826
FP	7	0.843

4.4.2 Measurement instrument

After adjusting the scales based on the feedback derived from pre-test, the final questionnaire comprised 93 items (see Table 4.7) that were measured on a five-point Likert-type scale. Altogether, the questionnaire consisted of four sections (see Appendix D). Section I included general information of the respondents and their associated firms, such as designation of respondent, firm age, firm size, firm's largest market, firm type and so on. All questions in this section were of either categorical or dichotomous types. Section II consisted of 16 items that indicated innovation activities while section III contained 70 items that indicated various types of organizational capabilities. Finally, Section IV included 7 items that indicated firm performance.

Table 4.7: Measurement items of innovation activities, organizational capabilities and firm performance

Variable 1. INNOVATION ACTIVITIES		
1. Technological innovation (indicators = 8)		
1.1	Product innovation	We introduce new goods/services that competitors do not offer in the market.
1.2		We improve existing goods/services to meet customer needs.
1.3		Our firm seeks to find new goods/services for customers.
1.4		Our firm offers new goods/services to customers.
1.5	Process innovation	We update (or review) production process to increase productivity.
1.6		We use technologies (new construction material, plant & equipment, software, etc.) in our production processes.
1.7		We introduce new production processes to improve output quality and/or to decrease production costs.
1.8		We identify and remove non-value added activities in our production processes.
2. Organizational innovation (indicators = 8)		
2.1	Managerial innovation	We introduce new ways of managing our business.
2.2		Our firm invests in updating management procedures (e.g. ISO, etc.).
2.3		Management seeks new ways to improve the management systems.
2.4		Our firm renews the organization structure to facilitate the coordination of activities.
2.5	Marketing innovation	We offer extended/customized services in providing our services (e.g. value engineering, going extra mile to ensure client's satisfaction, etc.).
2.6		We seek to expand into new market to sell our services (e.g. new location).
2.7		We seek new techniques to promote our services (e.g. advertising, maintaining company website, printing brochures, etc.).
2.8		We seek to provide more competitive price by renewing the pricing strategies (e.g. tender bid, etc.) to market our services.
Variable 2. ORGANIZATIONAL CAPABILITIES		
1. Entrepreneurship Orientation (indicators = 13)		
1.1	Autonomy	Employees are encouraged to take responsibility for their work.
1.2		Employees are supposed to get the job done with minimum supervision.
1.3		Employees are encouraged to prioritise their work.
1.4	Risk taking	In this firm, uncertainty is treated as a challenge.
1.5		Employees are encouraged to venture into unexplored territories.
1.6		Management accepts that certain suggestions may fail when implemented.
1.7		Our firm emphasises opportunity for success, rather than chances for failure.
1.8		In this firm, new venture failure is viewed as a learning experience.
1.9	Proactiveness	We constantly seek new opportunities related to the present operations.
1.10		We are usually the first to introduce new services in the industry.

Table 4.7, continued

1. Entrepreneurship Orientation (indicators = 13)		
1.11	Proactiveness	We constantly look out for business that can be acquired.
1.12		We constantly seek opportunities to improve our business performance.
1.13		We are always ahead of our competitors in responding to market challenges.
2. Integrated Market Orientation (indicators = 16)		
2.1	Customer orientation	Our business objectives are driven primarily by customer satisfaction.
2.2		We constantly monitor our level of commitment to serving customers' needs.
2.3		Our strategies are driven by the need to create value for our customer.
2.4		We believe that understanding customers' needs gives us a competitive advantage.
2.5	Latent need fulfillment	We seek to understand what customers might need in the future.
2.6		We continuously seek to uncover new customers' needs.
2.7		We develop solutions to unexpressed (i.e. not voiced out) customers' needs.
2.8		We use a number of techniques to discover currently unexpressed customers' needs.
2.9	Competitor orientation	We frequently collect information on our competitors to help direct our firm's strategies.
2.10		We regularly share information within our firm concerning competitors' strategies.
2.11		We rapidly respond to competitors' actions that threaten us.
2.12		Top management regularly discusses competitors' strategies.
2.13	Inter-functional coordination	We coordinate goals and objectives across all functions (i.e. departments).
2.14		All functions (i.e. departments) are integrated in serving the needs of our target market.
2.15		Market information is shared with all functions (i.e. departments) inside the firm.
2.16		Management understands how everyone in the firm can contribute to create value for customers.
3. Human Resources Practices (indicators = 10)		
3.1	Job related	Our firm seeks to match employees to specific job requirements.
3.2		We treat our employees as the most valuable resources within our firm.
3.3		Extensive training programs are provided for individuals in our firm.
3.4		Our firm emphasizes the importance of having satisfied employees.
3.5		Employees in this firm are provided with clear career paths
3.6		Job security is almost guaranteed to employees in our firm.
3.7		Our firm seeks to maintain high level of employee motivation.
3.8	Reward related	In our firm, employees receive benefits linked to their performance.
3.9		Employees are given bonuses for outstanding performance.
3.10		All employees receive effective feedback on their performance.
4. Organizational learning (indicators = 15)		
4.1	Managerial commitment	Managers frequently involve their staff in important decision-making processes.
4.2		The firm's management looks favorably on carrying out changes in any area to adapt to and/or keep ahead of new environmental situations.
4.3		Employee learning ability is considered a key factor in the firm.
4.4		In this firm, innovative ideas that work are rewarded.
4.5	System perspective	All employees have generalized knowledge regarding the firm's objectives.
4.6		All parts that make up the firm (departments, sections, work teams and individuals) are well aware of how they contribute to achieving the overall objectives.

Table 4.7, continued

4. Organizational learning (indicators = 15)		
4.7	System perspective	All parts that make up the firm (departments, sections, work teams and individuals) are interconnected and work together in a coordinated fashion.
4.8	Openness and experimenta-tion	The firm promotes experimentation and innovation as a way of improving the work process.
4.9		The firm follows up what other firms in the sector are doing, and adopts practices and techniques it believes to be useful and interesting.
4.10		Experiences and ideas provided by external sources (advisors, customers, training firms, etc.) are considered a useful instrument for this firm's learning.
4.11		Part of the firm's culture is that employees can express their opinions and make suggestions regarding procedures and methods in place for carrying out tasks.
4.12	Knowledge transfer	Errors and failures are always discussed and analysed by the firm at all levels.
4.13		In this firm, teamwork is not the usual way to work. (R)
4.14		Employees have the chance to talk among themselves about new ideas, programs and activities that might be of use to the firm.
4.15		The firm has instruments (manuals, databases, files, organizational routines, etc.) that allow what has been learnt in past situations to remain valid, although the employees are no longer the same.
5. Inter-organizational networks (indicators = 16)		
5.1	Heterogeneity (i.e. breadth of networks)	Customers
5.2		Suppliers of components, equipment and software
5.3		Competitors
5.4		Experts and consultancy firms
5.5		R&D firms or laboratories
5.6		Universities or centres of higher education
5.7		Public and non-profit research organizations
5.8		Firms outside your industry
5.9	Intensity (i.e. depth of networks)	Customers
5.10		Suppliers of components, equipment and software
5.11		Competitors
5.12		Experts and consultancy firms
5.13		R&D firms or laboratories
5.14		Universities or centres of higher education
5.15		Public and non-profit research organizations
5.16		Firms outside your industry
Variable 3. FIRM PERFORMANCE (indicators = 7)		
1.1	Financial	Profitability
1.2		Annual sales growth
1.3		Market share
1.4		Labour productivity
1.5	Non-financial	Customer satisfaction
1.6		Repeat business
1.7		Reputation

All items of the constructs were rated on a five-point Likert-type scale, where the respondents could write down a number (i.e., 1 to 5) at the end of each statement. Higher scores denoted higher levels of agreement with a particular statement. The researcher believed that the use of the scale might induce the respondents to rate each of the question more accurately and carefully. Each questionnaire required 10 to 15 minutes to answer.

4.4.3 Sampling design

The current study utilized judgment (i.e., one type of purposive) sampling categorized under non-probability sampling design (Sekaran, 2003). According to Babbie (2008), judgment sampling could be selected based on the purpose of research study as well as knowledge about the population and its elements. Unlike probability sampling, generalizability of the findings was curtailed in this kind of sampling (Sekaran, 2003). However, purposive sampling could offer a general understanding on the topic at hand (Babbie, 2010). Further, the judgment sampling was the only viable sampling method to locate and gain access to subjects who were in the best position to offer the information required (Sekaran, 2003). Moreover, it was best suited to study in which the population was difficult to identify (Babbie, 2010). Accordingly, the judgment sampling was suitable to study in which a limited amount or category of people possess the information that was sought (Sekaran, 2003). In such cases, any form of probability sampling design across a cross-section of the whole population was purposeless and not useful (Sekaran, 2003). Due to the purpose of the study and knowledge about the population, the judgment sampling was selected.

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. However, method of data analysis could affect the sample size. For instance, Cavana et al. (2001) recommended the sample size to be several times the number of variables in the study. According to Sekaran (2003), the sample size for a multivariate research should be several times (preferably 10 times or more) larger than the number of variables. Meanwhile, Hair et al. (2006) suggested a minimum ration of 1:5 (i.e., variables to cases). Further, the number of cases should not be less than 100 for multivariate analysis, especially factor analysis (Hair et al., 2006). On contrary, PLS did not require a large sample size for analysis as it involves a non-parametric test (Chin & Dibbern, 2010).

4.4.3.1 Choosing the sample

Samples of this study include selected contracting firms of SME size during the conduct of research. These firms were expected to present some features of smaller businesses, such as having limited resources in terms of financial strength and number of staffs. According to National SME Development Council (2005), firm size could be either determined by annual sales turnover or number of full-time employees. This study adopted 'number of full-time employees' as a measure to determine the firm size of the sample. For service industries, including the construction, small firms were those having 5 to 19 full-time employees whereas medium-size firms were those having 20 to 50 full-time employees (National SME Development Council, 2005). However, it was not easy to determine the exact population (i.e., total number of SMCFs in Malaysia).

Firstly, a sample of construction SMEs was assembled from the Malaysian SME Corporation listing. Although the listing includes firms of SME type, it was not a full list that covers all the SMCFs in Malaysia. This was because it included only construction SMEs which took an initiative to participate in business programs offered by the Malaysian SME Corporation; those which did not have an interest to participate in the business programs was not covered in the listing. Hence, the Malaysian SME Corporation listing was incomplete for not including all SMCFs. In alternative, the researcher acquired a sample of contracting firms from the Malaysian CIDB listings. The listing was a full list that covered all the contracting companies in Malaysia. Instead of using the Malaysian SME Corporation listing, the researcher therefore decided to use the Malaysian CIDB listings as it covered all contracting companies operate in Malaysia. However, the listing included several detailed information (company name, address, contact number, contractor's grade), except the information on the firm size. This was one of the reasons that affected the decision to select judgment sampling.

In this view, the researcher decided to sample those firms having contractor grade between four to six (G4 to G6). It was presumed that these firms were neither large firms (i.e., having more than 50 full-time employees) nor micro firms (i.e., having less than five full-time employees). Also, only firms located in Kuala Lumpur states were included for they were more likely to operate under competitive environment, and they were convenient in accessing. From these key construction firms, a final sample of approximate 750 firms was yielded. As it had been corroborated that member of executive-level in the firm, e.g., owner, managing director, CEOs, were the "single most knowledgeable and valid information sources” (Lechner, Dowling, & Welpe, 2006, p. 525), these people were selected as the key informants (unit of analysis).

4.4.4 Data collection

The sample obtained during the pilot study was excluded from this stage. An introductory cover letter and a self-addressed, stamped return envelope were attached together with the questionnaire survey as a mean to improve the response rate of the mail questionnaires (Sekaran, 2003). An approximate of 750 questionnaires were mailed to the targeted contracting firms (G4 to G6; general and specialist/trade contractors) located in Kuala Lumpur. The present study targeted on the managing directors who were the main person involves in the decision making of firm, therefore would most probably had a good overview of the company’s innovation activities over preceding years.

After three weeks from the first wave of main distribution, follow-up calls were made to the non-response firms. For firms which claimed for not receiving the surveys, the researcher resent the questionnaire (by fax, e-mail or postal mail) to them. Data collection lasted for three and a half months, starting from 30 July 2013 to 15 November 2013. Of these, only 201 firms answered, representing a response rate of 26.8%. Prior to data analyses, however, satisfying certain requirements of multivariate data analysis was important (Hair et al., 2006). The next section presented the examination of data for multivariate analysis.

4.4.5 Data examination

As the data were collected using questionnaire, some typical preliminary analyses were performed in the first place. These analyses included (but not limited to) suspicious response patterns, missing data, outliers and data distribution (Hair et al., 2013).

4.4.5.1 Suspicious response patterns

There were two types of suspicious response patterns, namely, inconsistencies in answers and straight lining (Hair et al., 2013). The former needed to be addressed when a survey starts with one or more screening questions, which were to ensure that only individuals who met the prescribed criteria complete the survey. Meanwhile, the latter occurred when a respondent marked the same response in almost all the questions. Accordingly, cases with suspicious response patterns should be removed from the data set. In the present study, the survey screened for individual who was associated with SMEs. To this end, the demographic variable of firm size (i.e., number of full-time employees) was checked for correspondence. In this regards, the data set was refined by respondents associated with small (5-19 full-time employees) or medium (20-50 full-time employees) firms. Only 162 usable questionnaires were fulfilling the criteria; the rest 39 responses were eliminated as they were either of micro or large companies. Similarly, it was found that two cases were selecting only 3s of a 5-point scale in all the items. Hence, they were eliminated from the data set and this reduced the number of the sample to 160 cases.

4.4.5.2 Outliers

According to Hair et al. (2006), outliers were referred to observations with a unique combination of characteristics that differed from other observations. In this regard, outliers could be categorized into procedural error (i.e., errors in data entry, which could be identified by boxplots and such errors must be corrected), extraordinary event, extraordinary observation (had no explanation and could be omitted unless it represented the populations), and unique in the combination of value across the variables. To detect outliers, univariate detection, bivariate detection and multivariate detection could be used (Hair et al., 2006). In the present study, both univariate and multivariate detections were used. The bivariate detection was not taken into consideration as scatterplots, which could be used to demonstrate the relationship between pairs of variables, required a significant amount of plots.

1. *Univariate detection:* Univariate outliers were cases which had an unusual value for a single variable. To detect univariate outliers, it involved the conversion of data values to standard scores with a mean of 0 and standard deviation of 1 (Hair et al., 2006). To do so, the following steps were followed using SPSS Statistics (version 16):

   a) From the menus, choose:

      Analyze

        Descriptive Statistics

          Descriptives…

b) Select all the metric variables (i.e., interval or ordinal variables that were treated as metric).

c) Choose model *Save standardized values as variables*.

According to Hair et al. (2006), standardized variables with values up to $\pm$ 4 were regarded as probable outliers. Further, decision to delete or retain outlier cases depended on whether the cases were aberrant and did not represent the populations. The researcher did not identify any probable univariate outliers.

2. *Multivariate detection:* Mahalanobis D^2 measure was used to detect any multivariate outliers in the data set. According to Hair et al. (2006), the value resulted from division of D^2 by number of variables involved (i.e., D^2/df) should be less than 3 or 4 for large samples with significance level of .005 or .001. The probability of MAH_1 (that denoted the score of D^2) was computed using SPSS Statistics (version 16), as shown below:

a) From the menus, choose:

Transform

Compute Variables…

b) From Function Group, choose **Cdf.Chisq**.

c) Assign (MAH_1) to the function, followed by comma, followed by the number of dependent variables.

d) From Target Variable, choose a name for the new computed variable (e.g. P_MAH_1).

e) Click on OK and notice the new added variable (P_MAH_1) in the Data View.

The current study identified three cases that had probable multivariate outliers. Again, the decision to delete outlier cases depended on whether the cases were aberrant and did not represent the populations. It was found that the respondents of these cases were not of construction-based (i.e. others project-based firms), had little experience (i.e., position in firm) and their answers were not highly consistent. Therefore, the researcher decided to eliminate these from the data set. This reduced the number of the sample from 160 to 157 cases. The researcher believed eliminating these cases would not influence the results as they represented a trivial percentage of the total number of cases.

4.4.5.3 Missing data

Missing data occurred when there was one or more lift-out question(s) that a respondent either purposely or inadvertently failed to answer. According to Hair et al. (2006), understanding the cause(s) of missing data before its remedy was important. The steps of managing missing data were presented as follows (Hair et al., 2006):

1. *Determine type of missing data:* The possibilities for missing data could be due to known or unknown reasons. For known reasons (i.e., procedural issues, including error in data entry, disclosure restriction, failure to complete the entire questionnaire,

or morbidity of respondents), the remedies were applicable if the missing data was found to be random. The unknown reasons were related to the respondents (i.e., refuse to respond or had insufficient knowledge). In the present study, both known and unknown missing data were found in the data set. The known reason (errors in data entry) was corrected accordingly while the remedies for unknown missing data were illustrated in the following steps.

2. *Determine the extent of missing data:* For an observation having exceeded 15% of missing data, removal of the observation from data file was an appropriate remedy (Hair et al., 2013). However, there was a condition where a questionnaire was subject to removal even though the overall missing data did not exceed 15%. This occurred when there was a high proportion of missing data on a single construct. In the present study, all cases had less than 15% missing data for each individual observation (see Appendix E). Hence, all cases with missing data were retained and treated with appropriate imputation methods as shown below.

3. *Diagnose the randomness of missing data:* There were two levels of randomness, namely, missing at random (MAR) and missing completely at random (MCAR). As the level of missing data for each case was insufficient to warrant action, the researcher decided to consider the missing data as MCAR.

4. *Select the imputation method:* To manage missing data of MCAR type, the imputation method included imputation using only valid data (i.e., including complete case approach and using all-available data) and imputation by using replacement values (i.e., including using known replacement values and calculating replacement values). In the present study, the imputation by using all-available data

method was chosen to remedy the missing data. In SPSS Statistics, PAIRWISE represented this method. also, the decision was made due to the relative low level of missing data, the sample size was not large enough to call for methods that excluded missing data from analysis (e.g., LISTWISE), and the relationship between variables was considered to be moderated (exclude the need to use replacement values method).

4.4.5.4 Test of normality (data distribution)

According to Hair et al. (2006), test of normality was important because large non-normality distribution led to invalid statistical test. In this connection, Shapiro-Wilks and Kolmogorov-Smirnov tests were the two well-known tests of normality (Mooi & Sarstedt, 2011). Moreover, normality could be tested using skewness and kurtosis values (Hair, Black, Babin, & Anderson, 2010). Using Shapiro-Wilks test, it was revealed that most of the variables were of non-normal distributions. Nonetheless, it was important to note that the distribution became an issue only when researcher wanted to use a statistical tool that required normally distributed data. In the present study, however, the PLS analysis did not necessitate normal distribution of the sample (Chin & Dibbern, 2010) for it was a non-parametric method (Hair et al., 2013).

4.4.6 Descriptive analysis

This section intended to show a general view on the descriptive statistics of the categorical variable only, including the frequencies of the respondents (i.e., unit of analysis) and their associated firms. As indicated in Table 4.8, the respondents were homogenous samples of managing director/owners (54.8%), senior managers (40.8%) and others (4.5%). The sample varied between firms that based on business upon main-contracting (47.8%), specialist-contracting (44.6%) or both (6.4%) basis. The distribution by number of full-time employees of the sample denoted the population characteristics in terms of firm size, where 55.4% of the firms were small (5–19 employees) and 41.4% were medium-sized (20–50 employees). Further, the contractor grades of the SMCFs were grade 4 (14%), grade 5 (32.5%), grade 6 (34.4%) and grade 7 (7.0%). Astonishingly, contracting firms of G7 had turned up in the data though the sample had been limited to SMCFs of G4 to G6 only. This was because a minority of them had been upgraded to G7 but such information had not been updated in the CIDB listing. The established year of firms were distributed as follow: between 1-5 years (3.8 %), between 6-10 years (16.6 %), between 11-15 years (25.5 %), between 16-20 years (29.9 %), between 21-25 years (12.1%), between 26-30 years (7.6%) and more than 30 years (2.6%). In terms of market size, vast majority (96.8%) of the firms operated in domestic market whereas a small minority (3.2%) operated in both domestic and international markets. Appendix F showed the distribution of the descriptive information of the respondents and their firms.

Table 4.8: Characteristics of respondents and their firms

		Frequency	Percent	Valid Percent	Cumulative Percent
Designation of respondents					
Valid	managing director/owner	86	54.8	54.8	54.8
	senior manager	64	40.8	40.8	95.5
	Other	7	4.5	4.5	100.0
	Total	157	100.0	100.0	
Firm type					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	general contractor	75	47.8	48.4	48.4
	specialist contractor	70	44.6	45.2	93.5
	mix (general/specialist)	10	6.4	6.5	100.0
	Total	155	98.7	100.0	
Missing	-99	2	1.3		
Total		157	100.0		
Firm age					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	between 1-5	6	3.8	3.9	3.9
	between 6-10	26	16.6	16.9	20.8
	between 11-15	40	25.5	26.0	46.8
	between 16-20	47	29.9	30.5	77.3
	between 21-25	19	12.1	12.3	89.6
	between 26-30	12	7.6	7.8	97.4
	more than 30	4	2.5	2.6	100.0
	Total	154	98.1	100.0	
Missing	-9	3	1.9		
Total		157	100.0		
Firm's largest market					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	domestic	152	96.8	96.8	96.8
	international	5	3.2	3.2	100.0
	Total	157	100.0	100.0	

Table 4.8, continued

Number of full-time employees					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	between 5-19	87	55.4	57.2	57.2
	between 20-50	65	41.4	42.8	100.0
	Total	152	96.8	100.0	
Missing	-99	5	3.2		
Total		157	100.0		
Contractor grade					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	grade 4	22	14.0	15.9	15.9
	grade 5	51	32.5	37.0	52.9
	grade 6	54	34.4	39.1	92.0
	grade 7	11	7.0	8.0	100.0
	Total	138	87.9	100.0	
Missing	-99	19	12.1		
Total		157	100.0		

4.5 Assessment of measurement models

In the fourth stage of PLS-SEM, the measurement models needed to be assessed for their quality. Parallel analysis, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were successively performed to refine the measurement model. The purpose of EFA was to identify factor structure of the key constructs (using SPSS Statistics, version 16.0) while the CFA was subsequently conducted to validate the results of EFA (using SmartPLS 2.0 M3). All these analyses aided in developing the measurement scales of various types of organizational capabilities, both technological and organizational innovations, and firm performance.

4.5.1 EFA using principal component method

In order to define the factor structure of key constructs, there were various EFA methods available for such purpose, such as principal components, maximum likelihood, principal axis factoring and so on. In this regard, the principal component analysis (PCA) method was found to align with PLS approach (Chin, 1995; Sosik, Kahai & Piovoso, 2009). According to Hair et al. (2006), PCA could be used to summarize or reduce data, of which in turn, defined the underlying structure among correlated variables. Hence, the present study utilized PCA to ensure its compatibility with the use of PLS approach later on. Further, both Kaiser–Meyer–Olkin (KMO) index and Bartlett's test of sphericity were used to determine the sufficiency of the data set for subsequent exploratory factor analysis (Chu & Murrmann, 2006). The threshold of KMO index was .60 (Tabachnick & Fidell, 1989) and the Barlett's sphericity test had to be of high significance (Field, 2000).

4.5.1.1 Identifying and interpreting components of PCA

In this study, PCA aided in reducing the number of variables (i.e., a total of 93 metric variables) and developing dimensions for each construct. To this end, a strong conceptual foundation for the structure and its rationale was required. According to Hair et al. (2006), this stage encompassed three processes, namely, estimation of factor matrix, factor rotation, and factor interpretation and re-specification. As in factor matrix, there would be a matrix of variables and components with factor loadings, all of which, were outputs produced by PCA. High factor loadings denoted high correspondence between variables and factors, and high representative of the factor (Hair et al., 2006).

As in factor rotation, it was required to decide the type of rotation for the factors in order to obtain a better interpretation of the factor, better underlying structure and more theoretical solution (Hair et al., 2006). For this purpose, two types of rotations (orthogonal and oblique) could be used. In the present study, the oblique rotation was performed for all the measures to examine their respective factor structures. According to Hair et al. (2006), this type of rotation was more realistic in that it allowed for correlated factors instead of maintaining independency between the rotated factors. Examples of the oblique rotation included direct oblimin, quartimin and promax.

Finally, to interpret and re-specify the factors in the matrix, Hair et al. (2006) suggested three types of problem to be identified, (1) the factor loading of variable (less than .4 means insignificant), (2) cross-loading variable in two different groups at a time, and (3) low communality between variables (i.e., amount of variance accounted for, in which value less than .50 was not significant). The factor model should be re-specified whenever it was needed, and the factors should be labelled with a variable having the highest loading as the most representative factor.

4.5.1.2 Parallel analysis

Prior to EFA (by using PCA for the present study), however, it was important to first determine the optimum number of extracted components for each key construct. According to Hair et al. (2006), traditional methods included latent root test (that identified all factors to have eigenvalues > 1) and scree test (that examine the cut-off point in the curve graph). Based on parallel analysis, O'Connor (2000) had also developed a syntax that will produce a plot called "Tsplot" for EFA. More specifically, the "Tsplot" was a plot with horizontal lines crossing the main line of the eigenvalue. The number of factors lied above the crossing lines determining the appropriate number of extracted factors. Using SPSS Statistics, the present study utilized the parallel analysis to determine the appropriate number of extracted factors for all constructs, as presented below.

4.5.1.3 Parallel analysis and PCA of integrated market orientation

The result of parallel analysis on integrated market orientation (IMO) suggested that three components should be extracted in subsequent PCA. As depicts in Figure 4.6, only factors lied above the extraction line were considered. Y-axis denoted the eigenvalue while X-axis denoted the number of variables. Appendix G showed O'Connor's syntax and the steps of conducting parallel analysis using SPSS Statistics (e.g. entrepreneurship).

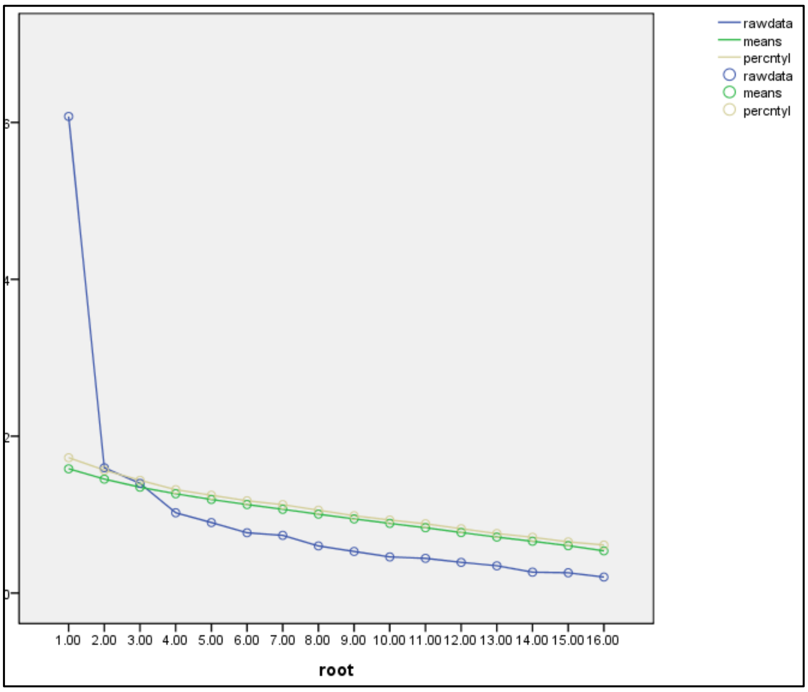


Figure 4.6: Tsplot of IMO

After parallel analysis, PCA was performed using SPSS Statistics (version 16) according to the following criteria:

- Extraction method: principal component – number of extracted factor was restricted by the results of parallel analysis (3 components);
- Rotation method: Oblique (Promax – kappa = 4)
- Missing data: excluding cases Pairwise; and
- Factor loading > .40 (Hair et al., 2006)

As observed in Table 4.9, the KMO index was .875, which was above the threshold level, while the result of Bartlett's sphericity test was 1072.856, with a significance level of .000. These results indicated the appropriateness of conducting EFA in the subsequent analysis. Also, it was found that these criteria yielded good results of communalities, total variance extracted and pattern matrix. The three extracted factor could explain 64.1% of the total variance. Commonalities of variables were generally good at above .50 for all variables. Loading of the extracted factors were illustrated in the pattern matrix in Table 4.10.

Table 4.9: KMO and Bartlett's test of IMO

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.875
Bartlett's Test of Sphericity	Approx. Chi-Square	1072.856
	df	91
	Sig.	.000

Table 4.10: Pattern matrix of IMO

Pattern Matrix[a]				
Variable	Label	Component's loading		
		1	2	3
Imor15	Share market information	1.004		
Imor14	All functions are integrated	.841		
Imor12	Discuss competitors' strategies	.713		
Imor11	Respond to competitors' actions	.592		
Imor10	Share competitors' strategies	.522		
Imor16	Contribute to create customer value	.485		
Imor13	*Coordinate goals and objectives*			
Imor8	Use technique to discover needs		.930	
Imor7	Develop solutions to unexpressed needs		.851	
Imor6	Uncover new customers' needs		.834	
Imor5	Understand customers' future need		.680	
Imor9	*Collect information on competitors*			
Imor1	High customer satisfaction			.984
Imor2	Monitor on employee commitment			.770
Imor3	Create customer value			.726
Imor4	Understanding customers need			.679

Extraction Method: Principal Component Analysis.

Rotation Method: Promax with Kaiser Normalization.

a. *Rotation converged in 5 iterations.*

b. *The variables in italic font will be eliminated from further analysis as they score less than .40*

Out of 16 variables in the original measurement, 14 variables were extracted to measure IMO as they scored loading of less than .40. It was worth noting that PCA changed the initial grouping of certain variables under other components. In this regards, the names of the new components could either be retained or changed according to the variables loaded to a particular component. According to Hair et al. (2006), a component could be assigned with a name based on the highest variable loaded to it. As such, Component 1 might be named as “integrated competitor orientation” as it involved the firm’s orientation towards competitors and integration of different functions. On the other hand, the names of the other two components were retained as their loaded factors were the same. Component 2 was “latent need fulfilment” while Component 3 was “customer orientation”.

4.5.1.4 Parallel analysis and PCA of organizational learning

A similar approach was used to determine the number of components for organizational learning (OL). As seen in Figure 4.7, the result of parallel analysis on OL suggested that two components should be extracted. After determining the appropriate number of components to be extracted, PCA of the construct of OL was conducted using the same criteria as the ones employed in the prior constructs:

- Extraction method: principal component – number of extracted factor was restricted by the results of parallel analysis (2 components);
- Rotation method: Oblique (Promax – kappa = 4)
- Missing data: excluding cases Pairwise; and
- Factor loading > .40 (Hair et al., 2006)

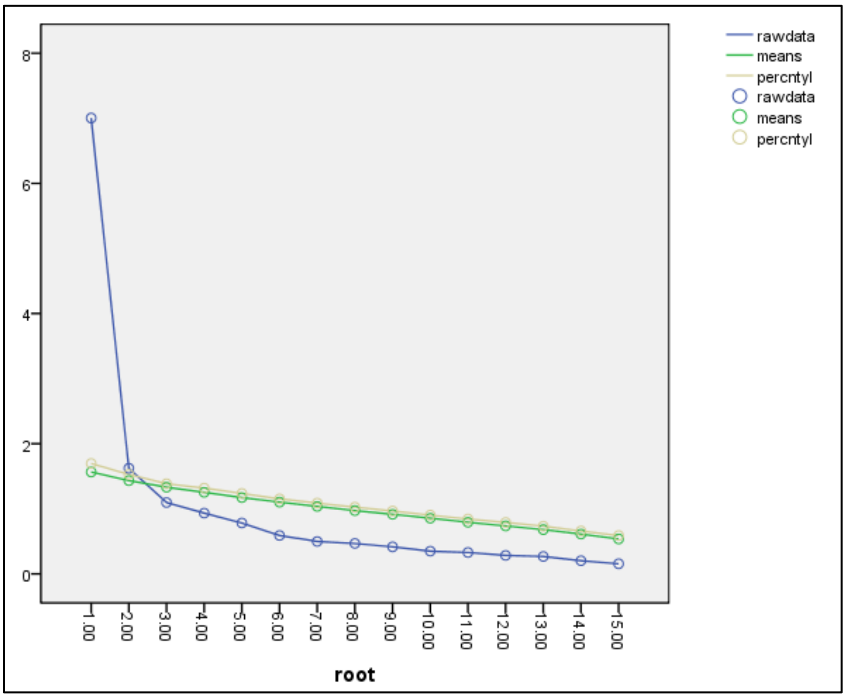


Figure 4.7: Tsplot of OL

The results of KMO index and Bartlett's sphericity test were illustrated in Table 4.11. The two extracted factor could explain 53.7% of the total variance. Commonalities of variables were generally good at above .50 for most variables; however, some variables loaded less than .50 but not less than .40, and that was generally satisfactory. Loading of the extracted factors were illustrated in Table 4.12.

Table 4.11: KMO and Bartlett's test of OL

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.912
Bartlett's Test of Sphericity	Approx. Chi-Square	944.636
	df	91
	Sig.	.000

Table 4.12: Pattern matrix of OL

Pattern Matrix[a]			
Variable	Label	Component's loading	
		1	2
Lcap9	Follow up others and adopt practices/techniques	.903	
Lcap1	Involve staff in decision making	.822	
Lcap8	Promote experimentation and innovation	.794	
Lcap10	Take experiences and ideas from others	.782	
Lcap3	Employees' learning capability	.522	
Lcap2	Carry out changes to adapt to new situations	.490	
Lcap4	*Reward on innovative idea*		
Lcap14	Teamwork of everyone		.813
Lcap12	Discuss and analyse errors/failure		.805
Lcap13	Talk about new ideas, programs and activities		.728
Lcap15	Has instruments to record past experiences		.713
Lcap5	Generalized knowledge on firm's objectives		.675
Lcap6	Contribute to overall objectives		.501
Lcap7	*Interconnection within firm*		
Lcap11	*Express opinions and suggestions*		

Extraction Method: Principal Component Analysis.

Rotation Method: Promax with Kaiser Normalization.

a. *Rotation converged in 3 iterations.*

b. *The variables in italic font will be eliminated from further analysis as they score less than .40*

Out of 15 variables, 12 were extracted under two new components. As such, Component 1 might be assigned the name of "Openness and experimentation" as it involved attribute of openness and experimentation towards learning while Component 2 might be named as "system perspective and knowledge transfer" as variables under this component indicated attribute of managerial efforts in emphasizing and transferring knowledge.

4.5.1.5 Parallel analysis and PCA of human resource practice

The criteria for determining the number of components in human resource practice (HRP) was similar to the previous procedure. It was suggested that two components of HRP to be extracted, as shown in the following Tsplot (Figure 4.8).

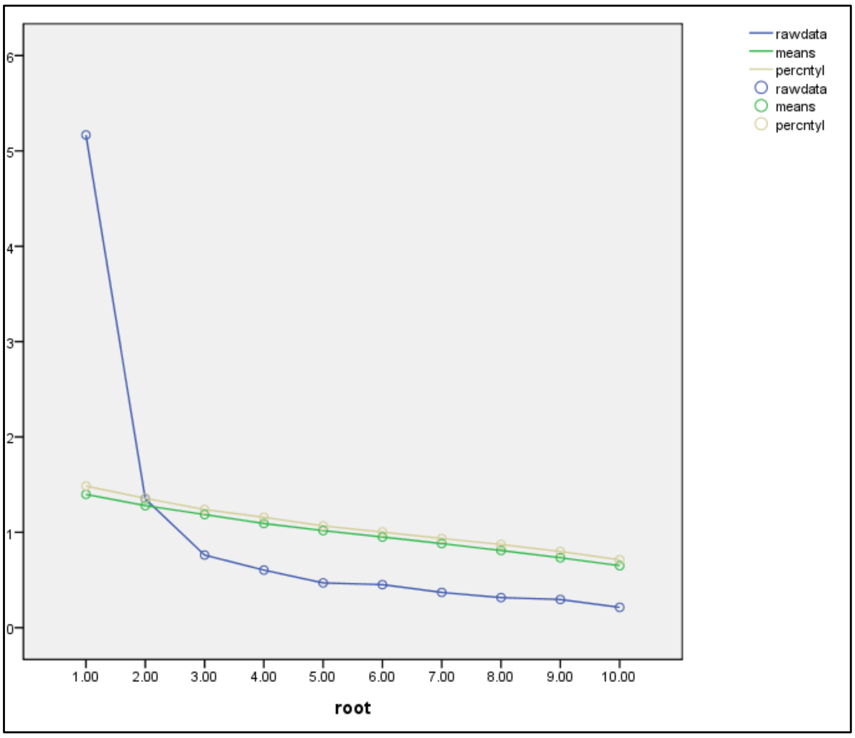


Figure 4.8: Tsplot of HRP

Likewise, the PCA of the construct of HRP was conducted using the same criteria as above. The results of KMO index and Bartlett's sphericity test were illustrated in Table 4.13. The two extracted factor could explain 62.1% of the total variance. Commonalities of variables were generally good at above .50 for most variables; however, two variables loaded less than .50 but not less than .30. Loading of the extracted factors were illustrated in Table 4.14.

Table 4.13: KMO and Bartlett's test of HRP

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.900
Bartlett's Test of Sphericity	Approx. Chi-Square	711.397
	df	45
	Sig.	.000

Table 4.14: Pattern matrix of HRP

Pattern Matrix[a]			
Variable	Label	Component's loading	
		1	2
Hrep2	Specific job requirements	.913	
Hrep4	Satisfied employees	.807	
Hrep1	Employees as the most valuable resources	.785	
Hrep5	Clear career paths	.722	
Hrep7	Maintain high level of employee motivation	.689	
Hrep6	Job security	.554	
Hrep3	*Training programs*		
Hrep9	Bonuses for outstanding performance		.915
Hrep10	Feedback on performance		.849
Hrep8	Benefits for performance		.827

Extraction Method: Principal Component Analysis.

Rotation Method: Promax with Kaiser Normalization.

a. *Rotation converged in 3 iterations.*

b. *The variables in italic font will be eliminated from further analysis as they score less than .40*

The results of PCA indicated 9 variables of HRP; only one variable had been eliminated for further analysis. The names of the two components were retained as their loaded factors remained the same. Component 1 was "job-related practices" whereas Component 2 was "reward-related practices".

4.5.1.6 Parallel analysis and PCA of entrepreneurship

As indicated in Figure 4.9, the parallel analysis of entrepreneurship (EO) suggested that two components to be extracted.

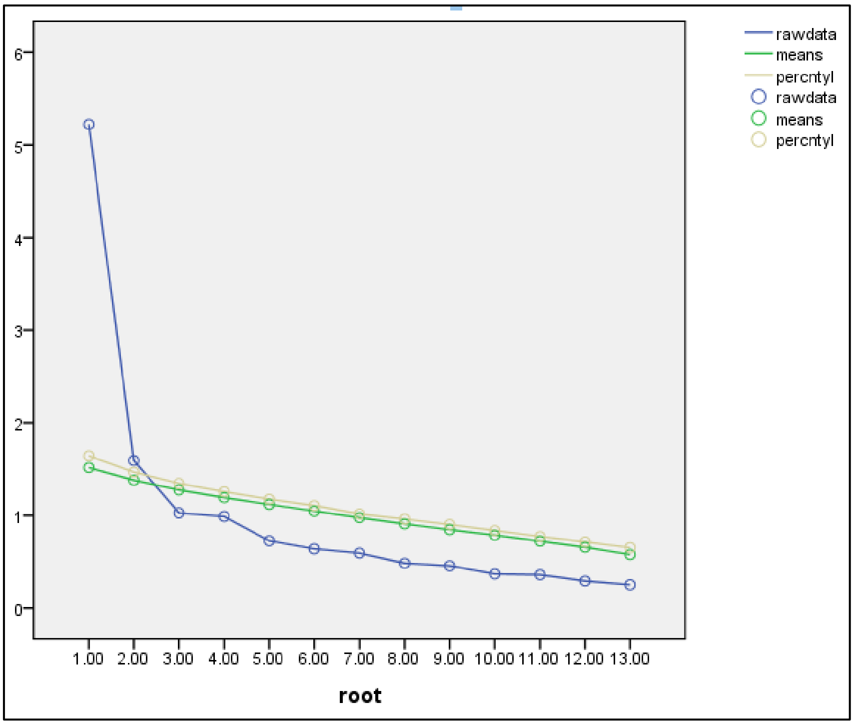


Figure 4.9: Tsplot of EO

The PCA of the construct of EO was performed using the same criteria as above. The results of KMO index and Bartlett's sphericity test (see Table 4.15) similarly indicated that the appropriateness of conducting EFA in the subsequent analysis. The two extracted factor could explain 54.4% of the total variance. Commonalities of variables were generally good at above .50 for most variables; however, two variables loaded less than .50 but not less than .30. The variables with low loading and cross-factor variable were deleted (see Table 4.16).

Table 4.15: KMO and Bartlett's test of EO

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.848
Bartlett's Test of Sphericity	Approx. Chi-Square	631.029
	df	55
	Sig.	.000

Table 4.16: Pattern matrix of EO

Pattern Matrix[a]			
Variable	Label	Component's loading	
		1	2
Enor11	Look out for business	.781	
Enor9	Seek new opportunities	.776	
Enor12	Seek opportunities to improve business performance	.682	
Enor10	First to introduce new services in the industry	.626	
Enor6	Accept that certain suggestions may fail	.619	
Enor5	To venture into unexplored territories	.532	
Enor7	Emphasize success rather than failure	.530	
Enor13	*Ahead of competitors in responding to challenges*		
Enor8	*Failure is viewed as a learning experience*		
Enor3	Employees to prioritise their work		.919
Enor1	Employees to take responsibility on work		.886
Enor2	To accomplish task with minimum supervision		.829
Enor4	Uncertainty is treated as a challenge		.441

Extraction Method: Principal Component Analysis.

Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

b. The variables in italic font will be eliminated from further analysis as they score less than .40

Out of 13 variables, 2 were eliminated and the rest were extracted under two new components. As such, Component 1 might be assigned the name of "risk taking and proactiveness" and Component 2 was "autonomy".

4.5.1.7 Parallel analysis and PCA of inter-organizational network

As noted earlier, inter-organizational network (IN) was a construct measured by two dimensions, i.e., heterogeneity and intensity. As heterogeneity was a single-item measure, only the dimension of intensity needed examination on its factor structure. In this regard, the result of parallel analysis indicated that two components should be extracted for the dimension of intensity (see Figure 4.10).

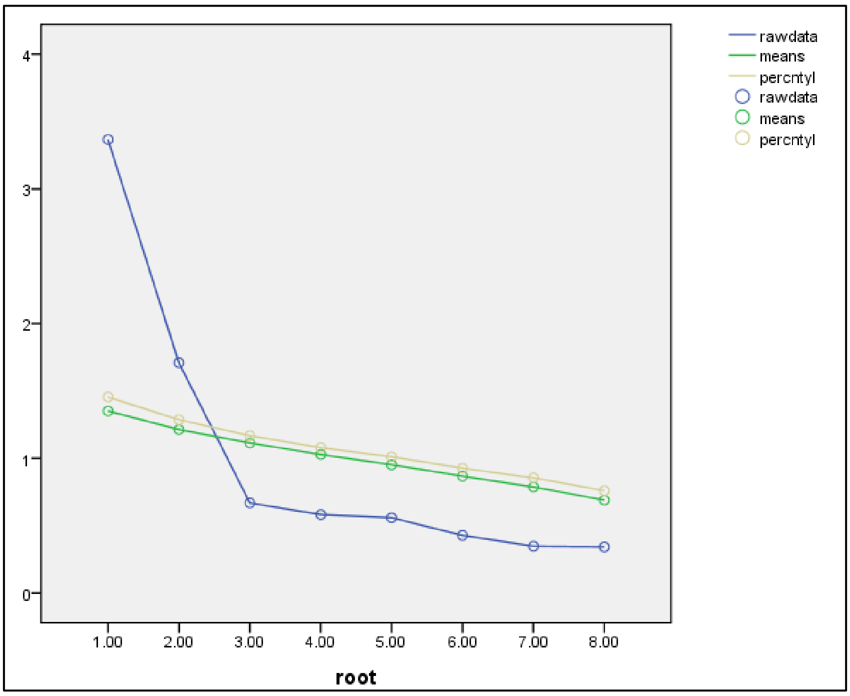


Figure 4.10: Tsplot of IN (dimension of intensity)

Similarly, the PCA of the dimension of intensity was conducted using the same criteria as above. The results of KMO index and Bartlett's sphericity test were shown in Table 4.17. Meanwhile, the two extracted factor could explain 60.0% of the total variance. Commonalities of variables were generally good at above .50 for most variables; however, some variables loaded less than .50 but not less than .40, and that was generally satisfactory. Loading of the extracted factors were illustrated in the pattern matrix in Table 4.18.

Table 4.17: KMO and Barlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.757
Bartlett's Test of Sphericity	Approx. Chi-Square	369.868
	df	28
	Sig.	.000

Table 4.18: Pattern matrix of Inter-organizational network (IN)

Pattern Matrix[a]			
Variable	Label	Component's loading	
		1	2
Iorg1	Customers	.868	
Iorg2	Suppliers of components, equipment and software	.865	
Iorg3	Competitors	.493	
Iorg4	Experts and consultancy firms	.701	
Iorg6	Universities or centres of higher education		-.900
Iorg7	Public and non-profit research organizations		-.765
Iorg5	R&D firms or laboratories		-.811
Iorg8	Other industries	~~.348~~	-.460

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

All the 8 variables were retained. However, there was one cross-factor variable shared by Component 1 and 2. The researcher decided to delete this variable from Component 1 and retain it in Component 2 because it shared some relevant aspects with other variables under this component. The names of the two components were retained, where Component 1 was "customers and value chain partners" and Component 2 was "universities and relating institutes".

4.5.1.8 Parallel analysis and PCA of technological innovation

The parallel analysis of technological innovation (TI) suggested that only one component to be extracted, as shown in Figure 4.11.

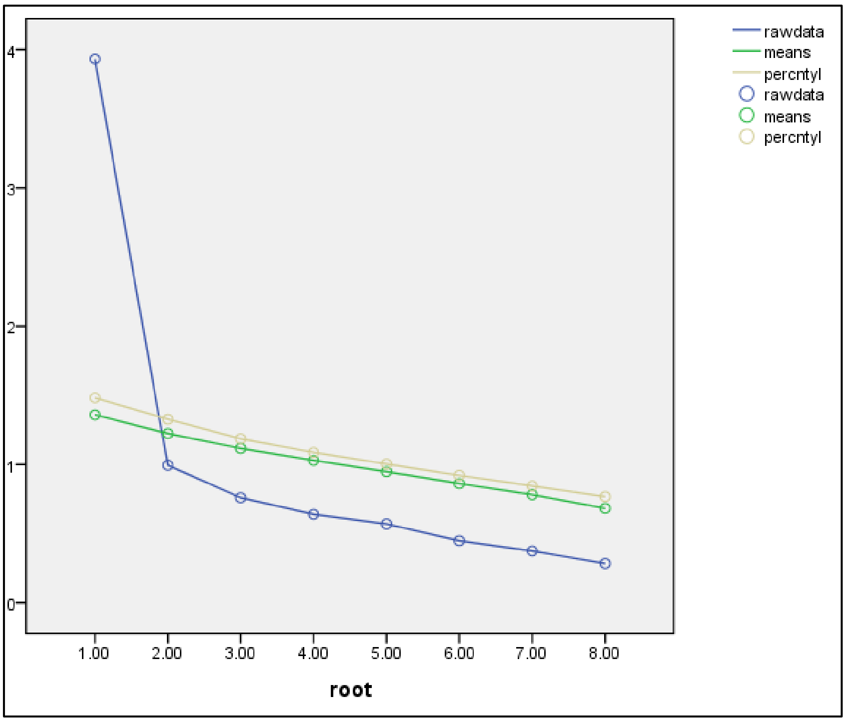


Figure 4.11: Tsplot of TI

Table 4.19: KMO and Bartlett's test of TI

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.865
Bartlett's Test of Sphericity	Approx. Chi-Square	442.744
	df	28
	Sig.	.000

Table 4.20: Component matrix of TI

Component Matrix[a]		
Variable	Label	Component's loading
		1
Tech7	New production processes	.776
Tech6	Technologies in production processes	.775
Tech5	Review/update of production processes	.758
Tech8	Removal of non-value added activities	.717
Tech3	New services/products	.712
Tech2	Improve existing services/products	.651
Tech4	Offers new services/products	.649
Tech1	Introduce services/products not offer in market	.532

Extraction Method: Principal Component Analysis.

a. 1 component extracted. The solution cannot be rotated.

The results of KMO index and Bartlett's sphericity test were presented in Table 4.19. The factor could explain 49.1% of the total variance. Commonalities of variables were generally good at above .50 for most variables; however, three variables loaded less than .50 but not less than .20, and that was generally satisfactory. Loading of the extracted factors were illustrated in Table 4.20. All the 8 variables were retained and the component might be named as its construct, which was "technological innovation" as it involved all kinds of innovation of technological nature.

4.5.1.9 Parallel analysis and PCA of organizational innovation

Similar to TI, the parallel analysis of organizational innovation (OI) suggested that only one component to be extracted (see Figure 4.12). The PCA of the construct of OI was performed using the same criteria as above. The results of KMO index and Bartlett's sphericity test were shown in Table 4.21. The factor could explain 59.8% of the total variance and the commonalities of variables were all above .50. Loading of the extracted factors were illustrated in Table 4.22.

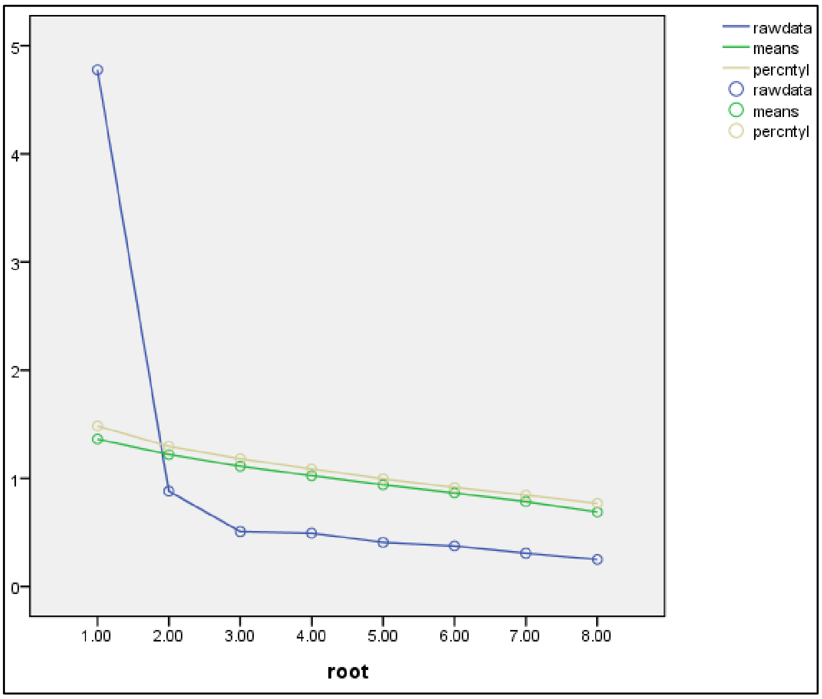


Figure 4.12: Tsplot of OI

Table 4.21: KMO and Bartlett's test of OI

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.899
Bartlett's Test of Sphericity	Approx. Chi-Square	667.016
	df	28
	Sig.	.000

Table 4.22: Component matrix of OI

Component Matrix[a]		
Variable	Label	Component's loading
		1
Ntec7	New promotion techniques	.825
Ntec1	New ways of managing business	.811
Ntec5	Changes in appearance of services/products	.781
Ntec6	New channels to provide services/products	.770
Ntec2	Investments in administrative procedures	.756
Ntec3	Improve of administrative systems	.751
Ntec4	Renew on organization structure	.748
Ntec8	Renew of pricing strategies	.739

Extraction Method: Principal Component Analysis.

a. 1 components extracted. The solution cannot be rotated.

Likewise, all the 8 variables were significantly loaded on the single component. The new component might be named as its construct, which was "organizational innovation" as it involved all kinds of innovation of non-technological nature.

4.5.1.10 Parallel analysis and PCA of firm performance

Lastly, the parallel analysis of firm performance (FP) suggested that only one component to be extracted (see Figure 4.13). The PCA of the construct of FP was performed using the same criteria as above. The results of KMO index and Bartlett's sphericity test were shown in Table 4.23. The factor could explain 59.8%. Commonalities of variables were generally good at above .50 for most variables; only one variable loaded less than .50 but not less than .40. As seen in Table 4.24, all the 7 variables were significantly loaded. The component might be named as its construct, which was "firm performance". In the next step, all the multi-items constructs were assessed by confirmatory factor analysis (CFA) using the PLS-PM.

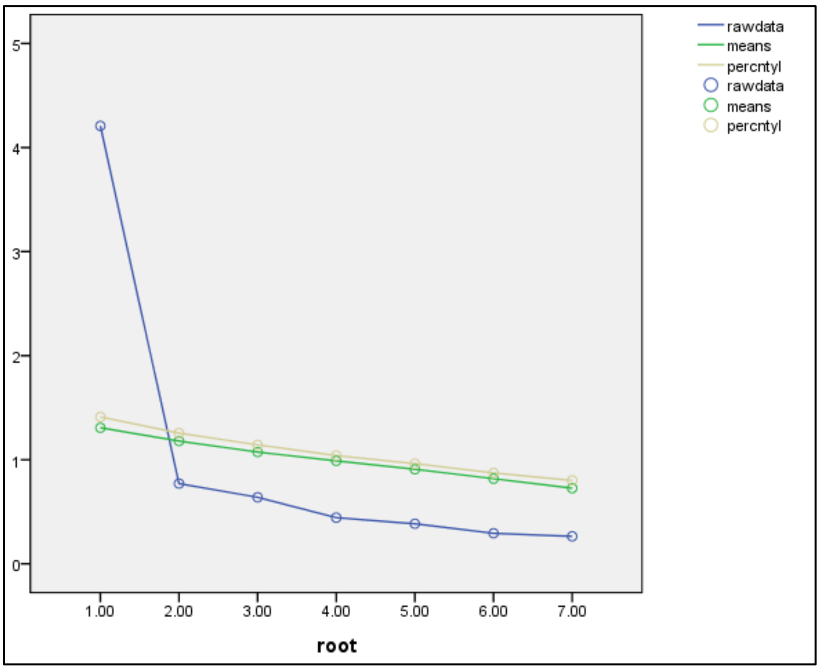


Figure 4.13: Tsplot of FP

Table 4.23: KMO and Bartlett's test of FP

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.883
Bartlett's Test of Sphericity	Approx. Chi-Square	551.249
	df	21
	Sig.	.000

Table 4.24: Component matrix of FP

Component Matrix[a]		
Variable	Label	Component's loading 1
Fper2	Annual sales growth	.821
Fper7	Reputation	.813
Fper3	Market share	.800
Fper5	Customer satisfaction	.784
Fper6	Repeat business	.772
Fper4	Labor productivity	.764
Fper1	Profitability	.662

Extraction Method: Principal Component Analysis.

a. 1 component extracted. The solution cannot be rotated.

4.5.2 Confirmatory factor analysis using PLS technique

Next, the extracted variables derived from PCA were further examined. As indicated earlier, CFA was one way to validate PCA (Hair et al., 2006). The analysis of the measurement models was preceded with CFA through the use of partial least square-path modeling (e.g. Tenenhaus & Hanafi, 2010). To estimate a correctly specified PLS path model, it was important to select algorithmic options and parameter settings that including path weighting method, the data metric, initial values to start the PLS-SEM algorithm, the stop criterion and the maximum number of iterations (Hair et al., 2013). In this connection, the current study used the recommended criteria to obtain the results of the measurement models via SmartPLS 2.0 M3 (Hair et al., 2013):

- Weighting Scheme: Path weighting scheme;
- Data Metric: Mean 0, Var 1 (the default in the program, to ensure normality);
- Maximum Iterations: 300 (the default in the program);
- Abort Criterion: 1.0E-5 (the default in the program);
- Initial Weight: 1 (the default in the program);

In this way, the model estimation delivered empirical measures of the measurement models. Unlike CB-SEM that required goodness-of-fit criterion to determine the quality of models, the fitting index of PLS-SEM built on the internal consistency reliability and validity of the construct measures (Hair et al., 2013). The specific measures included indicator reliability, internal consistency (composite reliability), convergent validity (average variance extracted) and discriminant validity. Indicators with low loading (less than .55) would be eliminated from the constructs to yield a better model quality, called scale purification (Chin, 1998). Meanwhile, the construct reliability was examined using a threshold value of .70 (Nunnally, 1978) and the average variance extracted (AVE) value was recommended to be greater than .50 (Fornell & Larcker, 1981). For discriminated validity to exist, an indicator's outer loading on the associated construct should be greater than all of its loadings on other constructs (i.e., the cross-loadings) (Hair et al., 2013). Alternatively, the Fornell-Lacker criterion was another approach to assess discriminated validity, in which the square root of AVE for each construct must be greater than its correlations with any other construct (Hair et al., 2006). The assessment for each measurement model was sequentially presented as follow.

4.5.2.1 Confirmatory factor analysis of integrated market orientation

The CFA of the construct of IMO involved higher-order model. According to Hair et al. (2013), researcher should never use the centroid weighting scheme when higher-order constructs were involved in the path model. Hence, the recommended path weighting scheme was used to determine the loadings of construct measures and the quality of the model. Using SmartPLS software, 11 variables remained after eliminating the variables with low loadings (see Figure 4.14). The three first-order models were respectively customer orientation (M_1), latent need fulfilment (M_2) and integrated competitor orientation (M_3).

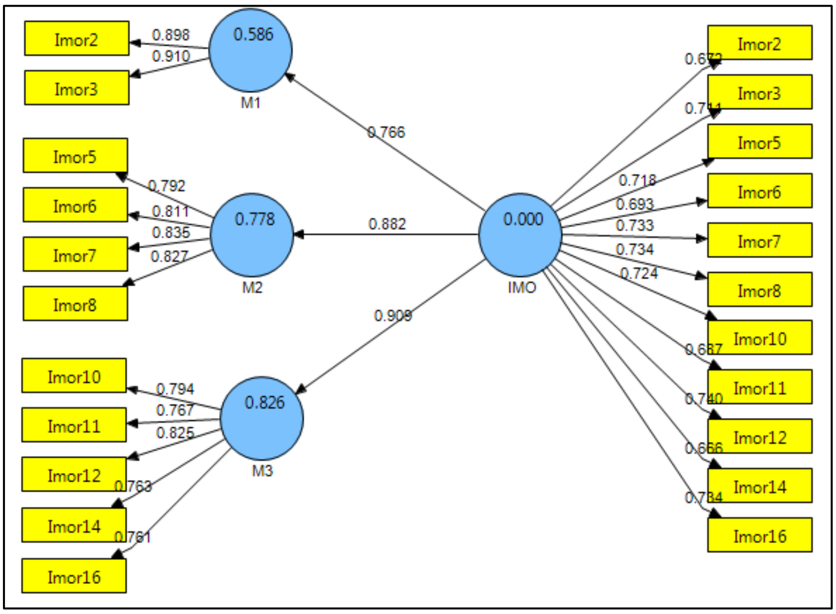


Figure 4.14: Confirmatory factor analysis of IMO using PLS technique

Table 4.26 showed the adequacy of the measurement model of IMO, which was assessed through the reliability and validity of the constructs. The factor loadings, which indicated the individual reliability of all indicators, demonstrate satisfactory level of composite reliability for IMO. Ranging from .88 to .89, the result indicated good reliabilities across the measures. Meanwhile, the average variance extract (AVE) values of the key constructs were higher than .50 (Fornell & Larcker, 1981) and therefore in support of convergent validity. Finally, the discriminant validity was depicted by the result of cross-loading of indicators, as shown in Table 4.25. Alternatively, Table 4.40 presented the Fornell-Larcker criterion of measurement models in all cases.

Table 4.25: Indicators' loadings and cross-loadings of IMO

	M_1	M_2	M_3
Imor10	0.4630	0.5343	**0.7938**
Imor11	0.3708	0.5322	**0.7671**
Imor12	0.4779	0.5262	**0.8248**
Imor14	0.3963	0.4718	**0.7625**
Imor16	0.5689	0.5304	**0.7607**
Imor2	**0.8982**	0.5045	0.4963
Imor3	**0.9096**	0.5182	0.5595
Imor5	0.4926	**0.7924**	0.5428
Imor6	0.3969	**0.8110**	0.5261
Imor7	0.4600	**0.8350**	0.5535
Imor8	0.4954	**0.8266**	0.5459

Table 4.26: Quality criteria of IMO

<table>
<tr><th>Second-order Construct</th><th>First-order Construct</th><th>Indicators</th><th>Loadings</th><th>Indicator reliability</th><th>Composite reliability</th><th>AVE</th><th>Discriminant validity?</th></tr>
<tr><td rowspan="11">IMO</td><td rowspan="2">M_1</td><td>Imor2</td><td>0.8982</td><td>0.6722</td><td rowspan="2">0.8993</td><td rowspan="2">0.8171</td><td rowspan="11">Yes</td></tr>
<tr><td>Imor3</td><td>0.9096</td><td>0.7113</td></tr>
<tr><td rowspan="4">M_2</td><td>Imor5</td><td>0.7924</td><td>0.7177</td><td rowspan="4">0.8888</td><td rowspan="4">0.6665</td></tr>
<tr><td>Imor6</td><td>0.8110</td><td>0.6934</td></tr>
<tr><td>Imor7</td><td>0.8350</td><td>0.7327</td></tr>
<tr><td>Imor8</td><td>0.8266</td><td>0.7344</td></tr>
<tr><td rowspan="5">M_3</td><td>Imor10</td><td>0.7938</td><td>0.7240</td><td rowspan="5">0.8873</td><td rowspan="5">0.6118</td></tr>
<tr><td>Imor11</td><td>0.7671</td><td>0.6868</td></tr>
<tr><td>Imor12</td><td>0.8248</td><td>0.7396</td></tr>
<tr><td>Imor14</td><td>0.7625</td><td>0.6662</td></tr>
<tr><td>Imor16</td><td>0.7607</td><td>0.7338</td></tr>
</table>

4.5.2.2 Confirmatory factor analysis of organizational learning

Similarly, path weighting scheme of algorithm was followed to determine the loadings as well as the quality of the model of OL. The final model of OL contained 10 indicators altogether, as illustrated in Figure 4.15. The two first-order models were respectively openness and experimentation (L_1) and system perspective and knowledge transfer (L_2).

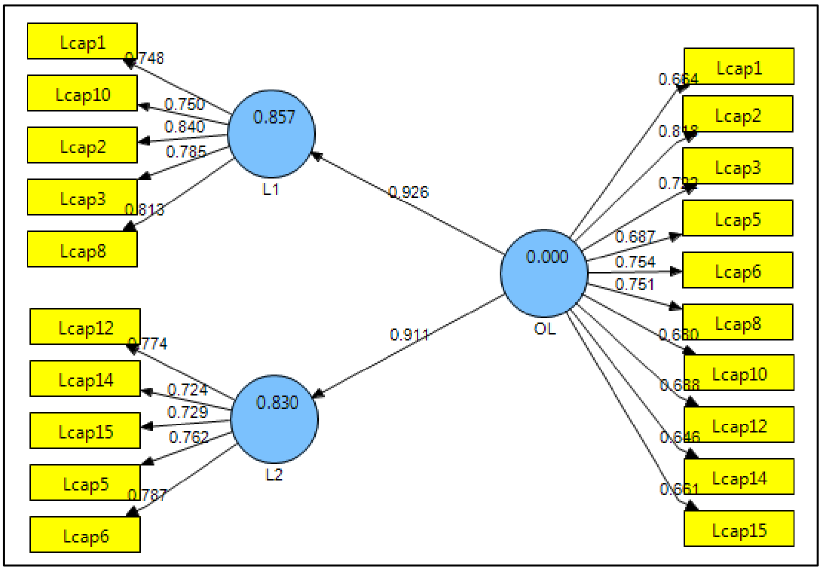


Figure 4.15: Confirmatory factor analysis of OL

Table 4.27 showed the result of loading and cross-loading of indicators. Also, Table 4.28 illustrated the quality criteria of all the indicators, i.e., internal consistency, indicator reliability, convergent and discriminant validities, and indicated that the reliability and validity of OL construct had been established.

Table 4.27: Indicators' loadings and cross-loadings of OL

	L_1	L_2
Lcap1	**0.7481**	0.4606
Lcap2	**0.8395**	0.6551
Lcap3	**0.7855**	0.5305
Lcap8	**0.8128**	0.5559
Lcap10	**0.7496**	0.4898
Lcap5	0.5119	**0.7621**
Lcap6	0.6073	**0.7865**
Lcap12	0.5022	**0.7737**
Lcap14	0.4736	**0.7239**
Lcap15	0.4948	**0.7292**

Table 4.28: Quality criteria of OL

Second-order Construct	First-order Construct	Indicators	Loadings	Indicator reliability	Composite reliability	AVE	Discriminant validity?
OL	L_1	Lcap1	0.7481	0.6643	0.8909	0.6208	Yes
		Lcap2	0.8395	0.8177			
		Lcap3	0.7855	0.7221			
		Lcap8	0.8128	0.7508			
		Lcap10	0.7496	0.6804			
	L_2	Lcap5	0.7621	0.6874	0.8691	0.5708	
		Lcap6	0.7865	0.7541			
		Lcap12	0.7737	0.6879			
		Lcap14	0.7239	0.6458			
		Lcap15	0.7292	0.6606			

4.5.2.3 Confirmatory factor analysis of human resource practice

A similarly path weighting scheme of algorithm was followed to determine the measurement model of HRP. The final model of OL contained 9 indicators altogether, as illustrated in Figure 4.16. The two first-order models were respectively job-related practices (H_1) and reward-related practices (H_2).

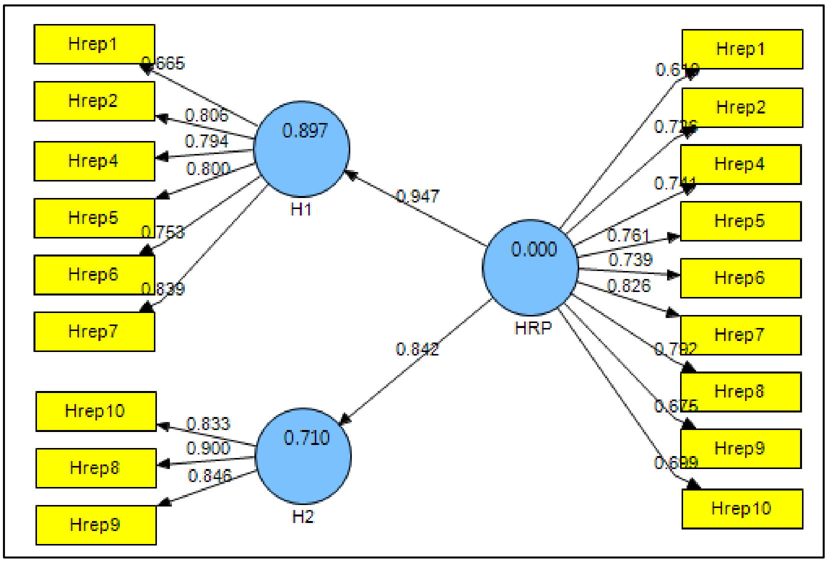


Figure 4.16: Confirmatory factor analysis of HRP

The result of loading and cross-loading of indicators was present in Table 4.29. As seen in Table 4.30, the quality criteria of all the indicators indicated the established reliability and validity of HRP construct.

Table 4.29: Indicators' loadings and cross-loadings of HRP

	H_1	H_2
Hrep1	**0.6646**	0.3711
Hrep2	**0.8062**	0.4137
Hrep4	**0.7944**	0.4691
Hrep5	**0.8002**	0.5083
Hrep6	**0.7532**	0.5308
Hrep7	**0.8392**	0.5988
Hrep8	0.6122	**0.8998**
Hrep9	0.4732	**0.8461**
Hrep10	0.5170	**0.8329**

Table 4.30: Quality criteria of HRP

Second-order Construct	First-order Construct	Indicators	Loadings	Indicator reliability	Composite reliability	AVE	Discriminant validity?
HRP	H_1	Hrep1	0.6646	0.6105	0.9017	0.6058	Yes
		Hrep2	0.8062	0.7257			
		Hrep4	0.7944	0.7409			
		Hrep5	0.8002	0.7614			
		Hrep6	0.7532	0.7388			
		Hrep7	0.8392	0.8259			
	H_2	Hrep8	0.8998	0.7922	0.8949	0.7397	
		Hrep9	0.8461	0.6750			
		Hrep10	0.8329	0.6995			

4.5.2.4 Confirmatory factor analysis of entrepreneurship

In a similarly approach, the final model of EO contained 7 indicators altogether, as illustrated in Figure 4.17. The low-loaded indicators were dropped to ensure that robustness of the measurement model was within acceptable level of error. Respectively, the first-order models were autonomy (E_1) and risk taking (E_2).

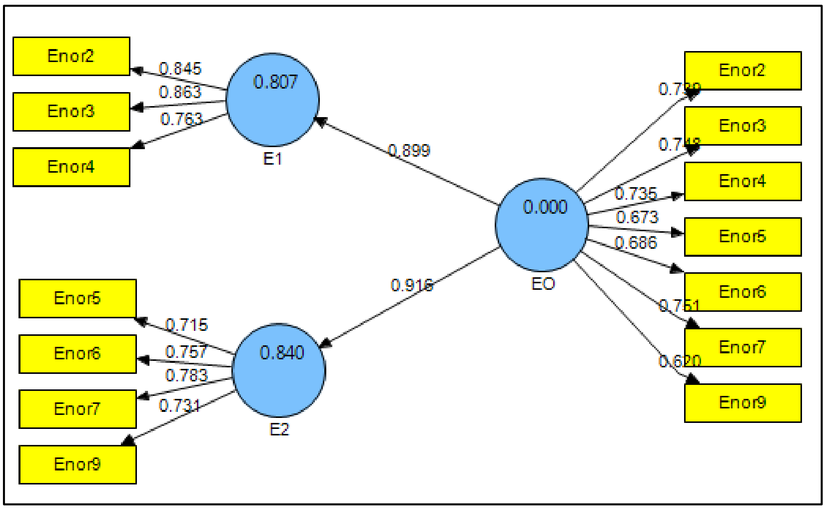


Figure 4.17: Confirmatory factor analysis of EO

The result of loading and cross-loading of indicators was present in Table 4.31. As seen in Table 4.32, the quality criteria of all the indicators denoted the established reliability and validity of EO construct.

Table 4.31: Indicators' loadings and cross-loadings of EO

	E_1	E_2
Enor2	**0.8452**	0.5110
Enor3	**0.8629**	0.5116
Enor4	**0.7634**	0.5800
Enor5	0.4965	**0.7150**
Enor6	0.4753	**0.7570**
Enor7	0.5708	**0.7829**
Enor9	0.3779	**0.7313**

Table 4.32: Quality criteria of EO

<table>
<tr><th>Second-order Construct</th><th>First-order Construct</th><th>Indicators</th><th>Loadings</th><th>Indicator reliability</th><th>Composite reliability</th><th>AVE</th><th>Discriminant validity?</th></tr>
<tr><td rowspan="7">EO</td><td rowspan="3">E_1</td><td>Enor2</td><td>0.8452</td><td>0.7385</td><td rowspan="3">0.8644</td><td rowspan="3">0.6806</td><td rowspan="7">Yes</td></tr>
<tr><td>Enor3</td><td>0.8629</td><td>0.7482</td></tr>
<tr><td>Enor4</td><td>0.7634</td><td>0.7348</td></tr>
<tr><td rowspan="4">E_2</td><td>Enor5</td><td>0.7150</td><td>0.6728</td><td rowspan="4">0.8345</td><td rowspan="4">0.5580</td></tr>
<tr><td>Enor6</td><td>0.7570</td><td>0.6857</td></tr>
<tr><td>Enor7</td><td>0.7829</td><td>0.7510</td></tr>
<tr><td>Enor9</td><td>0.7313</td><td>0.6195</td></tr>
</table>

4.5.2.5 Confirmatory factor analysis of inter-organizational network

As illustrated in Figure 4.18, the final model of IN contained 5 indicators altogether. Similarly, the low-loaded indicators were dropped to ensure that robustness of the measurement models were within acceptable level of error. Respectively, the first-order models were intensity (N_1) and heterogeneity (N_2).

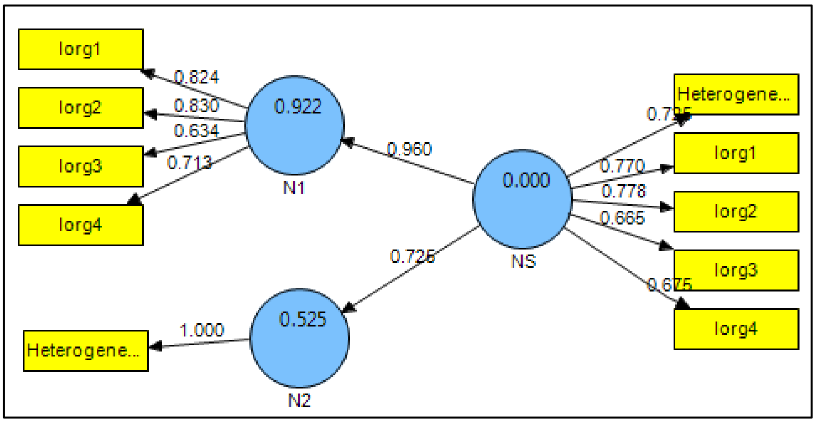


Figure 4.18: Confirmatory factor analysis of IN

The result of loading and cross-loading of indicators was present in Table 4.33. Also, the quality criteria of all the indicators, illustrated in Table 4.34, denoted the established reliability and validity of IN construct.

Table 4.33: Indicators' loadings and cross-loadings of IN

	N_1	N_2
Iorg1	**0.8243**	0.3549
Iorg2	**0.8299**	0.3653
Iorg3	**0.6341**	0.4736
Iorg4	**0.7126**	0.3356
Heterogeneity	0.5034	**1.0000**

Table 4.34: Quality criteria of IN

Second-order Construct	First-order Construct	Indicators	Loadings	Indicator reliability	Composite reliability	AVE	Discriminant validity?
IN	N_1	Iorg1	0.8243	0.7702	0.8395	0.5695	Yes
		Iorg2	0.8299	0.7778			
		Iorg3	0.6341	0.6652			
		Iorg4	0.7126	0.6752			
	N_2	Heteroge-neity	1.0000	0.7245	1.0000	1.0000	

4.5.2.6 Confirmatory factor analysis of innovations and firm performance (FP)

The same procedure was followed in analysing the two different types of innovation activities and firm performance. The only difference was that these constructs were not hierarchical models. As illustrated in Figure 4.19, the three components were organizational innovation (OI), technological innovation (TI) and firm performance (FP).

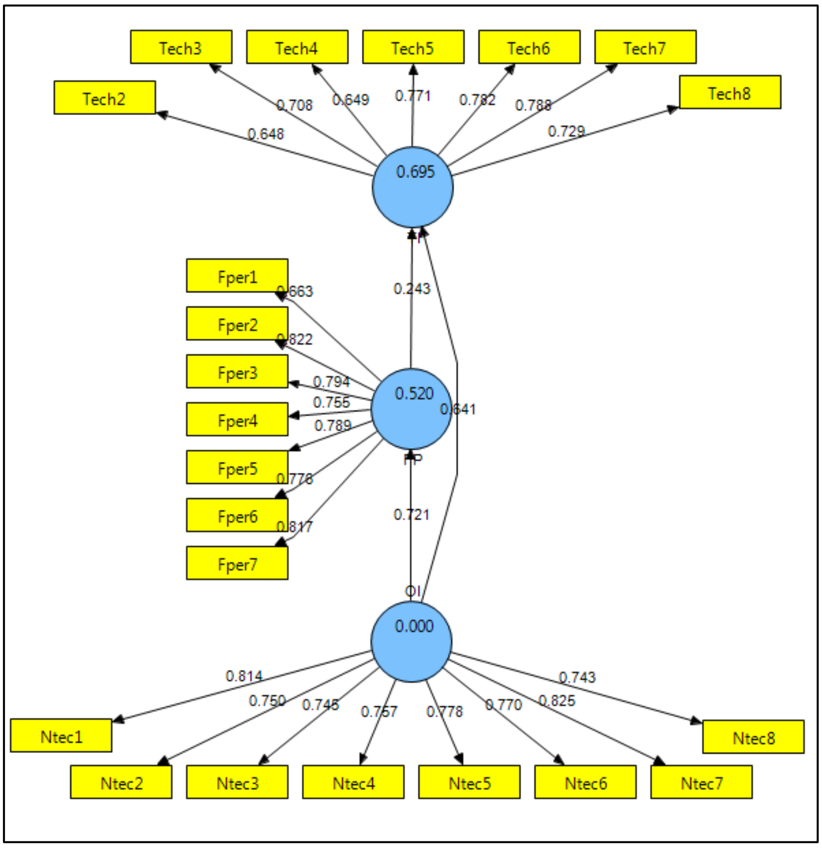


Figure 4.19: Confirmatory factor analysis of innovations and FP

It was important to note that the arrow in this model did not imply any causal effect; rather, it indicated a relationship (i.e., correlation) (Tenenhaus & Hanafi, 2010). This could be attained when choosing centroid weighting scheme, which did not consider the relationship effect among constructs, in the algorithm option of PLS. The result of loading and cross-loading of the three constructs was present in Table 4.35. Also, the quality criteria of all the constructs, as illustrated in Table 4.36, were denoted in terms of the established reliability and validity.

Table 4.35: Indicators' loadings and cross-loadings of FP, OI and TI

	OI	FP	TI
Fper1	0.4956	**0.6629**	0.4567
Fper2	0.6455	**0.8216**	0.5856
Fper3	0.5458	**0.7938**	0.5184
Fper4	0.4954	**0.7552**	0.4872
Fper5	0.5658	**0.7887**	0.6127
Fper6	0.5548	**0.7758**	0.5713
Fper7	0.5928	**0.8174**	0.5755
Ntec1	**0.8140**	0.5875	0.7036
Ntec2	**0.7501**	0.5524	0.6051
Ntec3	**0.7450**	0.5143	0.5784
Ntec4	**0.7565**	0.5779	0.6070
Ntec5	**0.7780**	0.5013	0.6354
Ntec6	**0.7704**	0.5655	0.6196
Ntec7	**0.8254**	0.6043	0.6745
Ntec8	**0.7426**	0.5510	0.6177
Tech2	0.5711	0.4834	**0.6476**
Tech3	0.5312	0.5043	**0.7080**
Tech4	0.5049	0.4728	**0.6489**
Tech5	0.6346	0.5369	**0.7706**
Tech6	0.6172	0.5489	**0.7819**
Tech7	0.6517	0.5232	**0.7885**
Tech8	0.6280	0.5164	**0.7294**

Table 4.36: Quality criteria of FP, OI and TI

Latent variable	Indicators	Loadings	Indicator reliability	Composite reliability	AVE	Discriminant validity?
FP	Fper1	0.6629	0.6629	0.9130	0.6010	Yes
	Fper2	0.8216	0.8216			
	Fper3	0.7938	0.7938			
	Fper4	0.7552	0.7552			
	Fper5	0.7887	0.7887			
	Fper6	0.7758	0.7758			
	Fper7	0.8174	0.8174			
OI	Ntec1	0.8140	0.8140	0.9224	0.5980	
	Ntec2	0.7501	0.7501			
	Ntec3	0.7450	0.7450			
	Ntec4	0.7565	0.7565			
	Ntec5	0.7780	0.7780			
	Ntec6	0.7704	0.7704			
	Ntec7	0.8254	0.8254			
	Ntec8	0.7426	0.7426			
TI	Tech2	0.6476	0.6476	0.8864	0.5287	
	Tech3	0.7080	0.7080			
	Tech4	0.6489	0.6489			
	Tech5	0.7706	0.7706			
	Tech6	0.7819	0.7819			
	Tech7	0.7885	0.7885			
	Tech8	0.7294	0.7294			

4.5.3 Full model of innovation

Via PLS technique, the full model was depicted by connecting all constructs according to the conceptual model. All manifest variables (i.e., indicators) were assigned to their latent constructs based on the results of analyses in the previous sections. As shown in Figures 4.20 and 4.21, the full model comprised both measurement and structural models. The measurements models displayed the relationship between the constructs (i.e., circles) and the indicator variables (i.e., rectangles) while the structural model displayed the relationship (or paths) between the constructs (e.g., OL and TI; TI and FP, etc.). The current study used the following criteria to run the algorithm in PLS to obtain the results of the full model:

- Weighting Scheme: Path weighting scheme (Hair et al., 2013);
- Data Metric: Mean 0, Var 1 (the default in the program, to ensure normality);
- Maximum Iterations: 300 (the default in the program);
- Abort Criterion: 1.0E-5 (the default in the program);
- Initial Weight: 1 (the default in the program);

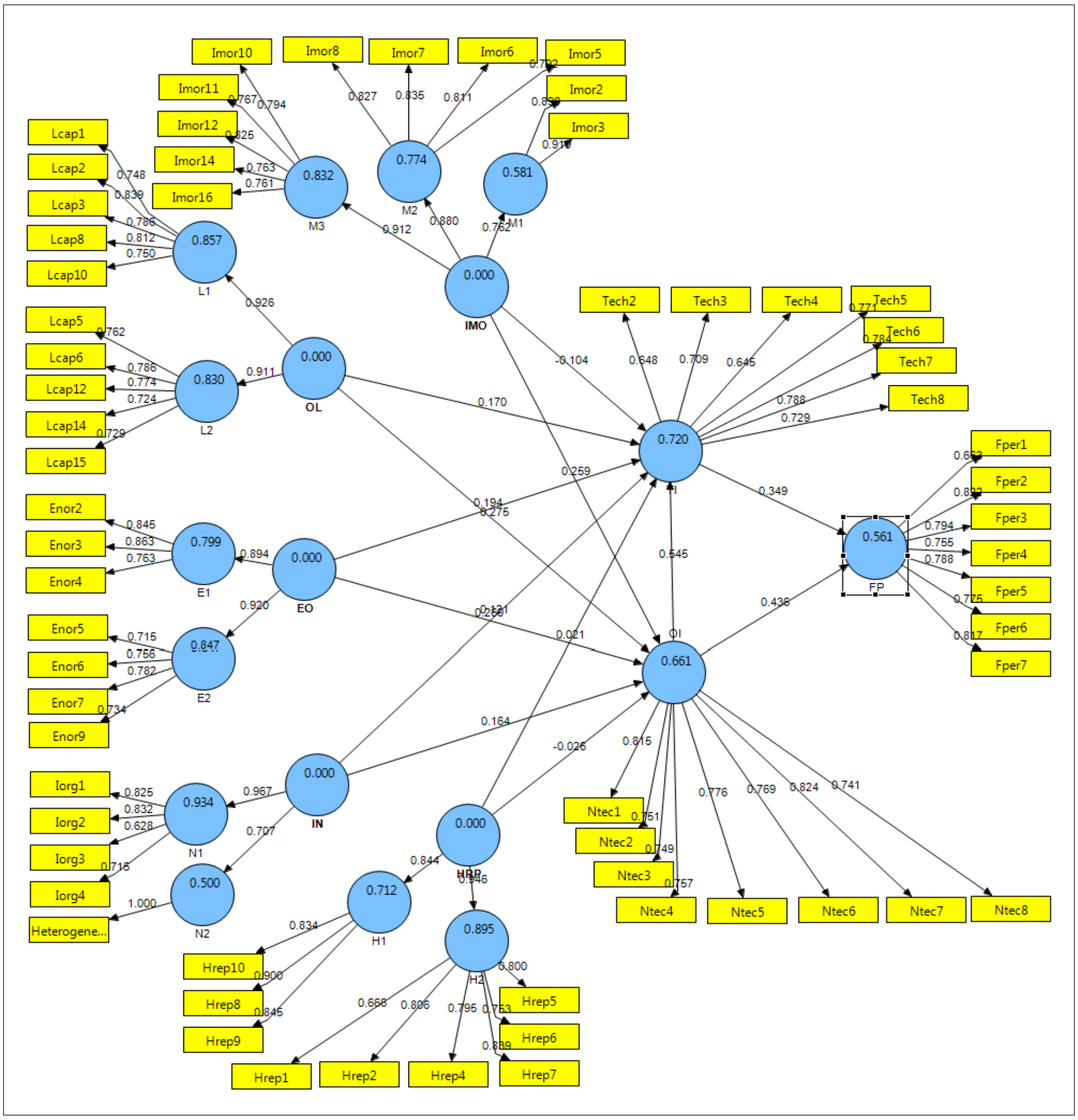


Figure 4.20: Full model of innovation (extending the manifest variables)

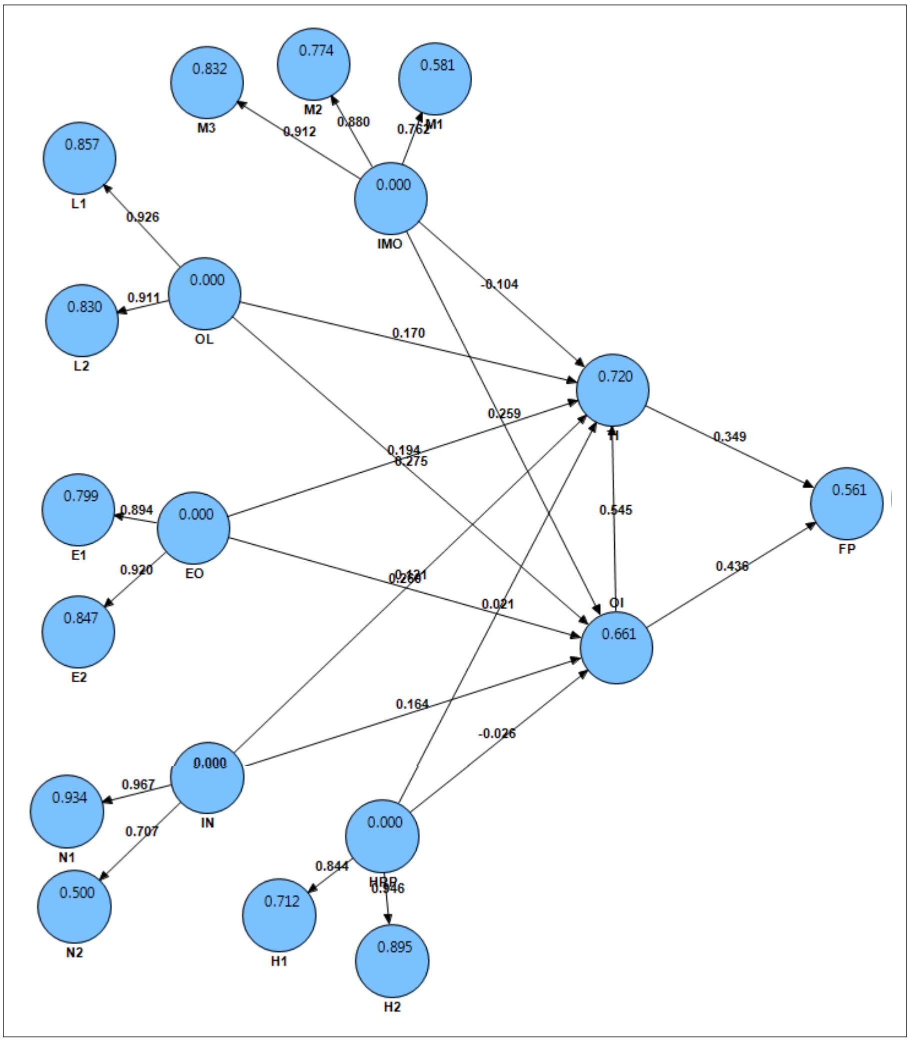


Figure 4.21: Full model of innovation (hiding the manifest variables)

4.5.3.1 Assessing quality of all measurement models

The assessment of the reflective latent constructs entailed the evaluation on the reliability and validity of the measurement (Hair et al., 2013). To do so, several steps were taken as the following:

- The significance of item's loading > .55 (Falk & Miller, 1992);
- The Cronbach's alphas or composite reliability > .70 (Nunnally, 1978);
- The convergent validity builds on AVE value of > .50 (Fornell & Larcker, 1981); and

- The discriminant validity builds on the value of square roots of AVE of the key construct to be greater than all the correlations between constructs (Tenenhaus, Vinzi, Chatelin, & Lauro, 2005).

Tables 4.37, Table 4.38 and Table 4.39 showed the assessment of all measurement models in terms of factor loadings, which were all above the threshold of .55. Meanwhile, Table 4.40 showed the Fornell-Larcker criterion that depicting the discriminant validity for all measurement models.

Table 4.37: Outer model (loadings) of integrated market orientation and organizational learning

	IMO (2nd-order)	M_1	M_2	M_3	OL (2nd-order)	L_1	L_2
Imor10	0.7268			0.7938			
Imor11	0.6914			0.7671			
Imor12	0.7425			0.8248			
Imor14	0.669			0.7625			
Imor16	0.7331			0.7607			
Imor2	0.6686	0.8982					
Imor3	0.7087	0.9096					
Imor5	0.7156		0.7924				
Imor6	0.6911		0.8110				
Imor7	0.7308		0.8350				
Imor8	0.7349		0.8266				
Lcap1					0.6642	0.7481	
Lcap2					0.8011	0.8395	
Lcap3					0.7208	0.7855	
Lcap8					0.7403	0.8128	
Lcap10					0.6841	0.7496	
Lcap5					0.6768		0.7621
Lcap6					0.7422		0.7865
Lcap12					0.6885		0.7737
Lcap14					0.6473		0.7239
Lcap15					0.6606		0.7292

Table 4.38: Outer model (loadings) of human resource practices, entrepreneurship orientation and inter-organizational network

	HRP (2nd-order)	H_1	H_2	EO (2nd-order)	E_1	E_2
Hrep1	0.6152	0.6646				
Hrep2	0.7216	0.8062				
Hrep4	0.7410	0.7944				
Hrep5	0.7596	0.8002				
Hrep6	0.7363	0.7532				
Hrep7	0.8265	0.8392				
Hrep8	0.7919		0.8998			
Hrep9	0.6726		0.8461			
Hrep10	0.7051		0.8329			
Enor2				0.7341	0.8452	
Enor3				0.7460	0.8629	
Enor4				0.7300	0.7634	
Enor5				0.6758		0.7150
Enor6				0.6847		0.7570
Enor7				0.7491		0.7829
Enor9				0.6325		0.7313

Table 4.39: Outer model (loadings) of firm performance, organizational innovation and technological innovation

	OI	FP	TI	IN (2nd-order)	N_1	N_2
Fper1		0.6629				
Fper2		0.8216				
Fper3		0.7938				
Fper4		0.7552				
Fper5		0.7887				
Fper6		0.7758				
Fper7		0.8174				
Ntec1	0.8140					
Ntec2	0.7501					
Ntec3	0.7450					
Ntec4	0.7565					
Ntec5	0.7780					
Ntec6	0.7704					
Ntec7	0.8254					
Ntec8	0.7426					
Tech2			0.6476			
Tech3			0.7080			
Tech4			0.6489			
Tech5			0.7706			
Tech6			0.7819			
Tech7			0.7885			
Tech8			0.7294			
Iorg1				0.7786	0.8243	
Iorg2				0.7891	0.8299	
Iorg3				0.6527	0.6341	
Iorg4				0.6866	0.7126	
Hetero-geneity				0.7069		1.0000

Table 4.40: Discriminant validity assessment (Fornell-Larcker criterion)

	E_1	E_2	H_1	H_2	L_1	L_2	M_1	M_2	M_3	N_1	N_2	OI	FP	TI
E_1	(0.8249)													
E_2	0.5452	(0.7470)												
H_1	0.4480	0.4850	(0.8600)											
H_2	0.5685	0.5514	0.6918	(0.7783)										
L_1	0.4753	0.5653	0.6552	0.6984	(0.7879)									
L_2	0.4805	0.5286	0.6176	0.7257	0.6813	(0.7555)								
M_1	0.5384	0.4978	0.5011	0.5985	0.5087	0.5898	(0.9039)							
M_2	0.4195	0.5054	0.3301	0.3314	0.3633	0.4795	0.4911	(0.8163)						
M_3	0.5312	0.5737	0.5059	0.5578	0.4702	0.6157	0.6326	0.6720	(0.7821)					
N_1	0.4897	0.4278	0.4638	0.4071	0.4509	0.5393	0.5032	0.5136	0.5235	(0.7547)				
N_2	0.3633	0.4530	0.3362	0.3694	0.3947	0.3961	0.3902	0.4441	0.4246	0.5019	Single-item construct			
OI	0.4470	0.5417	0.5040	0.4932	0.4965	0.6105	0.4884	0.5018	0.6145	0.5513	0.4437	(0.7733)		
FP	0.2651	0.3792	0.4757	0.4439	0.4150	0.4761	0.4583	0.3252	0.4317	0.4901	0.4221	0.5068	(0.7752)	
TI	0.3677	0.3875	0.3392	0.3359	0.4337	0.3718	0.3022	0.3352	0.3728	0.5545	0.4230	0.5969	0.4425	(0.7271)

Note: Correlations of the second-order constructs were not included in this table.

Values between parentheses on the diagonal were the square root of AVE, while values off the diagonal were the correlations between constructs. Discriminant validity could be established when the values on the diagonal were higher than any value off the diagonal.

Table 4.41 summarized the quality criteria of all measurement models, including indicator reliability, composite reliability, convergent and discriminant validities. It was important to mention that the values of indicator reliability here represented the outer loading of the first-order construct with respect to a particular second-order construct. As the constructs of firm performance, organizational and technological innovations were not hierarchical models, so their values of indicator reliability (outer loading) were irrelevant, and therefore, not presented in the Table 4.41.

Table 4.41: Result summary for all reflective measurement models

Second-order Construct	First-order Construct	Indicator reliability (outer loading)	Composite reliability	Convergent validity (AVE)	Discriminant validity?
EO	E_1	0.8940	0.8756	0.5022	Yes
	E_2	0.9201			
HRP	H_1	0.8436	0.9119	0.5364	Yes
	H_2	0.9462			
OL	L_1	0.9213	0.9170	0.5021	Yes
	L_2	0.9071			
IMO	M_1	0.7623	0.9181	0.5051	Yes
	M_2	0.8800			
	M_3	0.9121			
IN	N_1	0.9666	0.8462	0.5252	Yes
	N_2	0.7069			
-	OI	-	0.9224	0.5980	Yes
	FP	-	0.9130	0.6010	
	TI	-	0.8864	0.5287	

4.6 Assessment of the structural model

Once it was confirmed that the construct measures had good reliability and validity, the fifth stage of PLS-SEM proceeded to assessment of the structural model. In contrary to CBSEM sense, measures of GoF were not appropriate to be used to assess the structural model in PLS-SEM (Henseler & Sarstedt, 2012). Particularly, fit indices like TFI (Tucker-Lewis Fit Indices), RMSEA (Root Mean Square Error Approximation) or CFI (Comparative Fit Indices) did not allow for testing the overall goodness of the model fit. This was because the GoF was not able to separate valid models from invalid ones. Hence, researchers were advised not to use the GoF measure (Hair et al., 2013). Instead, Hair et al. (2013) introduced five criteria (see Figure 4.22) to determine the overall quality of the model. Specifically, the model was assessed by collinearity issue, significance of path coefficients, level of coefficient of determination (R^2 value), F test, and Q test, each presented as follows.

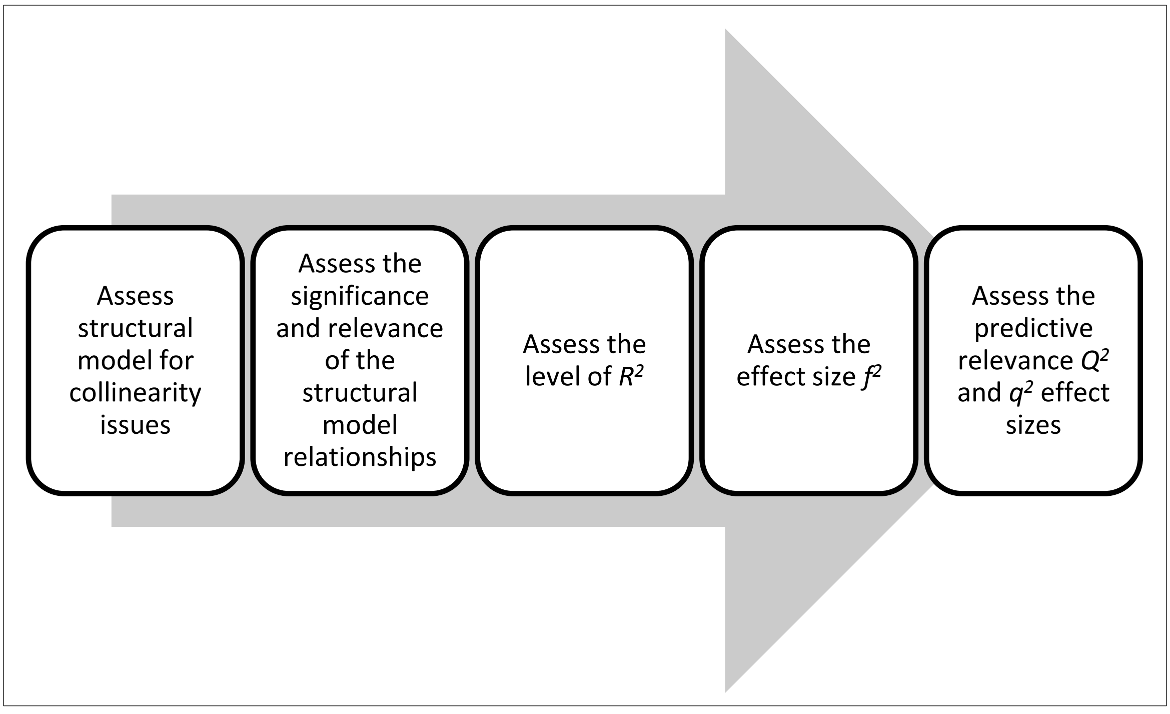


Figure 4.22: Structural model assessment procedure (adapted from Hair, et al., 2013)

4.6.1 Collinearity Assessment

First, the quality of the structural model could be evaluated by collinearity index. Collinearity occurred when two (or more) indicators were redundantly used in measuring a single indicator, or a single indicator was redundantly used to measure two (or more) indicators. As consequence, it presented methodological and interpretational problem in the PLS-SEM (Hair et al., 2013). To assess collinearity, variance inflation factor (VIF) could be used to determine the level of collinearity (Marquardt, 1970). Under this circumstance, VIF value of 5 or higher indicated collinearity (Hair, Ringle & Sarstedt, 2011) and researcher should consider on removing one of the corresponding indicator(s), merging predictors into a single construct, or creating higher-order constructs (Hair et al., 2013). To assess collinearity, each set of predictor constructs needed to be examined separately for each part of the structural model. For example, as shown in Figure 4.23, IMO, OL, EO, IN and HRP jointly explained TI as well as OI. Likewise, TI and OI acted as predictors of FP. Therefore, separate collinearity diagnostics were needed for each set of predictor constructs, i.e., TI, OI and FP.

To compute the values of VIF index, linear regression in SPSS Statistics (version 16) was performed. All the predictor constructs were assigned as independent variables and one of the manifest variables, which did not serve as a predictor in the analysis, was assigned randomly as a dependent variable. To ensure that the dependent variable would not have collinearity with other variables with respect to a particular set of predictor construct, the test was performed again by assigning a different variable as the dependent variable. Tables 4.42, 4.43 and 4.44 showed the VIF values of the three analyses. All VIF values were below the threshold of 5, therefore indicative of the absence of collinearity among the predictor constructs in the structural models.

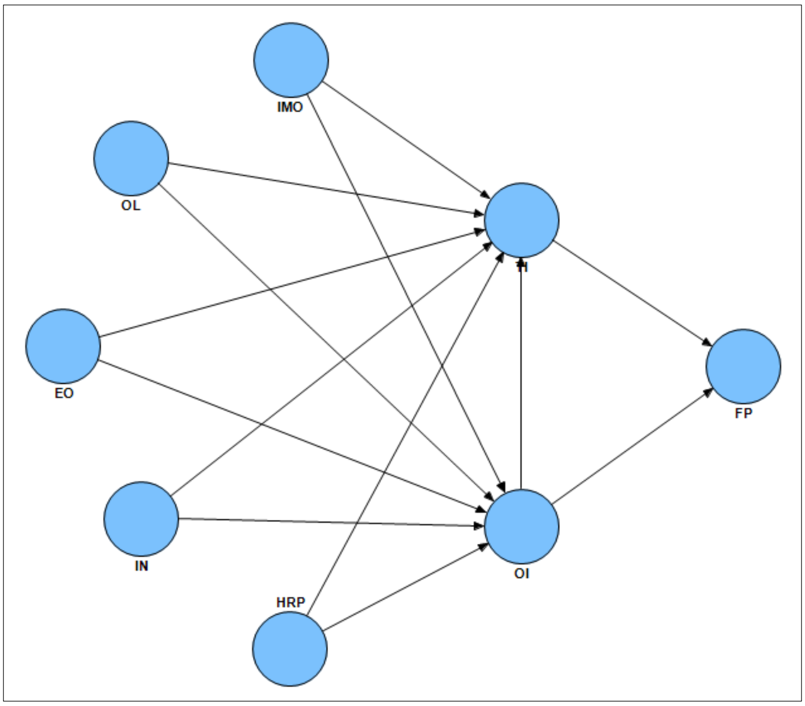


Figure 4.23: Structural model of the innovation path model

Table 4.42: VIF results with respect to technological innovation

OL		EO		HRP		IMO		IN		OI	
Indica-tors	VIF	Indica - tors	VIF	Indica-tors	VIF	Indica-tors	VIF	Indica -tors	VIF	Indica-tors	VIF
Lcap1	2.807	Enor2	2.629	Hrep1	2.769	Imor2	2.722	Iorg1	3.051	Ntec1	3.656
Lcap2	3.372	Enor3	3.197	Hrep2	3.370	Imor3	3.248	Iorg2	2.923	Ntec2	3.603
Lcap3	2.587	Enor4	2.527	Hrep4	3.795	Imor5	3.424	Iorg3	2.324	Ntec3	3.925
Lcap5	2.908	Enor5	2.130	Hrep5	3.205	Imor6	3.504	Iorg4	2.268	Ntec4	2.685
Lcap6	2.979	Enor6	2.911	Hrep6	3.081	Imor7	3.864	Hetero.	2.287	Ntec5	3.018
Lcap8	2.569	Enor7	2.646	Hrep7	4.988	Imor8	3.540			Ntec6	3.217
Lcap10	2.410	Enor9	2.665	Hrep8	4.139	Imor10	2.850			Ntec7	3.854
Lcap12	2.720			Hrep9	2.624	Imor11	2.967			Ntec8	3.266
Lcap14	2.698			Hrep10	3.068	Imor12	2.990				
Lcap15	2.901					Imor14	2.812				
						Imor16	4.470				

Note:

-dependent variable: Tech1

-set of predictor variables (OL, EO, HRP, IMO, IN and OI) with respect to TI

Table 4.43: VIF results with respect to organizational innovation

OL		EO		HRP		IMO		IN	
Indica-tors	VIF	Indica-tors	VIF	Indica-tors	VIF	Indica-tors	VIF	Indica-tors	VIF
Lcap1	2.469	Enor2	2.578	Hrep1	2.610	Imor2	2.508	Iorg1	2.827
Lcap2	3.280	Enor3	3.038	Hrep2	2.913	Imor3	2.916	Iorg2	2.610
Lcap3	2.413	Enor4	2.352	Hrep4	2.988	Imor5	2.935	Iorg3	2.016
Lcap5	2.653	Enor5	1.897	Hrep5	2.833	Imor6	3.045	Iorg4	2.151
Lcap6	2.725	Enor6	2.604	Hrep6	2.690	Imor7	3.087	Hetero.	2.103
Lcap8	2.437	Enor7	2.405	Hrep7	4.174	Imor8	2.953		
Lcap10	2.133	Enor9	2.395	Hrep8	3.923	Imor10	2.654		
Lcap12	2.447			Hrep9	2.419	Imor11	2.606		
Lcap14	2.405			Hrep10	2.733	Imor12	2.818		
Lcap15	2.639					Imor14	2.478		
						Imor16	3.899		

Note:

-dependent variable: Ntec1

-set of predictor variables (OL, EO, HRP, IMO and IN) with respect to OI

Table 4.44: VIF results with respect to firm performance

TI		OI	
Indicators	VIF	Indicators	VIF
Tech2	1.637	Ntec1	2.701
Tech3	1.778	Ntec2	2.167
Tech4	1.655	Ntec3	2.467
Tech5	2.239	Ntec4	2.164
Tech6	2.512	Ntec5	2.222
Tech7	2.655	Ntec6	2.215
Tech8	1.963	Ntec7	2.935
		Ntec8	2.224

Note:

-dependent variable: Fper1

-set of predictor variables (TI and OI) with respect to FP

4.6.2 Structural model path coefficients

Next, the path coefficients of the hypothesized structural relationships were computed. Generally, the path coefficients had standardized values between -1 and +1. According to Hair et al. (2013), an estimated path coefficient close to +1 denoted strong positive relationship (and vice versa for negative value of -1) that were almost always statistically significant; value close to 0 were usually non-significant. However, the significance of a coefficient (i.e., empirical *t* value) was ultimately relied on its standard error that was computed by means of bootstrapping. When the empirical *t* value exceeded the critical value, it was said that the coefficient was significant at a certain error probability (i.e., significance level). For two-tailed tests, the most common used critical values were 1.65 (significance level = 10%), 1.96 (significance level = 5%), 2.57 (significance level = 1%).

Table 4.45 showed the standardized path coefficient (β) and the associated t-values of each latent construct. The significance of the hypothesized relationships was computed via bootstrapping in PLS-SEM using the following criteria:

- Sign Changes: Individual changes [recommended by Hair et al. (2013)];
- Cases: 157 (number of cases in the current study)
- Samples: 500 [recommended by Chin (1998)].

As summarized in Table 4.45, most of the hypothesized paths had values higher than the theoretical *t* value of 1.65. For example, the effect of IN on technological innovation (β=0.12, t=1.740) and organizational innovation (β=0.16, t=2.143) were statistically significant, supporting H1 and H2. Similarly, IMO was observed to have a significant positive effect on organizational innovation (β=0.26, t=2.961), therefore supporting H4. Likewise, OL had a significant positive effect on technological innovation (β=0.16, t=1.740) and organizational innovation (β=0.27, t=2.143), supporting H6 and H7. Next, EO had also found to significantly relate to both technological innovation (β=0.19, t=3.354) and organizational innovation (β=0.26, t=3.891), supporting H9 and H10. The effect of technological innovation (β=0.35, t=3.615) and organizational innovation (β=0.43, t=4.511) on firm performance were also significant, giving support to H12 and H13. Contrary to prediction, however, no support was 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, an interesting significant effect was detected between technological innovation and organizational innovation (β=0.54, t=8.043). The insignificant paths would not be preceded with analyses in the forthcoming sections.

Table 4.45: Total effect among all latent constructs in the FULL model

Path	Path coefficients	t-Value	Significance	Hypothesis supported?
EO -> E_1	0.8940	47.777	****	Yes
EO -> E_2	0.9201	68.619	****	Yes
EO -> OI	0.2597	3.8910	****	Yes
EO -> TI	0.1941	3.3547	****	Yes
HRP -> H_1	0.8436	32.083	****	Yes
HRP -> H_2	0.9462	78.462	****	Yes
HRP -> OI	-0.0257	0.536	NS	No
HRP -> TI	0.0209	0.477	NS	No
IMO -> M_1	0.7623	21.909	****	Yes
IMO -> M_2	0.8800	43.391	****	Yes
IMO -> M_3	0.9121	59.018	****	Yes
IMO -> OI	0.2594	2.961	***	Yes
IMO -> TI	-0.1039	1.487	NS	No
OL -> L_1	0.9258	213.782	****	Yes
OL -> L_2	0.9112	14.5316	****	Yes
OL -> OI	0.2745	2.143	**	Yes
OL -> TI	0.1698	1.740	*	Yes
IN -> N_1	0.9666	213.782	****	Yes
IN -> N_2	0.7069	14.5316	****	Yes
IN -> OI	0.1644	2.143	**	Yes
IN -> TI	0.1208	1.740	*	Yes
OI -> FP	0.4361	4.511	****	Yes
OI -> TI	0.5446	8.043	****	Yes
TI -> FP	0.3494	3.615	****	Yes

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.*

4.6.3 Coefficient of determination (R^2 Value)

In PLS method, the most typical criterion used to determine how well the model fitted the hypothesized relationships was the coefficient of determination (R^2 value) (Cohen, 1988), which denoted the model's predictive accuracy (Hair et al., 2013). It represented the combined effects of all the exogenous latent variables linked to the endogenous latent variable. As noted by Breiman and Friedman (1985), the criterion of R^2 was critical in assessing a structural model. Ranging from 0 to 1, the higher the R^2 value, the higher the levels of predictive accuracy. As a rough rule of thumb, the R^2 values of .25, .50 or .75 for endogenous latent variables could be respectively regarded as weak, moderate or substantial (Hair et al., 2011). In the present study, EO, IMO, HRP, OL and IN were the exogenous constructs, with technological and organizational innovations as the intermediate endogenous constructs, and firm performance as the endogenous outcome. As indicated in Table 4.46, the square multiple correlations (R^2) value of the structural model revealed a very satisfactory level of predictability for the framework. The R^2 value for the intermediate endogenous constructs (i.e., technological innovation = .72; organizational innovation = .66) and the endogenous latent constructs (i.e., firm performance= .56) could be considered as moderate.

Table 4.46: Results of R^2 Value

Endogenous latent variable	R^2 Value	Predictive accuracy
TI	0.719	Moderate
OI	0.661	Moderate
FP	0.561	Moderate

Further to the criterion of R^2, the PLS structural model was also underpinned with the use of F test and Q test. The F test was used to assess the contribution of an exogenous construct on an endogenous latent variable's R^2 value while the Q test was applied to determine the predictive relevance of an exogenous construct on a certain endogenous construct. The following sections presented the steps for computing both tests in more detail.

4.6.4 F test (Effect size f^2)

According to Hair et al. (2013), the predictive accuracy significance of the R^2 values were evaluated by F test of significance. In this regards, the change in the R^2 value when a particular exogenous construct was omitted from the model could be used to assess whether the omitted construct had a substantive impact on the endogenous constructs. The effect size (also called f^2) could be computed as follow:

$$\boxed{f^2 = \frac{R^2 \text{ included} - R^2 \text{ excluded}}{1 - R^2 \text{ included}}}$$

R^2 included and R^2 excluded were the R^2 values of the endogenous construct when a selected exogenous construct (predictor) was included in or omitted from the model respectively. According to Cohen (1988), the effect size f^2 of .02, .15 and .35 could be used as guidelines to respectively represent small, medium and large effects of the exogenous construct. For example, as shown in Table 4.47, the R^2 included value of for all exogenous constructs (with respect to technological innovation) was .719. In contrast, the R^2 excluded values were respectively .709, .703, .714 and .622 for exogenous constructs of OL, EO, IN and OI. Consequently, they had f^2 effect sizes of .036, .057, .018 and .345, respectively. In other words, the effect size of construct OL and construct EO on the endogenous latent variable TI was small to medium; the effect size of construct IN on the endogenous latent variable TI was small; and construct OI had a large effect size. A similar application of F test was followed in the example on endogenous latent variables of OI and FP, as illustrated in Tables 4.48 and 4.49 respectively.

Table 4.47: Results of effect size f^2 analysis (with respect to TI)

Dependent construct	Independent construct	R^2 included	R^2 excluded	Effect size f^2 of latent factor	Inference
TI $R^2 = 0.72$	OL	0.719	0.709	0.036	Small to medium effect
	EO	0.719	0.703	0.057	Small to medium effect
	IN	0.719	0.714	0.018	Small effect
	OI	0.719	0.622	0.345	Large effect

Table 4.48: Results of effect size f^2 analysis (with respect to OI)

Dependent construct	Independent construct	R^2 included	R^2 excluded	Effect size f^2 of latent factor	Inference
OI $R^2 = 0.66$	OL	0.663	0.637	0.077	Small to medium effect
	EO	0.663	0.631	0.095	Small to medium effect
	IMO	0.663	0.642	0.062	Small to medium effect
	IN	0.663	0.650	0.039	Small to medium effect

Table 4.49: Results of effect size f^2 analysis (with respect to FP)

Dependent construct	Independent construct	R^2 included	R^2 excluded	Effect size f^2 of latent factor	Inference
FP $R^2 = 0.56$	TI	0.562	0.522	0.091	Small to medium effect
	OI	0.562	0.499	0.144	Medium effect

4.6.5 Q test (Blindfolding and predictive relevance Q^2)

Next, researcher should also examine Stone-Geisser's Q^2 measure (Geisser, 1975; Stone, 1974). Through the blindfolding procedure in PLS, the resulted Q^2 value was an indicator for the model's predictive relevance. The blinding folding procedure omitted every *d*th data point in a given endogenous construct's indicators and then predicted the parameters with the remaining data points (Tenenhaus et al., 2005). Therefore, Q^2 value indicated how well the data collected could be reconstructed with the aid of model and the PLS algorithm (Fornell & Cha, 1994). According to Hair et al. (2013), the Q^2 value could be computed using two different prediction techniques: cross-validated communality and cross-validated redundancy. The former involved the computation of the path model estimates of both structural and measurement model used for prediction whereas while the latter involved the computation of the construct scores estimated for the target endogenous construct (not including the structural model information). Chin (2010) suggested using the latter to estimate the predictive relevance of a large complex model. Table 4.50 provided the Q^2 values of all endogenous constructs (i.e., TI, OI and FP) in the present study. All Q^2 values were considerably above zero, therefore providing support for the model's predictive relevance regarding the three endogenous constructs (Hair et al., 2013).

Table 4.50: Results of Q^2 Value

Endogenous latent variable	Q^2 Value
TI	0.379
OI	0.392
FP	0.331

Similar to effect size f^2, the relative measure of predictive relevance (q^2) of a particular endogenous latent variable was computed using the following parameters (Hair et al., 2013):

$$q^2 = \frac{Q^2 \text{ included - } Q^2 \text{ excluded}}{1 - Q^2 \text{ included}}$$

Q^2 included and Q^2 excluded were the Q^2 values of a particular endogenous construct when a selected exogenous construct (predictor) was included in or omitted from the model respectively. In PLS, Q^2 was generally estimated using an omission distance (D) of 5-10. It was important to take note that the division of the number of observations (N = 157 in the present study) and the distance was not an integer (Hair et al., 2013). An omission distance of 7 (D = 7) had been used for this purpose. In Q test, the resulted effect size of q^2 values of 0.02, 0.15, and 0.35 indicated that an exogenous construct had a small, medium, or large predictive relevance for a selected endogenous construct. For example, as shown in Table 4.51, the Q^2 included value of for all exogenous constructs (with respect to technological innovation) was .379. In contrast, the Q^2 excluded values were respectively .368, .369, .370 and .324 for exogenous constructs of OL, EO, IN and OI. Using an omission distance of 7, their respective q^2 effect sizes were found to be .018, .016, .014 and .089. Accordingly, the effect size of constructs OL, EO and IN on the endogenous latent variable TI was small while construct OI had a small to medium effect. A similar application of Q test was followed in the endogenous latent variables of OI (see Table 4.52) and FP (see Table 4.53). Altogether, the results of path coefficients, F test and Q test on the three endogenous latent constructs was summarized in Table 4.54.

Table 4.51: Results of effect size q^2 analysis (with respect to TI)

Dependent construct	Independent construct	Q^2 included	Q^2 excluded	Effect size q^2 of latent factor	Inference
TI $Q^2 = 0.38$	OL	0.379	0.368	0.018	Small effect
	EO	0.379	0.369	0.016	Small effect
	IN	0.379	0.370	0.014	Small effect
	OI	0.379	0.324	0.089	Small to medium effect

Table 4.52: Results of effect size q^2 analysis (with respect to OI)

Dependent construct	Independent construct	Q^2 included	Q^2 excluded	Effect size q^2 of latent factor	Inference
OI $Q^2 = 0.39$	OL	0.392	0.377	0.025	Small to medium effect
	EO	0.392	0.373	0.031	Small to medium effect
	IMO	0.392	0.379	0.021	Small to medium effect
	IN	0.392	0.376	0.026	Small to medium effect

Table 4.53: Results of effect size q^2 analysis (with respect to FP)

Dependent construct	Independent construct	Q^2 included	Q^2 excluded	Effect size q^2 of latent factor	Inference
FP $Q^2 = 0.33$	TI	0.331	0.308	0.034	Small to medium effect
	OI	0.331	0.294	0.055	Small to medium effect

Table 4.54: Summary of results for path coefficients, F test and Q test

	TI			**OI**		
	Path coefficients	*f^2 effect size*	*q^2 effect size*	*Path coefficients*	*f^2 effect size*	*q^2 effect size*
OL	0.1698	0.036	0.018	0.2745	0.077	0.025
EO	0.1941	0.057	0.016	0.2597	0.095	0.031
IMO	-	-	-	0.2594	0.062	0.021
IN	0.1208	0.018	0.014	0.1644	0.039	0.026
OI	0.5446	0.345	0.089	-	-	-
	FP					
	Path coefficients	*f^2 effect size*	*q^2 effect size*			
OI	0.4361	0.091	0.034			
TI	0.3494	0.144	0.055			

4.7 Advanced analysis (mediation test)

The previous sections illustrated the use of PLS path model in examining the direct relationship between constructs. Often, it was important to explore not only one construct's direct effect on another but also its indirect effects via one (or more) mediating construct(s). In the final stage of PLS-SEM, the following question raised: Were the direct hypothesized paths mediated by innovation activities (i.e., technological and organizational innovations)? In this regards, Hair et al. (2013) suggested a three-step mediator analysis procedure, as shown in Figure 4.24. First, without the inclusion of the mediator(s) in the path model, the indirect effect of a particular exogenous construct to an endogenous construct should be significant. As mentioned earlier, the significance test was performed using bootstrapping procedure. If there was significant direct path relationship, the mediator analysis was preceded with second step that including the mediator(s) in the path model. When including the mediator(s), the indirect effect must be significant to support the assumption that the mediator(s) absorbed some of the direct effect. Finally, to determine how much the mediator(s) absorbed, researcher needed to assess the variance accounted for (VAF) that explained the mediating strength of the mediator(s). VAF of less than 20%, between 20% and 80%, and more than 80% respectively equated to no mediation, partial mediation and full mediation (Hair et al., 2013).

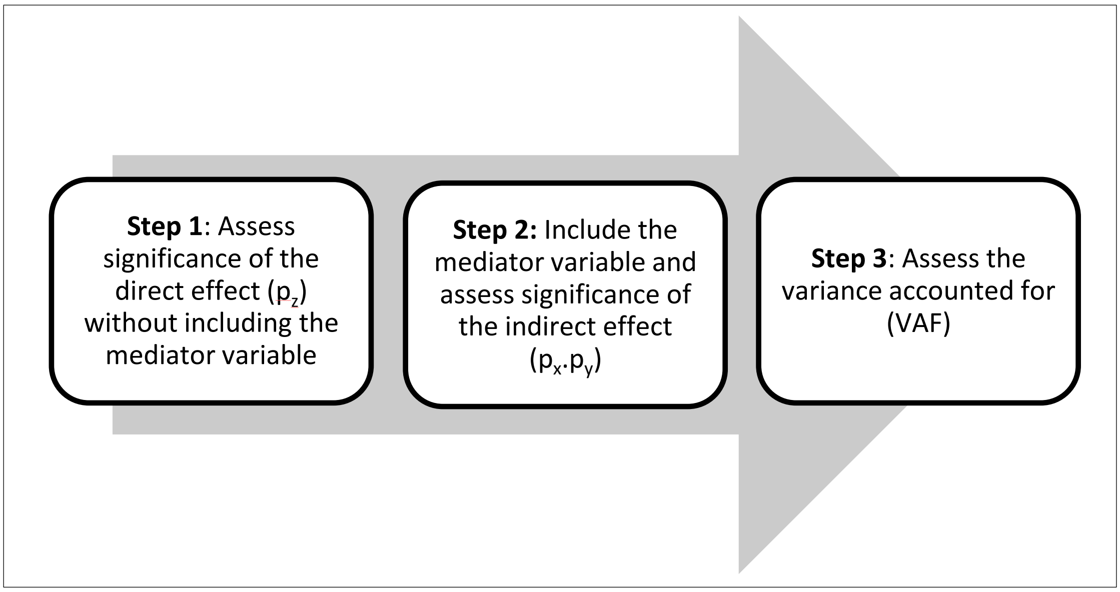


Figure 4.24: Mediator analysis procedure (adapted from Hair, et al., 2013)

To begin mediator analysis, the path model was evaluated without potential mediator variables of TI and OI. Table 4.55 showed the significance of these path coefficients, which resulted from computing the bootstrapping procedure (i.e., 157 observations per sample, 500 subsamples, and individual sign changes). The relationship between the several types of exogenous constructs (i.e., EO, IMO, OL and IN) and endogenous construct of FP was significant, while the HRP to FP relationship was not significant. Hence, it was assumed that the latter relationship was not mediated by FP and the present study focused on the mediator analysis on the relationship between exogenous constructs (i.e., EO, IMO, OL and IN) and endogenous construct FP.

Table 4.55: Significance analysis of path coefficients without the mediator

Path	Without mediator variable			
	Path coefficient	T-statistics	Significance	Could move on for mediator analysis?
EO -> FP	0.266	3.8208	****	Yes
HRP -> FP	0.047	0.8550	NS	No
IMO -> FP	0.189	2.0420	**	Yes
OL -> FP	0.171	1.6917	*	Yes
IN -> FP	0.226	2.9639	***	Yes

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.*

In the next step, the mediator variable was included. This was to analyse whether the indirect effect of several exogenous constructs (i.e., EO, IMO, OL and IN), via the mediator variables (i.e., TI and OI), on endogenous construct (i.e., FP) was significant. According to Hair et al. (2013), the indirect effect was the product of the direct effect between the endogenous constructs and the mediator variables, as well as between the mediator variables and the endogenous construct; the sum of direct and indirect effects of exogenous variable to endogenous variable was regarded as the total effect. For instance, as indicated in Table 4.56, the direct effects between IN and TI, as well as between TI and FP was .210 and .280 respectively. Hence, the indirect effect of IN to FP, via TI was .210• .280 = .059 while the total effect was .162 + .059 = .221. Also, the significance of both direct and indirect effects needed to be computed. Hair et al. (2013) recommended the use of Preacher and Hayes' (2008) test, and assisted by bootstrapping procedure (i.e., 157 observations per sample, 500 subsamples, and individual sign changes). In the test, both the path coefficient and standard error of IN to TI, as well as TI to FP were required to obtain the level of significance of the indirect path of IN to FP. In this vein, the significance of the indirect effect was used to conclude whether there was an existence of mediation effect in the hypothesized relationship. As seen in Table 4.56, the indirect effects of IN (β=0.06, t=1.795), OL (β=0.09, t=2.436) and EO (β=0.09, t=2.584) were significant in relation to FP except for IMO. Put differently, the relationships of the exogenous constructs (i.e., IN, OL and EO) and endogenous FP was mediated by TI; however, no mediation was suggested in the path between IMO and FP.

Last but not least, the strength of mediator TI was determined for each significant path by using VAF. According to Hair et al. (2013), the VAF equalled the indirect effect divided by the total effect. Hence, the VAF of mediator TI in mediating the path between IN and FP was .059/.221 = .267. As consequence, 26% of IN's effect on FP was explained via the TI mediator. Since the VAF was between 20% and 80%, this situation could be characterized as partial mediation. Accordingly, the same computation was followed and it was noted that the TI exerted a partial mediating effect in the paths of OL—FP (VAF = 47%) and EO—FP (VAF = 33%). The same three-step procedure was used to examine the mediation effect in relation to OI. Table 4.57 illustrated the results of direct, indirect and total effects of the hypothesized paths. Similarly, OI was observed to partially mediate the paths of IN—FP (VAF = 21%), IMO—FP (VAF = 37%), OL—FP (VAF = 40%) and EO—FP (VAF = 26%).

Table 4.56: Direct, indirect and total effects (with TI as mediator)

Variables	Endogenous					
	Technological innovation			Firm performance		
	Effect	t-Value	Significance	Effect	t-Value	Significance
Exogenous						
Inter-organizational network						
Direct	0.210	2.238	**	0.162	2.211	**
Indirect	-	-	-	0.059	1.795	*
Total				0.221	2.767	***
Integrated market orientation						
Direct	0.039	0.613	NS	0.191	2.149	**
Indirect	-	-	-	0.011	0.616	NS
Total				0.202	1.974	**
Organizational learning						
Direct	0.323	4.164	****	0.100	1.198	NS
Indirect	-	-	-	0.091	2.436	**
Total				0.191	1.962	**
Entrepreneurship						
Direct	0.337	5.064	****	0.184	2.437	**
Indirect	-	-	-	0.094	2.584	***
Total				0.278	4.038	****
Endogenous						
Technological innovation						
Direct				0.280	3.005	***
Indirect				-	-	-
Total				0.280	3.005	***

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.*

Table 4.57: Direct, indirect and total effects (with OI as mediator)

Variables	Endogenous					
	Organizational innovation			Firm performance		
	Effect	t-Value	Significance	Effect	t-Value	Significance
Exogenous						
Inter-organizational network						
Direct	0.164	2.163	**	0.174	2.240	**
Indirect	-	-	-	0.048	1.808	*
Total				0.222	2.754	***
Integrated market orientation						
Direct	0.256	3.081	***	0.125	1.459	NS
Indirect	-	-	-	0.075	2.267	**
Total				0.200	2.025	**
Organizational learning						
Direct	0.260	3.476	****	0.114	1.287	NS
Indirect	-	-	-	0.076	2.244	**
Total				0.190	1.892	*
Entrepreneurship						
Direct	0.257	3.844	****	0.205	2.869	***
Indirect	-	-	-	0.075	2.505	**
Total				0.280	4.013	****
Endogenous						
Organizational innovation						
Direct				0.291	3.498	****
Indirect				-	-	-
Total				0.291	3.498	****

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.*

4.8 Developed model of innovation

Figure 4.25 presented the developed structural model of innovation based on the quantitative strand. Through the use of PLS-SEM, the structural model indicated the factors that significantly relating to innovation practices of the SMCFs. These included organizational capabilities (all except human resource practice construct), innovations (include both technological and organizational innovation activities) and firm performance. Importantly, it depicted that SMCFs affiliated with certain capabilities could competently pursue the undertaking of innovations across projects and within firm to acquire higher performance.

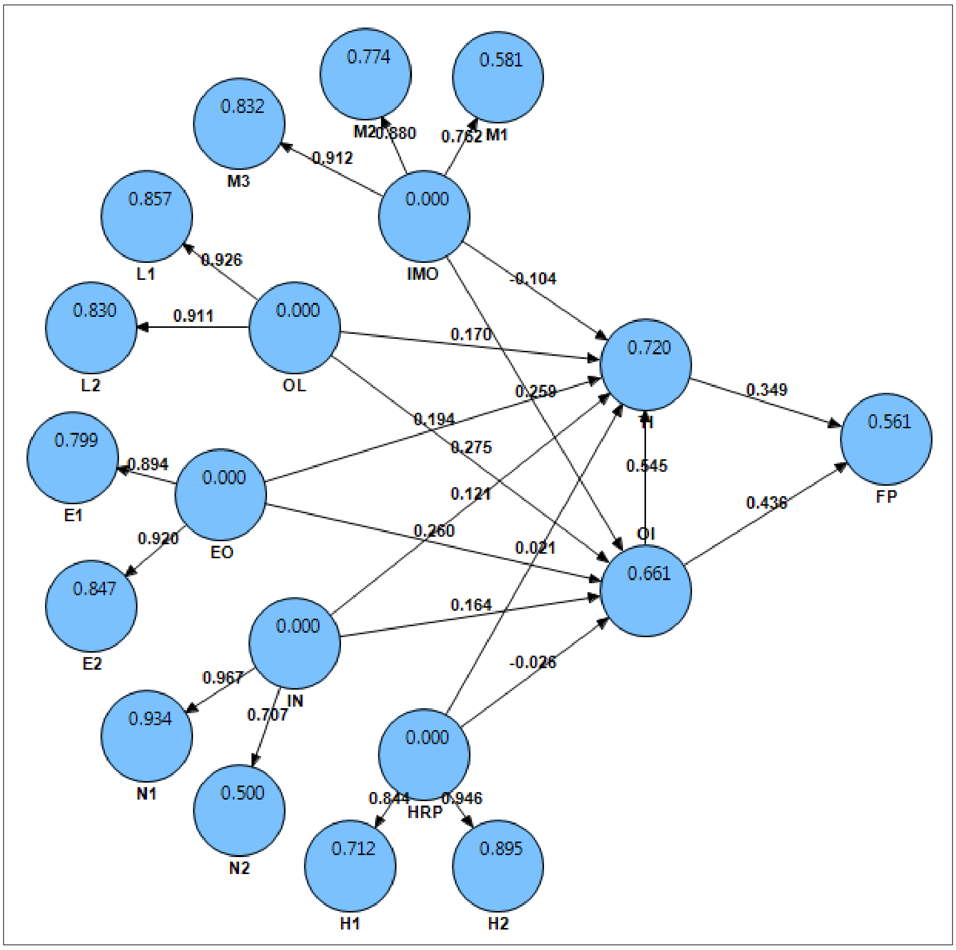


Figure 4.25: Structural model of innovation for SMCFs (the results of the quantitative study)

From the PLS-SEM, mathematical equations (Ling et al., 2012) to predict innovation were developed as well. They were presented below.

$$FP = 0.35TI + 0.44OI \tag{3}$$

$$TI = 0.17OL + 0.19EO + 0.12IN + 0.54OI \tag{4}$$

$$OI = 0.25IMO + 0.28OL + 0.26EO + 0.16IN \tag{5}$$

where:

OL construct score of a firm’s learning capability;

$$OL = 0.93L_1 + 0.91L_2 \tag{6}$$

EO construct score of a firm’s entrepreneurial capability;

$$EO = 0.89E_1 + 0.92E_2 \tag{7}$$

IN construct score of a firm’s inter-organizational networking capability;

$$IN = 0.97N_1 + 0.71N_2 \tag{8}$$

IMO construct score of a firm’s integrated market orientation capability;

$$IMO = 0.91M_1 + 0.88M_2 + 0.76M_3 \tag{9}$$

The coefficients in equation (3) explained the path relationship between dependent construct/firm performance (FP) and mediator constructs/innovations (TI and OI). Likewise, the coefficients in equations (4) and (5) explained the path relationship between mediator constructs/innovations (TI and OI) and independent constructs (IMO, IN, OL and EO). Positive coefficients denoted more application of a construct led to higher innovation activities or performance within the SMCFs. Also, coefficients in equations (6) to (9) depicted the information on the different types of capabilities for each innovation activities. For each construct, the observed first-order constructs and coefficient were used to calculate a construct's score (Fornell & Lacker, 1981). Notably, the mathematical equations could be used as a self-assessment tool (Ling et al., 2012) by SMCFs to estimate their level of firm performance, via innovations. For instance, to calculate FP, a SMCF should rate the extent to which it committed (or would commit) each capabilities shown in equations (6)–(9) on a 5-point scale, where 1 = did not commit and 5 = committed to a great extent. Using equation (6)–(9), construct scores could be calculated and input into equations (3), (4) and (5), so that the innovations (TI/OI) and performance (FP) of a SMCF could be determined. If the SMCF found a low level of innovation activities and/or firm performance, the mathematical equations would suggest ways to improve their overall success based on the capabilities and innovation activities they committed.

4.9 Chapter Summary

The chapter presented the six procedures of PLS-SEM for establishing the final model of innovation that entailed several constructs of organizational capabilities, two types of construction innovations, and firm performance. Prior to data collection, the path model was determined for their structural relationship and measurement scales using hierarchical models of reflective nature. These procedures were important for the formulation of a questionnaire, which was then pre-tested with four academia and 31 construction practitioners. Data was collected from approximate 750 constructing SMCFs, and the total number of valid questionnaire was 201. The chapter then elaborated on several issues, such as suspicious response patterns, outliers, missing data, and normality test to first examine the collected data. Based on these analyses, 157 cases were preceded with subsequent analyses. Parallel analysis, PCA and CFA were highlighted to develop and assess the measurement models. Next, PLS technique was conducted to test the structural model via a five-step approach. In the final part, the established path model was further evaluated by a mediator analysis and the results offered support for the existence of mediation effect for most of the paths in the innovation model. Eventually, a structural model of innovation model (associated with mathematical equations) was developed for the SMCFs. Further elaboration of the factors and other elements (if any) in the developed structural model of innovation was carried out using a qualitative strand in the next chapter.

CHAPTER 5

QUALITATIVE STUDY AND VALIDATION

5.0 Introduction

As to obtain qualitative support for the structural innovation model developed from the quantitative strand (in Chapter 4), this chapter presented the use of a qualitative strand to aid in explaining how innovation occurs in the SMCFs context. Specifically, the qualitative phase was designed such that it elaborated the results of the prior, quantitative phase in more depth. In this regards, interviews were adopted as the data collection approaches in the qualitative strand. A pilot study was first conducted to ensure clarity, sufficiency and accuracy of the interview questions. Data collection was then carried out through in-depth interviews with individual practitioners who possessed experience in construction industry. The qualitative results would help in favouring a better understanding of: 1) the perception and phenomena of innovation among SMCFs, and 2) the logics of the causal relationships between organizational capabilities, innovation activities and firm performance, in that they remained unclear in the extant literature.

5.1 Sampling design

As the purpose was not to generalize to the population, rather to develop an understanding of the phenomenon (Creswell, 2008), purposive sampling design was employed in the study. This mean that the participants were purposefully selected on the basis that they would best help in generating useful data relevant to the research problem and research questions (Creswell, 2009). Based on the above standpoint, the present study utilized snowball (also called chain, chain-referral or referral) sampling categorized under purposive, non-probability sampling design. The snowball sampling was adopted as it could facilitate the identification of hidden populations which were hard in access. Particularly in the present study, the sample was purposefully set to include only participants who were specifically associated with SMCFs. Where it was difficult for researcher to reach participants with known information pertaining to the size of the associated firm (as justified in Section 4.4.3.1), snowball sampling was adopted for the purpose. To ensure that the samples were controlled to have witnessed the phenomenon of innovation, only construction practitioners those located in Kuala Lumpur were chosen as targeted respondents. Conducting face-to-face interviews with construction practitioners was crucial to perceive how these individuals looking at the issue of innovation. To this end, some criteria were used to select the appropriate source of information, including experience and designation (Ling et al., 2012) of participants:

1. The participant possessed sufficient experience in construction (i.e., minimum 15 years of construction experience).
2. The participant was holding managerial positions (i.e., managing director, senior manager, CEO, etc.) in the firms;
3. The participant was currently associated with SMCFs (i.e., general or specialist/trade contracting firms of SME size);

5.2 Design of interview questions

The questions intended to explore further on the relationships among constructs of organizational capabilities, innovation activities and firm performance. As summarized in Table 5.1, five open-ended questions were used as guideline during interview section. The first and second questions were intended for perceiving the interviewees' opinion on the practical implementation of innovation in construction industry in Malaysia. The intention of third question was to understand the underlying nature of different types of capabilities in relation to innovation. The fourth and fifth questions were intended for understanding the consequences of innovation with regard to different type of innovations. The nature of in-depth interviews enabled the researcher to expand the discussion with the interviewees to explore the topic further. These questions aided in advancing the understanding of the phenomenon of innovation in SMCFs. Further, it was important to mention that Malaysia was a multilingual country; nevertheless, 1English was common in use, especially across the federal territory of Kuala Lumpur. Hence, English was chosen as the language used for the interviews and no translation was involved.

5.3 Interview procedures and recording of data

Before conducting any interview, a protocol was essential as to map on how to collect the qualitative data (Creswell, 2008). It was useful to carefully structure interview and collect data. In other words, it served as a reminder for the researcher of what to do, how and why. According to Creswell (2009), the interview protocol should successively proceed with icebreaker question, research questions and a concluding question. At the start of each interview, icebreaker questions such as the scope of work and the current development status of the company were asked, to put the interviewee at ease, and to allow the interviewer to understand better, the point of view of the interviewee in his responses. Next, the objective and a brief explanation of the structure of the interview were explained. Specifically, the interviewer explained the perspective of "innovation" to ensure that all interviewees understood the standpoint of the research study and aligned their frame of mind and experience to it.

Table 5.1: Questions for in-depth interviews

Questions	Purpose
1. Could you elaborate on the innovations (i.e. technological and organizational) introduced/adopted by your company?	To understand the phenomena of innovation in real practice in Malaysian construction.
2. Is organizational innovation supporting the implementation of technological innovation? If yes, how?	To understand how organizational innovation can have a supporting impact on technological innovation.
3. Are the listed factors (i.e. internal capabilities) influencing the introduction/adoption of innovations? If yes, how do they impact?	To understand further how each type of capabilities promotes the implementation of innovation.
4. Does the innovation introduced/adopted affect your company performance? How does this happen?	To understand the implication of innovation on firm performance of SMCFs.
5. Which type of innovation is more significant in impacting your company performance? Why?	To understand whether the technological and organizational innovations similarly, or differently, impact on firm performance.

Interview might be recorded, in addition to direct writing during the interview section (Bryman, 2004). Recorded interviews aided in correcting the natural limitation of the researcher's memories and her intuitive interpretation. However, it might cause the interviewees to be self-conscious or nervous about what they said or "picking the right words" to use. Nonetheless, a recorded interview enabled a more thorough analysis of what people said through repeated examination that would provide a clearer understanding of each respondent's reaction to a particular question. Hence, each interviewee was requested to allow the interview to be recorded. Meanwhile, detailed notes were taken. Results of the interviews were presented in Section 5.8.

5.4 Pilot study

The interview questions could be checked for clarity through pilot testing (Fellows & Liu, 2003). An academic was asked to check the clarity of interview questions to verify its accuracy, flow, and provide suggestions to enhance the questions. The first two interviews with individual practitioners were regarded as pilot study. In this connection, possible problems related to the interview procedure or questions were noted by the researcher. For instance, the academic expert advised simplifying or changing certain terms and attaching the research objectives to allow the interviewees to read it on paper rather than merely listening to a verbal explanation. In the pilot study, on the other hand, the interviewees faced difficulty in understanding terms such as "integrated market orientation", "organizational innovation", "resources", "organizational learning" and "firm performance". Besides elaborating the term, such as "integrated market orientation" as "responding to your customers' demands/competitors' threads", "organizational innovation" as "new change in non-technical practices", the researcher attached additional information for each of the term, i.e., derived the relevant items pertaining to a particular term from the prior established questionnaire survey. The researcher also realized the importance of flexibility in asking the question or expanding the topic during the pilot study. After improving the interview questions, the researcher continued with data collection with other targeted individual interviewees. However, the findings derived from pilot study were added into the main results.

5.5 Choosing samples

The research attempted to include a mixture of firms, i.e., general or specialist contracting firms, to obtain more comprehensive data. The samples of the present study were construction practitioners, such as managing directors, senior managers, project managers and a site manager, associated with either small or medium contracting firms. Tables 5.2 and 5.3 provided more details on these samples and the associated firms. Altogether, all the interview respondents had a minimum of 15 years of construction-based experience. The average age of the firms was 21 years with the respondents connected with the firms for approximately 16 years. Sampling proceeds until "theoretical saturation" (Bryman, 2004), which was achieved after 12 interviews were conducted.

5.6 Analysis and interpretation

The first interview fall on July 11, 2014 and the last interview fall on September 18, 2014. In an average, each interview lasted for 70 minute and took place in the interviewees' business premises. The interviews were recorded, transcribed and analysed to make a general sense out of the data. Overall, the analysis of qualitative data include the following features (Creswell, 2008): it was inductive (i.e., going from the particular to the general); it covered simultaneous and iterative data analysis and collection; it included developing deeper understanding of the data via several times of reading on the data; it was interpretive and requires personal assessment; and it entailed no single method. The present study followed a systematic process suggested by Creswell (2008) in the analysis of the qualitative data to discern repeated patterns of meaning relevant to this study. The process included six major steps, i.e., organized and prepared data, explored and coded the database, described findings and formed themes, represented and reported findings, interpreted the meaning of the findings, and validated the accuracy of the findings.

As in particular, organizing and preparing data included transcribing the audio interviews into text. Then, the researcher read the transcripts for several times in order to familiarize with the data. Before moving on to the next step, the researcher decided to use manual analysis method (rather than computer software) for the analysis, given that hand analysis was appropriate when the size of transcript was small (i.e., less than 500 pages of single spaced transcription). According to Creswell (2008), the exploration and coding of data included reading the transcript; writing memos on the margin of the text of ideas, phrases, or hunches; and dividing the text into segments. Each segment was then assigned with certain codes. Put differently, coding related to “the operations by which data are broken down, conceptualized and put back together in new ways” (Flick, 2002). This step was important to enhance internal validity (Pandit, 1995). Accordingly, the transcripts from each interview were organized into segments, and each segment was labelled with a term using the natural language of the participants, forming the basis of coding frame. Typically, a transcript of 20 pages entailed 10 to 15 codes (Creswell, 2008).

Table 5.2: Sample of qualitative study (Profile of interviewees)

Description	Frequency	%
Age		
40-49 years	7	58.3%
50-59 years	3	25.0%
≥ 60 years	2	16.7%
Education		
High school	4	33.3%
Diploma	1	8.3%
Bachelor	4	33.3%
Master	3	25.0%
Designation		
Managing director	6	50.0%
Senior manager	2	16.7%
Project/site manager	4	33.3%
Experience in construction industry (year)		
15-20 years	5	41.7%
21-30 years	4	33.3%
31-40 years	3	25.0%
Associate with current firm (year)		
≤ 5 years	1	8.3%
> 5 ≤ 10 years	2	16.7%
> 10 ≤ 20 years	5	41.7%
> 20 ≤ 30 years	2	16.7%
> 30 years	2	16.7%
Background		
Civil engineering	6	50.0%
Other	6	50.0%

Note: When total number was ≠ 12, it was because the respondents indicated more than one category

Table 5.3: Sample of qualitative study (details of the associated SMCFs)

Description	Frequency	%
Firm type (Main activities)		
General contracting	7	58.3%
Specialist contracting	5	41.7%
Firm age		
$> 10 \leq 20$ years	6	50.0%
$> 20 \leq 30$ years	5	41.7%
> 30 years	1	8.3%
Firm size		
Small (5-19 employees)	4	33.3%
Medium (20-50 employees)	8	66.7%
Firm's largest market		
Domestic	12	100.0%
Contractor grade		
Grade 5	2	16.7%
Grade 6	1	8.3%
Grade 7	9	75.0%
Project type		
Residential	10	83.3%
Non-residential	9	75.0%
Social amenities	7	58.3%
Mix development	10	83.3%
Infrastructure	6	50.0%

Note: When total number was $\neq 12$, it was because the respondents indicated more than one category

After coding the entire text, the analysis shifted to collation of the codes into categories or themes. Themes were similar codes aggregated together to form a major idea in the database (Creswell, 2008). Next, the themes were reviewed to discern the most salient themes relevant to the research question. Further, the themes were refined to be fit in with the overarching narrative of how SMCFs competed in the marketplace using innovation. Returning to the literature, these qualitative themes were finally compared with the quantitative results as well as the existing literature to seek both conflicting and similar works (see Chapter 6). As remarked by Eisenhardt (1989), tying emergent theory to existing literature increased the internal validity, generalizability and theoretical level of findings.

5.7 Verification of findings

According to Creswell (2009), qualitative data should be verified to ensure that the findings were accurate and credible during its collection and analysis. Qualitative validity indicated that the researcher checked for the accuracy of the finding via certain procedures while qualitative reliability denoted that the researcher's approach was consistent throughout different researchers and projects (Gibbs, 2007). To ensure reliability, Gibbs (2007) suggested the researcher to check the transcripts (i.e., ensured that they did not contain obvious mistakes made during transcription) and the definition of codes (i.e., made sure that there was not a shift in the meaning of the codes during the coding process). To ensure validity, one of the following methods could be used: triangulation (i.e., collecting data from different sources); member checking (i.e., asking one or more respondents to check the accuracy of findings); or external audit (i.e., academics or peers to review the different aspects of findings (Creswell, 2008). Two peers were asked to check for the wording of codes and whether they represented the segments (peer review) (Creswell, 2008). In particular, the peers were asked to check whether the codes provided sensible answers to the research questions. Accordingly, the codes were enhanced.

5.8 Findings

This section presented a summary of the responses collected from the interviews. Views of various construction practitioners were discussed in line with the specific issues of the current study raised from the developed structural innovation model in Chapter 4. The interview respondents were either coded as: General Contractor – GC; or Specialist Contractor – SC. Each of these codes was followed by a number indicator of the interviewee (example: GC3), to provide a consistent reference to the flow of arguments of a particular interviewee. Altogether, there were 12 interview respondents.

5.8.1 Contractor's perception of innovation

All 12 construction practitioners agreed that innovation was important in their ways of doing business. In particular, being innovative could enable the SMCFs to make a clear difference from others. For example, interviewee GC5 stated that,

> *'Nowadays you cannot run away from the fact, technology is taking over. That is where innovative all about; we cannot do it in conservative ways.'*

Also, interviewee SC1 related that,

> *'If everyone is at the same level, you've nothing outstanding. So you have to be innovative to impress people.'*

In general, it was agreed that the new technologies or practices used by the SMCFs were mostly adopted externally, rather than developed internally by the firms themselves. Further, the innovations were relating to the adoption of improved/modified technologies or practices, rather than R&D-related inventions. For instance, interviewee SC4 related that,

> *'Innovation is helping you to improve, innovation is not completely breakthrough. For instance, people can do something in three days, and you can it in two days, then you save the time.'*

Also, the contractors interviewed stated that the innovations being adopted were mostly new to their firms, rather than new to the industry or world. Further, they would only adopt the innovations most appropriate to the firms at a particular time of business. In this view, the motivation to initiate the use of an innovation was mainly due to the external environment, which had caused the SMCFs to realize that they could never stop a point to work in conventional way.

5.8.2 External driver of innovation

All the interviewees observed that, especially in the recent years, the industry was promoted to a higher standard in terms of the demands on high quality end-products. As such, the construction players in the industry had been under pressure to keep on upgrading themselves. Specifically, the pressure was known to be exerted by the new regulation of "Quality Assessment System in Construction" (QLASSIC) and "Construction Quality Assessment Scheme" (CONQUAS) that were used to measure, objectively, the level of quality attained on construction projects. For instance, interviewee GC2 related that, *'Now there is supervision from developer or the consultant, if we are doing very well to maintain the quality. Because end up, it might not be acceptable, so we are upgrading ourselves. All if I don't follow that sense, I think our company will be out of market, we will disappear, we cannot get job.'*

Accordingly, all the interviewees observed that they needed to put much attention in monitoring and improving their quality of works, such as delivery schedule, handwork and materials used on construction projects. They needed to catch up for the time to appropriately improve their way of working, via innovation, in order to satisfy the demands on higher standard of quality. Besides the demands on quality, innovation was essential to increase the productivity of works. In this view, some of the interviewees (GC2, GC3, GC4, GC5, GC6 and SC5) argued that they were prompted to improve their productivity, via innovation, due to the problem of manpower shortage. Basically, the issue of manpower shortage was seen to occur within the company and project site. For instance, interview respondent GC2 stated that,

'We are facing the workmanship problem, you see, locals doesn't want to do these type of jobs, a bit the smarter they become the bosses themselves. So we've to rely on the imported workers, the foreign workers especially the Indonesian. But what can we expect from them? The highest pay now is about eighty to hundred ringgits, so we have to get something to replace where we can overcome the workmanship problems.'

Further, the problem of worker shortage was further exacerbated by the recent government policy, which restricted the quota of imported foreign labours. This had driven the SME contractors to look for alternatives in order to reduce the great reliance on foreign labours. Using innovation, majority of the contractors interviewed highlighted that they could improve their productivity, and consequently, completed their job before the expiry date of contracts. In this way, innovations had led the SMCFs to create a good record for not having delay works. For instance, interviewee GC4 related that,

> *'So we need to let people see that, although we work very fast, but the quality is good. Some people they work fast, but their workmanship is bad. We can provide early delivery and our quality is within the standards.'*

Prior to the adoption of an innovation, majority of the contractors interviewed (except GC5 and SC4) highlighted that their managements would take consideration on the associated risks, expenses and long-term benefits acquired from the innovation. Accordingly, an innovation would be adopted if the level of risks was low, the expenses were affordable and the long-term benefits were desired by the firms. Moreover, it was agreed that the initial expenses could be offset, later on, by beneficial values brought by innovations.

5.8.3 Some example on the innovation practices

All 12 construction practitioners had provided some examples on the innovations adopted by their firms. Basically, the innovations engaged encompassed two distinct types, i.e., technological and organizational innovations. Both innovations were observed to be implemented either on project site or within business operation. The following sections were some examples given during the interviews.

5.8.3.1 Innovations implemented on project site

For innovations implemented on project site, one of the major changes was seen in the technical improvements (except SC2 and SC3), such as new building materials being introduced across construction projects. For instance, interviewee GC3 provided that,

> *'For the ground floor, normally we use BRC to reinforce the floor slab, but we use a new material, sort of iron scrap, toothpick-like, imported from overseas. You just need to mix it into the concrete mixture and spread on the ground floor. Then the floor slab wouldn't crack and gets stronger.'*

In addition, new technical changes had been observed in production methods or processes used to improve the construction works on-site. In this regards, some of the interviewees (GC1, GC2, GC5, SC2, SC4, SC5) had invested in buying new machineries to save up the manual time that were needed for works of hand approach. As a result, the adoption and use of the new machineries had improved the quality of works and efficiency of work process, and subsequently, led to faster delivery of services. For instance, interviewee SC2 explained that,

> *'Now we have purchase a few robotic winches. When the panels are sent to site, the particular winches will hoist them to the respective floors. From that particular floor, like for example, when I want to erect a panel at 28th floor, I cannot go to 28th floor. I have to lift it to 30th floor, and drop it down to do the installation. Before that we put brackets to receive the panels, and we use robotic winch at 30th floor to hoist it down, and a lot easier to move around. All these are investments and innovations.'*

Furthermore, new changes had been observed by all general contractors (except GC3) in the formworks used to improve the construction methods. In addition to timber formworks, there was a vast variety of non-timber formworks available in the markets.

Although the conventional timber formworks were relatively cheap in price, the contractors interviewed stated that they opted for non-timber alternatives. This was because the non-timber formworks were relatively significant in providing immediate value for cost. In comparison, the non-timber formworks could be used repeatedly (up to 50-100 times), produced higher quality of end products, and resulted in speedy construction and minimum waste (i.e., construction debris). In long-term basis, the non-timber formworks led to a significant decrease of construction costs. For instance, interviewee GC6 claimed that,

> *'Let say, in a house, it usually required 10 or 18 columns in its living room. But when you change to sheer wall system, we just need two blocks of walls to form the living room.'*

Further, all interviewees (except GC2, GC3 and SC3) highlighted the use of 'apps' (i.e., widgets of smartphone) to facilitate the daily communication among construction teams (such as employees on-site, peer contractors, suppliers, consultants and clients). Rather than communicating with the team members individually, the interviewees claimed that they were using 'apps' (such as Whatsapps, Line, Telegram, etc.) to ease the communication among teams. In this view, technical issues, such as the problems encountered or progress of works, were updated throughout the group members from time to time. Accordingly, the latest information was directly synchronized and circulated within relevant groups or across different projects. For instance, interviewee SC5 related that, *'You put all the staffs inside a group, so whatever going down there, VO, omission, whatever thing, work done or not done, everybody can see. When they complete the thing, they send in. And then it is notified what materials have arrived already.'*

Besides technical advancements, it was generally observed that the site involved the adoption of new managerial practices to coordinate the people and activities on site. A statement from interviewee SC1 might best describe the phenomenon, 'Every project has different situation that causes big changes in your management.' In general, it was important to promote a culture of openness, which often motivated the people to come out with innovative solutions to overcome the problems encountered or improve further the construction works. For instance, interviewee GC4 related that,

'Having staff meetings weekly to discuss on what you have seen because everyone look at thing from different view. If problem arises, you cannot go into personal, must discuss it together.'

Further, two interviewees (GC3 and GC5) provided examples on the appropriate use of monetary strategies to motivate construction teams (i.e., sub-contractors, workers on site) to work in a higher level of morale. This had subsequently resulted in an increased efficiency of works. For example, interviewee GC5 explained how they reduced the time of construction works that normally required approximately 14 to 16 days into 7 days,

'Normally the working time is 8 to 5, eight hours. But my workers work from 7 o'clock in morning until 8 o'clock at night and they are paid double, means wages of 16 hours. The requirement is no lunch time and no tea time. Meaning during lunch time, their rest time is 10 to 15 minutes. Once you finish eating you have to continue working. During tea time, they are given some drinks or teas. After 5 minutes they have to continue working. 13 hours of working, but they are paid for

16 hours.'

Overall, it was observed that both technological (i.e., product and process) innovations and organizational (i.e., managerial) innovations were being practised on the project sites. With the implementation of innovations, the SMCFs could acquire a number of beneficial outcomes that eventually resulted in a significant improvement of project performance. Besides the innovations being practised on project sites, the contractors interviewed similarly observed the need of innovations within their daily business operation as presented in the following section.

5.8.3.2 Innovations adopted into business operation

In general, the contractors interviewed were in consensus that improving the business operations was important to increase the efficiency of daily routinized works. In addition, the improved business operations were crucial to elevate the capacity of SMCFs to support the technical operations on site. For these reasons, both technological and organizational modes of innovations were viewed as important to achieve the purposes. In technological term of innovations, all 12 interviewees (except GC1 and SC3) stated that their firms had invested in purchasing IT system (i.e., new software) to computerize parts of the business operation as a mean to speed up the efficiency of works. For instance, interviewee GC2 related that,

> *'For instance, reading through the drawing, it's so time consuming, so we buy software, seven thousand and install, get soft copy from the consultant. We read the drawing from the computer instead of hard copy, and we get a very accurate dimension.'*

In addition, some practitioners (SC2, CG1, GC4, GC5, GC6 and GC7) addressed the recent implementation of ISO 9000 system had increased the organizational operation that in turn improved their technical capacity to support the site operations. In particular, the new practice of ISO 9000 system was a mandatory requirement of CIDB that was imposed on all G7 contractors. The criticality of continuity in practising the system was addressed by interviewee GC6, *'If you don't have ISO cert, CIDB won't let you renew your G7.'* With the adoption of ISO system into management, it was observed that the administrative procedures of the firms had been upgraded. This was because the firms needed to comply with the regulation specified by ISO system as a benchmark for the entire operations of business. By following the step-wise procedures written in the ISO manual, all types of works were systematically planned and properly done on site. Accordingly, this resulted in minor mistake or uncertainty, of which, improved the performance of works. For example, interviewee GC5 related that,

> *'In previous we have requested the consultants to come for inspection, then they come to check, if it is okay, we can then pour concrete, it was all herbal instructions. So now we need to record down every activity in written format.'*

Likewise, interviewee GC7 added that,

> *'ISO is nothing much, it captured data and information in a systematic way, so that it will help you to be better your future and next job.'*

Besides the implementation of ISO system, interviewees associated with medium-size firms generally observed a change in their firm structure to improve their business operations. Specifically, the firms encouraged the employees to share their experience or knowledge in groups. This had promoted greater communication and interaction among the employees. For instance, interviewee SC1 related that,

> *'We have some in-house seminars every month. The seniors will share a specified knowledge on works with the juniors. From there, the juniors gain the knowledge, though it might not be used immediately but in the future projects.'*

On contrary, majority of interviewees associated with small-size firms (GC1, GC2 and SC3) addressed that innovatively allocating and coordinating the resources of firms was important to support the continuity of business. Noting the pivotal role of upgrading the administrative procedure of firms, however, the small firms did not opt to renew their ways of business (such as having more departments to function more systematically) due to the lack of financial resources. Accordingly, they would focus more on innovations introduced on projects, rather than innovations to be adopted into firms. Hence, the implementation of innovation in terms of administrative aspect increased with the size, therefore, capacity of firms. For example, interviewee GC2 related,

> *'I would like to improve all these systems, but everything incurs a cost. Like our company size now, we still can manage our business in simple way. Once we grow bigger, these innovations become necessities.'*

In terms of marketing strategies, three interviewees (GC5, SC1 and SC4) claimed that they were updating their website to market their services. Information such as the finishing products used and the projects done was updated from time to time as a way to expose the firms and their services to the potential clients. For instance, interviewee SC1 stated that, *'In terms of marketing, we try to go into website, and few months ago into Facebook. To go into people, when we post something, people will like the post, this is how we make ourselves attracting.'*

In conflicting, other contractors interviewed argued that they did not utilize any advertisement tool to market themselves. In this regards, they stressed the importance of 'words of mouth' to promote the firms. Such promotion was built on the capability of the SMCFs to continuously safeguard on providing excellent services to the clients. A statement from interviewee GC5 might best described this,

'So we cannot mess up any job. No matter what we've complete, completed already, then the words will just go around the market. So innovation in that is non-technical, is like how we market ourselves, how we do our PR. There're so many things, all these are non-technical, oh, that one is business already.'

Meanwhile, the industry was observed to be intense in the sense that some construction players were suppressing their tender price to the lowest value. Hence, all the contractors interviewed claimed that they needed to continuously seek for the most competitive ways to succeed in winning tender bids. The pricing approaches varied for each project and mainly depended on the market condition, competitors' pricing strategies, and networks with the clients or consultants. Importantly, the interviewees highlighted that the cost-competitive nature of the industry led to low profit margins that in turn influenced on incentives to be allocated for innovation. Also, it encouraged the construction players to tangentially differentiate themselves in terms of cost rather than capabilities. For example, Interviewee GC6 related that,

> *'Sometimes the price is so low might be the case where the contractor is very desperate to win the tender, that is why he prices it so low. But the developer knows how much it should be different in the cost, if you are very low they will worry on how you are going to do the job, the labours and materials used, which might ruin their reputation. Having competitive price is very important, but competitive doesn't mean lowest price.'*

Further, it was noted that the marketing practices of SMCFs varied with the types of clients, i.e., public or private. Generally, the former called for tenders that open to all contractors while the latter called for restricted tenders to the selected, prequalified contractors. In the case of restricted tender, the clients would first scan through the SMCFs' company profile, or even visit their on-going project sites, to evaluate their technical experiences in completing projects. Also, the clients would evaluate the financial strength of the SMCFs. Hence, two of the general contractors interviewed (GC2 and GC3) viewed that offering flexible terms of service fee payment to clients as an important business attraction. This occurred at certain stage of development of project when the SMCFs could leverage their financial strength to share a portion of client's financial risks. Others interviewees (GC6, SC1, SC4 and SC5) observed that in every project, they would offer extra services to their clients. Such effort enabled the firm to establish excellent work experiences and stronger partnership with the clients. For instance, interviewee SC1 suggested that,

> *'Because we're more on services, we have additional value engineering work in our scope. Cost saving, try to breakdown the costing to a lower the project budget, which can still produce the same type of product.'*

Altogether, akin to the innovations introduced on project sites, it was observed that both technological (i.e., process) innovations and organizational (i.e., managerial and marketing) innovations were being incorporated into business operations of SMCFs. The implementation of innovations enabled the SMCFs to acquire beneficial outcomes that would enhance the operation of business as a whole. Next, how the SMCFs used their internal capabilities to succeed in implementing innovations on their businesses was presented in the forthcoming sections.

5.8.4 Inter-organizational network as antecedent of construction innovation

For all 12 interviewees, it was agreed that networking with other organizations was crucial to their daily business operations and innovation as well. A phrase from interviewee SC5 might best summarize the SMEs' opinion on networking within the industry, *'When you are small, you need people'*. In general, all contractors interviewed preferred networking with related and supporting firms (i.e., clients, suppliers, peer contractors and experts/consultants) to access to the latest technology or different ways of working. For example, interviewee GC1 explained that,

> *'Because we are all builders, so based on our discussion, we will share about how to do our job. And this will definitely influence us in adopting the innovations. Yes for contractors, for a large portion.'*

Additionally, majority of the general contractors interviewed (GC1, GC2, GC5 and GC6) agreed that there would be an increased chance in integrating innovation in company's services when their networking with suppliers improved. For instance, interviewee GC2 extended that, *'People like this, they even told me, and they try to see the architects, but no architects want to see them. So they come and see me, you know, maybe you can help to talk to them.'*

On the other hand, two interviewees (GC3 and GC6) addressed the role of sub-contractors as major source to acquire latest knowledge about innovation. Anyhow, it was noted that the linkage with public research centres or R&D associations was relatively weak. All 12 interviewed respondents highlighted that they would adopt an innovation directly from external market rather than involving in the development of innovation. For example, interviewee GC1 questioned the need to engage with R&D parties,

'We don't involve in R&D because we're neither consultant nor engineer; we're just builders. When my friends and I have dinner together, we will share our experiences in our projects. But how a contractor communicates with R&D parties?'

Instead of getting new ideas from public research centres, interviewee GC2 added that it was the research centres that were lacking of new ideas, and therefore, needed the construction firms to provide them for new inputs,

'I received a call, quite some time ago, saying that he wish to introduce us some management ways, something like that, or some new methods. But it's that, that is to refine from our method. From on our method, they improve it, so he asked for my firm's information, project, this and that, how I manage, why do I have that. End up I find that they are getting information from me, they are not helping me. They are getting information from us.'

Meanwhile, some interviewees (GC6, SC1, SC3, SC4 and SC5) stated that they would utilize opportunities to interact with their customers (such as main contractors or developers) to gain additional insights for improvement in their ways of delivering services. Consequently, this had inspired them on how to provide extra service to their customers in each different project. For instance, interviewee SC5 noted that,

> *'We provide them extra service, yes of course we have to come out with the prototype, or we come out with the mock-up. You have to provide extra services to the clients and to fulfil their requirements.'*

After all, it was agreed that the 'quality' of linkages was important to actively access to external resources pertaining to innovation or to gain access to new jobs and clients. More particularly, 'trust' was the key element in the network relationships. Anyhow, the search for the type of networks depended, to a large extent, on the nature of innovation being pursued. For SMCFs, networks like clients, suppliers, peer contractors and experts/consultants were more relevant to support them in accessing and exploiting external resources required for innovation.

5.8.5 Integrated market orientation as antecedent of construction innovation

The 12 interviews indicated that all respondents were aware of the norm of the market, i.e., the clients always demanded for the completion of projects within short period of time, in addition to good quality and minimum construction cost. Whether such demands were clearly expressed or indirectly implied by the customers, the SMCFs had consistently oriented their business strategies to satisfy the customers' needs. Accordingly, this had motivated the SMCFs to seek for new or different ways of working wherever possible. For instance, interviewee GC3 stated that,

> *'Because as an owner, if you own a building and you want to construct a building, you would like to spend as little as possible, to get as much as possible.'*

However, some of the interviewees (SC1, SC3, GC2 and GC3) observed that the intention to introduce innovation might be impeded in some cases where the clients or their consultants were risk-averse towards the use of innovation. Hence, being customer-oriented did not necessarily lead the SME contractors to better realization of innovation. For instance, interviewee GC3 related that,

> *'The engineers are ok with the new idea, but the clients see nothing in the mixture. The clients doubted if we are cheating them, doubted on the result of using this new material, so they rejected the new idea.'*

All the interviewees (except GC4 and GC6) highlighted that 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. For most of the time, the contractors noted that they could only do their jobs based on the specification. For instance, interviewee SC3 stated that,

> *'Whether we want to use a different type of tile, a better one, it is not our right to decide. The developer will consult the architect, not us. Normally we don't suggest on that also.'*

In relation to competitors, on the other hand, most of the interviewees displayed a responsive behaviour towards their competitors' strategies to seek for new opportunities to improve their business deliveries. For instance, interviewee SC5 related that,

> *'If you want to keep alive your company, you have to know actually what your company do and what others do. Everybody has their way of doing, so we share it or we learn from each other.'*

Nonetheless, two interviewees (GC3 and GC7) justified that the response to the competitors' threads was limited to those within the organizational capacity. For instance, interviewee GC7 addressed that,

> *'Especially now, most people already talking about IBS, you have to join the bandwagon. If you are just sticking to your old thing without any product innovation, no client will want you. But this is the challenging part because we have to think ahead of the competitors, maybe in terms of not only the products, in terms of managing as well. Meaning, you use new software to control your project, where the client see, this is so impressive. We are still in old stage actually, if not we are already competitive.'*

In addition, the intention to introduce innovation, especially of product-based, had been demotivated in situation where the customers and peer competitors stressed on low-priced tenders. In general, the contractors interviewed noted a great increase in the price of materials, machineries and labours over the years. Dealing with the changes, they were also confronted with the difficulties to make profit from the low-tendered jobs while safeguarding on the continuity of getting new jobs. In such a situation, they would be demotivated to offer and initiate any innovative solution to their customers. For instance, interviewee GC1 related that,

> *'When you have the margin, you can have innovation, and vice versa. Innovation goes along with the bottom line; pricing will affect the use of innovation on site, about 60-70%.'*

Additionally, the clients' preference on lower bids had triggered a culture of over suppression of the price of tenders, i.e., suppressing the tender cost to the lowest value. This had caused an intense competition among the tremendous players in the industry. For firms that offered over-suppressed tender price, they were expected to create a crisis of low profits, productivity and efficiency, all of which, exacerbated the problem of turnover of businesses. Instead of joining the statistic, the contractors interviewed generally claimed that they would like to differentiate themselves by their quality of works and services. For instance, interviewee SC4 argued that, *'Cheap without quality is nonsense'*. Further, he added that,

> *'Many are not really doing business; they want to grow big using shortcuts. They take a lot of jobs in very low price, and using margin of this project to cover other projects. But soon they bankrupt, many can't survive more than 5 years. But they ruin the market price.'*

Hence, how SMCFs leveraged their marketing strategies or administrative practices depended on the both the customers and peer competitors as well. Nonetheless, majority of the interview respondents argued that during bad market condition, the survival of firms became the first priority of business. Due to their scale disadvantage, it was always critical for the SMCFs to find an optimum balance between profit, innovation and survival.

5.8.6 Entrepreneurship as antecedent of construction innovation

All interviewees (except GC3 and SC5) displayed entrepreneurial behavioural characteristics of risk taking in their decision making towards innovation. Most often, the adoption process of innovation was not always straightforward and without risk. In this view, the interviewees stated that they need to be entrepreneurial enough to treat the potential risk of the innovation adopted as a chance for the firms to gain success. For instance, interviewee GC7 highlighted that,

> *'You look at the problem, the current situation and you treat the problem as an opportunity for you to fully capture this opportunity. All entrepreneurs are the one who willing to take the risks.'*

Noting the potential risk associated with every particular innovation, some interviewees (GC1, GC2, GC7, SC1 and SC3) enlightened that they would calculate and evaluate the pros and cons of using an innovation prior to its final adoption and implementation. Upon engagement, the innovation was constantly monitored to ensure that any risk arose was treated in time. For instance, interviewee GC1 related that,

> *'We have calculated the risk, for instance, we see that other firms are applying something new, only we dare to use it because for most of the times, the new technology is not cheap.'*

Additionally, some interviewed respondents (GC1, GC6 and SC1) related that the management would always like to empower the staffs to make decision by themselves and to work independently (autonomy). Prior to this, the top management needed to supervise and work closely with the employees in their way of obtaining hands-on experience dealing with the daily business routines. From the interviews, it was generally agreed that being autonomy would disclose a higher chance for new way of working. For instance, interviewee GC6 related that,

> *'By letting them to do work independently, they will find their way to think of the problem faced and make decision themselves. So from there, my staffs can even improve my methods.'*

In general, the contractors interviewed viewed that their firms would always seek for alternatives to improve their present operation, which in turn led to an implementation of new solution or practice. In specific, the SMCFs would continuously figure out on how they could gain more profits by using new or different methods to deal with the routinized works. For instance, interviewee GC7 related that,

> *'We as contractor, what happens to be, we know about this product as it has been used and it can be used for this project for cost saving. So this is the entrepreneurial skill like I said. So we can bid better, other people, say, bid hundred million, we can do it seventy million because why? Because our entrepreneurial skill, you can still get the same product, better quality at lower price.*

Likewise, two interviewees (GC4 and GC6) claimed that they could bring up their margin by further fine-tuning their use of building materials (e.g. tiles, sanitary fittings, lock sets) which were imported from China. The price was lower but the quality was within standard range. As such, it resulted in cost-saving due to the lower budget derived from the new building products, which had equivalent quality with that of local products. For example, GC4 stated that,

> *'For example, we imported a lot of materials from China. The materials are very cheap but we can make it in such a way that, in overall, they look good.'*

Overall, majority of the sampled SMCFs exhibited entrepreneurial characteristics of risk-taking and autonomy. The entrepreneurial behaviour usually based on the intention of firms to improve the performance of projects or daily operations. This had supported them to capture the advantages of innovation and differentiate their services among others.

5.8.7 Organizational learning as antecedent of construction innovation

In general, all 12 contractors interviewed agreed that organizational learning was important to support the pursuit of innovation. For instance, some interviewees (GC1, GC2, GC5 and GC6) observed that an organizational culture of openness was important by which the staff members were encouraged to express opinions on how to improve the business operation or construction activities. The sharing of how to improve the firms' services often promoted a new or different ways of doing things, and subsequently, the adoption of innovation. For instance, interviewee GC5 provided that,

> *'We welcome ideas from the workers or staffs on how to speed up or improve quality of our works. It is more informal, you just voice out your opinion and we know, based on experience, whether the suggestion can be applied.'*

Moreover, some of the interviewees (SC1, SC5, GC1 and GC7) claimed that the top management had favourably sent the staff members to attend talks, seminars, conferences, and others program to expose them with the latest technologies or practices available in the industry. This was a useful way, through the staff members, to absorb new ideas and knowledge into firms. Accordingly, the external ideas and knowledge might later favour the adoption of a particular innovation to improve firm performance. For instance, interviewee GC1 stated that,

> *'The staffs knew the new information about latest products, then they will tell the boss whether the product is better than previously used.'*

In addition, some interviewees (SC3, SC4, SC5, GC6 and GC7) observed the importance of teamwork throughout all parts that make up the firm. In particular, both the team on site and members in firms needed to work in a coordinated manner. Altogether, this would support the initial implementation and final success of innovation. For instance, interviewee GC6 related that,

> *'Not only tower crane, plants like material hoist, even our rubbish chute cannot be too nearby people's area, all these were discussed openly by our site teams to find out the best solution.'*

Further, all interviewees (except SC3) noted the importance of knowledge transfer, i.e., using instruments to record information about projects. Accordingly, the SMCFs could easily improve the efficiency of organizational operations or even promote innovative ways of working to further enhance their administrative processes. For instance, interviewee GC2 highlighted that,

> *'Like purchasing, every time they asked for price and then we have to get people to quote us. If you keep on repeating without having own record, that is too bad. So we have to find a method to record down, and update them from time to time.'*

Overall, the interviewees observed that the learning capability of each member within firms was not the same. It depended largely on education level, working experience or job scope of employees. Due to such difference, it was important to promote an environment where the staff members could share and learn from each other with regards to their knowledge or experience. As consequence, the integration of different level of employees contributed to a higher chance of innovations within the SMCFs.

5.8.8 Human resource practice not an antecedent to construction innovation

In generally, all the contractors interviewed were in consensus that their employees were one of the most value resources within the company. In this regards, most of the interviewees claimed that they would provide monetary rewards, such as bonus, promotion and salary increment, and company trip, etc., to their employees in relation to their outstanding performance. For instance, interviewee GC4 stated that,

> *'If my staffs can complete a project, within time, within budget, sure we will reward them, in terms of monetary. If you don't take care of your staffs, they will be easily poached by other firms.'*

However, the construction practitioners stated that their firms did not provide any reward in relation to employees' contribution to new ideas or solutions attributed to firm improvement. Put differently, the reward system mainly accounted for the promotion on the employees' personal performance, rather than their contribution towards innovation. Specifically, interviewee GC2 justified the reason beneath, *'We don't offer any rewards for staffs that share or establish innovative idea because our firm is not big. We are not corporate, so we didn't allocate bonus for that.'*

5.8.9 Impact of innovation on project and firm performance

All 12 contractors interviewed agreed that innovation was important to their firms. Because they were small in size, innovation was essential to enhance the organizational capacity in undertaking project-based businesses. A statement from interviewee SC4 might best summarize the impact of innovation to the SMCFs, *'Without innovation, my firm won't go this far'*. In general, it was observed that the adoption of innovations, whether of project-based or firm-based, ultimately resulted in increased performance of firms. Even if the use of an innovation necessitated an initial investment and company resources, it had not stopped the firms from innovating due to the desired long-term, beneficial impacts of innovation. For instance, interviewee GC1 provided that,

> *'Even though it incurs a cost, but it is more economical in terms of the completion time and labour paid, because work can be done faster, means the labour hour is lesser. We gain profit from a long-term perspective.'*

As regards to innovation implemented on site, all the interviewees observed that a minor cost saving on site could bring about significant profits to the firms. For instance, the innovations implemented on projects led to higher productivity, increased quality, reduced construction period, effective site management, and etc. In turns, these outcomes were eventually transferred into advantages in the forms of profit and reputation of SMCFs. For instance, interviewee GC2 related that,

> *'Then you will see, of course, you have cut down construction period, instead of a year you can complete in ten months by using all the new methods, and more effective workman and management. It's just two months, it's a lot of money to us.'*

Meanwhile, two interviewees (GC4 and GC6) addressed that the innovations introduced on project sites resulting in lesser site wastages, which were said to be expensive in treatment. For instance, interviewee GC6 highlighted that,

> *'The construction debris is reduced such as the brickworks waste, plastic and so on. So when we use sheer wall, we just install two sets of steel moulds, put reinforcement in the middle of course, pour the concrete, after pouring wait for cure, then remove the moulds, and that is it, the completed product.'*

As regards to innovation adopted within company, most of the interviewees associated with medium-sized firms viewed continuously upgraded management system as important to the overall firm performance. Despite their smallness, they needed to incorporate new managerial practices into the firms in order to cultivate an environment conducive to overall enhancement of business. This was especially crucial when the firms were expanding in size, i.e., recruiting new members into firms. For instance, interviewee SC1 addressed that,

> *'When your management is good, the way you manage your company will influence your staff, when staffs are motivated, their skill and productivity will increase accordingly. So the turnover of staffs is lower, therefore the firm' performance will keep increasing. If the management is poor or out-dated, the staffs will run away, lead to shortage of staffs, so whatever the kind of performance, it will never be.'*

In addition, interviewees (SC2, CG1, GC4, GC5, GC6 and GC7) associated with G7 graded firms observed the impact of ISO 9000 system on their work operations on site and administrative procedures within firm. For each project, the SMCFs were required to formally record down for each procedure undertook at different stages of construction. It enabled the firms to learn from the past projects after they carried out post-mortem analysis on the problems encountered. Accordingly, this had improved their technical capability to coordinate their administrative works with the site operations in future projects. As regard the impact of ISO 9000 on site, interviewee GC6 related that,

> *'All needed forms are provided in the ISO for all activities on site, from beginning till the end. It helps us in making sure that we have kicked off meetings, minute of meetings, progress reports.'*

As regard the impact of ISO 9000 on firm, interviewee GC7 added that,

> *'When you have a very structure and organized management style, when the clients look at it, they are impressed in term of your pre-planning, your program, your logistic, your handling. This is part of your marketing strategies where the client looks at you.'*

After all, the interviewed contractors owed much of their success to the innovative ways of doing business, which in turn, brought about enhanced reputation of firms. Specifically, it was agreed that both technological and organizational innovations were important in realizing the goals of achieving good quality and high productivity, both of which, stimulated the people working around to help them in advertising their services. From this, they gained good reputation in the market. For example, interviewee GC7 highlighted that,

> *'It's not saying loud how good you are, it's about doing good, and slowly people will see it.'*

As a whole, the interview respondents claimed that they needed to take themselves as good contractors. For industry like construction, the SMCFs depended largely on their reputation to secure on new jobs. To this end, being innovative was seen as a distinguishing approach for the SMCFs to establish themselves in the competitive market.

5.8.10 Complementary roles of technological and organizational innovations

In general, all the 12 contractors interviewed (except SC2) agreed that both technological and organizational innovations were of equal importance. According to interviewee SC2, the impact of organizational innovation was far more impressive than that of technological innovation,

> *'Let it say, if you're not so good in design, the loss that whatever you supposed to make is not that significant compared to people that are not work for you properly, people are not encouraged to work. The morale of the company is so low, the loss is so significant, it's so important.'*

On contrary, interviewees GC5 stressed that the importance of keeping a balance on both types of innovation to maximize their synergistic effects,

> *'If you increase one side, you have to increase the other side. It depends on your capabilities and management technique. Once you balance on both, that is the optimum, the maximum level.'*

Further, some of the interviewed contractors (SC2, SC4, GC4, GC6 and GC7) observed that the use of technological innovation frequently necessitated a concurrent change in the organizational practices, and vice versa. Hence, both types of innovations were mostly undertaken in a simultaneous manner. For instance, interviewee GC4 related that,

> *'For example, in previous time when we use the conventional type, my boss will say okay, give you this tower crane. This tower crane is for assembling the formwork, lifting steel, casting, all included inside. But if you use system form, you need another set of machines to help you. You need pump machines including some mechanical devices to ensure the effectiveness. So how the group is going to do the work is depending on what type of the system being adopted.'*

Notably, it was observed that the SMCFs had specifically translated the positive outcomes of technological innovation into one kind of organizational innovations. This happened when a particular project-based innovation (technological innovation) resulted in reduced completion period of project. For this reason, the SMCFs could safeguard on their completion of work, i.e., had no record for abandoned or delayed works. This would, in turns, lead to a higher level of motivation and morale among the firm members and establishing an encouraging environment to promote the employees to work productively.

5.8.11 Contractors' will to expand firm into larger size

All interviewees (except SC2 and GC6) indicated that they opt to maintain the original SME size, rather than expanding the firms into larger size. However, majority of the interviewees stated that they had diversified, or diversifying, themselves from specialist contractor to general contractor. With smaller size, it was relatively easier to make profit from project businesses due to the lower overheads (i.e., plants and machineries, employed staffs and other expenses). For instance, interviewee GC6 addressed that,

> *'G7 not necessary means big firms having over 100 employees. Like us, we have 10 something staffs over these years. But we cannot tender for too big projects that have thousands unit of houses because our company cannot support for that.'*

Further, the interviewees owed the reasons to the stiff competition among domestic and foreign firms in the local market. In particular, foreign firms seeking international job opportunities were gradually penetrating once restricted markets such as China and the fast developing East Asian countries. This had led to an expansion of the local construction market, where the relatively big players that dominated the market in the past, would be increasingly overtaken by newcomers with niche-strategies. This had demotivated the SMCFs to expand further. For instance, interviewee GC6 related that,

> *'There are China people who operate their businesses here, as developers and main contractors. Their site meetings, construction drawings, all are in Mandarin.'*

Further, interviewee SC4 added that,

'They have great numbers of people and money. For one project, they can have lots of workers and specialists. How do you compete with them? It is just like we are a small grocery and they are big Tesco. I don't worry about other foreign companies because their services are expensive, Japan or Korea. But China is super good and cheap.'

As such, all interviewees (except SC2 and GC6) claimed that the current time was not suitable for expansion. For the time being, they would focus on the delivery of good quality of works, rather than expansion of firm, to stay competitive in the market. Eventually, the government played a major role in transforming the construction into an innovative, and therefore, competitive industry as suggested by interviewee SC5,

'Actually like Malaysia, you can build standard size of houses. You build according to the size, everything in a full dimension. But why we still cannot? You want to build a window also you have to do the site measurement. You can't because all these thing is using labour to do. But in Japan or Hong Kong, you see their house everything they do DIY already. They cut everything and put it together, you take it back to do yourself. It's our nation haven't come to this stage. But I think this will happen in future.'

Despite the above arguments, however, both interviewee GC6 and SC2 took the tough circumstance as a challenging opportunity to expand their businesses. Interviewee GC6 stated that the top management had joint-ventured with other firm to attempt to expand their services. Meanwhile, interviewee SC2 addressed that his firm was transforming into a general contracting firm to offer wider services to the market. Further, he added that transforming into a developer was one of his firm's future plans.

5.9 Validation of the proposed framework

According to Abdul-Rahman, Wang and Lee (2013), a validation process of the developed framework was essential to determine whether it was of an application value for evaluation in construction practice. In the present study, the validation of the innovation framework was carried out by the 12 SME practitioners those involved in the prior interviews. Since they had sufficient construction experience (i.e., at least 15 years) and designation (of managerial position) (Ling et al., 2012), and were currently associated with SMCFs, they were therefore in position to evaluate the robustness and ability of the framework to predict innovation within the construction framework. To this end, the experts were requested to fill in an evaluation form (Abdul-Rahman et al., 2013) that based scores on the value of completeness, reliability, user friendly level, and assistance in decision-making, with each parameter had a 10-scale evaluation. The format of questions of the validation form was shown in Table 5.4.

5.9.1 The validation result

The validation result (see Table 5.5) indicated that the innovation framework was acceptable since the overall assessment was between satisfactory and excellent. In general, the experts agreed that the structure of capabilities-innovation-performance as depicted in the innovation framework could systematically help them to self-assess their firms' current orientation of innovation more objectively and fairly than before. Accordingly, the framework inspired them to strengthen different types of capabilities whichever they think inadequate to obtain a higher level of firm performance, via the two different types of innovation activities. This indicated that the proposed framework was sufficient to evaluate and improve the practice of construction innovation in construction-based SME setting. However, future study to enhance the framework was recommended by two experts. One expert recommended the integration of how strategic allocation of resources into the framework could flexibly support the innovation activities in SMCFs. Another expert recommended the refinement of the framework based on the firm size, i.e. small and medium, to understand how the framework varied with the size of firms.

Table 5.4: The validation form of innovation framework

Evaluation: 1. Do you think the framework explain the nature of Construction Innovation management? (Yes / No) 2. How would you rate this framework? (Excellent / Good / Satisfactory Average / Below Average) 3. Please rate the framework according to the statement below: **1** is **Disagree** with the statement. **10** is **Agree** with the statement.										
	Not Agree~~~~~~~~~~~~~~~~~~~~~~ **Agree**									
a. It is acceptable and reliable.	1	2	3	4	5	6	7	8	9	10
b. It provides a complete set of construction innovation management.	1	2	3	4	5	6	7	8	9	10
c. It provides a learning process for the junior construction practitioners.	1	2	3	4	5	6	7	8	9	10
d. It is user friendly and easy to understand.	1	2	3	4	5	6	7	8	9	10
e. The design of the framework is clear and clean.	1	2	3	4	5	6	7	8	9	10
f. It helps a lot in improving your management quality.	1	2	3	4	5	6	7	8	9	10

Table 5.5: The validation results of innovation framework

Experts	Question 1	Question 2	Question 3					
			a.	b.	c.	d.	e.	f.
GC1	Yes	Good	7	5	8	8	5	7
GC2	Yes	Good	8	7	7	8	8	8
GC3	Yes	Good	7	8	8	8	9	8
GC4	Yes	Good	8	9	8	9	8	8
GC5	Yes	Satisfactory	7	7	8	6	7	7
GC6	Yes	Good	10	8	9	8	9	8
GC7	Yes	Good	8	7	8	9	9	9
SC1	Yes	Good	8	8	9	9	8	9
SC2	Yes	Excellent	8	7	8	8	7	7
SC3	Yes	Excellent	7	9	8	9	8	9
SC4	Yes	Good	8	8	9	9	9	9
SC5	Yes	Good	8	8	7	7	7	7

5.10 Summary

This chapter had provided in Section 5.8, a summary of the responses gathered from 12 interviews. These interview responses were categorised according to the specific themes of this study raised from the discussion of the developed innovation framework. Overall, the interview method of this study, together with the statistical evaluation in Chapter 4, facilitated the development and validation of the innovation framework formulated from the theoretical RBV and the preceding literature. This had demonstrated the merits of the qualitative interview approach in the present study.

CHAPTER 6

DISCUSSION

6.0 Introduction

The present chapter aimed to underscore some findings of the quantitative study (see Chapter 4) and the qualitative study (see Chapter 5). To begin, an overview of the main findings derived from both quantitative and qualitative studies were drawn. Next, both the statistical survey findings and qualitative interview responses were discussed to provide new insights in relation to the study's purpose. For this purpose, both the quantitative and qualitative results were compared with the extant literature in order to seek both conflicting and similar works.

6.1 Highlights of the main findings and results

In the empirical parts of the study, it had been systematically scrutinized how innovations supported the business of SMCFs. By means of RBV (Penrose, 1959; Wernerfelt 1984; Barney, 1991), the present study had responded to the call for an understanding of the implication of innovation activities on smaller construction firms (Barrett & Sexton, 2006; Hillebrandt, 2006). Overall, both the survey results of 157 SMCFs and the interview responses of 12 construction experts had added valuable insights to the foregoing research streams of SMEs by which a new innovation framework was developed and validated. Both the findings from quantitative and qualitative studies were respectively presented as follows.

6.1.1 Main findings of quantitative study

The firstly conducted quantitative study involved the development of three hierarchical measurement models, namely, organizational capabilities, innovation activities and firm performance. Also, it involved developments of the whole model of innovation, which encompassed two levels of models—the structural and mathematical models. Based on the analysis, the extent of the impact of capabilities-based antecedents had on innovations, which in turn impacted on firm-based consequence, was affirmed. Except the construct of human resource practice, all constructs of organizational capabilities had a positive and significant influence on innovation activities of firms. These innovation activities, which appeared in both technological and organizational types, had positively and significantly linked to firm performance. Moreover, the two different innovation activities generally exerted partial mediations on all paths in the model.

To obtain a valid and reliable measurement scale, the present study conducted content validity, pilot study, principal component analysis and confirmatory factor analysis prior to the use of partial least square modelling to develop the innovation framework. In this connection, the reliability and validity for each of the measurement model was attained. As shown in Table 6.1, the final model consisted of 55 variables measuring the main constructs. The values of variance explained (R^2) for the intermediate endogenous constructs (i.e., technological innovation and organizational innovation) and the endogenous latent constructs (i.e., firm performance) were considered as moderate, demonstrating a good theoretical structural model. Other assessment tests on the quality of model, such as collinearity, path coefficient, F test and Q test supported this finding. Hence, it was confirmed that innovation was an important consideration in SME research in addressing capabilities and performance of project-based constructing firms.

Table 6.1: Variables of the full model of innovation

Constructs		Items
1. Innovation activities		
1.1	Technological innovation (TI) (7 items)	Improved existing goods/services (Tech2); seek on new goods/services (Tech3); offer new goods/services (Tech4); updated production to increase productivity (Tech5); use of technologies (Tech6); new production to improve quality and/or decrease cost (Tech7); removal of non-value added activities (Tech8).
1.2	Organizational innovation (OI) (8 items)	New management approaches (Ntec1); investment in management (Ntec2); seek to improve management (Ntec3); renew of organizational structure (Ntec4); extended/customized service (Ntec5); new market (Ntec6); new promotion techniques (Ntec7); renew of pricing strategies (Ntec8).
2. Organizational capabilities		
2.1 Entrepreneurship (EO)		
a.	Autonomy (3 items)	Minimum supervision (Enor2); work prioritization (Enor3); uncertainty as challenge (Enor4).
b.	Risk taking (4 items)	Venture into unexplored territories (Enor5); acceptance on failure (Enor6); emphasis on success rather than failure (Enor7); seek for new opportunities for present operations (Enor9).
2.2 Integrated market orientation (IMO)		
a.	Customer orientation (2 items)	Monitor on firm’s commitment toward customers’ needs (Imor2); firm’s strategies driven by the need to create value for customers (Imor3).
b.	Latent need fulfilment (4 items)	Understand unexpressed customers’ needs (Imor5); seek on uncovering new customers’ needs (Imor6); develop solutions (Imor7); firm’s techniques to discover unexpressed customer needs (Imor8).
2.2 Integrated market orientation (IMO)		
c.	Integrated competitor orientation (5 items)	Share information (Imor10); rapid respond to thread (Imor11); discussion on competitors’ strategies by top management (Imor12); integrated functions (Imor14); management understands how everyone can contribute to firm (Imor16).

Table 6.1, continued

2.3 Organizational learning (OL)		
a.	Openness and experimentation (5 items)	Involve staff in important decision making (Lcap1); favourably in carrying out changes to adapt to and/or keep ahead of new situation (Lcap2); employees' learning capability (Lcap3); promotion on experimentation and innovation (Lcap8); external experiences and ideas as useful instruments for firm's learning (Lcap10).
b.	System perspective and knowledge transfer (5 items)	Employees' generalized knowledge on firm's objectives (Lcap5); contribution of all parts of the firm to achieve overall objectives (Lcap6); discussion and analysis on errors and failures (Lcap12); open discussion (Lcap14); instruments to record down the past situation (Lcap15).
2.4 Inter-organizational network (IN)		
a.	Heterogeneity (1 item)	Diversity on the type of linkage with other firms (Heterogeneity).
b.	Depth (4 items)	Customers (Iorg1); suppliers of components (Iorg2); equipment and software, competitors (Iorg3); experts and consultancy firms (Iorg4).
3. Firm performance (FP)		
3.1	Firm performances (7 items)	Profitability (Fper1); annual sales growth (Fper2); market share (Fper3); labour productivity (Fper4); customer satisfaction (Fper5); repeat business (Fper6); reputation (Fper7).

6.1.2 Main findings of qualitative study

The secondly conducted qualitative study involved the elaboration and validation of the innovation framework that was firstly developed by prior quantitative study. In particular, it explored the causal nature between innovation activities and their capabilities-based antecedents and firm-based consequence. Importantly, the innovation framework had been eventually validated by 12 construction experts.

1. SME contractors' innovation in local practice: In general, the interviewees viewed innovation as an adoption (rather than development) of new technologies or practices by the firms. Further, the adopted innovations, whether technological or organizational mode, were implemented onto construction projects or within business operation. The purpose of integrating innovation within project or firm arena was to improve the traditional ways of working, which were rather insufficient to support the sustainability of business in the rapidly changing marketplace. However, these interviewees indicated that the innovations adopted were mostly incremental in nature (i.e., improved technologies or practices) and new to the firms (i.e., not new to the industry or the world). Mainly, the decision to pursue innovation was motivated by external forces those exerted by government and clients upon the local industry. An innovation was adopted when it was expected to meet the demands of producing satisfied productivity and quality, and at the same time, accrued beneficial values (such as profit, reputation, etc.) to the SMCFs. Especially facing the problems of worker shortage, the use of innovation could help in merchandizing the construction or business processes and in turn reducing the great reliance on manpower. Overall, both technological (i.e., product and process) and organizational (i.e., managerial and marketing) innovations were important to satisfy the external demands and internal needs.

2. Organizational capabilities: Most of the interviewees affirmed the positive influence of capabilities on innovation. In specific, the leverage of capabilities within SME perspective not only favoured the growth of technological innovation, but also constituted impetus for new organizational practices. As presented earlier, several types of capabilities, combined from the literature and findings of quantitative study, were used to develop the innovation framework (see Chapters 3 and 4). In particular, the first phase, quantitative study was employed to test and identify the capabilities of those significant to innovation of SME contracting nature. In consistent with the quantitative study, the results of second phase, qualitative study identified certain capabilities as important to facilitate the SMCFs in pursuing innovations: entrepreneurship (i.e., risk taking and autonomy), inter-organizational network (i.e., linkages with several types of external firms), integrated market orientation (i.e., orientation towards customers and competitors) and organizational learning (i.e., openness and experimentation, system perspective and knowledge transfer). In addition, validation of the framework with construction experts was used to verify whether the framework was accurate and comprehensive, and was of an application value for the project-based SMCFs.

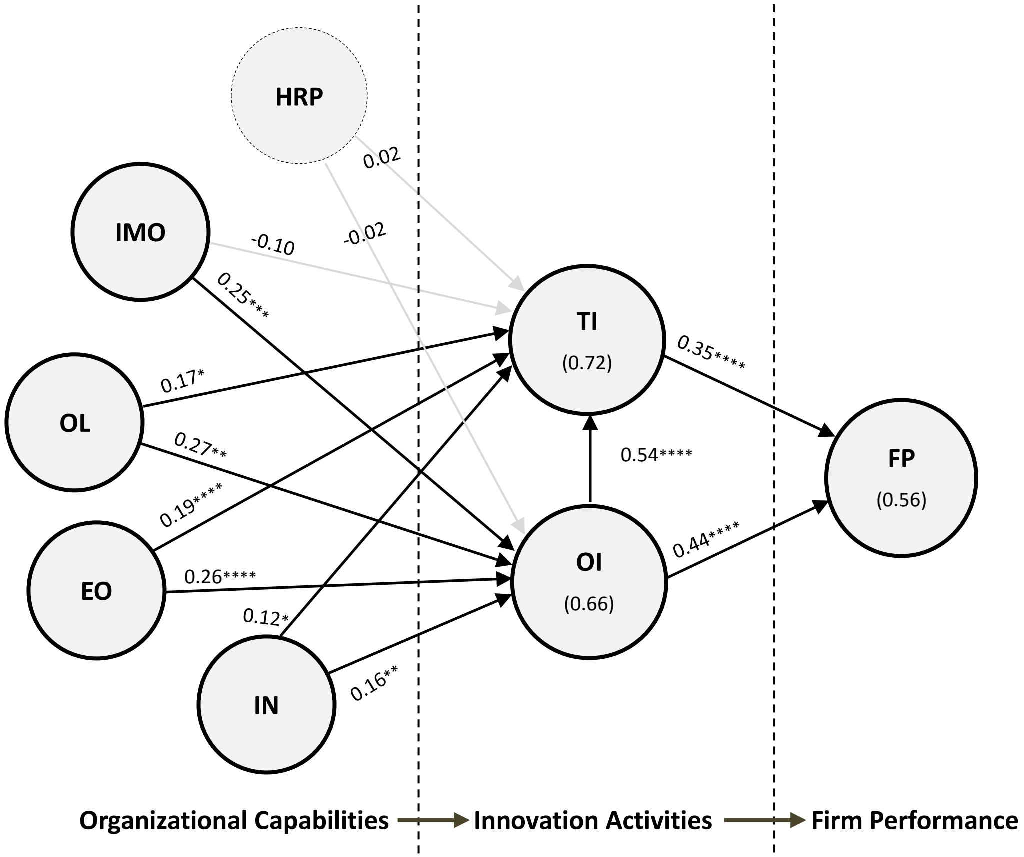
3. Firm performance: All of the interviewees viewed innovation as one of the important sources toward enhanced firm performance of SMCFs. In specific, the adoption of innovations, whether of project-based or firm-based, ultimately led to increased performance of firms. For instance, the innovation being implemented on project had improve the project performance, such as higher productivity, increased quality, reduced construction period, effective site management, minimum construction waste, and etc., all of which, eventually translated into business advantages of SMCFs in the forms of profit and reputation. This was similarly reflected by innovations implemented within the firms that they improved the efficiency of business operations and the technical capability to support the site operations. However, the adoption of every innovation required the SMCFs to have enough financial strength and company resources. Nevertheless, all interviewees highlighted that they based their consideration on the long-term, beneficial effects of innovation had on firms.

6.2 Discussion and interpretation

Overall, both the statistical results and interview responses indicated that SMCFs could attain superior performance along two different innovation activities (TI and OI), which were supported by four capabilities-based approaches (IN, IMO, OL and EO). On one hand, the findings revealed that ‘capabilities’ was an important antecedent to SMCFs’ pursuit of innovation. This was consistent with the past research works (e.g. Sexton & Barrett, 2003a, b; Barrett & Sexton, 2006; Lu & Sexton, 2006; Sexton et al., 2006; Manley, 2008) which stressed on smaller firms’ capabilities in overcoming the barriers of scale disadvantage in order to engage in innovation activities. On the other hand, it was clear from both the quantitative and qualitative results that innovation resulted in an increased performance of SMCFs. This was concurred with other studies on small firms (e.g. Freel & Robson, 2004; Laforet, 2013).

The forthcoming sections discussed and compared the results derived from the quantitative surveys and qualitative interview with that of extant literature. In particular, the discussion on the statistical results elaborated the two levels, i.e., structural and measurement models, of the innovation model. The relationship among main constructs and the relationship between a particular construct and its manifest variables were included. Figures 6.1 and 6.2 depicted the final framework of innovation (including both structural model and mathematical equations) of SMCFs that considered capabilities-based antecedents and performance-based consequence. Values on the arrows indicated path coefficient and associated significance level while values in each constructs indicated the variance explained (R^2).

Structural model:



Mathematical equations:

FP = 0.35TI + 0.44OI

TI = 0.17OL + 0.19EO + 0.12IN + 0.54OI

OI = 0.25IMO + 0.28OL + 0.26EO + 0.16IN

Note 1:

N=157,

HRP = Human resource practice;

IMO = Integrated market orientation;

OL = Organizational learning;

EO = Entrepreneurship;

IN = Inter-organizational network;

TI = Technological innovations;

OI = Organizational innovation;

FP = Firm performance.

Note 2:

→ Significant effect

→ Non-significant effect

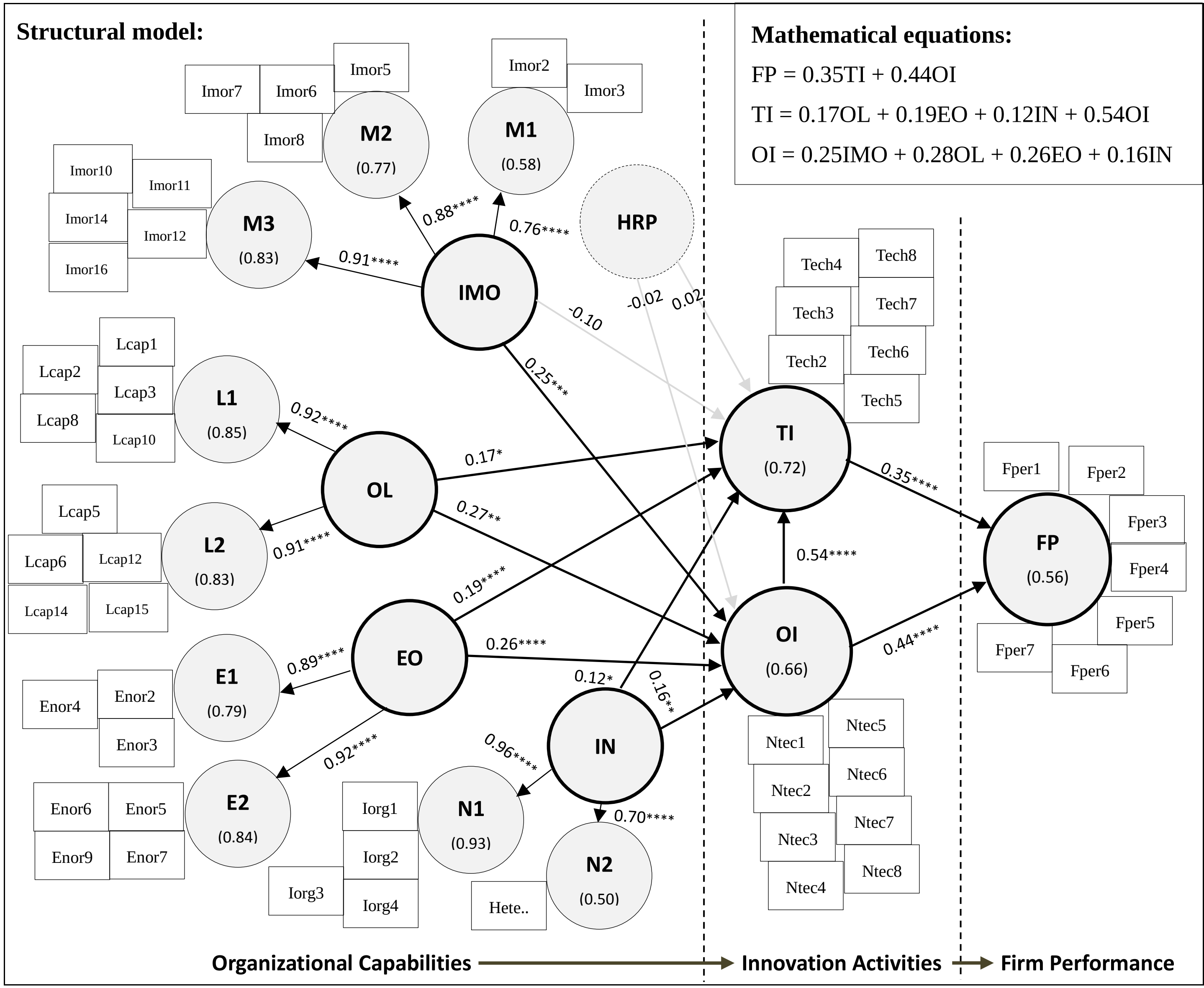
* significant at $p < .1$.

** significant at $p < .05$.

*** significant at $p < .01$.

**** significant at $p < .001$.

Figure 6.1: Final innovation framework for SMCFs (hiding first-order constructs and manifest variables)



Mathematical equations:

FP = 0.35TI + 0.44OI

TI = 0.17OL + 0.19EO + 0.12IN + 0.54OI

OI = 0.25IMO + 0.28OL + 0.26EO + 0.16IN

Note 1:

N=157, HRP = Human resource practice; IMO = Integrated market orientation; M1= Customer orientation; M2 = Latent need fulfillment; M3 = Integrated competitor orientation; OL = Organizational learning; O1 = Openness and experimentation; L2 = System perspective and knowledge transfer; EO = Entrepreneurship; E1 = Autonomy; E2 = Risk taking; IN = Inter-organizational network; N1 = Depth; N2 = Heterogeneity; TI = Technological innovation; OI = Organizational innovation; FP = Firm performance.

Note 2:

Significant effect

Non-significant effect

* significant at p < .1.

** significant at p < .05.

*** significant at p < .01.

**** significant at p < .001.

Figure 6.2: Final innovation framework for SMCFs (expanding first-order constructs and manifest variables)

6.2.1 Inter-organizational network and its linkage with construction innovation

Table 6.2 showed the measurement of inter-organizational network (IN) that included five reflective items within the full model. Given that SMCFs generally worked under resource-constrained environment, the depth (N_1) and breadth (N_2) of networks with other firms (see equation (8)) ensured that a SMCF would expose to a pool of resources required for innovation activities (Manley, 2008; Gronum et al., 2012). In this connection, the SMCFs viewed “Suppliers”, “Clients”, “Experts and consultancy firms” and “Competitors” as important sources to nurture activities that promoting innovation. As pointed out by some of the interviewees, their firms preferred networking with clients and value-chain partners for the innovations they pursued were mostly out-in adoptions, rather than in-out inventions that required technical expertise from industrial actors like universities or research bodies. Such finding conflicted with the work of Manley (2008) who asserted the importance of having linkages with research centres.

Table 6.2: Items of inter-organizational network and their loading

Dimension of 1st order construct	Variable (loading)
N_1 *(Depth)*	Customers (0.824)
	Suppliers of components, equipment and software (0.829)
	Competitors (0.634)
	Experts and consultancy firms (0.712)
N_2 *(Heterogeneity)*	Breadth (diverse number) of networks (1.000)

By comparison, the results from both the questionnaire and interviews were consistent for the paths ‘Inter-organizational network’ to ‘Technological innovation’ and

‘Inter-organizational network’ to ‘Organizational innovation’. As revealed in Figure 6.2, the statistical results first disclosed that inter-organizational network had a direct significant and positive association with both technological innovation (β=0.12, t=1.740) and organizational innovation (β=0.16, t=2.143). These paths achieved the conventional significant level of 0.1 and 0.05 respectively. From the interview, it was similarly affirmed that networking with external firms was important in supporting both technological and organizational innovations. These findings were in line with the previous works (Toole, 1998; Sexton et al., 2006; Hardie & Manley, 2008; Hardie et al., 2013) which asserted that small construction firms needed to exploit critical resources needed for innovation beyond the firms’ boundaries. In sum, the SME builders would purposefully build linkages with multiple actors as a strategic solution to succeed in undertaking innovation activities.

6.2.2 Integrated market orientation and its linkage with construction innovation

Table 6.3 illustrated the items and the associated loadings of three components that determined the construct of integrated market orientation. In this regards, the three sub-construct (M_1, M_2 and M_3) loading on integrated market orientation (refer equation (9)) were significantly important to support organizational innovations; however, they had no effect on technological innovations. For the path ‘Integrated market orientation’ to ‘Organizational innovation’, the most influential factor was “integrated competitor orientation” and followed by “latent need fulfilment” and “customer orientation”. Among the integrated competitor orientation, the SMCFs focused primarily on “Discussion on competitors’ strategies by top management”, followed by “Share information about competitors' strategies", "Rapid respond to thread", "Integrated functions" and "Management understands how everyone can contribute to firm". The highest loading carried by integrated competitor orientation (M_3) (Sexton et al., 2006) suggested that firms should respond quickly towards the innovation-related threads posed by their rivals. As disclosed by the interviews, additionally, such orientation was refined by the capacity of firms (i.e., whether they had sufficient resources to undertaken the innovation) and the market condition (i.e., during bad condition, survival came before profit and innovation).

Table 6.3: Items of integrated market orientation (IMO) and their loading

Dimension of 1st order construct	Variable (loading)
M_1 *(Customer orientation)*	Monitor on firm's commitment toward customers' needs (0.898)
	firm's strategies driven by the need to create value for customers (0.909)
M_2 *(Latent need fulfilment)*	Understand unexpressed customers' needs (0.792)
	Seek on uncovering new customers' needs (0.811)
	Develop solutions to unexpressed customers' needs (0.835)
	Firm's techniques to discover unexpressed customer needs (0.826)
M_3 *(Integrated competitor orientation)*	Share information about competitors' strategies (0.793)
	Rapid respond to thread (0.767)
	Discussion on competitors' strategies by top management (0.824)
	Integrated functions (0.762)
	Management understands how everyone can contribute to firm (0.760)

Meanwhile, the insignificant path of 'Integrated market orientation' to 'Technological innovation', as depicted in Figure 6.2, was pointed out by some of the experts. They explained that too much emphasis on the product or process innovations could result in a negative impact when the clients were risk-averse towards innovations or when the margin of tenders was barely enough for firms' survival. Thereby, the results added knowledge into the prior literature (Sexton & Barrett, 2003b; Barrett & Sexton, 2006; Sexton et al., 2006; Thorpe & Ryan, 2007) that integrated market orientation had been seen as one of the important approaches for the innovative SMCFs to continuously secure themselves in the marketplace.

6.2.3 Entrepreneurship and its linkage with construction innovation

As shown in Table 6.4, entrepreneurship could be measured by two main components in the context of the current study. The first component (E_1) contained different items, including minimum supervision, work prioritization, and uncertainty as challenge. Meanwhile, the second component (E_2) comprised items related to risk taking, such as venture into unexplored territories, acceptance on failure, emphasis on success rather than failure and seek for new opportunities for present operations.

Table 6.4: Items of entrepreneurship (EO) and their loading

Dimension of 1st order construct	Variable (loading)
E_1 *(Autonomy)*	Minimum supervision (0.845)
	Work prioritization (0.862)
	Uncertainty as challenge (0.763)
E_2 *(Risk taking)*	Venture into unexplored territories (0.715)
	Acceptance on failure (0.757)
	Emphasis on success rather than failure (0.782)
	Seek for new opportunities for present operations (0.731)

Figure 6.2 showed that entrepreneurship played a favouring role in spurring both the technological innovation (β=0.19, t=3.354) and organizational innovation (β=0.25, t=3.891) at the conventional significant level of 0.001. To remain entrepreneurial in business place, it appeared that the SMCFs emphasized more on risk taking (E_2), followed by autonomy (E_1) (see equation (7)). In terms of risk taking (E_2), the SMCFs were much affected by “emphasis on success rather than failure” followed by “Acceptance on failure”, “Seek for new opportunities for present operations” and “Venture into unexplored territories” in their innovation activities. Some of the interviewees emphasized that they often needed to act as risk-takers in pursuing innovations, which might present a chance of failure upon implementation. The entrepreneurial orientation of the firms, however, was mainly established according to the vision of the owner (Barrett & Sexton, 2006).

6.2.4 Organizational learning and its linkage with construction innovation

Organizational learning (OL) stood out to be another capability that enabled SMCFs to work innovatively. As depicted in equation (6), the positive coefficients of the sub-constructs indicated that more openness and experimentation (L_1) as well as system perspective and knowledge transfer (L_2) would lead to higher capability of firms to pursue two different types of innovation activities. From the survey finding, it was found that organizational learning had disclosed a direct significant and positive relationship with both technological innovation (β=0.16, t=1.740) and organizational innovation (β=0.27, t=2.143).

Table 6.5: Items of organizational learning (OL) and their loading

Dimension of 1st order construct	Variable (loading)
L_1 *(Openness and experimentation)*	Involve staff in important decision making (0.748)
	Management favourably in carrying out changes to adapt to and/or keep ahead of new situation (0.839)
	Employees' learning capability (0.785)
	Promotion on experimentation and innovation (0.812)
	External experiences and ideas as useful instruments for firm's learning (0.749)
L_2 *(System perspective and knowledge transfer)*	Employees' generalized knowledge on firm's objectives (0.762)
	Contribution of all parts of the firm to achieve overall objectives (0.786)
	Discussion and analysis on errors and failures (0.773)
	Open discussion (0.723)
	Instruments to record down the past situation (0.729)

With regard to openness and experimentation (L_1) (as seen in Table 6.5), the most influential factor was "Management favourably in carrying out changes to adapt to and/or keep ahead of new situation", followed by "Promotion on experimentation and innovation", "Employees' learning capability", "External experiences and ideas as useful instruments for firm's learning" and "Involve staff in important decision making". This notion was elaborated by most of the interviewees such that the openness of the top management was conducive to encourage learning throughout the entire firms, and subsequently, triggered the adoption of innovative ideas or practices by the SMCFs.

With regard to system perspective and knowledge transfer (L_2), the SMCFs appeared to emphasize more on "Contribution of all parts of the firm to achieve overall objectives", followed by "Discussion and analysis on errors and failures", "Employees' generalized knowledge on firm's objectives", "Instruments to record down the past situation" and

“Open discussion”. These empirical investigations were in support of the prior findings (Barnett & Storey, 2000; Chaston et al., 2001; Laforet, 2013) who asserted that small innovative firms viewed learning as a vital element to discover novel ways of performance terms. In construction specific, the results were in support of the work of Manley (2008) who observed that for firms of small size, their known liabilities of smallness could turn into a positive feature during the knowledge transposal processes, which were relatively easier due to the small scale of activities undertaken.

6.2.5 Construction innovation and firm performance: The linkages

After all, the four capabilities-based approaches turned out as a function of two different innovation activities, which was in combination a function of performance of SMCFs. Instead of R&D-based innovations (Bygballe & Ingemansson, 2014), the innovations being pursued by the SMCFs were identified to include non-R&D-related activities, such as adoption of new products, renewed production processes, updated managerial practices and marketing strategies. As seen in Table 6.6, the technological innovation included seven items that measure on the product- and process-based activities whereas the organizational innovation involved eight items that denote the managerial and marketing activities that were perceived as new to the SME firms. Further, ‘Firm performance’ was measured by seven reflective items, namely profitability, annual sales growth, market share, labour productivity, customer satisfaction, repeat business and reputation. In this connection, equation (3) showed that the engagement in both technological innovations (TI) and organizational innovations (OI) made it important for SMCFs to achieve superior performance.

Table 6.6: Items of innovations and firm performance with their associated loading

Dimension of 1st order construct	Variable (loading)
TI *(Technological innovation)*	Improve existing goods/services (0.647)
	Seek on new goods/services (0.708)
	Offer new goods/services (0.648)
	Updated production to increase productivity (0.770)
	Use of technologies (0.781)
	New production to improve quality and/or decrease cost (0.788)
	Removal of non-value added activities (0.729)
OI *(Organizational innovation)*	New management approaches (0.814)
	Investment in updating management procedures (0.750)
	Seek to improve management (0.745)
	Renew organizational structure (0.756)
	Extended/customized service (0.778)
	New market (0.770)
	New promotion techniques (0.825)
	Renew pricing strategies (0.742)
FP *(Firm performance)*	Profitability (0.662)
	Annual sales growth (0.821)
	Market share (0.793)
	Labour productivity (0.755)
	Customer satisfaction (0.788)
	Repeat business (0.775)
	Reputation (0.817)

For the path of 'Technological innovation' to 'Firm performance', the process-based innovation appeared to be more influential than the product-based innovation. Among the process-based innovation, the SMCFs emphasized more on "new production to improve quality and/or decrease cost", followed by "use of technologies", "updated production to increase productivity" and "removal of non-value added activities". Such finding was in line with prior works (Sexton et al., 2006; Manley, 2008; Hardie et al., 2013) that observed that the small construction firms tended to engage in technical-based innovations as their main innovation activities. Meanwhile, for the path of ‘Organizational innovation’ to ‘Firm performance’, it appeared that “new promotion technique” and “new management approaches” were the most influential factors that positively shaped the performance of SMCFs. Importantly, some innovations had intangibly occurred throughout the business routinized activities though they were more difficult to be recognized in contrast to the technical innovations (Gambatese & Hallowell, 2011b). This finding extended the essence of prior works that ubiquitously centred on the technological enhancements (Sexton et al., 2006; Manley, 2008; Hardie et al., 2013) by offering a clear conclusion on the role of organizational innovations with respect to firm performance. In this view, the present study answered the call of Brochner (2010) that advocated the need to advance the understanding of non-technological trajectories of innovation in the construction industry.

In a comparison view, the greater impact organizational innovation had on firm performance, as compared to that of technological innovation, contradicted the work of Thorpe et al. (2009) that asserted that small builders would focus largely on improving their product or daily tasks rather than marketing their products and services per se. Nonetheless, majority of the experts provided a neutral point of view that the two innovation activities were equally important in ensuring the success and continuity of their businesses. In a combination view, both technological and organizational types of innovation activities mutually complemented each other as shown in their significant and positive interrelationship (β=0.54, t=8.043). Practically, they often needed to be undertaken concurrently to result in a synergistic impact to the firms (Hardie & Manley

2008). This view had been similarly echoed in the qualitative interviews that the adoption of technological innovation frequently required a simultaneous change in the organizational practices, and vice versa.

6.3 Summary

This chapter commenced with an overview of the main findings of both quantitative and qualitative studies. In particular, the primary purpose of this chapter was to discuss and compare the empirical results with the extant literature. The discussion of quantitative result was divided into two parts: structural and measurement models. The first involved interpreting the relationship between organizational capabilities, innovation activities and firm performance. The argument was that organizational capabilities, as a distinguished characteristic of the resource-poor SMEs, had a significant influence on the innovation activities and it been important to be considered in achieving superior firm performance. Meantime, the qualitative discussions were integrated to elaborate and interpret the causal nature of relationship derived from the quantitative study. Overall, both quantitative and qualitative studies, in connection with the essence of prior literature, were useful to develop and validate the innovation model for the SMCFs.

CHAPTER 7

CONCLUSION AND RECOMMENDATION

7.0 Summary of objectives and main findings

Altogether, there were four objectives in the present study. The first objective was to identify the types of innovation activities among the small and medium construction firms. Built on the literature and the empirical findings of the present study, it was identified that the SMEs mainly engaged in two types of innovation activities: technological and organizational innovations (both occur within firms and across projects). Unlike larger organizations, the SMEs were generally lacking of resources, such as finances, human resources, hard assets, etc. This was important for the resources were crucial for innovation activities, such as investment in R&D or patenting. Nevertheless, it was identified that the SMCFs could work innovatively by pursuing non-R&D-related activities, such as adopting new products, production processes, managerial practices and marketing strategies.

The second objective was to identify the potential effect of innovation activities with regards to capability-based antecedents and firm-based performance of the SMCFs. In considering the resource-poor nature of the SMCFs, the present study conjectured that capabilities, instead of resources, were the determinants of SMCFs' innovation configuration. To this end, a quantitative study was firstly used to test the capabilities-based and firm-based factors in relation to two different types of innovation activities. Four main constructs comprised the organizational capabilities, i.e., entrepreneurship (EO), integrated market orientation (IMO), organizational learning (OL) and inter-organizational network (IN), were identified to be statistically significant. Further, the capabilities-based constructs were found to associate with performance of SMCFs via the mediating effect of innovation activities. From this, a first framework of innovation (including both structural model and mathematical equations) was developed for the SMCFs. Second, a qualitative study was used to elaborate the nature of relationships between the identified linkages within the framework in further depth. Through the sequential mixed method approach, a final framework of innovation was established for SMCFs, and consequently, led to the achievement of third objective.

Eventually, the last objective was to validate the developed innovation framework. To do so, the innovation framework was qualitatively validated by construction experts for its practicality and comprehensiveness. Overall, it was agreed that the innovation framework enables the SMCFs to predict their performance based on their committed capabilities and innovation activities. At the beginning of the study, it was assumed that organizational capabilities had a positive and significant relationship on both technological and organizational innovations. In turns, the two different innovations were assumed to stimulate the achievement of higher performance within the SMCFs. The empirical investigations had, quantitatively and qualitatively, proven these assumptions.

7.1 Theoretical contribution of the study

Unlike previous studies that had ubiquitously elucidated the large firms' connection with innovation, the present study specifically focused on the SMEs to inform new insights to academic research. To this end, the present study developed a new framework of innovation for the SMCFs that rested originality in two aspects. First, the framework had established the structural relationships between organizational capabilities, innovation activities and firm performance. As aforementioned, the extant literature remained silent on investigating the degree of interrelationships. Hence, the new framework had contributed to the body of knowledge by connecting both capabilities-based antecedents and firm-based consequence to understand the nature of innovation in an SME setting. Based on the innovation framework, it was clear that a couple of capabilities-based postures, such as entrepreneurship, integrated market orientation, inter-organizational networks and organizational learning, were crucial to synergistically spur the development of construction innovations, which in turn led to higher firm performance. Accordingly, the framework unlocked interesting extension to the extant literature of SMEs in that SMCFs would strive to exploit novel value creation via certain capabilities to acquire beneficial consequences pertaining to the firms.

Second, the new framework of innovation was distinguishing from any other prior works by consolidating on two different types of innovation activities. As noted earlier, the extant literature had predominantly focused on the implication of technological types of innovations, i.e., product and process innovations. To the author's knowledge, very scarce attention had been paid to the organizational types of innovations, which was suggested to occur throughout the construction firms. In order to complement the biased evidences in the extant literature, the framework was designed to investigate two distinct types of innovation activities, scilicet, technological and organizational innovations. While the emphasis towards the tangible, technological-based innovations was inherently valuable, the framework informed that innovative offerings in SMFCs were equally intertwined with the intangible, organizational innovations. Notably, it was noted that the new service offerings of the SMCFs did not based solely on a product-and-process viewpoint, but also from a managerial-and-marketing prospect. Accordingly, the empirical findings, both quantitatively and qualitatively, had provided novel insight to the theorists in the construction field such that both technological and organizational innovations should be included for innovation-related studies of SMEs of construction nature. Moreover, the new framework highlighted a broader paradigm and contribution of construction innovation.

7.2 Methodological contribution of the study

The present study also contributed to research methodology in construction innovation and management by describing in detail the rationale and the application of analytic PLS-SEM approach (see Chapter 4). It had systematically demonstrated the application of structural equation modelling with partial least square estimation approach to research problem in construction, especially in the field of innovation management. Thus, the present study provided useful framework to other researchers who might wish to conduct research of a similar nature under a similar data and model constraints.

7.3 Managerial implication of the study

Additionally, the present study offered valuable implications for both construction SMEs' practitioners and policy planners. As presented earlier (in Chapter 5), the innovation framework had been validated by 12 experts and proven for its industrial acceptance. Together with the thorough empirical findings, the new developed innovation framework (including both structural model and mathematical equations) could act as a useful guide for both practitioners and policy planners that intended to stimulate continuous improvement, via innovations, within and among the SMCFs. Specifically, the present study contributed to practice by proposing ways for both the practitioners and policy planners to evaluate the level of performance for innovative SMCFs (Equations (3)—(9)). For the SMCFs' practitioners, they could make use of the mathematical equations to evaluate and improve their innovative performance where appropriate. If performance was found to be low, the practitioners could adjust their commitment on innovation activities and/or capabilities based on those identified in the innovation framework. For SMCFs' policy makers, the new framework presented evidence on the undertaking of innovation, and consequently, offering inputs in scheming out a SME-focused innovation policy for firms with finite resources. The policy makers should strive to nurture the internal development of capabilities, such as entrepreneurship, integrated market orientation, inter-organizational networks and organizational learning, of the innovative SMEs to appropriately aid them in sustaining their performance within the stiff economic rents.

7.4 Limitations and recommendations for future works

The present research presented several limitations that, nevertheless, held great opportunity for future research. First, the design of cross-sectional analysis in the present study impeded a full consideration on the causality nature between the constructs. Future research should apply longitudinal research to enable a higher accuracy in interpreting the causal nature of the relationships. Second, the empirical setting was 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, generalisation of the resulted in varying professional service firms (i.e., architects, designers, engineers, quantity surveying, etc.) should be made in caution. Furthermore, more research works was necessary to help in generalizing the framework in other professional service firms as to enable its application in a wider context. Third, the present study did not consider all factors influencing construction innovation. Further research should consider also the external factors, such as regulatory environment, that could majorly leverage SMEs' innovative competence and competitiveness in the marketplace. Also, the inclusion of the incremental/radical characters of innovation could better advance the knowledge on existing innovation practices. Fourth, the present study did not include the large firms in explaining the potential difference in their innovation patterns as opposed to SMEs. Future studies should examine the large, medium and small firms in their distinct behaviour in seeking and managing innovations. Fifth, this study had been conducted in Malaysian SMCFs in which the research findings might incline towards Malaysian, Asian or developing countries' construction sector. In future works, the innovation framework could be tested in different country contexts as an international comparison. Sixth, the research focused on both technological and organizational innovations to understand the nature of innovation activities undertaken by SMCFs. Future studies could consider also other types of innovations, such as economical innovation, business model innovation, open innovations, etc. to exhaustively explore the nature of innovation activities among the SMCFs. Seventh, the framework required the innovating SMCFs' practitioners to conduct a series of calculations, based on equations (3)—(9), in order to predict of their likely firm performance. Future work could possibly probe into these equations to establish an innovation performance index, which could serve as a benchmarking for the SMCFs to predict their innovation-related development. Put differently, the SMCFs could review the key capabilities that underpin their innovation-based performance by utilizing the innovation performance index to assess the extent of their firms' innovativeness, scilicet, higher and lower innovative performance in the marketplace. Eighth, instead of manual calculation based on equations (3)—(9), the development of an automated decision support system (DSS) in future study would enable more SMCFs to use the innovation model more readily, to better understand their current performance, and to take appropriate steps to further enhance their firm performance based on recommendations from the proposed DSS. Finally, the partial mediation impacts exerted by innovation on the framework suggested that innovation was only one of the factors contributing to the positive performance of firms. Other factors such as internationalization activity, management competence, location, market strategy, etc. might prove to be important to the business success of SMEs in construction field, and therefore, should be included in future investigation.

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Appendix A: Publications

1. Lee, Y. L., Abdul-Rahman, H., & Wang, C. (2013). Nano-toxicology in engineering: Health risk of nano-materials in built environment. *Advanced Science Letters, 19*(9), 2662-2666.
2. Lee, Y. L., Hamzah, A.-R., & Wang, C. (2014). Construction innovation: Inter-firm network as antecedent factor with effect on organizational performance. ICIBET 2013. *Proceedings of the 2014 3rd International Conference on Information, Business and Education Technology*. Atlantis Press.
3. Lee, Y. L., Hamzah, A.-R., Wang, C., Loo, S. C., & Low, W. W. Predicting the performance of innovative small and medium construction firms: The use of capabilities-based approaches (submitted to Canadian Journal of Civil Engineering/ISI-cited).
4. Lee, Y. L., Hamzah, A.-R., & Wang, C. Innovative Performance of Small Construction Firms: The Effect of Entrepreneurship and Networking (Submitted to Construction Management and Economics).
5. Lee, Y. L., Hamzah, A.-R., Wang, C., Loo, S. C., & Low, W. W. Capabilities of Small Project-Based Service Firms: The Performance Effect of Non-Technical Innovation (Submitted to Innovation: Management, Policy & Practice/ISI-cited).

Appendix B: Content validity

1. Organizational capabilities

Organizational capabilities refer to a firm's processes that support the implementation of innovation within an organization, include: integrated market orientation, organizational learning, human resource practice, entrepreneurship and networking with external firms. Kindly indicate whether the questions are relevant and important to measure capabilities within construction SMEs. Kindly write down other items that you think are relevant to organizational capabilities of construction SMEs at the end of the questions.

Please rate the relevancy and importance of each of the following questions to the definition of the construction given above by using the following scale:

1 = **Not R / I** (Not Relevant nor Important) **2** = **R** (Relevant) **3** = **I** (Important)
4 = **R & I** (Relevant and Important)

No.	QUESTION	Not R / I	R	I	R & I
1	The objectives of our organization are driven by the need to achieve high customer satisfaction.	1	2	3	4
2	The organization constantly monitors the level of employee commitment to serving customers' needs.	1	2	3	4
3	Our strategies are driven by the need to create customer value.	1	2	3	4
4	We believe that understanding customers need gives us a competitive advantage.	1	2	3	4
5	We seek to understand what customers might need in the future.	1	2	3	4
6	We continuously seek to uncover new customers needs.	1	2	3	4
7	We develop solutions to unexpressed customers needs.	1	2	3	4
8	We use a number of techniques to discover currently unexpressed customer needs.	1	2	3	4
9	We frequently collect information on our competitors to help direct our firm's strategies.	1	2	3	4
10	We regularly share information within our firm concerning competitors' strategies.	1	2	3	4
11	We rapidly respond to competitors' actions that threaten us.	1	2	3	4
12	Top management regularly discusses competitors' strategies.	1	2	3	4
13	We coordinate goals and objectives across all functions (i.e. departments).	1	2	3	4

14	All functions are integrated in serving the needs of our target market.	1	2	3	4
15	Market information is shared with all functions.	1	2	3	4
16	Management understands how everyone in this organization can contribute to create customer value.	1	2	3	4
17	The managers frequently involve their staff in important decision-making processes.	1	2	3	4
18	The firm's management looks favorably on carrying out changes in any area to adapt to and/or keep ahead of new environmental situations.	1	2	3	4
19	Employee learning ability is considered a key factor in the firm.	1	2	3	4
20	In this firm, innovative ideas that work are rewarded.	1	2	3	4
21	All employees have generalized knowledge regarding the firm's objectives.	1	2	3	4
22	All parts that make up the firm (departments, sections, work teams and individuals) are well aware of how they contribute to achieving the overall objectives.	1	2	3	4
23	All parts that make up the firm are interconnected and work together in a coordinated fashion.	1	2	3	4
24	The firm promotes experimentation and innovation as a way of improving the work process.	1	2	3	4
25	The firm follows up what other firms in the sector are doing, and adopts practices and techniques it believes to be useful and interesting.	1	2	3	4
26	Experiences and ideas provided by external sources (advisors, customers, training firms, etc.) are considered a useful instrument for this firm's learning.	1	2	3	4
27	Part of the firm's culture is that employees can express their opinions and make suggestions regarding procedures and methods in place for carrying out tasks.	1	2	3	4
28	Errors and failures are always discussed and analysed by the firm at all levels.	1	2	3	4
29	Employees have the chance to talk among themselves about new ideas, programs and activities that might be of use to the firm.	1	2	3	4
30	In this firm, teamwork is not the usual way to	1	2	3	4

	work.				
31	The firm has instruments (manuals, databases, files, organizational routines, etc.) that allow what has been learnt in past situations to remain valid, although the employees are no longer the same.	1	2	3	4
32	Our organization seeks to match employees to specific job requirements.	1	2	3	4
33	We treat our employees as the most valuable resources within our organization.	1	2	3	4
34	Extensive training programs are provided for individuals in our organization.	1	2	3	4
35	Employees in this organization are provided with clear career paths	1	2	3	4
36	Job security is almost guaranteed to employees in our organization.	1	2	3	4
37	The organization seeks to maintain high level of employee motivation.	1	2	3	4
38	In our organization employees receive benefits linked to their performance.	1	2	3	4
39	Employees are given bonuses for outstanding performance.	1	2	3	4
40	All employees receive effective feedback on their performance.	1	2	3	4
41	Employees are encouraged to take responsibility for their work.	1	2	3	4
42	Employees are supposed to get the job done with minimum supervision.	1	2	3	4
43	Employees are encouraged to prioritise their work.	1	2	3	4
44	In this organization uncertainty is treated as a challenge.	1	2	3	4
45	Employees are encouraged to venture into unexplored territories.	1	2	3	4
46	Management accepts that certain suggestions may fail when implemented.	1	2	3	4
47	Our organization emphasises opportunity for success, rather than chances for failure.	1	2	3	4
48	In this organization new venture failure is viewed as a learning experience.	1	2	3	4
49	We constantly seek new opportunities related to the present operations.	1	2	3	4
50	We are usually the first to introduce new services in the industry.	1	2	3	4
51	We constantly look out for business that can be	1	2	3	4

	acquired.				
52	We constantly seek opportunities to improve our business performance.	1	2	3	4
53	We are always ahead of our competitors in responding to market challenges.	1	2	3	4
54	Our organization networks with our customers to acquire information and knowledge and/or access to resources required for innovation.	1	2	3	4
55	Our organization networks with suppliers of components, equipment and software to acquire information and knowledge and/or access to resources required for innovation.	1	2	3	4
56	Our organization networks with our competitors to acquire information and knowledge and/or access to resources required for innovation.	1	2	3	4
57	Our organization networks with experts and consultancy firms to acquire information and knowledge and/or access to resources required for innovation.	1	2	3	4
58	Our organization networks with R&D firms or laboratories to acquire information and knowledge and/or access to resources required for innovation.	1	2	3	4
59	Our organization networks with universities or centres of higher education to acquire information and knowledge and/or access to resources required for innovation.	1	2	3	4
60	Our organization networks with public and non-profit research organizations to acquire information and knowledge and/or access to resources required for innovation.	1	2	3	4
Do you think that there are other items can be used to indicate innovation-related practice inside an organization according to the definition? Please specify the items below and rate them accordingly.					

2. Innovation in construction

Innovation in construction refers to the introduction of an idea, practice, or object that is new to a construction firm, especially a SME. Innovations come in a variety of forms, either new or improved goods or services, production methods, business management processes or marketing techniques. Similar to the previous section, kindly indicate whether the questions are relevant and important to measure innovation in construction.

Please rate the relevancy and importance of each of the following questions to the definition of the construction given above by using the following scale:

1 = **Not R / I** (Not Relevant nor Important) **2** = **R** (Relevant) **3** = **I** (Important)
4 = **R & I** (Relevant and Important)

No.	QUESTION	Not R / I	R	I	R & I
1	Our organization has introduced new (or broader range of) goods/services to the market.	1	2	3	4
2	Our organization has developed newness for current services leading to improved ease of use for customers and to improved customer satisfaction.	1	2	3	4
3	Our organization has increased the quality of our current services.	1	2	3	4
4	Our organization constantly seeks to find new goods/services.	1	2	3	4
5	Work practices are constantly updated to increase productivity.	1	2	3	4
6	We used technologies (new construction material, equipment or software) in the production processes.	1	2	3	4
7	Our organization introduced new production method/technique to improve our output quality and/or decreasing production costs.	1	2	3	4
8	We continuously determine and eliminate non-value adding activities in our operational process.	1	2	3	4
9	We constantly introduce new ways of managing our business.	1	2	3	4
10	Our organization invests heavily in updating administrative procedures.	1	2	3	4
11	Management constantly seeks new ways to improve administrative systems.	1	2	3	4
12	Our organization renews the organization structure to facilitate teamwork.	1	2	3	4
13	We have introduced changes in the appearance or packaging of our services.	1	2	3	4
14	We have introduced new distribution channels (i.e. location) to sale our firm's services.	1	2	3	4
15	We seek new techniques to promote our services.	1	2	3	4
16	We renew the pricing strategies to market our firm's services.	1	2	3	4

17	We develop long term contact with client to target and satisfy their needs.	1	2	3	4
Do you think that there are other items can be used to indicate innovation within a firm according to the definition? Please specify the items below and rate them accordingly.					

3. Firm performance

Firm performance refers to the firm's possession of superior financial and non-financial advantages, which are not capable of being duplicated by competitors. It includes profitability, annual sales growth, market share, etc. Similar to the previous section, kindly indicate whether the questions are relevant and important to measure firm performance.

Please rate the relevancy and importance of each of the following questions to the definition of the construction given above by using the following scale:

1 = **Not R / I** (Not Relevant nor Important) **2** = **R** (Relevant) **3** = **I** (Important)
4 = **R & I** (Relevant and Important)

No.	QUESTION	Not R / I	R	I	R & I
1	Profitability of our organization is better as compared to key competitors.	1	2	3	4
2	Annual sales growth of our organization is better as compared to key competitors.	1	2	3	4
3	Market share of our organization is better as compared to key competitors.	1	2	3	4
4	Labor productivity of our organization is better as compared to key competitors.	1	2	3	4
5	Customer satisfaction of our organization is better as compared to key competitors.	1	2	3	4
6	Strength of competitive position of our organization is better as compared to key competitors.	1	2	3	4
7	Reputation of our organization is better as compared to key competitors.	1	2	3	4
Do you think that there are other items can be used to indicate firm's sustained competitive advantage according to the definition? Please specify the items below and rate them accordingly.					

This is the end, thank you very much for your response.

Appendix C: Cover letter (Questionnaire)

Faculty of Built Environment, University of Malaya,
50603, Kuala Lumpur, Malaysia

CAPABILITIES AND PERFORMANCE EFFECT OF A DUAL-MODE INNOVATION: PROJECT-BASED SME FIRMS

Questionnaire Survey

----------------------------------Part of requirements to fulfill Ph.D. study------------------------------------

The aim of this survey is to examine the small- and medium-sized organizations' in house capabilities and how these capabilities would have an impact on the implementation of innovation within the firms and their impact on the firm performance.

Innovation refers to the introduction of an idea, practice, or object that is new to an organization. Innovations come in a variety of forms, such as new or improved goods or services, production methods, business management processes and marketing techniques.

Organizational capabilities refer to the organizational processes undergone within the firm, include entrepreneurship orientation, organizational learning, human resource practice, inter-organizational network and integrated market orientation.

Your positive respond to this survey is very much appreciated and would contribute towards the betterment of construction industry in Malaysia. Kindly complete the following questions. Your response will be treated as confidential and the results of this survey will be used for the purpose of the academic research only. Filling up this survey will take about **15 minutes** of your valuable time. We really appreciate your effort and support to accomplish this research and we are willing to share part of the result of this survey upon your request.

Yours,

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Appendix D: Questionnaire

SECTION 1: Corporate and Personal Information

(Please state or tick the appropriate answer):

1. Firm age	2. Number of full-time employees	3. Firm's largest market
☐ years	1) Between 1 - 4 ☐ 2) Between 5 - 19 ☐ 3) Between 20 – 50 ☐ 4) More than 50 ☐	1) Domestic ☐ 2) International ☐
4. Firm type	**5. Contractor Grade**	**6. Designation**
1) General contractor ☐ 2) Specialist/Trade contractor ☐ 3) Other:____________ ☐	1) Grade 1-3 ☐ 2) Grade 4 ☐ 3) Grade 5 ☐ 4) Grade 6 ☐ 5) Grade 7 ☐	1) Managing Director/ Owner ☐ 2) Senior management ☐ 3) Other: ______________ ☐

SECTION 2: Innovation

Innovation refers to the use of new idea, practice, or object by a firm. Examples are new or improved goods/services, production methods, business management processes or marketing techniques.

Please indicate to what extent your firm, in the past 3 years, has introduced innovation in the following aspects. Kindly use the scale from 1 to 5; where **1** denotes *Never*, **2** denotes *Rarely*, **3** denotes *Sometimes*, **4** denotes *Very Often* and **5** denotes *Always*. Kindly write the appropriate number in the last column ***Your response*** for each statement.

Never 1	Rarely 2 Sometimes 3 Very Often 4 Always 5	***Your response***
1	We introduce new goods/services that competitors do not offer in the market.	
2	We improve existing goods/services to meet customer needs.	
3	Our firm seeks to find new goods/services for customers.	
4	Our firm offers new goods/services to customers.	
5	We update (or review) production process to increase productivity.	
6	We use technologies (new construction material, plant & equipment, software, etc.) in our production processes.	
7	We introduce new production processes to improve output quality and/or to decrease production costs.	
8	We identify and remove non-value added activities in our production processes.	
9	We introduce new ways of managing our business.	
10	Our firm invests in updating management procedures (e.g. ISO, etc.).	
11	Management seeks new ways to improve the management systems.	
12	Our firm renews the organization structure to facilitate the coordination of activities.	

13	We offer extended/customized services in providing our services (e.g. value engineering, going extra mile to ensure client's satisfaction, etc.).	
14	We seek to expand into new market to sell our services (e.g. new location).	
15	We seek new techniques to promote our services (e.g. advertising, maintaining company website, printing brochures, etc.).	
16	We seek to provide more competitive price by renewing the pricing strategies (e.g. tender bid, etc.) to market our services.	

<u>SECTION 3:</u> Organizational Capabilities

Organizational capabilities refer to the processes undergone within the firm. Examples are entrepreneurship orientation, responding to customers and competitors, human resource practice, organizational learning, and networks with external firms. Please indicate to what extent your firm undertakes the following processes.

A) Entrepreneurship Orientation

Kindly write the appropriate number in the last column ***Your response*** for each statement.

Never **<u>1</u>** **Rarely** **<u>2</u>** **Sometimes** **<u>3</u>** **Very Often** **<u>4</u>** **Always** **<u>5</u>**		***Your response***
1	Employees are encouraged to take responsibility for their work.	
2	Employees are supposed to get the job done with minimum supervision.	
3	Employees are encouraged to prioritise their work.	
4	In this firm, uncertainty is treated as a challenge.	
5	Employees are encouraged to venture into unexplored territories.	
6	Management accepts that certain suggestions may fail when implemented.	
7	Our firm emphasises opportunity for success, rather than chances for failure.	
8	In this firm, new venture failure is viewed as a learning experience.	
9	We constantly seek new opportunities related to the present operations.	
10	We are usually the first to introduce new services in the industry.	
11	We constantly look out for business that can be acquired.	
12	We constantly seek opportunities to improve our business performance.	
13	We are always ahead of our competitors in responding to market challenges.	

B) Responding to Customers and Competitors

Kindly write the appropriate number in the last column ***Your response*** for each statement.

Never **<u>1</u>** **Rarely** **<u>2</u>** **Sometimes** **<u>3</u>** **Very Often** **<u>4</u>** **Always** **<u>5</u>**		***Your response***
1	Our business objectives are driven primarily by customer satisfaction.	
2	We constantly monitor our level of commitment to serving customers' needs.	
3	Our strategies are driven by the need to create value for our customer.	
4	We believe that understanding customers' needs gives us a competitive advantage.	
5	We seek to understand what customers might need in the future.	
6	We continuously seek to uncover new customers' needs.	
7	We develop solutions to unexpressed (i.e. not voiced out) customers' needs.	

8	We use a number of techniques to discover currently unexpressed customers' needs.	
9	We frequently collect information on our competitors to help direct our firm's strategies.	
10	We regularly share information within our firm concerning competitors' strategies.	
11	We rapidly respond to competitors' actions that threaten us.	
12	Top management regularly discusses competitors' strategies.	
13	We coordinate goals and objectives across all functions (i.e. departments).	
14	All functions (i.e. departments) are integrated in serving the needs of our target market.	
15	Market information is shared with all functions (i.e. departments) inside the firm.	
16	Management understands how everyone in the firm can contribute to create value for customers.	

C) Human Resource Practice

Kindly write the appropriate number in the last column ***Your response*** for each statement.

Never <u>**1**</u>	**Rarely** <u>**2**</u> **Sometimes** <u>**3**</u> **Very Often** <u>**4**</u> **Always** <u>**5**</u>	***Your response***
1	Our firm seeks to match employees to specific job requirements.	
2	We treat our employees as the most valuable resources within our firm.	
3	Extensive training programs are provided for individuals in our firm.	
4	Our firm emphasizes the importance of having satisfied employees.	
5	Employees in this firm are provided with clear career paths	
6	Job security is almost guaranteed to employees in our firm.	
7	Our firm seeks to maintain high level of employee motivation.	
8	In our firm, employees receive benefits linked to their performance.	
9	Employees are given bonuses for outstanding performance.	
10	All employees receive effective feedback on their performance.	

D) Organizational Learning

Kindly write the appropriate number in the last column ***Your response*** for each statement.

Never <u>**1**</u>	**Rarely** <u>**2**</u> **Sometimes** <u>**3**</u> **Very Often** <u>**4**</u> **Always** <u>**5**</u>	***Your response***
1	Managers frequently involve their staff in important decision-making processes.	
2	The firm's management looks favorably on carrying out changes in any area to adapt to and/or keep ahead of new environmental situations.	
3	Employee learning ability is considered a key factor in the firm.	
4	In this firm, innovative ideas that work are rewarded.	
5	All employees have generalized knowledge regarding the firm's objectives.	
6	All parts that make up the firm (departments, sections, work teams and individuals) are well aware of how they contribute to achieving the overall	

	objectives.	
7	All parts that make up the firm (departments, sections, work teams and individuals) are interconnected and work together in a coordinated fashion.	
8	The firm promotes experimentation and innovation as a way of improving the work process.	
9	The firm follows up what other firms in the sector are doing, and adopts practices and techniques it believes to be useful and interesting.	
10	Experiences and ideas provided by external sources (advisors, customers, training firms, etc.) are considered a useful instrument for this firm's learning.	
11	Part of the firm's culture is that employees can express their opinions and make suggestions regarding procedures and methods in place for carrying out tasks.	
12	Errors and failures are always discussed and analysed by the firm at all levels.	
13	In this firm, teamwork is not the usual way to work.	
14	Employees have the chance to talk among themselves about new ideas, programs and activities that might be of use to the firm.	
15	The firm has instruments (manuals, databases, files, organizational routines, etc.) that allow what has been learnt in past situations to remain valid, although the employees are no longer the same.	

E) Networking with External Firms

Similar to the previous section, please indicate to what extent your firm undertakes the following practices.

1. Does your firm network with the following partners to acquire information and knowledge and/or access to resources required for innovation?		
1	Customers	☐ Yes ☐ No
2	Suppliers of components, equipment and software	☐ Yes ☐ No
3	Competitors	☐ Yes ☐ No
4	Experts and consultancy firms	☐ Yes ☐ No
5	R&D firms or laboratories	☐ Yes ☐ No
6	Universities or centres of higher education	☐ Yes ☐ No
7	Public and non-profit research organizations	☐ Yes ☐ No
8	Firms outside your industry	☐ Yes ☐ No

2. How frequently does your firm interact with the following partners to acquire information and knowledge and/or access to resources required for innovation?		
Never 1	**Rarely 2 Sometimes 3 Very Often 4 Always 5**	***Your response***
1	Customers	
2	Suppliers of components, equipment and software	
3	Competitors	
4	Experts and consultancy firms	
5	R&D firms or laboratories	
6	Universities or centres of higher education	
7	Public and non-profit research organizations	

8	Firms outside your industry	

<u>SECTION 4:</u> Firm Performance

Compared to your direct competitors, how well did your firm do in terms of the following measures? Kindly use the scale below, from 1 to 5, where **1** denotes "Much worse than competitors" and **5** denotes "Much better than competitors".

Much worse **1** — **Slightly worse** **2** — **About the same** **3** — **Better** **4** — **Much better** **5**		***Your response***
1	Profitability	
2	Annual sales growth	
3	Market share	
4	Labor productivity	
5	Customer satisfaction	
6	Repeat business	
7	Reputation	

This is the end of this survey. Thank you very much for your kind response ☺

Appendix E: Missing data analysis

Missing Data Analysis

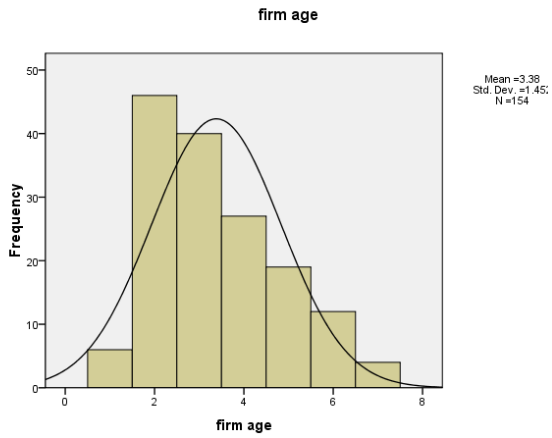
	N	Mean	Std. Deviation	Missing		No. of Extremes[b]	
				Count	Percent	Low	High
position	157	1.50	.584	0	.0	0	0
conTgrade	138	5.39	.850	19	12.1	0	0
firmtype	155	1.58	.612	2	1.3	0	0
employee	152	1.43	.496	5	3.2	0	0
market	157	1.03	.176	0	.0	.	.
firmAge	154	3.38	1.452	3	1.9	0	4
Lcap1	157	3.71	.877	0	.0	1	0
Lcap2	157	3.76	.729	0	.0	0	0
Lcap3	156	3.91	.774	1	.6	0	0
Lcap4	157	3.66	.882	0	.0	1	0
Lcap5	157	3.78	.762	0	.0	0	0
Lcap6	157	3.80	.780	0	.0	0	0
Lcap7	157	3.82	.791	0	.0	0	0
Lcap8	157	3.61	.822	0	.0	0	0
Lcap9	157	3.68	.825	0	.0	0	0
Lcap10	157	3.69	.829	0	.0	0	0
Lcap11	157	3.74	.810	0	.0	0	0
Lcap12	157	3.84	.828	0	.0	0	0
Lcap13	157	3.90	.878	0	.0	0	0
Lcap14	156	3.78	.854	1	.6	0	0
Lcap15	156	3.50	1.000	1	.6	4	0
Enor1	157	4.44	.719	0	.0	0	0
Enor2	157	4.21	.848	0	.0	8	0
Enor3	157	4.20	.804	0	.0	5	0
Enor4	157	3.88	.835	0	.0	0	0
Enor5	157	3.53	.844	0	.0	1	0
Enor6	157	3.50	.882	0	.0	1	0
Enor7	157	4.03	.804	0	.0	0	0
Enor8	157	3.75	.860	0	.0	0	0
Enor9	157	3.98	.820	0	.0	0	0
Enor10	157	3.01	.873	0	.0	8	0
Enor11	157	3.46	1.083	0	.0	9	0

Enor12	157	4.09	.771	0	.0	3	0
Enor13	157	3.48	.881	0	.0	2	0
Hrep1	156	3.96	.897	1	.6	0	0
Hrep2	157	4.38	.755	0	.0	4	0
Hrep3	157	3.36	.968	0	.0	5	0
Hrep4	157	4.01	.792	0	.0	3	0
Hrep5	157	3.76	.950	0	.0	4	0
Hrep6	157	4.03	.891	0	.0	10	0
Hrep7	157	4.01	.820	0	.0	6	0
Hrep8	157	4.08	.898	0	.0	8	0
Hrep9	157	4.13	.932	0	.0	0	0
Hrep10	156	3.67	.911	1	.6	4	0
Imor1	157	4.38	.755	0	.0	0	0
Imor2	157	4.32	.680	0	.0	1	0
Imor3	157	4.18	.799	0	.0	2	0
Imor4	157	4.32	.793	0	.0	2	0
Imor5	157	4.11	.685	0	.0	1	0
Imor6	157	3.80	.790	0	.0	0	0
Imor7	157	3.70	.796	0	.0	1	0
Imor8	157	3.49	.852	0	.0	3	0
Imor9	157	3.41	.960	0	.0	3	0
Imor10	157	3.41	1.026	0	.0	7	0
Imor11	157	3.61	.904	0	.0	2	0
Imor12	157	3.61	1.011	0	.0	5	0
Imor13	155	3.82	.849	2	1.3	1	0
Imor14	157	3.87	.845	0	.0	2	0
Imor15	157	3.78	.852	0	.0	1	0
Imor16	157	4.07	.785	0	.0	1	0
Iorg1	157	3.83	.999	0	.0	0	0
Iorg2	157	3.97	.902	0	.0	0	0
Iorg3	157	2.41	1.187	0	.0	0	0
Iorg4	157	3.53	1.089	0	.0	9	0
Iorg5	157	2.13	1.241	0	.0	0	0
Iorg6	157	1.87	1.121	0	.0	0	18
Iorg7	157	1.94	1.145	0	.0	0	0
Iorg8	152	2.59	1.231	5	3.2	0	0
heterogeneity	157	3.55	.930	0	.0	3	0
Tech1	155	3.39	.871	2	1.3	1	0

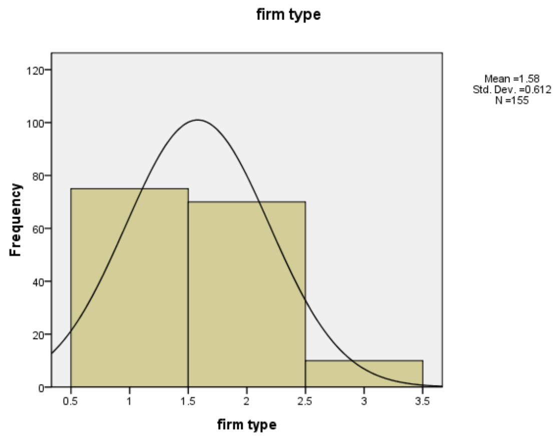
Tech2	157	3.96	.750	0	.0	0	0
Tech3	157	3.78	.837	0	.0	0	0
Tech4	157	3.30	.873	0	.0	5	0
Tech5	156	3.71	.930	1	.6	3	0
Tech6	157	3.63	.834	0	.0	1	0
Tech7	157	3.68	.817	0	.0	1	0
Tech8	157	3.62	.888	0	.0	4	0
Ntec1	156	3.61	.847	1	.6	0	0
Ntec2	157	3.31	.867	0	.0	2	0
Ntec3	157	3.52	.859	0	.0	1	0
Ntec4	157	3.52	.837	0	.0	1	0
Ntec5	157	3.31	.940	0	.0	6	0
Ntec6	157	3.36	.942	0	.0	4	0
Ntec7	157	3.66	.964	0	.0	4	0
Ntec8	157	3.72	.939	0	.0	4	0
Fper1	157	3.57	.672	0	.0	0	0
Fper2	157	3.67	.779	0	.0	0	0
Fper3	157	3.43	.893	0	.0	3	0
Fper4	157	3.57	.727	0	.0	1	0
Fper5	157	3.85	.723	0	.0	0	0
Fper6	157	3.90	.783	0	.0	1	0
Fper7	157	3.94	.753	0	.0	1	0

b. Number of cases outside the range (Q1 - 1.5*IQR, Q3 + 1.5*IQR).

Appendix F: Distributions

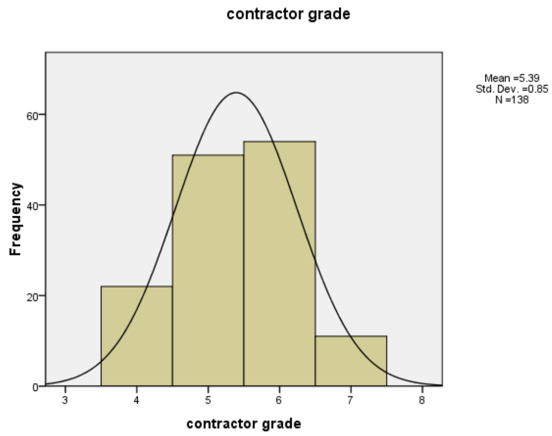


1=1-5years; 2=6-10 years; 3=11-15years; 4=16-20 years; 5=21-25 years; 6=26-30 years; 7= more than 30 years

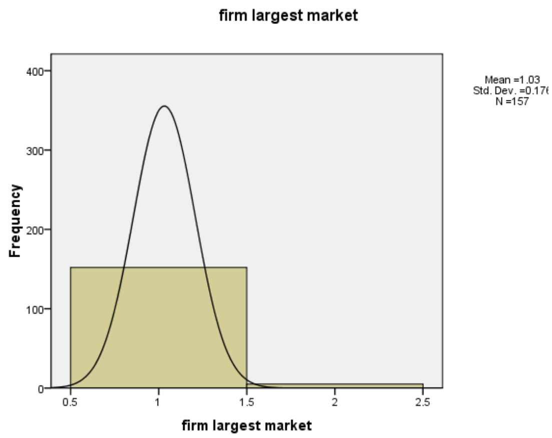


1=general contractor; 2=specialist contractor; 3=mix-

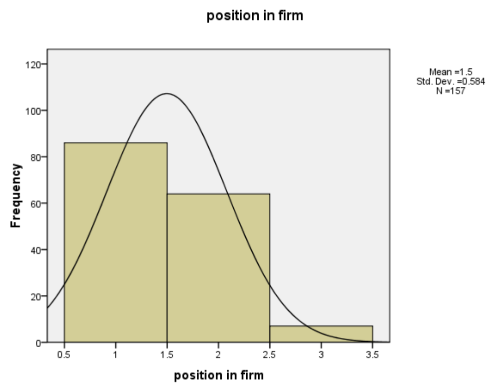
1=5-19 employees; =20-50 employees



4=grade 4; 5=grade 5; 6=grade 6; 7=grade 7



1=domestic; 2=domestic and international



1=managing director/owner; 2=senior manager; 3=other

Appendix G: Parallel Analysis

1. O'Connor's Syntax of Parallel Specification:

```
* Enter the name/location of the data file for analyses after "FILE =";
  If you specify "FILE = *", then the program will read the current,
  active SPSS data file; Alternatively, enter the name/location
  of a previously saved SPSS data file instead of "*";
  you can use the "/ VAR =" subcommand after "/ missing=omit"
  subcommand to select variables for the analyses.
GET raw / FILE = * / missing=omit / VAR = VAR1 to VAR10.

* Enter the desired number of parallel data sets here.
compute ndatsets = 100.

* Enter the desired percentile here.
compute percent  = 95.

* Enter either
  1 for principal components analysis, or
  2 for principal axis/common factor analysis.
compute kind = 1 .

* Enter either
  1 for normally distributed random data generation parallel analysis, or
  2 for permutations of the raw data set.
compute randtype = 1.


****************** End of user specifications. ******************
```

2. Steps of conducting the analysis using SPSS:

i. Copy O'Connor's syntax to a new syntax in the data set.
ii. Determine five criteria in the syntax, including the indication of the name of variables, number of data set (default number: 100), percentile (e.g., 95%), type of analysis (either principal component analysis or common factor analysis), and distribution of data (either normal distribution or permutations).
iii. Run the syntax to obtain the output.

3. Specifications and output of the parallel analysis (example: Entrepreneurship orientation):

Specifications used to run the analysis of entrepreneurship orientation are as follow:
Variables' name (VAR = Enor1 to Enor13);
Number of parallel data sets (ndatsets = 100);
Percentile = 95;
Extraction method = 1 (principal component analysis); and
Distribution = 1 (normally distributed random data generation parallel analysis).

The output after running the syntax in SPSS is as follows:

```
Run MATRIX procedure:

PARALLEL ANALYSIS:

Principal Components & Random Normal Data Generation

Specifications for this Run:
Ncases    168
Nvars      13
Ndatsets  100
Percent    95

Raw Data Eigenvalues, & Mean & Percentile Random Data Eigenvalues
         Root     Raw Data        Means     Prcntyle
     1.000000     5.268922     1.497683     1.627042
     2.000000     1.419426     1.360914     1.445818
     3.000000     1.147123     1.262476     1.327847
     4.000000      .946845     1.184014     1.237548
     5.000000      .776671     1.109143     1.171093
     6.000000      .725734     1.040799     1.085964
     7.000000      .504008      .976600     1.025115
     8.000000      .474057      .915698      .965609
     9.000000      .440831      .854645      .904818
    10.000000      .389317      .797528      .841838
    11.000000      .335345      .735105      .780651
    12.000000      .310715      .669640      .721287
    13.000000      .261005      .595754      .657436

------ END MATRIX -----
```

Sequence plot

Notes

Output Created		25-Oct-2013 15:11:18
Comments		
Input	Data	C:\Program Files\SPSSInc\SPSS16\screedata.sav
	File Label	MATRIX saved file
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	13
	Date	<none>
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	All the cases or all the specified cases are used to define the sequence.
Syntax		TSPLOT VARIABLES= rawdata means percntyl /ID= root /NOLOG.
Resources	Processor Time	00:00:00.546
	Elapsed Time	00:00:00.342
Use	From	First observation
	To	Last observation
Time Series Settings (TSET)	Amount of Output	PRINT = DEFAULT
	Saving New Variables	NEWVAR = CURRENT
	Maximum Number of Lags in Autocorrelation or Partial Autocorrelation Plots	MXAUTO = 16
	Maximum Number of Lags Per Cross-Correlation Plots	MXCROSS = 7
	Maximum Number of New Variables Generated Per Procedure	MXNEWVAR = 60
	Maximum Number of New Cases Per Procedure	MXPREDICT = 1000
	Treatment of User-Missing Values	MISSING = EXCLUDE
	Confidence Interval Percentage Value	CIN = 95
	Tolerance for Entering Variables in Regression Equations	TOLER = .0001
	Maximum Iterative Parameter Change	CNVERGE = .001
	Method of Calculating Std. Errors for Autocorrelations	ACFSE = IND
	Length of Seasonal Period	Unspecified
	Variable Whose Values Label Observations in Plots	Unspecified
	Equations Include	CONSTANT

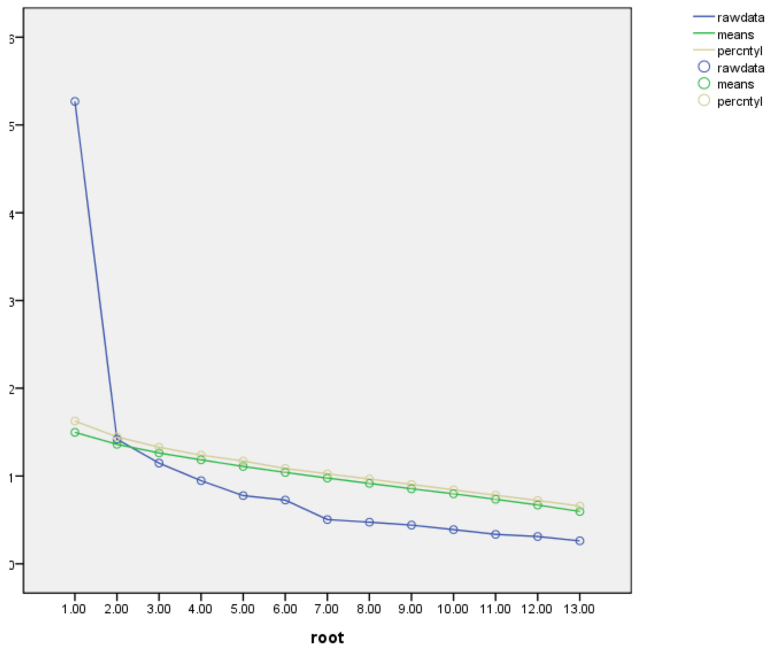
Model Description

Model Name		MOD_20
Series or Sequence	1	rawdata
	2	means
	3	percntyl
Transformation		None
Non-Seasonal Differencing		0
Seasonal Differencing		0
Length of Seasonal Period		No periodicity
Horizontal Axis Labels		root
Intervention Onsets		None
For Each Observation		Values not joined

Applying the model specifications from MOD_20

Case Processing Summary

		rawdata	means	percntyl
Series or Sequence Length		13	13	13
Number of Missing Values in the Plot	User-Missing	0	0	0
	System-Missing	0	0	0



[Tsplot of entrepreneurship construct]

Appendix H: Cover letter (Interview)

Faculty of Built Environment, University of Malaya,
50603, Kuala Lumpur, Malaysia

CAPABILITIES AND PERFORMANCE EFFECT OF A DUAL-MODE INNOVATION: PROJECT-BASED SME FIRMS

------------------------------------Part of requirements to fulfill Ph.D. study------------------------------------

This research aims, (a) to examine your firm's capabilities, (b) how these capabilities would impact on the implementation of construction innovation that potentially impact on the company performance.

Innovation refers to the introduction of an idea or practice that is new to your firm. The innovations come in two forms: technological and organizational innovations. Technological innovation includes new changes introduced into goods/services (e.g. new building materials, etc.) and production methods (e.g. all activities on project site, etc.) while organizational innovation includes new or improved management practices (e.g. the procedures and structure of company, etc.) and marketing techniques (e.g. tender pricing, target on special market, etc.).

Organizational capabilities refer to the competency of firm that promotes innovation, such as entrepreneurship, learning, networking with other firms and integrated market orientation.

Your positive respond to this interview is very much appreciated and would contribute towards the betterment of construction industry in Malaysia. Your response will be treated as confidential and the results of this interview will be used for the purpose of the academic research only. We really appreciate your effort and support to accomplish this research and we are willing to share part of the result of this interview upon your request.

Yours,

Lee Yee Lin

The Faculty of Built Environment
University of Malaya
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President/CEO
International University of Malaya-Wales
Tel: 03-26173198
E-mail: arhamzah@um.edu.my

SECTION 1: **Corporate Information**

(Please state or tick the appropriate answer):

Firm age	Number of full-time employees	Firm’s largest market
__________years	1) Between 1 - 4 ☐ 2) Between 5 – 9 ☐ 3) Between 10 – 19 ☐ 4) Between 20 – 49 ☐ 5) More than 50 ☐	1) Domestic ☐ 2) International ☐
Firm type	**Contractor Grade**	**Project type**
1) General contractor ☐ 2) Specialist/Trade contractor ☐ 3) Other:____________ ☐	1) Grade 1-3 ☐ 2) Grade 4 ☐ 3) Grade 5 ☐ 4) Grade 6 ☐ 5) Grade 7 ☐	1) Residential ☐ 2) Non-residential ☐ 3) Social amenities ☐ 4) Mix development ☐ 5) Infrasturucture ☐ 6) Other:___________ ☐

SECTION 2: **Personal Information**

(Please state or tick the appropriate answer):

Working experience in construction industry	Working experience incurrent firm	Your position in the firm
__________years	__________years	1) Managing Director/ Owner/CEO ☐ 2) Senior management: ☐ __________________ 3) Other: ___________ ☐
Education level	**Your age**	**Your background**
1) High school ☐ 2) Bachelor degree ☐ 3) Master degree ☐ 4) PhD ☐	1) Less than 30 ☐ 2) Between 30-39 ☐ 3) Between 40-49 ☐ 4) Between 50-59 ☐ 5) More than 60 ☐	1) Civil engineering ☐ 2) Architecture ☐ 3) Quantity Surveying ☐ 4) Mechanical Engineering ☐ 5) Other: _____________ ☐

SECTION 3: Interview

Referring to the figure below…

1) Could you elaborate on the innovations (i.e. technological and organizational) introduced/adopted by your company?
2) Is organizational innovation supporting the implementation of technological innovation? If yes, how?
3) Are the listed factors (i.e. internal capabilities) influencing the introduction/adoption of innovations? If yes, how do they impact?
4) Does the innovation introduced/adopted affect your company performance? How does this happen?
5) Which type of innovation is more significant in impacting your company performance? Why?

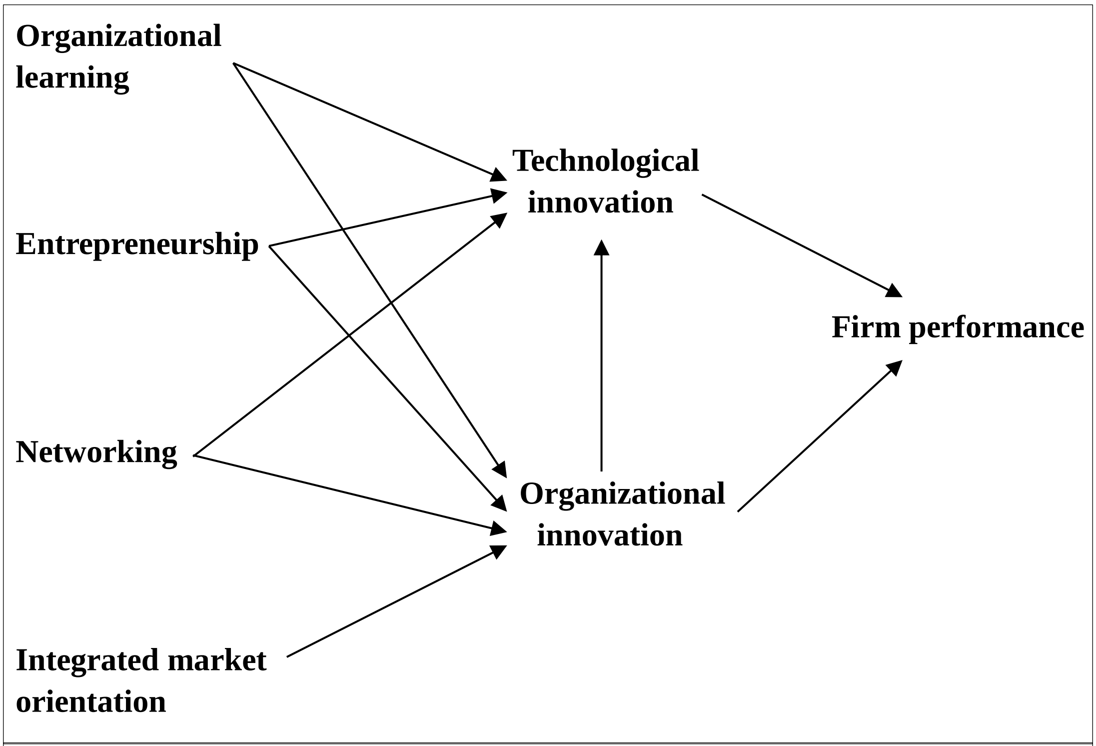

Figure: Innovation model for SMCFs (Capabilities-innovation-performance)

SECTION 4: **Validation of the innovation framework**

Evaluation: 1. Do you think the framework explain the nature of Construction Innovation management? (Yes / No) 2. How would you rate this framework? (Excellent / Good / Satisfactory Average / Below Average) 3. Please rate the framework according to the statement below: **1** is **Disagree** with the statement. **10** is **Agree** with the statement.	
	Not Agree~~~~~~~~~~~~~~~~~~~~~~ Agree
a. It is acceptable and reliable.	1 2 3 4 5 6 7 8 9 10
b. It provides a complete set of construction innovation management.	1 2 3 4 5 6 7 8 9 10
c. It provides a learning process for the junior construction practitioners.	1 2 3 4 5 6 7 8 9 10
d. It is user friendly and easy to understand.	1 2 3 4 5 6 7 8 9 10
e. The design of the framework is clear and clean.	1 2 3 4 5 6 7 8 9 10
f. It helps a lot in improving your management quality.	1 2 3 4 5 6 7 8 9 10

This is the end. Thank you ☺