THE ROLE OF THE PROJECT MANAGER AS A CHAMPION OF CONSTRUCTION INNOVATION

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SUMMARY

The Construction 21, also known as ‘C21’ report, has set one of its strategic thrusts to enhance professionalism and increase the level of innovation through the promotion, recognition and reward of creativity, quality work, and innovation in the construction industry in Singapore. Moreover, as Singapore is preparing for the knowledge-based economy, innovation and initiatives at the individual level are critical. Furthermore, there has been growing concern among researchers that organizations need to develop connections between people, system and culture or environment to achieve competitiveness through innovation.

Despite a growing concern in construction innovations, previous studies have rarely focused on the role of the Project Manager (PM) in the innovation process. In an effort to address this research gap, the current research investigates the championing role of the PM on construction innovation and analyzes the effectiveness of such a role to enable innovative practices on site and improve project performance. In addition, this research also identifies a number of individual and situational variables or factors, and explores their interaction with PM’s championing, the level of innovation, and project performance.

Three critical dimensions of the championing role of the PM have been identified: (a) displaying the project leadership role, (b) demonstrating commitment in the innovation, and (c) stimulating project team members for innovation. The findings indicate that the role of the PM in construction innovation is multi-faceted. Moreover, such a role should be complemented by PM's competency and professionalism. In addition, PMs need to be tactical in influencing team members, seniors in their organization, and other parties involved in the project to increase their effectiveness. The championing role of the PM has been found to have a significant impact on project performance. Therefore, there is a need to create a conducive environment or organizational culture that nurtures and facilitates the PM's role in the construction project as a champion of innovation.

The research results suggest that construction organizations should foster innovation on projects by creating a proper organizational climate – providing resources and a sustained support for innovation. In addition, the decision authority of the PM has been found to be a critical factor in enhancing the effectiveness of the PM as a champion. The present study also suggests that innovative practices could increase organizational effectiveness and bring long-term benefits to the company. This has an important implication for local companies in Singapore on how to increase their innovative capacity for long-term survival and sustainability.

This research has provided insights and contributed to our current knowledge of innovation in construction through an empirical study. The findings and

recommendations suggested in the research could be useful for practitioners as a step towards preparing for the knowledge-based economy and to increase the competitiveness of the construction industry.

Keywords: Behaviour, Champion, Construction, Innovation, Organizational Climate, Project Manager, Project Performance, Singapore, Structural Equation Modelling

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1. INTRODUCTION

1.1 Background

A nation's competitiveness depends on the capacity of its industry to innovate and upgrade (Porter, 1990). Innovation also becomes essential as local and global competitive pressures are increasing in all sectors of the economy to deliver better value or services to customers. This also applies to the construction industry, which is a major contributor to the GDP of many economies of the world. Not surprisingly, innovation creates possibilities of achieving competitive advantages for the construction company (Slaughter, 1998; Pries and Janszen, 1995). Moreover, as project owners are becoming more sophisticated in terms of product needs and requirements, innovation becomes essential to the success of a construction project. Over the last 15 years innovation has been a subject of great interest in the built environment, which has been stimulated by the recognition that innovation can play a significant role in improving performance in construction and its related supply-industries (Gann, 2003).

The Global Competitiveness Report (2001-2002) ranks Singapore nineteenth in the world on ***Innovation*** and thirteenth in the world on ***National Innovative Capacity***. Singapore Productivity and Standards Board (SPRING)'s Mr. Lee Suan Hiang (Innovation, 2002) notes that the ranking is a good reality check for Singapore that should give added impetus to improve performance. He further suggests that Singapore can no longer depend simply on labour and capital investment to drive economic growth and increased employment opportunity; it rather needs an innovation-based economy to add value to labour and capital. By indicating the above report and Singapore's relative ranking on it, Mr. Lee acknowledges Singapore as having established real strengths in macroeconomic factors – policy, infrastructure, and institutions – but relatively weaker at the microeconomic level. As such, organizations in Singapore need an environment or culture that fosters creativity; they need strong linkage between creative idea generation and process design, as well as keen entrepreneurs (Lambe, 2002). In light of the above facts, it appears that organizations need to develop connections between people, system and culture or environment to foster innovation.

The report of the Construction 21 Steering Committee (1999), also known as 'C21' has the vision to develop the Singapore Construction Industry 'To Be a World Class Builder' by moving towards a knowledge-based industry. The report has set forth many strategic thrusts and recommendations to achieve this objective. One of its strategic thrusts is to enhance professionalism and encourage increased level of innovation in the construction industry through the promotion, recognition and reward of creativity, quality work, and innovation. This would require initiatives at the professional, company, and industry levels to create a culture that encourages and promotes innovation and creativity (Dulaimi *et al*., 2002).

On the other hand, the construction industry develops in tandem with the rest of the economy, and as countries make economic progress, their construction needs and demands increase and become more sophisticated (Ofori, 1996). In particular, since Singapore is moving towards the knowledge-based economy, innovation, entrepreneurship, and individual initiatives will be the key attributes in the construction industry to be recognized and rewarded appropriately (Ofori, 2002, 2003).

It should be noted that the individuals working for different entities in the construction value chain could play a significant role not only to achieve project objectives but also to improve industry performance, mostly through innovation. The research initiative taken in this thesis investigates the championing role of the Project Manager (PM) on construction innovation in Singapore and examines the effectiveness of such a role. To achieve this aim, the present research develops an objective behavioural measure of the PM's championing behaviour, identifies its relationship with the personal characteristics of the PM and the project characteristics and environment, and their interaction with project performance indicators and the level of innovation on construction site.

1.2 Statement of Problem

Previous studies on construction innovation have commonly recognized the importance of organizational climate and the role of the key individuals in the innovation process. However, they rarely focus on the role of the PM. Moreover, little is known about the championing role of the PM, and the degree of influence it has on innovation and consequently on project performance. In addition, a number of individual and situational factors significantly affect this role and its effectiveness. These factors also influence directly and/or indirectly the level of innovation and/or project performance. The present research systematically analyzes these issues. The research is built upon the fundamental argument that the role of the PM in construction is essentially that of a champion, which through interaction with individual and situational variables, impacts innovation and project performance.

1.3 Aims and Objectives

The general aim of this research is to identify the PM's role in the construction project to enable increased level of innovation on site. With respect to that aim, this research seeks to fulfill the following objectives:

1. Identify the pattern of the PM's championing role on a construction project;

2. Assess the influence of *individual variables* of the PM (e.g., education, experience, and other personality traits) and the project characteristics and environment known as *situational variables* (e.g., influence in decision making, project size, project complexity, resource supply, support for innovation) on PM's championing, the level of innovation and project performance;

3. Investigate the effectiveness of the championing role of the PM in enabling innovation practices on construction site and to improve project performance; and

4. Identify strategies that construction firms can deploy to create an "environment" that would deliver desired project outcomes and increase the level of innovation on construction projects.

1.4 Scope of the Research

This research was conducted with PMs and their team members working for general contractors in Singapore. The projects to be studied were ongoing building and civil engineering projects, which had preferably passed more than six months of their contract duration. As applicable to this research, PM would mean an individual (Project Manager, or site manager or anyone with a similar title) who had the sole responsibility for the day-to-day management of the project for a contractor. "Team members" refers to practitioners such as a quantity surveyor, an engineer of any discipline (Civil, Mechanical, Electrical) or any other technical person who had been working closely with the PM on the site/project.

1.5 Organization of the Report

Chapter 1 of the thesis presents a general research background, problem statement, aims, objectives, and scope of the research.

Chapter 2 covers the literature review, which presents among others, the definitions for major terminologies used in the research, innovation in construction, the role of champions, managerial job behaviour, and managerial effectiveness. This chapter also briefly highlights an overview of Singapore construction industry.

In chapter 3, a conceptual research framework is presented and research hypotheses are developed. The hypotheses are translated into the structural model.

Chapter 4 describes the research methodology that includes research design, an overview of main statistical techniques used in the research, and the data processing and analysis.

In chapter 5 analysis results are presented and the implications of the results are discussed.

Finally, in chapter 6, the major findings of the research are presented. This chapter also highlights the strategies for construction firms and provides recommendations for further study.

2. LITERATURE REVIEW

2.1 Definitions

2.1.1 Innovation

‘Innovation’ can be categorized into two groups, technological and organizational innovation. Under the former, several authors distinguish between product innovation and process innovation. Product innovation refers to the development and introduction of new or improved products and/or services (Neely *et al*., 2001). Process innovation, on the other hand, is an adoption of or improvement in methods to accomplish the usual operations, or to improve the efficiency of operation (Tatum, 1989). Organizational innovation involves new organizational structure and administrative processes, or a new plan or programme pertaining to organizational members; it is more directly related to the management (Damanpour, 1991).

There are several generalized definitions of innovation found in the literature. An innovation is seen as a new idea, which may be a recombination of old ideas, a scheme challenging the present order, a formula, or a unique approach which is perceived as new by the individuals involved (Zaltman *et al*., 1973; Rogers, 1983). Van de Ven (1986) argues that as long as an idea is perceived as new by the people involved, it is an “innovation” even though it may appear to others to be an “imitation” of something that exists elsewhere. Damanpour (1991) defines innovation as adoption of an internally generated or purchased device, system, policy program, process, product, or service that is new to the adopting organization.

For the purpose of this research, ‘innovation’ is defined as the generation, development, and implementation of ideas that are perceived to be new to an organization and that has practical or commercial benefits. This definition also encompasses the adoption and implementation of products or processes developed outside the adopting organization.

2.1.2 Champions and Championing Behaviour

Champions are defined in many ways. For example, Schon (1963) defines the champion as: “a man willing to put himself on the line for an idea of doubtful success. He is willing to fail. But he is capable of using any and every means, informal sales and pressure in order to succeed.” Champions are the ones who seek out creative ideas from information sources and then enthusiastically sell them within an organization (Howell and Higgins, 1990). Champions achieve distinctiveness by expending the energy and accepting risk (Maidique, 1980).

The early SAPPHO study (cited in Maidique, 1980) identified four categories of key individuals. In the study business innovator, or individual responsible for the “overall progress of the project” emerged as a principal factor in successful innovation. The four types of key individuals identified by this study are:

- *Technical innovator* - The individual who makes the major contribution on the technical side to the development and/or design of the innovation.

- *Business innovator* - The individual within the managerial structure who is responsible for the overall progress of the project
- *Product champion* - Any individual who contributes to the innovation by actively and enthusiastically promoting it through critical stages.
- *Chief executive* - The head of the executive structure of the innovating organization.

Previous researchers have studied the behaviours of champions in organizations and suggested a number of definitions of championing behaviour. For example, Howell and Shea (2001) define championing behaviour as expressing confidence in innovation, involving and motivating others to support innovation, and persisting under adversity. Other researchers describe it as identifying/generating an issue or idea, packaging it as attractive, and selling it to organizational decision makers (Anderson and Bateman, 2000); recognizing and proposing a new technical idea or procedure and pushing it for formal management approval (Roberts and Fusfeld, 1981).

This study posits that the role of the PM is essentially that of a champion for construction innovation. This research further argues that PMs' championing is manifested in their behaviours, i.e., championing behaviour, hereinafter used interchangeably with championing. For the purpose of this research, PM's championing behaviour is defined as the PM's observable actions directed towards seeking, stimulating, supporting, carrying, and promoting innovation in the project.

2.2 Innovation in Construction

Unlike manufacturing and service industries, the construction industry has long been recognized as being slow to adopt new technology and to innovate speedily. This is because the nature of the construction industry differs in many aspects such as scale, complexity, and durability of the facilities, together with the organizational and sociopolitical contexts. Those industry features subsequently influence the nature, development and implementation of innovation (Nam and Tatum, 1988; Slaughter, 1998). However, the advantages such as project organization, necessity and challenge, engineering and construction integration, low capital investment, capability and experience of personnel, process emphasis and variation in methods provide a vast possibility for innovation in the construction industry (Tatum, 1986). In addition, the highly diverse, skilled, and experienced construction people create innovations in such a way that it improves the function and integrity of the different systems to the viable final product (Slaughter, 1993).

2.2.1 Previous Innovation Research in Construction

Innovation has increasingly become a hot topic among construction researchers. Many scholars have focused on technological innovations. Several innovation models have also appeared in the literature (Laborde and Sanvido, 1994; Tatum 1989, 1987; Winch, 1998; Gann and Salter, 2000; Slaughter, 1998; Pries and Janszen, 1995; Seaden *et al*., 2003). Moreover, these studies are concentrated mainly at the company/firm and industry levels, focusing on how to manage innovation. Researchers have also stressed on the need of inter-organizational integration and integrity of information within the project and its linkages (Dulaimi *et al*. 2003, Gann and Salter, 2000). However, the innovation research at the project level is limited.

Construction is a project-based organization; the impetus for project participants towards innovation on a particular project could be to solve problems that had not been encountered before (Winch, 1998). Innovation may thus begin with the problem recognition and generation of useful ideas. However, innovative ideas must be implemented in a project to realize their effects. As mentioned earlier, there are many barriers for successful implementation of new ideas in construction. Research in construction innovation indicates that an organizational climate that is supportive towards innovation fosters innovation (Tatum, 1986) by overcoming those barriers. Previous researchers have also raised a number of issues relating to knowledge management and learning on projects and stressed the need for their integration with the business process (Gann and Salter, 2000; Winch, 1998). This calls for the active role of key individuals to manage innovation in construction.

2.2.2 The Innovation Process Model

Laborde and Sanvido (1994) developed the four-stage innovation model for construction companies that comprises four elements, namely, technology identification, evaluation, implementation, and feedback. Tatum (1987) describes the process view of technological innovation in the construction firm as: 1) recognizing forces and opportunities for innovation; 2) creating climate for innovation; 3) developing necessary capabilities; 4) providing new construction technologies; 5) experimenting, testing and refining the new technologies; and 6) implementing the new technologies on projects and in the firm.

Following his earlier model, Tatum (1989) further refined the process view of innovation as: 1) defining the project and recognizing the forces and opportunities for innovation; 2) considering the alternate construction technologies in planning construction methods; 3) selecting and defining the construction methods; 4) implementing, developing and using these methods; and 5) transferring the innovations to future projects.

Kangari and Miyatake (1997) analyzed major factors that contributed to the development of innovative construction technology in large Japanese companies. According to them, the capacity of a firm to form strategic alliances, effective, valuable and timely information gathering, reputation gained by developing innovative technology, and the fusion of the construction technology have played a pivotal role in the technological leadership of Japanese firms.

Based on the two attributes—magnitude of change from current state-of-the-art associated with the innovation and expected linkages of the innovation to other components—Slaughter (1998) developed five models of innovation: incremental, radical, modular, architectural and system innovations. According to her, these five models present a number of implications for the implementation of innovation into specific projects. The first implication is the timing of the commitment to use innovation.

This, basically, indicates a particular project development stage, in which an organization needs to commit and acknowledge the use of resources to the implementation of innovation. The second implication is the degree to which use of an innovation requires implicit and explicit coordination among the members of a project team and other contractual parties. Implicit coordination can include informal negotiation and collaboration to solve problems, exchange information, and coordinate activities, while explicit coordination may include special provisions in the contract regarding design or construction changes, delay, and assumption of risk. The third consideration for the incorporation of an innovation into a specific project is the type and source of special resources. The fourth consideration is the type and level of supervisory activity required to effectively implement the innovation.

Winch (1998) argues that the construction industry is a *complex system industry*, owing to the complex nature of its constructed product and related activities that produce it. To manage innovation effectively, in such a complex product system, the author argues that the principal architect/engineer and principal contractor could share the role of a system integrator, the former one being at the design stage and latter one at the construction stage. The author further notes that the role of a system integrator is vital in the two key innovation dynamics – top-down adoption/implementation dynamics and the bottom up problem solving/learning dynamics.

2.2.3 Factors Influencing Innovation Process

There are numerous factors that influence the innovation process in construction. Laborde and Sanvido (1994) found three factors – size of the company, type of innovation, and breadth of application of the innovation – that influence the innovation process in a specific project or company. The innovation process can vary between a small and a large company in terms of factors such as financial risk, research and development resources, internal communication speed, and management style. The introduction of new products in projects is generally achieved by specifying those products during the design phase. Construction companies, however, have full control of process innovation—the implementation of any method that improves the efficiency of the standard operations (Laborde and Sanvido, 1994).

The extensive survey study of Canadian construction firms by Seaden *et al*. (2003) revealed that smaller firms are more averse to risk. They generally have a lower intensity of use of innovative practices than larger firms, indicating that an innovative behaviour varies with the size of the firm. Their study also indicated that the perceived business environment and business strategy are significantly related to firm innovativeness.

Tatum (1989) has identified some of the elements related to organizational structure and culture that foster innovation in the construction industry. These common elements are supportive policies and priorities, flexibility in unit size and grouping, intra- and inter-organizational co-ordination, and staffing to satisfy specific requirements for key positions. Supportive policies and priorities as identified by Tatum (1989) include long-term view, a broader view of risk when considering new technology, implicit vertical integration, a commitment to planning, and an innovative culture. Flexibility in grouping and adequate technical resources characterize the organizational characteristics of innovative construction firms with open project teams, broad and deep technical capability, and slack resources. However, the degree of internal coordination between the functional groups of a firm and the extent of networking with external organizations are key elements for innovation. The author further notes that in order to fulfill specific requirements, innovative construction firms need certain critical roles. These are: (1) the design and construction visionary; (2) the technological gatekeeper; (3) the operations iconoclast (the opportunistic individual); (4) and the management, commercial and technical champions.

2.3 The Role of Champions in the Innovation Process

When new ideas encounter sharp resistance from different stakeholders, the emergence of a champion is essential to keep the ideas alive (Schon, 1963). Champions show personal commitment in projects of their involvement, contribute to the project by generating support from other people in the firm, and advocate the project beyond job requirement in a distinctive manner (Markham, 1998). Organizational literature also suggests that champions achieve distinctiveness by accepting risk, vigorously supporting or advocating the project, helping the project through critical times, overcoming opposition, or leading coalitions.

Specific to construction, many researchers have stressed the role of champions as vital for innovation. Winch (1998) has identified two possible ways in which innovation can occur in construction. The first is top down adoption/implementation dynamics where new ideas can be adopted and implemented. The second is bottom up problem solving/learning approach where solutions are sought for problems encountered on the project. Since both types of innovation are implemented at the project level, the role of the system integrator becomes essential for successful implementation of construction innovations (Winch, 1998).

However, construction projects have significant co-ordination and integration problems due to extreme specialization of functions and/or involvement of various professions (Nam and Tatum, 1992a). This calls for an integration champion who can lead, co-ordinate, and combine the technical creativeness of the various organizations involved in the construction project. Low and Chua (2002) also suggest that innovations need champions in order to carry and mobilize ideas. They further argue that changes are likely to be slow, unless the system integrator is convinced of the merits of new ideas, and has the skills to incorporate them into the system as a whole.

As discussed, construction is a complex production system. Successful innovation in construction requires convincing several organizations, such as regulators and designers, outside the contractor's firm, to allow the use of innovation (Tatum, 1987). This is apparent from the fact that the implementation of a new construction method or technology may invite risk in a project. However, the project must be secured. Therefore, the ability of a contractor to get the support of key project stakeholders is vital in the innovation process.

Nam and Tatum (1997) have emphasized that construction companies need champions, who exert great influence in the process of technological innovation. The construction literature also gives an impression that champions are highly enthusiastic and committed individuals; they are willing to make special efforts in the innovation by carrying ideas from conception through development into a viable process or product. However, the role of these individuals in the construction projects is unclear.

2.4 Managerial Job Behaviour

The manager's job can be described in terms of various roles or organized sets of behaviours linked with the position. Three types of managerial roles, namely interpersonal, informational, and decisional are highlighted by Mintzberg (1975). According to him, formal authority of the manager enables him/her three interpersonal roles, i.e., figurehead, leader and liaison. The interpersonal role gives three informational roles to the manager: monitor, disseminator, and spokesman. Both interpersonal and informational roles enable the manager to play four decisional roles as entrepreneur, disturbance handler, resource allocator, and negotiator (Mintzberg, 1975). The above description indicates that the manager's job is varied, brief, fragmented and highly interpersonal; further it is becoming more dynamic, challenging and complex in today's business environment.

Previous studies have attempted to assess the job behaviour of managers. The behaviour approach of job assessment looks at what managers do in day-to-day work and how it is influenced by both content and context (social and institutional). This approach, according to Noordegraaf and Stewart (2000), studies the background characteristics, mental characteristics and behavioural characteristics of individual managers. Gibs (1994), on the other hand, argues that the environmental complexity and dynamism are good predictors of job behaviour.

It is also believed that the manager comes to a managerial job with a set of values or belief systems ((Minzberg, 1994). Besides, he or she brings a body of experiences in the form of skills or competencies and knowledge. Knowledge can be used directly or converted into a set of mental models, which is the key to interpreting different situations. All these characteristics – values, skills, and knowledge – guide the style or behaviour of the manager (Minzberg, 1994).

Along with personal attributes, the manager has the *frame* for the job associated with some purpose (what the manager is seeking to do), perspective (overall approach or strategy), and position (Mintzberg, 1994). Mintzberg (1994) further argues that different managers conceive their job frame in different ways in performing their role. Given a particular job frame and the job context (what to be managed, e.g., the manager's own unit, rest of the organization or units, or units outside the formal organization), actual behaviours that mangers engage in to do their jobs emerge.

Looking further into the nature of a managerial work, according to Hales (1986), four types of managerial work elements, namely, simple behaviour, activities (complex behaviour), tasks (defined goals of activity), and functions (the intended contribution of managerial tasks to the organization as a whole) can be identified. Whitley (1989) argues that it is first essential to identify the major characteristics of managerial tasks before determining an appropriate managerial capacity to perform them. The author mentions five major characteristics of managerial tasks:

- Managerial tasks are highly interdependent, contextual and systematic. They are closely linked with organizational context. The generalizability of successful practices in one situation to other contexts (such as space, time and culture) differs and, it calls for an extensive diffuse knowledge base including extensive local knowledge.
- They are relatively unstandardized. This follows from both the discretionary nature of managerial activities and their interdependence.
- They are changeable and developing. The low level of standardization but high level of interdependency, and dynamic nature of tasks manifest a changing nature of tasks. This is because the manager, in the course of time, learns from experience, develops new skills and knowledge.
- They are ideally concerned both with the maintenance of administrative structures and with the improvement of resource co-ordination and use, thus combining continuity with innovation. This can, in practice, produce conflicts.

- Managerial work can only be evaluated in terms of the collective output of the whole system of which it is a part and so competence cannot be determined by the value of direct, visible results of task performance. Managerial tasks assessment is quite dependent upon a particular context and circumstances. As such, more systematic approach for the measurement of their outcome is needed.

2.5 Behaviour Research in the Project Management Arena

Most of the research in the project management arena emphasizes the leadership behaviour of PMs. The role of effective leadership on the part of the PM has been shown to be one of the most important single characteristics in successfully implementing projects. In their study, Zimmerer and Yasin (1998) found that the effective leadership of PMs was responsible for the success of most of the projects. PMs who recognized team building, reinforced positive behaviour, set goal and communicated them, demonstrated trust, and developed and empowered team members were highly successful compared to those who lacked these behaviours. However, Slevin and Pinto (1991) argue that the successful project management is greatly affected by the required level of information and decision-making authority. Based on these two critical dimensions, according to the authors, it is possible to determine what makes a leader act in a particular way in a given condition. Also, it is possible for a leader to act differently, depending upon three kinds of pressure: problem attributes, leader personality, and organizational/group pressure.

Thoms and Pinto (1999) argue that project leaders must possess or develop a number of temporal skills that match the various tasks and situations they are called upon to address. "Temporal skills", which refers to specific project management skills relating the past, present, and future, can determine the nature of the tasks project leaders are engaged in on the job. Their study suggests that specific individual differences may impact project leader effectiveness.

A growing body of literature on project leadership also suggests that project leaders must possess effective leadership characteristics. For example, in their study of leadership behaviour of the design team leaders, Cheung *et al*. (2001) found that charismatic and participative leadership behaviours influenced the satisfaction of their team members. In yet another study (Walters, 2001), the flexibility of leaders to adapt their style to the team members' ability and willingness to change affected the implementation of an effective quality system. In her study, Walters (2001) explained how better quality performance could be delivered when leaders were flexible and aware of critical situational factors such as the ability and willingness of members to change.

Fraser (2000) attempted to develop the personal characteristics that were believed to influence the effectiveness of construction site managers (CSMs) using the Nominal Group Technique. From the study of 61 CSMs in Australia, 11 characteristics that were believed to have had a relationship with CSMs' effectiveness were found. The characteristics, among others, include the number of firms worked for, educational level, membership of professional bodies, and the leadership style.

El-Sabaa (2001) also categorized the personal characteristics, traits and skills needed for a PM into three skill areas: human skill, conceptual and organizational skill, and technical skill. Human skill – the skill of the PM to work efficiently as a group member and to build a co-operative effort within the project team he or she leads – was found to have the greatest influence on project management practices. One of the most comprehensive analyses of behavioural skills based on extensive pilot research however was Green's (1989) work involving 18 behavioural skills. The study was designed to evaluate information system project managers' competencies.

2.6 Measurement of Managerial Behaviour

There are quite a few research techniques available for behavioural type of research. The foremost and most popular technique discussed in an organizational literature is the observational technique. This technique is more distinct, empirical, inductive and capable of capturing managers' behaviour in actions (Noordegraaf and Stewart, 2000). Most of the early studies used diaries as their major data collection method. However, a number of researchers have replicated and extended Minzberg's direct non-participant observation as their primary data collection procedure (Martinko and Gardner, 1990).

Other common methodologies that are designed to capture individual job behaviour include the use of the rating scale that has behaviour attached to each of the behaviour incidents and the use of Behaviourally Anchored Rating Scales (BARS). In the construction literature, the use of questionnaires to measure the frequency of displaying a particular behaviour on a behavioural frequency scale is quite common. The research presented in this thesis also adopts the same technique in measuring the championing behaviour of the PM.

2.7 Managerial Effectiveness

As mentioned earlier, it has been argued that managers' effectiveness is related to the nature of the job and situations in which they work (Minzberg, 1975). There is a little doubt in saying that managers tend to have a greater flexibility in their jobs owing to inherent characteristics, demands, constraints and choices of managerial work (Stewart, 1989). Given these job characteristics, Noordegraaf and Stewart (2000) argue that behavioural studies, which capture most aspects of managerial jobs, could be used to assess the effectiveness of managers.

The person-process-product model proposed by Campbell *et al*. (1970) of managerial effectiveness has gained popularity since early 1970s. The "person" in the model refers to the individual manager's characteristic traits and abilities. The "process" refers to the manager's on-the-job behaviour and activities, while the "product" is the measure of organizational outcomes such as profit maximization and productivity. Campbell *et al*. (1970) emphasize that those three components – person, process and product – need to be understood in evaluating the effectiveness of managerial performance but, the "process" which is the managers' on the job observable behaviour and activities has drawn less attention (Morse and Wagner, 1978). Hales (1986) further says that the managerial practices may be compared either with some absolute, objective benchmark or in terms of the extent to which managers' performance matches others' expectation.

2.8 The Structure of the Singapore Construction Industry

According to the Survey of Construction Industry (BCA, 2001), the Singapore construction industry is characterized by the presence of a large number of small and medium-sized enterprises. Out of 18,909 active enterprises in the construction industry, small and medium enterprises constitute 85.8% and 11.6% respectively of the local construction enterprises (BCA, 2001). The enterprises with paid-up capital less than S$250,000, between S$250,000 and 2.5 million, and more than S$2.5 million are considered small, medium, and large enterprises respectively. According to the same survey, 88.8% of the construction enterprises generated construction turnover less than S$ 2 million, while 11.2% of the construction enterprises had construction turnover between S$2 million and S$50 million.

In 1999, local contractors made up 98.5% of the total number of enterprises; foreign owned contractors made up 1.25% of the total enterprises; and joint ventures between local and foreign contractors made up the rest of the enterprises. However, local construction firms in Singapore are increasingly facing greater competition from larger foreign firms, which can offer more innovative and complete services to clients (Ofori *et al*., 1999). Ofori *et al*. (1999) observed that foreign contactors were superior to their local counterparts in terms of capacity, capability, and competitiveness, and therefore dominate large and complex projects. The survey of the construction industry (BCA, 2001) also reported that foreign companies generated the highest value added per enterprise (5.6 million), whereas value added per employee for local enterprise stood at 0.466 million. The same survey also indicted that the value added per employee was the highest for large enterprises and the lowest for small enterprises.

In addition, the Singapore construction industry has a short history compared to many of their foreign counterparts. Many of the major local contractors in Singapore started only some 30 to 40 years ago as small family-owned businesses; and, in fact, many continue to remain in the control of family members (Low, 1996). Construction is also a business that also reflects the relatively low barriers of entry (Lee, 2003). The fragmented nature of the industry with its numerous smaller players doesn't encourage industry in its upgrading efforts and economies of scale (C21, 1999).

The nature of the Singapore construction industry as highlighted above has a number of implications. It shows that the construction industry in Singapore is facing a low level of productivity that can have tremendous effect on the ability of the industry to maintain its competitiveness. The fragmented nature of the industry could also mean little investment or not at all in R&D work, technological, product and process innovation. Construction innovation offers the potential to improve the efficiency of the industry. Furthermore, as local companies are facing greater competition among themselves and from large foreign contractors, innovation will be necessary to them in order to compete with their foreign counterparts. In addition, construction companies will also need sound innovation strategies at the project level so that they can adequately address project challenges and improve their products and services.

3. RESEARCH FRAMEWORK

3.1 Background

The role of key individuals often called "champions" has been extensively researched in a new product development process. But the research in other areas is inadequate to explain the role of champions in construction. This is because the role of key individuals as champions in a project-based business such as construction can be different (Tatum, 1989). Previous research on construction innovation has commonly recognized the importance of organizational climate and key individuals to the success of innovation (e.g., Tatum, 1986, 1987, Nam and Tatum, 1992a, 1997; Winch, 1998). However, our understanding of how project participants, particularly PMs facilitate and/or influence innovation is limited. Moreover, the role of the PM in construction projects as a champion of innovation has been mostly neglected. There seems to be a gap in the research regarding the role of the PM in construction innovation. In an attempt to fill this knowledge gap, this research study has been conducted.

This research considers that the PM's role is essentially that of a champion in order to promote the creation, adoption and implementation of new ideas, and solutions in the construction project environment. As such, PMs may be able to identify the potential benefits of innovation, absorb the risks, and drive for change. They may further extend their role as facilitators to those who carry that role. They can play a key role in integrating information from different sources and to encourage project personnel to work together to generate innovations, and identify opportunities to improve project processes even if a specific project problem does not exist (Mitropoulos and Tatum, 1999). Nam and Tatum (1992b) argue that it is not the availability of ideas that hinders construction innovation but the decision to use them or the environment that influences them. The environment, as mentioned by the authors, basically refers to the organizational climate for innovation, which is often described in terms of psychological climate, and will be discussed later.

3.2 A Conceptual Research Framework

From the literature in the field of organizational behaviour and construction management, as discussed in the previous chapter, two main groups of variables—individual and situational—can be identified that may influence PM's championing behaviour. Many scholars, for example, Dulaimi and Langford (1999); Bresnen *et al*. (1986); Fraser, (2000); Mustapha and Naoum (1998) have emphasized the need to include these factors in assessing the job behaviour of PMs/site managers and their effectiveness. Based on the literature survey, it is also inferred that innovative practices on projects are also influenced by these sets of variables. Furthermore, the individual and situational variables may also influence project performance.

Based on the discussion so far, a conceptual research framework as represented in Figure 3.1 has been developed. In this research, individual variables represent what PMs bring to the situation. Thus, individual variables such as qualification, experience, and other personality-related factors are directly related to the PM. On the other hand, situational variables are what PMs find in their work on projects; thus, they are related to the project and organization. They include variables such as contract value, project duration, project complexity, resource supply, support for innovation, and so forth. PMs may have little or no control on these variables.

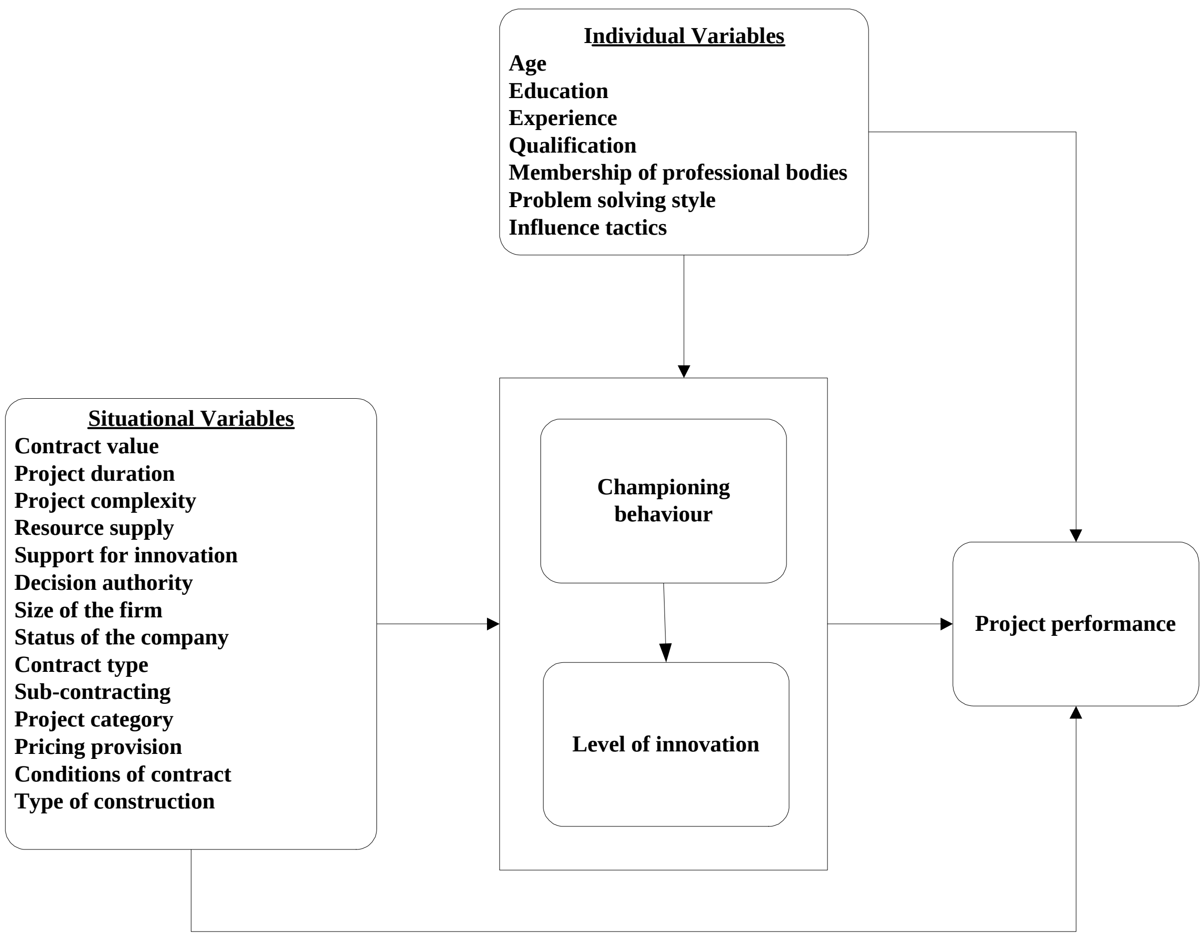


Figure 3.1: Research Framework

The framework as presented in Figure 3.1 is complex including the interaction of many factors or variables. The complete analysis of all these factors in a single study such as the current one is beyond the scope of this research. Based on this conceptual framework, this research develops a number of hypotheses, which are then translated into the structural model for the analysis of the collected data. The author next discusses the development of research hypotheses.

3.3 Hypotheses Development

3.3.1 Problem Solving Style

The "problem solving style" is one's preferred or characteristic pattern of creativity, problem solving and decision-making (Kirton, 1976; Goldsmith, 1984). The Kirton Adaptation-Innovation Inventory (KAI) is one of the most versatile measures of problem solving style – a cognitive style that is an important determinant of innovative behaviour (Sadler-Smith and Badger, 1998). In addition, the KAI is a measure of personality, stable over time and not easily changed (Kirton, 1976). The contention of Kirton's theory is that everyone can be located on a continuum ranging from an ability to "do things better" to an ability to "do things differently", and the ends of this continuum are labeled *adaptive* and *innovative*. For Kirton (1978), both adaptors and innovators are creative. Adaptors are innovative in a narrow range, seeking minor improvements, initiating changes that lie near current organizational practices, and pushing a boundary incrementally. Innovators, however, proliferate ideas, change the frameworks of problems and do things differently.

It is inferred from the organizational literature that champions have high innovative orientation (Maidique, 1980; Keller and Holland, 1978). Since the KAI purports to measure an individual's propensity to innovate, innovative problem solving style of PMs can be expected to influence their championing and the extent to which innovative practices are adopted on construction sites. It is thus hypothesized:

Hypothesis 1: The degree to which the PM's problem solving style is innovative is positively related to their championing behaviour and the level of innovation in the project.

Given the lack of theoretical explanations, the test of the relationship between problem solving style and project performance is considered exploratory and no specific hypothesis was made.

3.3.2 Influence Tactics

There is both theoretical and empirical research that supports the use of influence tactics or strategies by a champion as part of innovation and issue selling process (Dutton and Ashford, 1993; Frost and Egri, 1991; Howell and Higgins, 1990; Howell *et al.*, 1998; Markham, 2001). Frost and Egri (1991) reported that successful champions were able to influence important players in their organizations to envision the strategic importance of their ideas. However, the use of influence tactics varies with subordinates, peers and superiors to achieve desired objectives – assign work; change behaviours; get assistance, support and personal benefits (Yukl *et al.*, 1995). Previous studies suggest that four tactics namely, rational persuasion, inspirational, consultation and coalition building may be most appropriate for champions in influencing targets in their organization (Yukl *et al.*, 1993; Yukl and Tracey, 1992; Lee and Sweeney, 2001). Each of them is briefly described below.

Rational persuasion – the use of logical arguments, clear explanation and factual evidence to persuade the target – is the most often used method of influencing superiors (Yulk *et al*., 1993; Yukl and Tracey, 1992) and is effective for selling complex and technical issues (Frost and Egri, 1991). This tactic is often used to obtain resources, approvals, and political support. In their study, Keys and Case (1990) observed that managers made extensive use of rational facts or ideas. They often presented an example of another organization to support their case.

Consultation – seeking participation of others in planning a strategy, activity or change in desired program or innovation – is often used with subordinates or peers to assign work and solicit their support (Yukl and Falbe, 1990). In coalition tactics, an individual enlists the support (particularly political support, assistance, and commitment) of others who are knowledgeable and interested in the proposed work. Citing a number of researchers, Yukl and Falbe (1990) have highlighted the fact that coalition building may be one of the most effective means for introducing innovations in an organization and influencing peers and superiors over whom one has no authority. Meanwhile, inspirational tactics involve selling a request or proposal that arouses enthusiasm by appealing the target's values, ideals and aspirations, and are useful to assign work, to obtain assistance and get support for changes (Yukl *et al*., 1993).

The discussion thus far implies that PMs could also use the above-mentioned the four influence tactics depending upon the target and purpose to implement major strategies and innovations. As contractual requirements and the specifications have already set the desired project performance criteria for a contractor, it is the PM who is expected to take action to meet the expected performance level. This may be achieved by influencing team members and key project individuals. It is thus hypothesized:

Hypothesis 2: The use of influence tactics is positively related to championing behaviour and project performance.

3.3.3 Organizational Climate for Innovation

Organizational climate, which is often described in terms of psychological climate, represents the cognitive interpretation of an organizational situation perceived by individuals and signals they receive concerning organizational expectations for behaviour and potential outcomes of the behaviour (James *et al*., 1990; James and Sells, 1981; Scott and Bruce, 1994). It is a multi-dimensional construct, which can be conceptualized and operationalized at the individual level (Glick, 1985; Koys and DeCotiis, 1991). Schneider and Reichers (1983) argue that climate perceptions are a result of individuals' efforts to understand the organization and their roles within it. The signals project team members receive from the organization about the expectations for innovation play a crucial role in activating or inhibiting innovation. The manner by which organizations signal an expectation for innovation is by providing resources and support for innovation (Kanter, 1988; Amabile, 1997). The supportive organizational climate can also motivate team members if their efforts and successes are properly acknowledged and rewarded (Mitropoulos and Howell, 2001).

A large body of research suggests that an organizational climate that a) establishes supportive policies towards innovation; b) takes a broader view of risk, failure and mistakes; c) encourages employees to experiment with new ideas; and d) provides necessary resources is conducive to construction innovation (Tatum, 1989; Laborde and Sanvido, 1994; Mitropoulos and Tatum, 1999; Tatum *et al*., 1989; Low and Chua, 2002). In addition, availability of resources that could be used for other than operational expenses and organizational culture that values innovation are reported to drive innovative behaviour of individuals in an organization (Mitropoulos and Tatum, 2000). It is therefore argued that perception of the project environment in terms of support for innovation and resource supply is crucial to understand the championing behaviour and, such perception also determines the level of innovation on a project. The discussion leads to the following hypotheses:

Hypothesis 3: The degree to which individuals perceive project climate as supportive of innovation is positively related with PM's championing behaviour and the level of innovation on a project.

Hypothesis 4: There is a positive relationship of resource supply with PM's championing behaviour and the level of innovation on a project.

3.3.4 Decision Authority of the Project Manager

It has been reported that successful innovations in construction are indicated by the presence of champions who hold positions of authority as well as power beyond the authority (Nam and Tatum, 1997). Therefore, the delegation of autonomy and decision authority to the PM may be the most important factor for success of innovation. Nam and Tatum (1992b) have reported that the availability of technical ideas was not the major hindrance to innovation. Rather, the determining factor in bringing the innovation to realization, in most of the cases, was the decision to use them or the environment that influenced that decision. Arguably, PMs who have enough authority and decision power would presumably have sufficient control over their project, and are likely to engage in more championing activities. It is also likely that PMs' involvement in making a decision about work done on their site will increase innovation and project performance, mainly because PMs probably try harder to make their decision succeed. This leads to a hypothesis:

Hypothesis 5: PM's decision authority is positively related with championing behaviour, the level of innovation and project performance.

3.3.5 Outcomes of Championing Behaviour

Construction-related research provides little evidence, if any, relating PM's championing behaviour with project performance. However, the presence of extant literature investigating the relationships between champion behaviour and project performance in manufacturing and R&D organizations provides support of such relationships. A number of studies have reported that champion behaviour is positively related to project performance (Howell *et al.*, 1998; Howell and Shea, 2001). Kessler and Chakrabarti (1996) argue that the positive role played by a champion on a product innovation process through multitudes of championing activities is vital.

Innovation in construction projects is primarily initiated to address challenges, opportunities and problems encountered at work to meet project objectives or to improve performance. If PMs were convinced of the merit of proposed innovations, they would adopt and carry them in a distinctive manner. It is also argued that an increased level of innovation on site should have a higher efficacy of meeting project objectives or outcomes, for instance, cost reduction or increase in profit margins, productivity improvement, early project completion, just to name a few. Since construction companies have a full control of process innovation (Laborde and Sanvido, 1994), innovative practices, if properly managed, can be expected to increase the efficiency and effectiveness of construction operations. Researchers, for example, Toole (2001), and Nam and Tatum (1997) suggest that innovation is pursued as a means of improving the performance of the final product, which should invariably be related with project performance indicators, as identified in this research. It is thus hypothesized:

Hypothesis 6: PM's championing behaviour is related positively with the level of innovation and project performance.

Hypothesis 7: There is a positive relationship between the level of innovation and project performance.

3.3.6 Other Variables

In testing the hypotheses, several other individual and situational variables that may influence championing behaviour, the level of innovation or both have also been included. The individual factors considered in the structural model are the PM's job tenure and education. Previous studies have reported that knowledge gained from experience in previous projects and the education of a champion are important (Tatum, 1987; Nam and Tatum, 1997), which also help to overcome the risk and uncertainties innovation may bring. In addition, situational factors such as project size and complexity of the project may also influence the behaviour of PMs. These factors can overwhelmingly influence the volume of innovative ideas to be generated during the construction. Further, many researchers agree that construction projects provide numerous opportunities for innovation (Winch 1998; Nam and Tatum, 1992a), mainly because technical challenges on a construction project demand innovative methods for improved performance (Tatum, 1984).

3.4 The Structural Model

In order to test the hypotheses and explore the influence of individual and situational variables as discussed above, it is necessary to represent them in a robust and empirically testable model. This was accomplished by representing them in the structural model as shown in Figure 3.2. The author adopted the structural equation modeling technique to test the hypothesized relationships in the model and will be discussed in the following chapters.

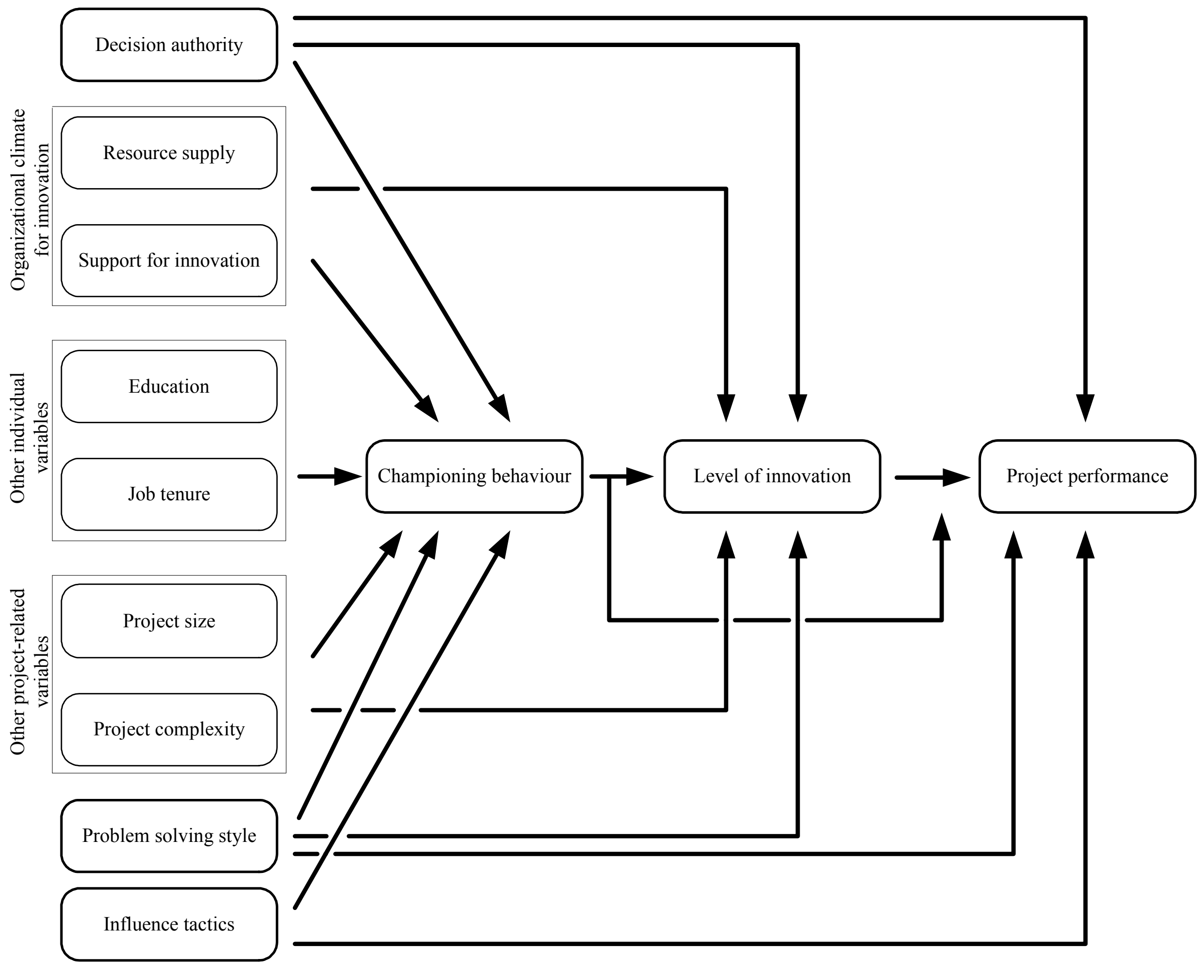


Figure 3.2 The Structural Model

4. METHODOLOGY

4.1 General

The research process adopted in this thesis is summarized in Figure 4.1. The problem identification, literature review, development of theoretical framework and hypotheses development have been discussed in earlier chapters. This chapter describes the research methodology that includes research design, an overview of main statistical techniques that were used in this research, and the processing and analysis of data.

4.2 Research Design

This research used survey questionnaires to collect the necessary data. This technique enabled the author to obtain a large number of samples for a meaningful empirical investigation. It also made possible the qualitative attributes in the research to be assessed subjectively. Also, low cost both in time and money, ease of getting information from a lot of industry practitioners, and possibility of collecting unbiased information sufficed the use of survey questionnaire as the main research method. The author also sought additional information from face-to-face interviews with PMs during site visits.

Based on the research framework and hypotheses, the survey questionnaire was designed. Preliminary feedback from two faculty members in the Department of Building at the National University of Singapore was incorporated before it was sent for a pilot test conducted in two construction projects in Singapore. After the pilot test, minor changes were made to the survey items that were not clear to the practitioners.

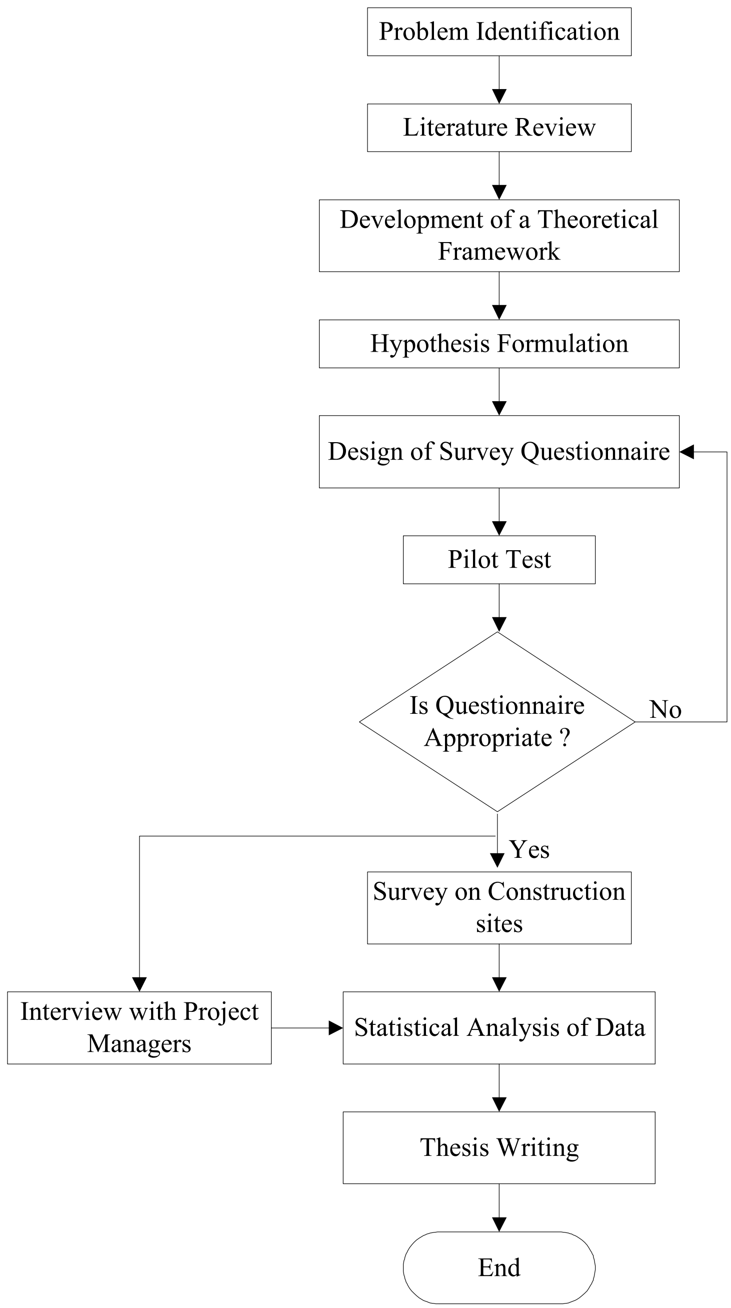


Figure 4.1 The Research Process

4.2.1 Survey Measures

This section describes in detail the procedure by which the variables were measured and illustrates how the survey items related to those variables were constructed.

Job tenure of the PM was assessed using the PM's experience in the construction industry, in the current company, and his or her experience working in the status of the PM. The PM's score on each of these three experience factors was standardized and the average score was taken to calculate the PM's job tenure.

PM's *education* was measured by asking PMs the highest degree they had earned and, it was coded as: 1 = Diploma, 2 = Bachelors, 3 = Masters, and 4 = PhD.

The *size of the project* was assessed in terms of *contract value* and the *duration of the project.* Since there was a high correlation between the later two variables, a score was calculated by standardizing the score on each variable and averaging them to represent a proxy for project size.

The *complexity of the project* was measured using a single item by asking PMs how complex their project was. It was measured on a scale of seven ranging from 1 (not complex at all) to 7 (very complex).

Problem solving style was measured using 32 items of the Kirton Adaptation-Innovation Inventory (Kirton, 1976). The items were completed by each of the PMs in a five-point scale 1 (very easy) to 5 (very hard).

Influence tactics was measured using 13 items based on the work of Kipnis *et al*. (1980), Yukl and Falbe (1990) and Yulk *et al*. (1995). PMs were asked to indicate how often they used each of the influence tactics on a scale of 1 to 5, where 1 means 'never' and 5 means 'usually'.

Organizational climate for innovation was measured, using 22 items developed and validated by Scott and Bruce (1994) on a scale of 1 (strongly disagree) to 5 (strongly agree). The measure, which is a modification and extension of the innovative climate measure developed by Siegel and Kaemmerer (1978), has two dimensions, namely, support for innovation and resource supply. The *support for innovation* was assessed with 16 items measuring the degree to which individuals viewed the organization as open to change, supportive of new ideas from members, and tolerant of member diversity. The dimension, *resource supply*, was assessed using six items measuring the degree to which resources (i.e., personnel, funding, time etc.) were perceived as adequate in the project. Minor changes were made to the items so as to make them suitable for the current research.

Decision authority was measured using nine items as developed by Dulaimi (1991). The statements included items such as the process of selection of subcontractors, equipment, materials, work activities and workers, modifying existing designs, or cost plans. PMs were asked to indicate the degree of influence they have in decisions made about the work on their sites on a scale of 1 (virtually no influence) to 5 (a very great deal of influence).

PM's championing behaviour was assessed using 33 items. The author adopted 13 items from the work of Howell *et al*. (1998) and added 20 items to the construct. The overall measure provided a more comprehensive definition of the championing behaviour of the PM. Project team members were asked to rate the championing behaviour of their respective PMs on a scale of 1 (not at all) to five (frequently).

Project performance was measured by 12 subjective items. The construct is based on the criteria of cost, time, client satisfaction, safety, productivity, organizational learning, project team satisfaction, continuous improvement, enabling company's reputation, and competitive advantages. This research argues that these measures are more comprehensive and capture both the traditional project performance indicators as well as innovation induced outcomes. Project team members assessed each of the indicators of project performance on a scale of 1 (not at all) to 5 (a great deal).

The level of innovation was measured on a scale of 1 (strongly agree) to 5 (strongly disagree), using three items that were originally developed by Lewis-Beck (1977) to assess the innovativeness of the project. The items were slightly modified by the author to suit the construction project environment. The items included statements to the extent that the project had utilized the most adequate equipment and materials; new construction methods or techniques; and the application of new ideas in the planning, organizing, and management of work on site. This construct reflects the degree of innovative practices adopted on construction sites.

4.2.2 Data Collection

The data for this research was collected in Singapore from June to September 2002. The subjects for the research were PMs and their project team members working for general contractors operating in Singapore. The survey required PMs and three of their project team members that included practitioners such as engineers, mangers, quantity surveyors, site supervisors, project coordinators, and other technical staffs who were working closely with the PM and chosen by the PM, respond to the survey. It is this author's belief that such a triangulation approach of research could provide an accurate evaluation of an organizational situation and the PM's effectiveness on a project. The samples of the survey used for PMs and project team members are presented in appendices A.1 through A.2.

Before the survey was conducted, a list of ongoing construction projects was identified from the Building and Construction Authority (BCA) web site. Communication was established with the contractors undertaking the projects requesting them to participate in the research. 10 contractors expressed their willingness to participate in the survey and provided contact details of their PMs. As a result, 19 projects were identified for the study. Contact was made with the respective PMs on the construction sites through telephone conversation. Following this, the questionnaires were hand delivered to them. Out of the 19 projects, response was received from 12 projects.

Next, the author established direct personal contact with PMs in 13 construction projects identified earlier, kindly requesting them to participate in the survey. The author visited all 13 projects and hand delivered the survey forms to the respective PMs. Following this, response from eight projects was obtained. However, the number of response was still low for a statistical analysis of the data. With this in mind, the author made an additional attempt to involve more PMs in this research study. The author made contact with the Housing and Development Board (HDB) of Singapore and requested for assistance in conducting the survey. The request was greatly appreciated. A total of 35 projects, including 20 building and 15 civil engineering projects, which were commissioned by HDB, were identified as suitable for the survey. Survey was then administered in those identified projects through the HDB PMs/site engineers who were responsible in supervising the work of contractors. Out of these 35 projects, response was obtained from 12 projects.

4.3 An Overview of Statistical Techniques Used

The aim of this section is to explain the major statistical data analysis techniques that were adopted in the analyses of the collected data. A number of statistical procedures were used in the data analysis. A general overview of these methods is presented below.

4.3.1 Reliability Analysis

In Section 4.2.1 how the major variables were operationalized was discussed. A subset of relevant items was used in the construct to measure the variables. It is essential to measure the internal consistency of the construct; that is, do all items within the construct measure the same thing? Cronbach's alpha (also known as coefficient alpha or α) is most widely used measure of reliability. The value of alpha varies between 0 and 1. The closer the alpha is to 1.0, the greater the internal consistency of the items in the construct being measured (George and Mallery, 2001). There is no exact interpretation as to what is an acceptable alpha value. A rule of thumb that applies to most situation is: $\alpha > 0.9$, excellent; $\alpha > 0.8$, good; $\alpha > 0.7$, acceptable, $\alpha > 0.6$, questionable; $\alpha > 0.5$, poor; $\alpha < 0.5$, unacceptable. However, it should be noted that as the number of items in the construct increases, the value of α becomes larger (George and Mallery, 2001). Also, if the intercorrelation between items is large, the corresponding α will also be large.

4.3.2 Analysis of Variance Test

Analysis of Variance (ANOVA) test is used to compare two or more sample means to see if there are significant differences among them. ANOVA is really a set of analytical procedures based on a comparison of two estimates of variance. One estimate comes from differences among scores within each group; this estimate is considered random or error variance. The second estimate comes from differences in group means and is considered a reflection of group difference or treatment effects plus error. If these two estimates of variance do not differ appreciably, one concludes that all of the group means come from the same sampling distribution of means, and that the slight differences among them are due to random error. If, on the other hand, the group means differ more than expected, it is concluded that they were drawn form different sampling distributions of means, and the null hypothesis that the means are the same is rejected (Tabachnick and Fidell, 2001).

Differences among variances are evaluated as ratios, where the variance associated with differences among sample means is in the numerator and the variance associated with error is in the denominator. The ratio between these variances forms F distribution, from which F ratio is calculated (Tabachnick and Fidell, 2001). The varieties of ANOVA are conveniently summarized in terms of the partition of sums of squares, that is, sums of squared differences between scores and their means.

4.3.3 Factor Analysis

Factor analysis is a statistical technique that attempts to identify underlying variables, or factors, that explain the pattern of correlations within a set of observed variables. Factor analysis is often used in data reduction to identify a small number of factors that explain most of the variance observed in a much larger number of manifest variables (Tabachnick and Fidell, 2001). Variables that are correlated with one another are combined into factors.

There are basically two different approaches to factor analysis, namely, exploratory factor analysis and confirmatory analysis. This thesis is concerned with exploratory factor analysis, which begins with the relationships among the indicator variables and strives to uncover the factors (dimensions) underlying them. There are a number of exploratory factor analytic procedures, which differ in the way factors are extracted. The most commonly used procedure is a Principal Components Analysis (PCA).

There are three stages in a PCA (Gardner, 2001). Stage 1 is concerned with the computation of the relationships among the variables, which is generally expressed in the form of a correlation matrix. Stage 2 involves extraction of the factors. Stage 3 is concerned with identifying factors that more simply describe the relations among the variables. This is achieved by rotating the factors to produce what is called simple structure, that is, high factor loadings on one factor and low loadings on all others. Factor rotation ensures more interpretable structure. Factor loadings vary between ± 1.0 and indicate the strength of relationship between a particular variable and a particular factor, in a way similar to a correlation (George and Mallery, 2001). The factors are interpreted by considering each factor and determining what is common to all the variables that load highly on a factor and not common to all the variables obtaining low loadings.

4.3.4 Structural Equation Modelling

Structural Equation Modelling (SEM) is becoming very popular for three reasons: (a) to conduct confirmatory factor analysis that deals with how well the measures reflect their intended construct, (b) to test predictive models, using path analysis, and (c) to estimate a complete model, incorporating both measurement and prediction (Kelloway, 1998). This research adopts SEM for path analysis. Path analysis is a technique to assess the direct causal contribution of one variable to another in a non-experimental situation. The path analysis involves specifying the assumed causal relationships among the variables (in the form of a path diagram) hypothesized by the researcher and then estimating the coefficients of a set of linear structural equations that represent the cause and effect relationships (Jöreskog and Sörbom, 1993).

There are two types of variables in the path analysis. The first is measured variables, also called observed variables, indicators, or manifest variables. The other is called latent variables or constructs. In path analysis a distinction is often made between exogenous and endogenous variables. "An exogenous variable is one whose assumed causes have not been measured or tested while and an endogenous variable is one for which one or more possible causes have been measured and have been posited in the causal model" (Howitt and Cramer, 1999). The varieties of techniques have been evolved over the years in solving the set of structural equations. However, LISREL is very popular among researchers. The term "LISREL" is an acronym for *LI*near *S*tructural *REL*ationships (Diamantopoulos and Siguaw, 2000). LISREL is a computer program that performs SEM. It was developed by Karl G. Jöreskog and Dag Sörbom. The specific issues that are relevant to this research in the path analysis using SEM are discussed later in the chapter.

4.3.5 Nonparametric Tests

Nonparametric tests make no assumptions about the parameters (such as the mean and variance) of a distribution, nor do they assume that any particular distribution is being used (Norušis, 2002). In this section, the author briefly discusses two nonparametric tests for independent samples, the Mann-Whitney test and the Kruskal-Wallis test.

The Mann-Whitney Test is the most popular of the two-independent-samples tests. Mann-Whitney tests whether two independent samples (groups) come from the same population. The observations from both groups are combined and ranked, with the average rank assigned in the case of ties. If the populations are identical, the ranks should be randomly mixed between the two samples. The number of times a score from group 1 precedes a score from group 2 and the number of times a score from group 2 precedes a score from group 1 are calculated. The Mann-Whitney U statistic is the smaller of these two numbers.

The Kruskal-Wallis Test is the nonparametric tests for multiple independent samples and is useful for determining whether or not the values of a particular variable differ between two or more groups. The Kruskal-Wallis test is a popular nonparametric alternative to the standard one-way ANOVA. It tests the null hypothesis that multiple independent samples come from the same population. Unlike standard ANOVA, it does not assume normality, and it can be used to test ordinal variables. However, the Kruskal-Wallis test does not tell us how the groups are different; it only states that some difference is present. To identify

4.4 Data Processing and Analysis

4.4.1 Sample

As explained in Section 4.2.2, survey forms were hand delivered to 67 ongoing building and civil engineering projects in Singapore. Some of the projects were at a stage of completion. Altogether, 32 PMs and 94 project team members from 32 projects responded to the survey. In 30 projects, the response was received from PMs and three of their project team members, while in the other two projects, response was received from PMs and two of their project team members.

4.4.2 Profile of the Respondents

Table 4.1 shows the profile of PMs who responded to the survey. One fourth of them had only diploma, while the largest group of PMs possessed bachelors degree. Only 5 out of total 32 PMs, had earned masters degree. The majority of PMs were in the age range of 35-50. Few of them however were reluctant to reveal their age. Table 4.1 also portrays personal experience of PMs in the construction industry, working experience in the capacity of the PM, and the number of years they have worked with the current company. Majority of PMs (almost 72%) had spent 10-20 years in the construction industry. Five PMs had more than 20 years of experience.

Table 4.1 Profile of the Project Managers

Particulars	Category	Frequency	Percentage
Education	Diploma	8	25.0
	Bachelors	19	59.4
	Masters	5	15.6
	Total	**32**	**100**
Age (years)	30-35	1	3.1
	35-40	10	31.3
	40-45	8	25.0
	45-50	6	18.8
	50-55	4	12.5
	Missing	3	9.4
	Total	**32**	**100**
Experience in the Construction Industry (years)	5-10	4	12.5
	10-15	11	34.4
	15-20	12	37.5
	20-25	1	3.1
	25-30	4	12.5
	Total	**32**	**100**
Working Experience in the Current Company (years)	Less than or equal to 1	5	15.6
	1-2	2	6.3
	2-5	4	12.5
	5-10	7	21.9
	10-15	9	28.1
	15-20	2	6.3
	Above 20	2	6.3
	Missing	1	3.1
	Total	**32**	**100**
Experience as a PM (years)	Less than or equal to 2	4	12.5
	2-5	7	21.9
	5-10	11	34.4
	10-15	8	25.0
	15-20	1	3.1
	Missing	1	3.1
	Total	**32**	**100**
Membership of the Professional Body	SIA	1	3.1
	IES	4	12.5
	Others	2	6.3
	Nil	10	31.3
	Missing	15	46.9
	Total	**32**	**100**

Many PMs had been working in the same company. But there were also some PMs who had not worked long in the current company; they had probably been recruited to work for the current project of the company. Most PMs had worked as a PM for more than five years. However, about one third of PMs had worked 1-5 years in the status of the PM. In terms of the professional membership, most PMs did not have any professional membership. Very few of them were members of professional organizations such as IES (Institution of Engineers Singapore, SIA (Singapore Institute of Architect), and the foreign project management organizations.

Table 4.2 presents the profile of 94 project team members who responded to the survey. It shows that practitioners belonging to the wide range of job position participated in the survey. A majority of them were professional ones working as engineers, managers, quantity surveyors, and project coordinators. The remaining (about 25%) of the respondents were working as project coordinators, safety officers, technical officers, site supervisors, foreman, and others.

Table 4.2 Profile of Project Team Members

Respondents	Frequency	Percentage
Engineer	28	29.8
Managers	14	14.9
Site Engineer	11	11.7
Quantity Surveyor	10	10.6
Resident Engineer	7	7.4
Site Supervisor	6	6.4
Project Coordinator	6	6.4
Foreman	4	4.3
Technical Officer	3	3.2
Safety Officer	2	2.1
Others	3	3.2
Total	**94**	**100**

4.4.3 Profile of the Study Projects

Table 4.3 summarizes the profile of the study projects into a number of criteria. It appears that a large number of projects were executed under traditional design-bid-build type of contract followed by design and build. Out of the total 32 study projects, 18 projects were private and 13 were public ones. It is understood that the largest number of projects were priced under the lump sum contract. One fourth of the projects were executed on the basis of unit price contract. Table 4.3 shows that 50% of the study projects were residential construction, while 25% projects were industrial construction. The rest of the projects belonged to institutional, commercial, infrastructure and other types of construction.

In terms of contract value, a wide variation among the projects was noticed. Only about one third of the projects had contract value in the range of 2 to 20 million dollars; nine projects had contract value in the range of 20 to 40 million dollars, while the rest of the projects had contract worth more than 40 million Singapore dollars. Four very large projects valued more than 100 million Singapore dollars. A majority of the projects had project duration of one to three years, while only four projects had less than a year of project duration.

Table 4.3 Profile of the Study Projects

Project Particulars	Category	Frequency
Contract Type	Traditional	17
	Design & build	8
	Others	7
Project Category	Private	18
	Public	13
	Mixed	1
Pricing Provision	Lump sum contract	20
	Unit price contract	8
	Others	4
Type of Construction	Residential	16
	Industrial	8
	Institutional	2
	Commercial	2
	Infrastructure	2
	Others	2
Contract Value (in Million Singapore Dollars)	2- 20	11
	20-40	9
	40-60	5
	60-100	2
	Above 100	4
	Missing	1
Project Duration (years)	Less than year	4
	1-2	11
	2-3	15
	Above 3	2

4.4.4 Profile of the Companies Undertaking Projects

Table 4.4 shows the profile of the companies undertaking the study projects. Out of 32 projects, local companies were involved in 25 projects; foreign companies were involved in 7 projects. Most of the companies had operated for more than 20 years in the construction business, while nine and five companies were in the business for the last 15-20 years and 10-15 years respectively. The major activity of the majority of the companies was related to the building and building and civil works.

Table 4.4 also shows the average annual turnover of the companies. As evident, about half of the companies had average annual turnover more than 100 million Singapore dollars; some of them were large foreign companies. 12 companies had the average annual turnover in the range of 50-100 millions, while only five companies had less than 50 million dollars of average annual turnover.

Table 4.4 Profile of the Companies Undertaking Projects

Company Particulars	Category	Frequency	Percentage
Company Status	Local	25	78.1
	Foreign	6	18.8
	Foreign J/V	1	3.1
	Total	**32**	**100**
Years of Operation of the Company	Less than or equal to 10	2	6.3
	10-15	5	15.6
	15-20	9	28.1
	20-25	1	3.1
	25-30	2	6.3
	30-40	4	12.5
	Above 40	3	9.4
	Missing	6	18.8
	Total	**32**	**100**
Main Activity	Building	13	40.6
	Civil	1	3.1
	Building and Civil	13	40.6
	Building, Civil and Piling	3	9.4
	Others	2	6.3
	Total	**32**	**100**
Average Annual Turnover (Million Singapore Dollars)	Less than or equal to 10	1	3.1
	10-20	3	9.4
	20-30	0	0.0
	30-40	1	3.1
	50-75	5	15.6
	75-100	6	18.8
	100-200	4	12.5
	200-500	3	9.4
	500-1000	3	9.4
	Above 1000	3	9.4
	Missing	3	9.4
	Total	**32**	**100**

4.4.5 Reliability and Validity of the Constructs

As explained earlier, it is essential to ensure an internal consistency of the construct. This was calculated, using SPSS for windows program. The scale reliabilities for eight constructs, computed in terms of Cronbach's alpha, are presented in Table 4.5. Scale reliabilities from the available previous research are also shown. The reliability of all the measures was ensured as Cronbach's alpha for each construct was equal to and/or greater than 0.70, a generally accepted minimum value.

Table 4.5 Cronbach's Alpha of the Constructs

Construct	**Cronbach's Alpha**	
	Current Research	**Previous Research**
Problem Solving Style	0.92	0.88 (Kirton, 1976)
Influence Tactics	0.73	N/A
Support for Innovation	0.80	0.92 (Scott and Bruce, 1994)
Resource Supply	0.70	0.77 (Scott and Bruce, 1994)
Decision Making Authority	0.86	0.71 (Dulaimi, 1991)
Championing Behaviour	0.93	N/A
Level of Innovation	0.75	N/A
Project Performance	0.87	N/A

The author also checked the validity of the survey measures by comparing the response of PMs and project team members on three constructs, namely support for innovation, resource supply, and the level of innovation. The ANOVA test was conducted to identify whether there was a significant difference in the ranking of each of these constructs by PMs and project team members. The results are presented in Table 4.6, where 'N' represents number of subjects in each group i.e., PMs and project team members. Between groups sum of squares represents the sum of squared deviations between the grand mean and each group mean weighted (multiplied) by the number of subjects in each group, while between groups sum of squares represents the sum of squared deviations between the mean for each group and the observed values of each subject within that group. Between groups degree of freedom (df) is given by the number of groups minus one while within group degree of freedom is the number of subjects minus number of groups minus one. When sum of squares is divided by degrees of freedom, the resulting term is known as mean square. The ratio of between groups mean square and within groups mean square is termed as F ratio, which is compared with the critical F for hypothesis testing. The last column of Table 4.6 shows that the ANOVA results are statistically insignificant. The non-significant values of 0.416, 0.863, and 0.656 associated with support for innovation, resource supply, and the level of innovation respectively indicate that there was no significant difference in an assessment of these variables by PMs and project team members.

Table 4.6 ANOVA Test: Agreement in Ranking

Dependent Variable	Subjects	N	Source of Variation	Sum of Squares	df	Mean Square	F	Sig. 2 tailed
Support for Innovation	Team member	91	Between Groups	24.18	1	24.178	0.666	0.416
	Project Manager	32	Within Groups	4395.65	121	36.328		
	Total	123	Total	4419.83	122			
Resource Supply	Team member	90	Between Groups	0.28	1	0.281	0.030	0.863
	Project Manager	32	Within Groups	1119.42	120	9.329		
	Total	122	Total	1119.70	121			
Level of Innovation	Team member	93	Between Groups	1.10	1	1.098	0.199	0.656
	Project Manager	32	Within Groups	677.67	123	5.510		
	Total	125	Total	678.77	124			

It is worth noting that the same checks for the validity of other measures was not possible for two reasons. First, the research design required PMs to respond basically on their individual, project and organizational measures; project team members, on the other hand, had to assess their PMs' observable behaviours and their effectiveness on project performance. Second, there was difficulty in administering the long questionnaire, which possibly could have prevented potential respondents from participation in the survey.

4.4.6 PM's Championing Behaviour Pattern

In order to identify the pattern of PM's championing behaviour, it is essential to identify the factors that describe it. This is commonly done by exploratory factor analysis technique that adopts Principal Components Analysis (PCA) for factor extraction. The goal of PCA is to extract maximum variance from the data set with each component. PCA is the solution of choice in reducing a large number of variables down to a smaller number of components.

In the present research, the researcher is interested in uncovering the underlying factors or dimensions of the PM's championing behaviour, which was measured by 33 items. However, before any further analysis is performed, it is necessary to examine whether or not the data follow certain characteristics. There are two tests that are commonly used by researchers for this purpose, Kaiser-Meyer-Oklin (KMO) Measure of Sampling Adequacy test and Bartlett's Test of Sphericity. The first criterion measures the adequacy of variables for conducting factor analysis. Kaiser has designated the following interpretation of this test result: A KMO measure of > 0.9 is marvelous, > 0.8 is meritorious, > 0.7 is middling, > 6 is mediocre, > 0.5 is miserable, and < 0.5 is unacceptable (George and Mallery, 2001). In this research, KMO measure of sampling adequacy for championing behaviour construct was 0.87, almost marvelous. The Bartlett's Test of Sphericity is a measure of the multivariate normality of the set of distributions. It also tests whether the correlation matrix is an identity matrix (factor analysis would be meaningless with an identity matrix). In the present analysis, this measure was found significant (p = 0.000), which indicates that the data do not produce an identity matrix and are thus approximately multivariate, supporting the factor analysis.

The 33 items representing the championing behaviour construct were factor analyzed using principal components analysis and varimax rotation. The analysis revealed the presence of six components with eigenvalues exceeding 1. Eigenvalue is the proportion of variance explained by each factor. The factors with eigenvalue less than 1 are generally considered insignificant. However, an inspection of the component matrix revealed that most of the items loaded on three factors. Interpretation of the scree plot (Figure 4.2) also suggested that three factors should be extracted. Therefore it was decided that three factors be extracted instead of six.

Table 4.7 presents the three-factor solution of championing behaviour with the corresponding item loadings. Only those items (shown in boldface, Table 4.7) that loaded strongly on a single factor with loadings greater than 0.40 were retained. 12 items either failed to load substantially on any of the factors or loaded on more than one factors, and thus they were removed from the analysis. The analysis finally left 21 items for the championing behaviour construct for use in the subsequent data analysis. Table 4.8

summarizes the extracted factors with corresponding eigenvalue and the percentage of variance explained by each of the factors.

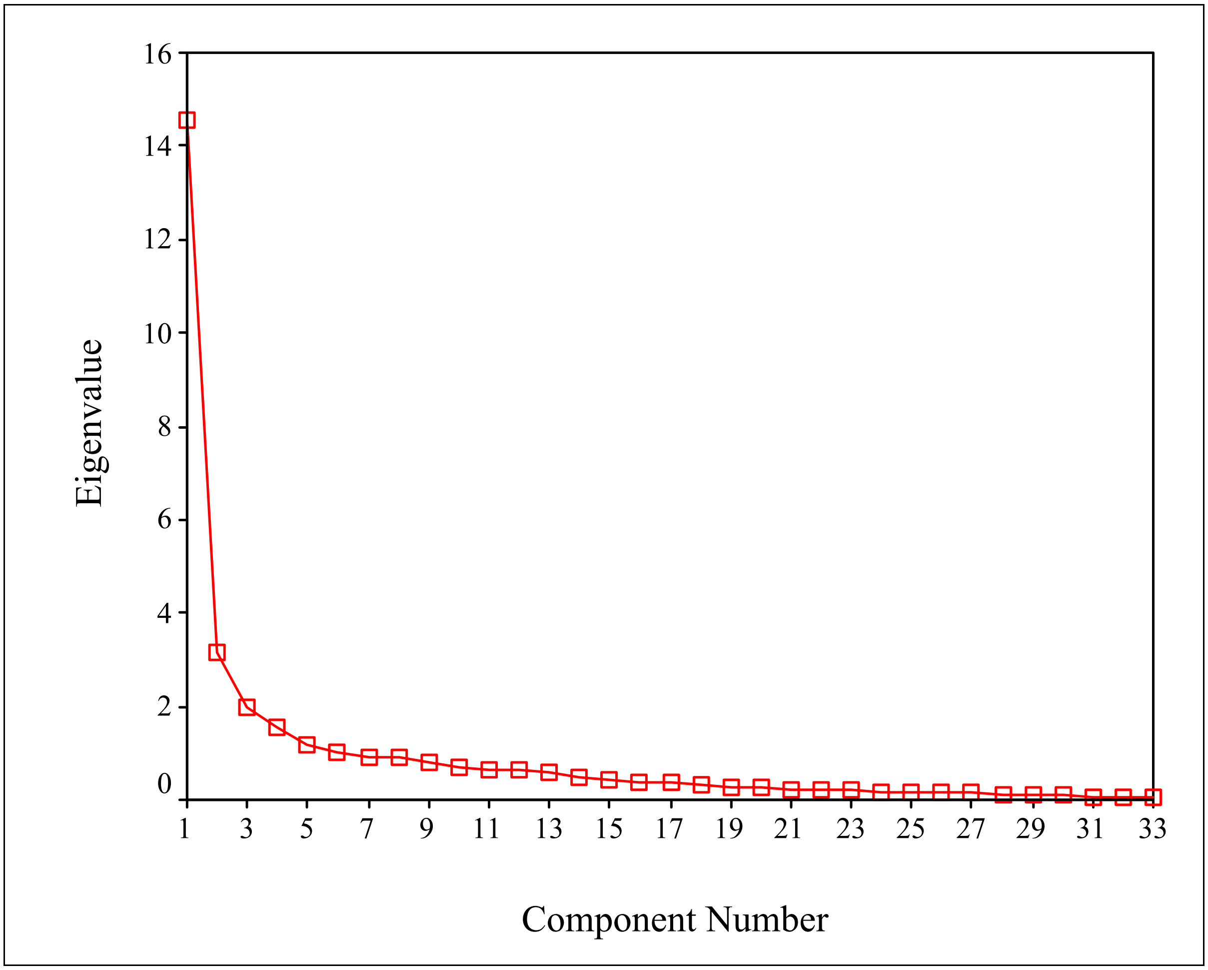


Figure 4.2 Scree Plot

The three-factor solution explained 59.7% of the variance in championing behaviour construct. It should be emphasized here that the more factors are extracted, the better the fit and the greater the percent of variance in the data explained by the factor solution is. However, the more factors are extracted, the less parsimonious the solution is (Tabachnick and Fidell, 2001). It is thus understandable that there is a tradeoff in the factor analysis.

Three factors as extracted from the analysis were interpreted as follows:

- Leads the innovation process (Factor 1) – Factor 1 comprised of 11 items. This factor, which explained 22.85% of the variance in the PM's championing, demonstrates the PM's leadership in coordinating the work and contribution of the project team members and project entities, and getting their support and involvement in the innovation process.

- Demonstrates commitment in the innovation process (Factor 2) – This factor contained six items explained 20.7% of the variance in the championing behaviour. The factor displays the PM's commitment in the innovation by taking risk, showing confidence, and commitment.

- Stimulates for innovation (Factor 3) – Factor 3 contained four items relating the PM's action towards promoting innovative ideas in the project. This factor explained 16.15% of the variance in the PM's championing behaviour.

Table 4.7 Results of a Principal Components of the Champion Behaviour Items

Items	**Champion Behaviour Category**	**Factor**		
		1	**2**	**3**
Retained Items:				
Accepts responsibility for the results	Leads the innovation process	**0.50**	0.19	0.28
Gives top priority to getting results		**0.57**	0.23	0.33
Co-ordinates the group and brings together the key individuals		**0.69**	0.32	0.10
Gets the necessary resources to implement new ideas		**0.55**	0.39	0.26
Backs the people involved		**0.66**	0.04	0.26
Builds trust		**0.83**	0.14	0.15
Gets the problems into the hands of those who can solve them		**0.64**	0.02	0.29
Gets support from the top level		**0.65**	0.31	0.10
Accepts feedback		**0.77**	0.16	0.20
Sets up harmonious and cooperative working environment amongst parties		**0.58**	0.25	0.10
Keeps project stakeholders involved in the process		**0.73**	-0.04	0.30
Challenges the way it has been done before as the only answer	Demonstrates commitment in the innovation process	0.26	**0.68**	0.04
Expresses confidence in what the innovation can do and achieve		0.06	**0.81**	0.32
Enthusiastically promotes the advantages of new ideas and solutions		0.24	**0.82**	0.22
Promotes and enthusiastically pushes innovation actively and vigorously		0.22	**0.86**	0.06
Shows optimism about the success of innovation		0.27	**0.80**	0.16
Shows tenacity in overcoming obstacles		0.17	**0.66**	0.37
Seeks out new technologies, process, techniques, and /or product ideas	Stimulates for innovation	0.26	0.28	**0.64**
Maintains a network of contacts		0.21	0.03	**0.70**
Seeks differing perspectives when solving problems		0.39	0.17	**0.62**
Gets others to look at problems from many different angles		0.3	0.33	**0.59**
Dropped Items:				
Creates the opportunities for improvement		0.42	0.14	0.76
Generates creative ideas and solutions		0.24	0.45	0.69
Experiments with ideas and solutions		0.02	0.48	0.61
Keeps informed of related development that occur outside the organization through journals, conferences, colleagues, and other companies		0.32	0.32	0.11
Suggests new ways of looking at how to complete an assignment		0.40	0.67	0.14
Displays a high level of energy and takes necessary risks to make innovations happen		0.10	0.65	0.58
Articulates the compelling vision of the future of innovation		0.15	0.66	0.47
Doesn't give up when others say it cannot be done		0.23	0.49	0.43
Persists in the face of obstacles, large or small		0.24	0.50	0.48
Knocks down barriers to the innovation		0.20	0.45	0.58
Makes improvements/adjustments based on feedback received		0.66	0.43	0.06
Convinces several organizations outside the contractor's firm of implementing ideas		0.60	0.45	0.09

Table 4.8 Summary Factor Statistics for the Champion Behaviour Measure

Factor	Eigenvalue	Percentage of Variance Explained	Cumulative Percentage of Variance Explained
1	14.57	22.85	22.85
2	3.15	20.73	43.58
3	1.99	16.15	59.73

4.4.7 Structural Model Analysis

Structural Equation Modelling (SEM) was used to examine the hypothesized structural model. It also enabled the researcher to identify the relationships between the latent variables. The estimated path coefficients would explain whether there is a significant negative/positive relationship between the variables as hypothesized in the structural model.

In the model analysis the latent variables or constructs were coded as shown in Table 4.9. This research adopted the SIMPLIS syntax in LISREL 8.52 to estimate the parameters. However, in the model, all constructs were operationalized either through a single/composite indicator or through their summed scaled indexes, resulting in one indicator per construct. For example, education and project complexity were single item measures while the project size and job tenure were composite measures. All other constructs used single indicator with summed scaled index. For instance, the level of innovation construct was measured by three items. For each subject, the scores on these three items (indicator variables) were added to derive a single indicator for this construct. Bentler and Chou (1987) suggest that the ratio of sample size to an estimated parameter should be between 5:1 and 10:1. The sample size to estimated parameters ratio in this research was 5.25:1. Had the multiple indicators been used in the analysis, the strategy to use LISREL would not have been possible, given the fact that most constructs in this research were measured using multiple indicators.

Table 4.9 Latent Variables and their Coding

Variable	Coding
Education	edu
Job Tenure	job_tenu
Project Size	pj_size
Project Complexity	pj_compl
Problem Solving Style	prob_sty
Influence Strategies	infl_str
Support for Innovation	sup_inn
Resource Supply	res_sup
Decision Authority	dec_auth
Championing Behaviour	champ
Level of Innovation	lvl_inn
Project Performance	pj_per

There are a number of researchers who have used single and/or composite indicators of latent variables in the SEM analysis (Williams and Hazer, 1986; Netemeyer *et al.* 1990; Scott and Bruce, 1994; Wayne *et al*., 1997). Netemeyer *et al*. (1990) have shown that path estimates combining indicator variables into composite scales incorporating random measurement error are virtually identical to those of the latent variables using multiple indicators. In this research, in order to incorporate the effects of random measurement error in the model, the factor loadings from indicator to latent construct were fixed to the square root of the coefficient alpha internal consistency estimate (reliability) for each construct, and their respective error terms were fixed to 1 minus alpha as suggested by Williams and Hazer (1986).

Further in this study, it was assumed that there was no measurement error for education. Cronbach's alpha for the job tenure and size of the project was each set at 0.95; for the project complexity, it was fixed at 0.90. All model tests were based on the covariance matrix and used maximum likelihood estimation as implemented in LISREL (Jöreskog & Sörbom, 1993). In the survey form, some negatively worded items had been used in the level of innovation, resource supply, and support for innovation constructs. In the analysis, those negatively worded items were reverse coded to enable consistency in the interpretation of the results.

Furthermore, in the estimation of the structural model, the exogenous variables were allowed to co-vary. It should be noted that endogenous variables can affect other endogenous variables, i.e. they can act as both independent and dependent variables. So in the structural model, decision authority, resource supply, support for innovation, education, job tenure, project size, project complexity, problem solving style and influence tactics are exogenous variables while championing behaviour, the level of innovation, and project performance are endogenous variables.

5. RESULTS AND DISCUSSIONS

5.1 Results

5.1.1 Correlation Results

Means, standard deviations, inter-correlations, and co-variances among the constructs are presented in Table 5.1. The job tenure and project size had zero mean value mainly because, as explained in the section 4.2.1, these variables were standardized. As explained earlier, this research used summed scale measure for each construct in the structural model analysis. As a result of that, the means and standard deviation reported in Table 5.1 vary in magnitude by large amounts. For instance, resource supply was measured by six items on a five-point scale, which means the total score for a subject to this construct can vary between 6 (minimum) to 30 (maximum). Similarly, the decision authority was measured on a scale of 5 by using nine items. Therefore, the total score for a subject to this construct can vary from 9 to 45. In table 5.1, the variances for the variables are shown in boldface along the diagonal; correlations for the variables fill lower half of the matrix while covariance matrix occupies off diagonal upper half of the matrix. The covariance matrix is used in the structural modelling.

The correlation results indicate that the PM's championing behavior significantly correlated with the independent variables, namely the PM's education (r = 0.19, $p < 0.05$), resource supply (r = 0.37, $p < 0.01$), support for innovation (r = 0.29, $p < 0.01$), influence tactics (r = 0.20, $p < 0.05$) and decision authority (r = 0.25, $p < 0.05$). However, the job tenure, size of the project, and problem solving style did not correlate with championing behaviour. The independent variables that were significantly related with the level of innovation were project size (r = 0.26, $p < 0.05$), resource supply (r = 0.37, $p < 0.01$), support for innovation (r = 0.40, $p < 0.01$), decision authority (r = 0.28, $p < 0.01$), and championing behaviour (r = 0.26, $p < 0.05$). The independent variables that were significantly positively correlated with project performance were influence tactics (r = 0.34, $p < 0.01$), championing behaviour (r = 0.60, $p < 0.01$) and the level of innovation (r = 0.28, $p < 0.01$). Problem solving style showed significant negative correlation (r = -0.19, $p < 0.05$) with project performance.

Table 5.1 Descriptive Statistics, Inter-correlations and Co-variances

	Variables	Means	S.D	1	2	3	4	5	6	7	8	9	10	11	12
1	Education	1.91	0.63	**0.40**	-0.03	-0.08	0.00	0.88	-0.32	0.45	0.20	-0.98	1.45	-0.23	0.25
2	Job Tenure	0.00	0.67	-0.07	**0.46**	0.15	0.36	2.13	0.11	0.42	-0.01	0.58	0.55	0.37	0.03
3	Project Size	0.00	0.88	-0.15	0.25	**0.79**	0.03	-0.23	0.25	0.09	0.24	-0.79	0.51	0.54	0.21
4	Project Complexity	4.63	1.41	0.00	0.38	0.02	**2.01**	0.02	1.68	0.57	0.17	2.16	2.24	0.46	1.24
5	Problem Solving Style	87.62	14.28	0.09	0.22	-0.02	0.00	**204.08**	0.64	0.57	-0.14	-0.80	9.49	5.20	-15.77
6	Influence Tactics	46.32	4.56	-0.11	0.03	0.06	0.26	0.01	**20.87**	3.11	2.74	16.10	11.24	1.73	8.98
7	Support for Innovation	50.33	5.97	0.12	0.10	0.02	0.06	0.00	0.11	**35.69**	6.50	10.04	20.62	5.50	11.89
8	Resource Supply	17.88	2.98	0.10	0.00	0.09	0.04	0.00	0.20	0.36	**8.91**	3.56	13.08	2.57	4.11
9	Decision Authority	31.94	5.49	-0.28	0.15	-0.16	0.27	-0.01	0.64	0.30	0.21	**30.21**	16.09	3.57	10.08
10	Championing Behavior	76.64	11.86	0.19	0.06	0.04	0.13	0.05	0.20	0.29	0.37	0.25	**140.73**	7.19	40.11
11	Level of Innovation	9.87	2.29	-0.16	0.24	0.26	0.14	0.16	0.16	0.40	0.37	0.28	0.26	**5.27**	3.68
12	Project Performance	38.33	5.65	0.07	0.00	0.04	0.15	-0.19	0.34	0.35	0.24	0.32	0.60	0.28	**31.98**

Note: a) N = 94; correlations fill lower half of the matrix; the variance/covariance matrix occupies diagonal and off diagonal upper half of the matrix.

b) Correlations with an absolute value greater than 0.19 and 0.27 are significant at $p < 0.05$ and $p < 0.01$ respectively.

5.1.2 Model Fit Statistics

The fit statistics for the hypothesized model indicated an acceptable fit of the model to the data. The chi-square was 9.65 (df = 9, p = 0.38, ns). A non-significant chi-square indicates that the model fits the data. Other fit indices for the overall model were: goodness of fit index (GFI = 0.98), adjusted goodness of fit index (AGFI = 0.86), normed fit index (NFI = 0.97), non-normed fit index (NNFI = 0.98), incremental fit index (IFI = 1.00), comparative fit index (CFI = 1.00), relative fit index (RFI = 0.77). These indices also indicate an acceptable fit of the model to the data (Kelloway, 1998).

Standardized parameter estimates for the hypothesized model with corresponding standard error of estimate are presented in Table 5.2. The interpretation of the standardized parameter estimates is straightforward. Their magnitudes show the resulting change in a dependent variable from a standard deviation change in an independent variable. The direction of the change is captured by the sign of the relevant parameter i.e., positive signs signify an increase in the value of the dependent variable and negative signs a decrease). The standard error shows how precisely the value of the parameter has been estimated: the smaller the standard error, the better the estimation (Diamantopoulos and Siguaw, 2000). If the value of a parameter is divided by its standard error, the t-value is obtained. The t-values are used to determine whether a particular parameter is significantly different from zero in the population; t-values between –1.96 and 1.96 indicate that the corresponding parameter is not significantly different from zero (at the 5% significance level) while t-values between –1.645 and 1.645 indicate that the corresponding parameter is not significantly different from zero (at the 10% significance level). Larger t-values signify significant relationships at a lower significance level.

Table 5.2 Standardized Path Estimate for Hypothesized Model

Dependent Variable	Independent Variable	Standardized Path Estimate	Standard Error	T-Value
Championing Behaviour	Education	0.23	0.110	2.18 **
	Job Tenure	-0.02	0.130	0.15
	Project Size	0.11	0.120	0.92
	Project Complexity	0.05	0.110	0.50
	Problem Solving Style	0.04	0.096	0.44
	Influence Tactics	0.00	0.130	0.00
	Support for Innovation	0.09	0.110	0.89
	Resource Supply	0.25	0.110	2.38 ***
	Decision Authority	0.24	0.160	1.51
Level of Innovation	Project Size	0.29	0.093	3.10 ***
	Project Complexity	0.05	0.093	0.58
	Problem Solving Style	0.17	0.087	1.92 *
	Support for Innovation	0.25	0.099	2.59 ***
	Resource Supply	0.21	0.100	2.03 **
	Decision Authority	0.19	0.099	1.93 *
	Championing Behaviour	0.04	0.096	0.41
Project Performance	Problem Solving Style	-0.25	0.078	3.21 ***
	Influence Tactics	0.21	0.100	2.04 **
	Decision Authority	0.02	0.100	0.17
	Championing Behaviour	0.53	0.079	6.63 ***
	Level of Innovation	0.15	0.084	1.80 *

* $p < 0.10$

** $p < 0.05$

*** $p < 0.01$

The analysis results in Table 5.2 suggest that the championing behaviour was predicted by resource supply (ß = 0.25, $p < 0.01$) and education of the PM (ß = 0.23, $p < 0.01$). But the championing behaviour was not predicted significantly by other variables as hypothesized in the model. The level of innovation was predicted significantly by decision authority (ß = 0.19, $p < 0.10$), support for innovation (ß = 0.25, $p < 0.01$), resource supply (ß = 0.21, $p < 0.01$), size of the project (ß = 0.29, $p < 0.01$), and problem solving style (ß = 0.17, $p < .01$). But, championing behaviour did not significantly predict the level of innovation on site (ß = 0.04, ns). Both championing behaviour ($\gamma = 0.53$, $p < 0.01$) and the level of innovation ($\gamma = 0.15$, $p < 0.10$) subsequently predicted project performance. In addition, influence tactics (ß = 0.21, $p < 0.01$) and problem solving style (ß = - 0.25, $p < 0.01$) both predicted project performance. Decision authority of the PM, however, did not contribute to predict project performance. It should be emphasized that the structural coefficients relating exogenous variables to endogenous variables are denoted by beta (β) and the structural coefficients relating endogenous variables to other endogenous variables are denoted by gamma (γ).

The structural equations for three dependent variables (i.e., championing behaviour, the level of innovation, and project performance) are shown below in Equations 1 through 3. The model accounted for 24%, 37% and 49% of the variance in championing behaviour, the level of innovation and project performance respectively.

Structural Equations:

champ = 0.23 * edu – 0.02 * job_tenu + 0.11 Pj_size + 0.056 * pj_compl + 0.25 * res_sup + 0.095 * sup_inn – 0.00038 * infl_str + 0.043 * prob_sty + 0.24 * dec_auth; $\mathbf{R^2 = 0.24}$ (1)

lvl_inn = 0.039 * champ + 0.29 * pj_size + 0.054 * pj_ compl + 0.21 * res_sup + 0.25 * sup_inn + 0.17 * prob_sty + 0.19 * dec_auth; $\mathbf{R^2 = 0.37}$ (2)

pj_per = 0.53 * champ + 0.15 * lvl_inn + 0.21 * infl_str – 0.25 * prob_sty + 0.017 * dec_auth; $\mathbf{R^2 = 0.49}$ (3)

The standardized solutions from the LISREL output are presented in Figure 5.1, where X1, X2, … X12 represents observed or manifest variables. The latent variables or constructs are shown in ovals. The one-way arrows pointing towards the observed variables are the residuals, which are also called unique factors or error variances. These error terms are usually interpreted as errors (or observational errors) in the observed variables. The arrows linking the latent variables with the corresponding observed or indicator variables are standardized factor loadings. The paths connecting latent variables are path coefficients. These are the standardized parameter estimates (in regression terms, the βs).

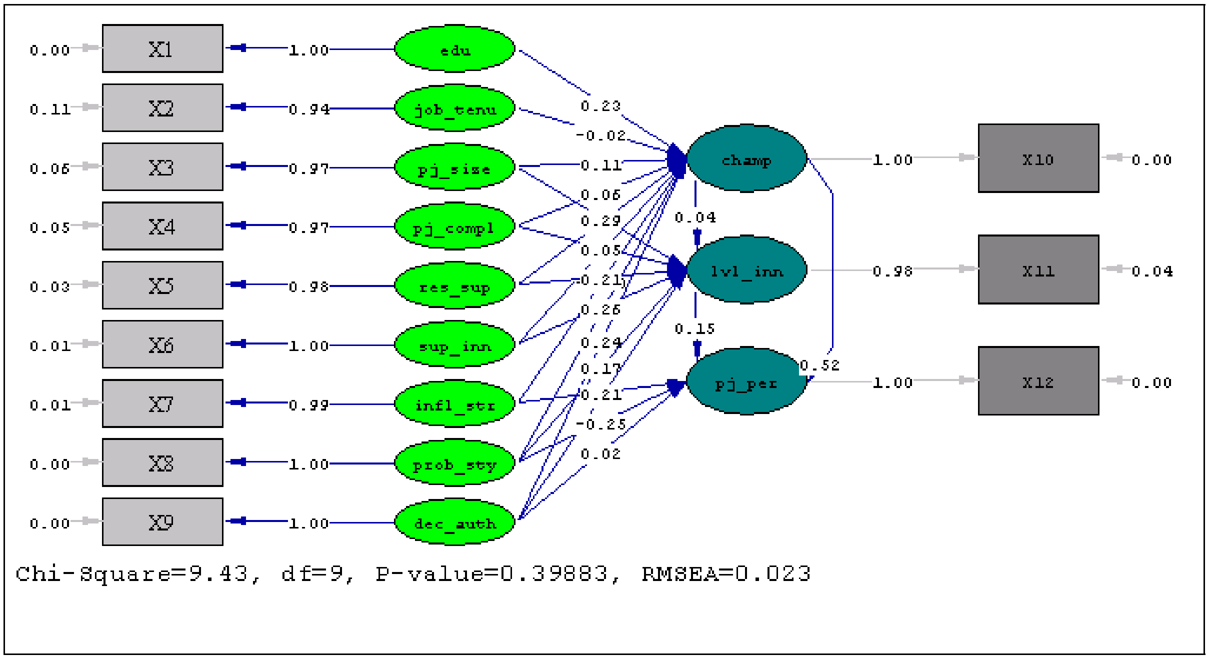


Figure 5.1 Basic Model: Standardized Solution

Figure 5.2 presents the final model with non-significant paths deleted. The numbers in the path diagram are standardized beta coefficients and are interpreted exactly the same as betas derived from multiple regression analyses. Deleting the non-significant paths from the model did not result in a significant change to model fit [$\chi^2_{\text{difference}}$ = 18.67 – 9.65 = 9.02 with 19 – 9 = 10 df]. Because the critical value for χ^2 with 10 degrees of freedom (df) at 0.05 significance level is 18.30, and the obtained value {9.02} was less than the critical value {18.30, it is concluded that there is no significant difference between the two models (Kelloway, 1998).

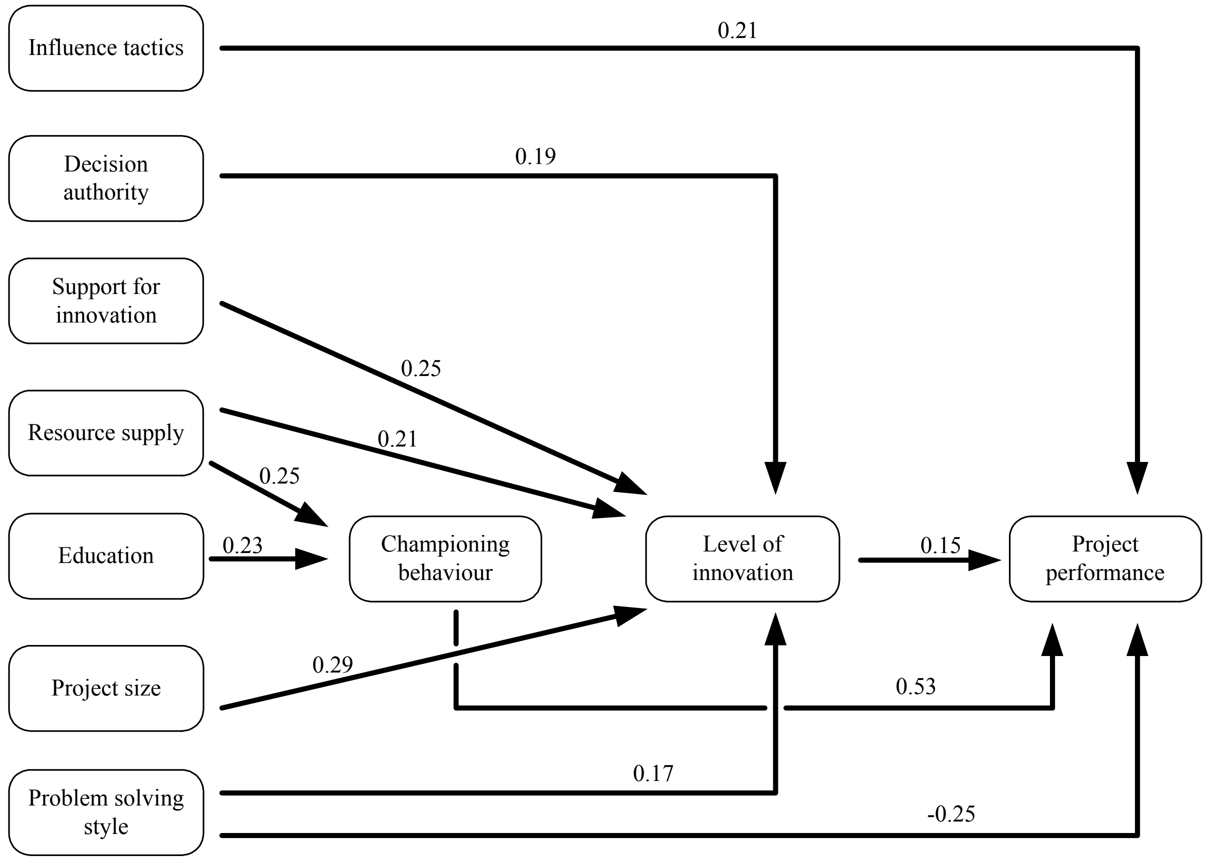


Figure 5.2 Revised Model with Non-significant Paths Deleted

5.2 Discussions

The study has provided the empirical evidence that the PM as a champion of innovation in construction has multiple roles. This somehow contradicts the discussions of champions found in manufacturing and R&D organizations or in a new product development process, in that champions generally take a particular role.

PMs can influence construction innovation in a number of ways. For instance, the leadership of the PM provides direction and leads the project team towards common goals. Thus, PMs should understand the project environment and context, ability and willingness of the team members and, then, choose an appropriate leadership style. The PM as a leader can convince and sell innovative ideas to potential allies, and obtain necessary support and approval from them; coordinate different entities such as subcontractors, designers, and other approval agencies; and facilitate the implementation of internally generated and/or imitated ideas in the project.

Another major role that PMs can play is to combine the creativity of project team members and facilitate idea generation among them. They can integrate or channel necessary information from various sources; promote the generation of new ideas by motivating and inspiring team members and encouraging individuals to work together to innovation. Moreover, PMs, to some extent, could act as a pressure agent forcing team members to increase their efforts towards innovation. This would arise when team members were not paying attention to the development of new ideas to address project challenges, as it is difficult to channel and direct individuals' action thresholds to pay attention to the needs and opportunities and, only crises, dissatisfaction, tension, or significant external stress stimulate people to act (Van de Ven, 1986).

Finally, PMs need to exhibit commitment in the innovation process by expending their energy, taking responsibility and reasonable risk. As innovation would bring changes or even certain risks or uncertainties, the PM's conviction and confidence can overcome inertia and resistance and provide impetus to those who are involved in the innovation.

The survey results showed that PMs' education is positively related to championing, indicating the extent to which PMs rely on their personal knowledge to become an effective innovation champions. Also, as expected, the size of the project is positively related to the level of innovation on site. This result may reflect the level of resources available for the project, the number of opportunities to innovate, as well as the opportunity to benefit more from a particular innovation. It may be in the best interest of an organization to recognize the innovation opportunities in the project and create an environment that would enable and demand the appropriate innovative behaviour of project participants.

5.2.1 Tests of Hypotheses

Turning to the research hypotheses, the first part of Hypothesis 1, which stated that the PM's innovative problem solving style is positively related with PM's championing behaviour was not supported. No significant path from problem solving style to championing behaviour was observed. The mean KAI score for PMs in this research was 87.62 (SD = 14.28). The KAI construct contains three sub-constructs, namely, Sufficiency vs. Proliferation of Originality (O), Efficiency (E), and Rule/Group Conformity (R). The equivalent scores for O, E, and R factor in this research were 87.98, 81.06, and 91.03 respectively. The mean KAI score and equivalent scores for each of the three sub-constructs, which is less than the empirical mean score of 95, indicates that PMs have an adaptive problem solving style. The result is not surprising in that the construction work environment normally insists on conformity, reliability, efficiency, and operating within present practices and procedures.

The research provided the evidence for the second part of Hypothesis 1, as innovative problem solving style of the PM significantly contributed to increase the level of innovation on site. This is probably explained from the fact that the PM's innovative attitude can be expected to bring new possibilities of trying new approaches or methods on site. Interestingly, the results also revealed the significant negative path coefficient from problem solving style to project performance. Discussions with the five PMs revealed that the construction project environment offered less flexibility and more adherence to established rules and disciplinary regulations. They felt that innovators who may undermine established organizational policies and practices might trigger an increased risk on project objectives. In this case, securing the support of project parties may become increasingly challenging. Organizations may thus face the paradoxical challenge of maintaining the satisfaction level of their current stakeholders while seeking new opportunities and more effective ways of delivering products (Bobic *et al*., 1999). This would require organizations restructuring the environment and/or programs to enable innovation on site without sacrificing project objectives.

The first part of Hypothesis 2, which claimed that the influence tactics would significantly contribute to predict championing behaviour, was not supported. Despite the significant correlation between influence tactics and championing behaviour (see Table 5.1; r = 0.20, $p < 0.05$), structural analysis did not reveal the significant relationship between these variables. It seems to suggest that PMs who claimed to be engaging in frequent influence tactics were not perceived by their subordinates as exercising frequent championing compared to those who engaged in less frequent influence attempts. It is observed from Table 5.1 that influence tactics strongly correlated with decision authority, which also correlated significantly with championing. However, when the effect of decision authority was partialed out or removed, the correlation between influence tactics and championing was negligible.

It appears that PMs would use influence attempts more frequently when they did not have sufficient decision-making power. Sotlrlou and Wittmer (2001) also reported that PMs used different influence tactics to overcome the authority gap. As expected, influence tactics significantly influenced project performance. In the current study, some PMs revealed that they used their authority to influence subordinates to get work done as they wished, while seeking support from other project stakeholders and securing adequate resources from the head office.

Table 5.3 presents descriptive statistics of four influence tactics. The results suggest that consultation, inspirational and rational persuasion are frequently used influence tactics or strategies by PMs, whereas coalition is less often used.

Table 5.3 Summary Statistics for Influence Tactics

Influence Strategies	Mean	Median	Mode	SD	Percentiles		
					25	50	75
Rational Persuasion	3.56	3.71	3.86	0.47	3.14	3.71	3.85
Consultation	3.95	4.00	4.00	0.40	3.67	4.00	4.33
Inspirational	3.66	3.75	4.00	0.44	3.25	3.75	4.00
Coalition	2.88	2.80	2.80	0.58	2.40	2.80	3.25

In regard to Hypothesis 3, no significant path was observed between support for innovation and championing behaviour. However, the structural model supported the last part of the hypothesis, which posited that the perceived degree of support for innovation would significantly predict the level of innovation. Hypothesis 4, which postulated that resource supply would be positively related with championing behaviour and the level of innovation, was supported from the analysis. It appears that PMs tend to give more emphasis to resources compared to support for innovation. Project participants might also have perceived support for innovation measure less precisely as it had more abstract sense than resource supply. Many PMs in this study pointed out that very tight schedule and undue emphasis on cost cutting measures impeded their ability to innovate. Some of the PMs even pointed to the economic recession, lowest bidding practices, and very short project duration as a hindrance to innovations.

The significance of "resource supply" and "support for innovation" factors in predicting the level of innovation indicates that project team members can be motivated to enhance the level of innovation on site by providing adequate resources and support for innovation. Senior management may, therefore, respond to this by ensuring that the necessary funds, materials, information, and personnel are committed to supporting the innovation effort. These results are supported by a previous study, which has shown that a solid commitment from the company to encourage and try new ideas has created the environment conducive for innovation (Tatum, 1987). A sustained support for innovation would also motivate team members. In this study PMs have expressed the view that support for innovation serves as a backing for implementation of ideas that usually have high risks and uncertain results.

Hypothesis 5, which posited a positive relationship between decision authority and championing behaviour, level of innovation, and resource supply, was partially supported; only the level of innovation, but not championing behaviour and project performance, was significantly related to decision authority of the PM. Despite the high beta coefficient, the relationship between decision authority and the level of innovation was less significant owing to the high standard error (($ß = 0.24$, standard error = 0.16, see Table 5.2), but the relationship is as hypothesized, i.e. higher decision authority is associated with higher championing behaviour. The significant positive relationship between decision authority and the level of innovation suggests that the PM must have sufficient power to introduce innovative ideas in the project. However, construction business is known to be plagued by lack of trustworthiness, unnecessary bureaucracy, and delay in decision-making process.

The non-significant path from decision authority to project performance is probably explained by the fact that other factors that were beyond the control of the PM might have mediated such a relationship. For instance, frequent change orders, design changes, incomplete design, and default of a subcontractor, just to name a few, would adversely affect project performance. The author also tested the possibility that decision-making authority (DMA) would probably have an influence on project performance above some threshold level. For this purpose, DMA scores for the subjects were divided into two categories (≤ 3.5 and > 3.5) and the regression test was performed for each of them. It was observed that DMA significantly predicted project performance ($r = 0.365$; $R^2 = 0.133$; $\beta = 0.365$; $p = 0.017$) when its value was less than or equal to 3.5. But DMA above such a threshold level had less direct influence on performance ($r = 0.049$; $R^2 = 0.002$; $\beta = 0.049$; $p = 0.731$, ns).

Hypothesis 6 regarding positive relationship between championing behaviour with the level of innovation and project performance was partially supported. It was found that only project performance was strongly related to championing behaviour. One possible explanation for the lack of significant relationship between championing and the level of innovation is probably due to the existence of additional intervening variables such as innovation efforts of team members and the implementation of ideas that would also influence the innovation process.

Finally, Hypothesis 7, which stated that an increased level of innovation on the project would help to increase project performance, was supported at 0.10 significance level. It is possible that from the time innovative practices are introduced in a project to when improved project performance is recognizable to project participants can take significant project time. To further explore the effect of the level of innovation on each project performance measure, the author performed additional regression analyses. The level of innovation was regressed on each of the project performance measures (indicators). Table 5.4 shows the results.

Table 5.4 Regression Output of Innovation with Project Performance Indicators

Project Performance Indicators	**Constant**	**Standardized Coefficient (Beta)**	**Adjusted R^2**
Facilitate learning within the project	2.85	0.243 **	4.9
Enable continuous improvement	2.92	0.238 **	4.6
Enhance client satisfaction	3.32	0.207 **	3.2
Enhance the image of the company	3.07	0.288 ***	7.3
Enable competitive advantages to the company	3.14	0.172 *	1.9
Retain talents with the company	3.43	0.048	0.9
Finish project on time	3.40	0.144	1.0
Finish project within the budget	3.28	0.182	2.2
Promote better safety practices	3.11	0.229 **	4.2
Increase level of productivity on this project	3.31	0.247 **	5.1
Lead to improved project team satisfaction	3.09	0.235 **	4.5
Enable and motivate innovation on this site	2.85	0.243 **	4.9

All regression constants were significant at $p < 0.000$

* $p < 0.10$

** $p < 0.05$

*** $p < 0.01$

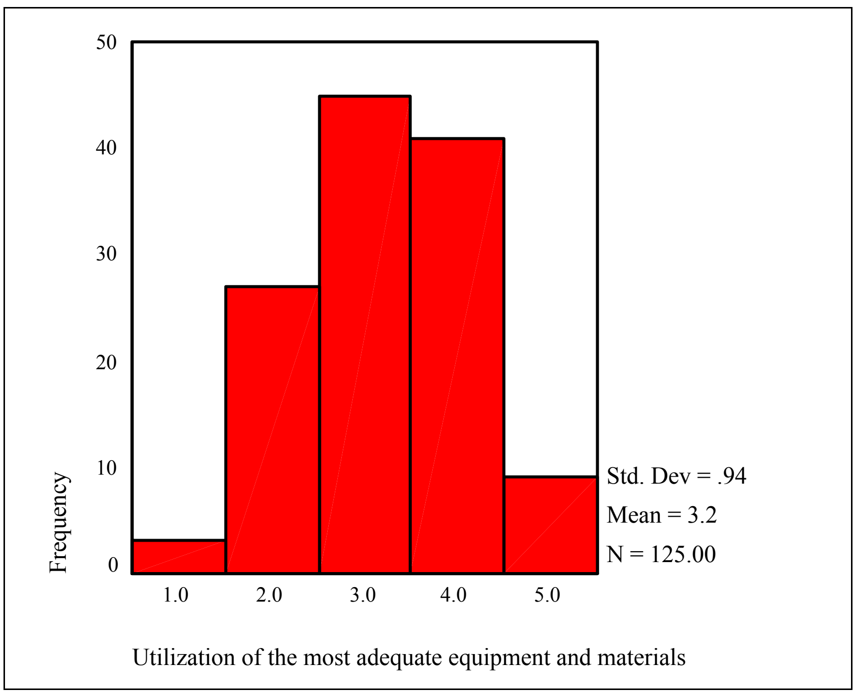
It was found that the level of innovation had less effect on cost and schedule. Also, a lack of significant relationship between the level of innovation and the extent to which the construction company could retain talents was found. As shown in Table 5.4, the level of significance for other project indicators, which varied from 0.10 to 0.01, indicated their strong relationship with the level of innovation. The above analysis implies that innovation may bring long-term benefits to a construction company but relatively less measurable impact on the project where it was first implemented.

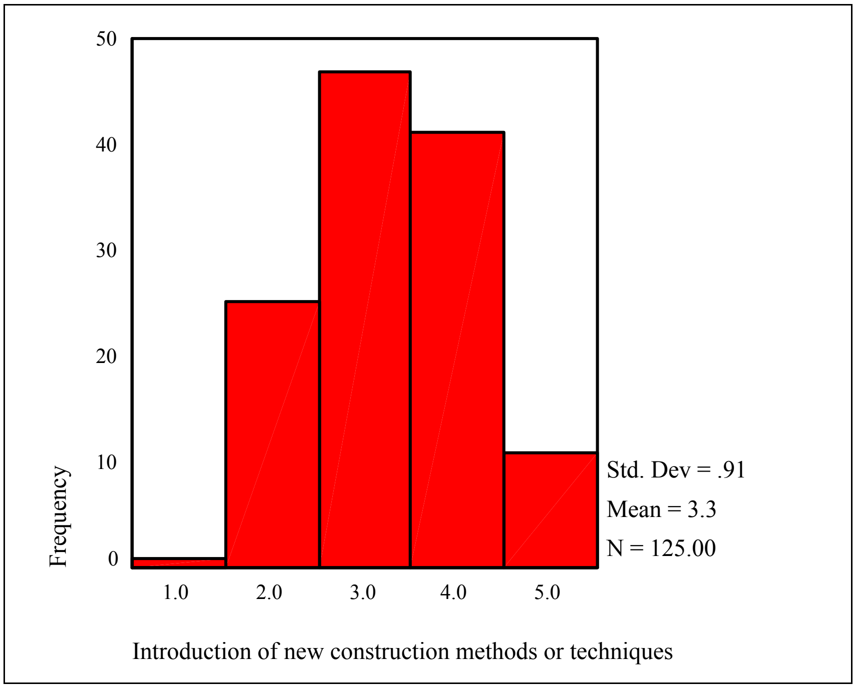
5.2.2 The Level of Innovation on Projects

As discussed in the previous chapter, the level of innovation on projects was measured by three items that reflected the extent to which innovative practices had been adopted on construction sites. PMs and project team members assessed the level of innovation by indicating their response on a scale of five, where 1 means ‘strongly disagree’ and 5 means ‘strongly agree’. The frequencies of innovative practices, as indicated by the practitioners on each of the three measures of innovative practices, are presented in Table 5.5 and Figures 4.5a through 4.5c.

Table 5.5 Frequencies of Innovative Practices on Site

Innovative Practice	Frequency (N = 125)				
	1	**2**	**3**	**4**	**5**
1. This project is a little bit behind in utilizing the most adequate equipment and materials.	3 2.4%	27 21.6%	45 36.0%	41 32.8%	9 7.2%
2. This project has not introduced any new construction methods or techniques.	1 0.8%	25 20.0%	47 37.6%	41 32.8%	11 8.8%
3. This project is very behind in the application of new ideas in the planning, organizing and management of work on site.	3 2.4%	15 12.0%	42 33.6%	47 37.6%	18 14.4%
1= Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree					





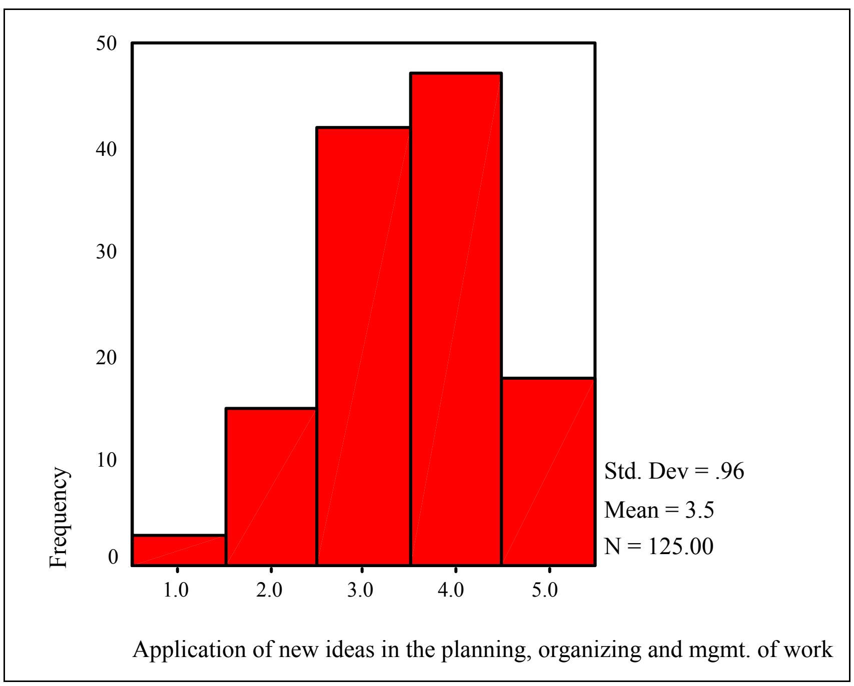


Figure 5.3a-c On-Site Innovative Practices

Although about one third of the practitioners maintained their indifference by choosing "neither agree nor disagree category" of the five-point scale, the distribution of response across the scale gives some insights. It was observed that practitioners strongly disagreed that their sites had not adopted any form of innovative practices, as there were a negligible number of respondents in this category. Results in Table 5.5 show some similarities in the way respondents assessed the first two innovative measures. About one fifth of the respondents (≈ 20%) disagreed that their sites had not utilized the most adequate equipment and materials or had not introduced the new construction methods or techniques. However, a large number of practitioners (see the percentage values under 'agree') agreed with those statements. There were also a significant number of respondents that strongly felt that their sites were falling behind in those aspects.

In terms of application of new ideas in the planning, organizing, and management of work on site, only 12% respondents denied that they had not applied any new ideas. However, about 38% of the respondents agreed that their project was lacking in the application of new ideas in the planning, organizing, and management of work on site. Furthermore, about 14% respondents even strongly agreed with the former group of respondents. The above results may suggest that only few projects had actually been engaged in innovation. A large number of construction projects however seemed not to have been able to utilize innovative ideas, new construction methods or techniques, and even the most adequate equipment and materials on their sites. Therefore, there is a need for and impetus from the concerned parties to enhance innovation on construction projects.

5.2.3 Effect of Other Situational Variables

Many situational factors, which were not included in the path analysis, may also influence the PM's championing behaviour and the level of innovation. The influence of those variables was analyzed, using non-parametric tests that included Mann-Whitney test and Kruskal-Wallis test. These tests were chosen for analyses as the sample sizes were not identical among the categories and the tests required few or no assumptions about the shape of the underlying distributions. Mann-Whitney test is the most commonly used alternative to the independent-samples t-test while Kruskal-Wallis test is a nonparametric alternative to one-way ANOVA.

The Mann-Whitney test was used to analyze the influence of procurement type, project category, pricing provision and the company status on two dependent variables – championing behaviour and the level of innovation. Each independent variable has two groups. For example, as shown in Table 5.6 under the procurement type, the two groups are whether the project was design & build or design-bid-build. The term 'N' represents a number of samples in each group. The mean ranks shown indicate whether there are more high ranks in one group than in the other. For example, in the second row of Table 5.6, the mean rank for design & build is higher (46.54) than the mean rank for design-bid-build (32.03). The assigned ranks in each group are added and shown under the sum of ranks column. The Mann-Whitney U statistics is the number of times members of the lower-ranked group precede members of the higher-ranked group. Z is the standardized score associated with the significance value; in the above case, the value of Z is –2.801 associated with the significance value, $p = 0.005$. Since the p-value is small (less than 0.05), it is concluded that design & build projects scored significantly higher in the level of innovation than design-bid-build projects.

The results of the Mann-Whitney test are presented in Table 5.6. It was suggested that there was no significant difference between design & build and design-bid-build projects in the way they affected championing behaviour. However there was significant difference in the level of innovation with these types of procurement systems; the mean ranking for design and build type of project delivery was higher than the traditional (design-bid-build) one. Nam and Tatum (1992a) found that separate design and construction, lowest bid, and fixed price, could be a hindrance to innovation.

It is also known that the design-build approach of production provides close cooperation between design and construction from start to finish and possibility of using fast-track construction methods. Nam and Tatum (1992b) reported that projects with design-build contract facilitated a high degree of interaction between the design and production functions and was closely linked to successful innovations. The need towards an increased level of innovation in Singapore construction through the use of design and build type of contract has also been echoed in a recent study by Dulaimi *et al*. (2002) and in the report of C21 (1999).

Table 5.6 Results of the Mann Whitney Test

Dependent Variable	Categorical Variable	N	Mean Rank	Sum of Rank	Mann Whitney U	Z	Sig. (2-tailed)
Championing	Procurement Type						
	Design & Build	22	33.00	726.00	473.00	0.000	1.000
	Design-Bid-Build	43	33.00	1419.00			
	Total	65					
Level of Innovation	Procurement Type						
	Design & Build	25	46.54	1163.50	361.50	-2.801	0.005
	Design-Bid-Build	48	32.03	1537.50			
	Total	73					
Championing	Project Category						
	Public Projects	35	39.44	1380.50	750.50	-0.520	0.603
	Private Projects	46	42.18	1940.50			
	Total	81					
Level of Innovation	Project Category						
	Public Projects	38	38.28	1454.50	713.50	-2.266	0.023
	Private Projects	52	50.78	2640.50			
	Total	90					
Championing	Pricing Provision						
	Lump Sum Contract	54	36.70	1982.00	497.00	-0.826	0.409
	Unit Price Contract	21	41.33	868.00			
	Total	75					
Level of Innovation	Pricing Provision						
	Lump Sum Contract	60	43.05	2583.00	567.00	-0.986	0.324
	Unit Price Contract	22	37.27	820.00			
	Total	82					
Championing	Company Status						
	Local	67	42.18	2826.00	457.00	-0.546	0.585
	Foreign	15	38.47	577.00			
	Total	82					
Level of Innovation	Company Status						
	Local	72	40.57	2921.00	293.00	-3.622	0.000
	Foreign	18	65.22	1174.00			
	Total	90					

The Mann-Whitney test also confirmed that there was no significant difference between public and private types of project in the way they influenced championing behaviour of the PM ($U = 750.50$, $N_1 = 35$, $N_2 = 46$, $p = 0.603$, two-tailed). There was however the significant difference in the level of innovation ($U = 713.50$, $N_1 = 38$, $N_2 = 52$, $p = 0.023$, two-tailed), public projects being ranked lower than the private projects. One possible explanation for this is the effect of type of contract being used by the public and private owners. For public agencies, competitive bidding on lump-sum basis is seen as an efficient way to reach the market price and eliminate the possibility of favoritism and corruption (Gordon, 1994). In this study none of the public projects were awarded on a design-build basis.

The results of the Mann-Whitney test showed no significant difference in championing behaviour as well as in the level of innovation for lump sum contract and unit price/BQ contract. The test results also showed no significant difference between local and foreign contractors carrying out the projects in the championing behaviour. However, there was a significant difference in the level of innovation between the two ($U = 567$, $N_1 = 72$, $N_2 = 18$, $p = 0.000$, two-tailed). Projects that were undertaken by foreign contractors ranked significantly higher than those constructed by local contractors. Ofori *et al.* (1999) observed that foreign contractors were superior to local contractors in terms of capacity, capability, and competitiveness. As a result, foreign contractors dominated large and complex projects. Furthermore, they adopt strategies such as bidding selectively, adopting innovative project procurement approaches, offering the financial package and providing better quality service to owners. Apparently, foreign contractors could have ranked high in the level of innovation as they could have put more emphasis on innovative construction.

The Kruskal-Wallis test was used to analyze the influence of the condition of contract used in a project and the type of construction on PMs' championing behaviour and the level of innovation. The Kruskal-Wallis test can be considered as an extension of the Mann-Whitney test, except that there are more than two groups. The results of the Kruskal-Wallis test are shown in Table 5.7. The calculated value for the Kruskal-Wallis is assessed for significance using chi-square distribution. The degrees of freedom (df) are the number of levels of the factor minus 1. The other terms are interpreted in the same way to that of the Mann-Whitney test.

The results of the Kruskal-Wallis test in Table 5.7 indicate that there was no significant difference among the contracts – SIA Standard form of Building Contract, PSSCOC, JCT, and HDB type of contract – in the way they could influence championing behaviour and the level of innovation. The level of significance for championing (p = 0.110) and the level of innovation (p = 0.647) were insignificant. The test also confirmed that there was no significant difference in championing behaviour for different types of construction viz. residential, commercial, industrial, infrastructure and industrial.

However, the Kruskal-Wallis test showed a significant difference in the level of innovation for these types of construction (chi-square = 9.081, df = 4, p = 0.059, two-tailed). To confirm which group had a difference, the Mann-Whitney test was used using two different groups at a time. It was found that there was a significant difference in the level of innovation between residential construction and industrial construction (Mann-Whitney U = 352.50, N_1 = 46, N_2 = 24, p = 0.013, two-tailed). The industrial construction ranked higher than the residential construction. The industrial projects are generally large, complex and more sophisticated to construct than residential projects. They often demand a new technique, construction methods, and so forth. As such, the level of innovation in industrial construction could have ranked higher.

Table 5.7 Kruskal-Wallis Test Results

Dependent Variable	Categorical Variable	N	Mean Rank	Chi-Square	df	Sig. (2 tailed)
Championing	Conditions of Contract					
	SIA Bldg. Contract	44	36.90	6.039	3	0.110
	PSSCOC	17	45.62			
	JCT	6	36.83			
	HDB type	7	22.14			
	Total	74				
Level of Innovation	Conditions of Contract					
	SIA Bldg. Contract	49	42.93	1.653	3	0.647
	PSSCOC	18	36.17			
	JCT	6	45.67			
	HDB type	8	36.56			
	Total	81				
Championing	Type of Construction					
	Residential	44	38.27	0.384	4	0.984
	Commercial	6	39.67			
	Industrial	18	40.64			
	Infrastructure	4	42.25			
	Institutional	6	43.08			
	Total	78				
Level of Innovation	Type of Construction					
	Residential	46	39.18	9.081	4	0.059
	Commercial	6	47.75			
	Industrial	24	54.75			
	Infrastructure	5	26.10			
	Institutional	6	49.08			
	Total	87				

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This research examined the role of the Project Manager (PM) as a champion of innovation and the effectiveness of such a role in enabling innovative practices on site and to improve project performance. The research developed a structural model of innovation and project performance, focusing on individual and situational factors and the PM's championing behaviour. Data for this research were collected using a questionnaire survey conducted with PMs and their project team members working for general contractors in Singapore. Structural Equation Modelling (SEM) technique was used to examine the model and to test the hypothesized relationships in the model. The model provided an acceptable fit to the data. The model accounted for 24%, 37%, and 49% of the variance in championing, the level of innovation, and project performance respectively.

In addition, this research explored several situational factors and their influence in the PM's championing behaviour and the level of innovation on a project site. The research results have provided insights and contributed to our understanding of innovation in construction through an empirical study. Furthermore, the results could be useful for practitioners in Singapore to prepare for the knowledge-based economy, and to increase industry competitiveness through innovation. From this research several conclusions can be drawn; they are summarized below.

- The study has provided the evidence that the role of the PM as a champion of innovation is multi-faceted. In the construction project environment, the PM's role is that of a leader, facilitator, coordinator, information integrator and team leader.

- Three critical dimensions of championing behaviour of the PM were identified. The first and foremost important role of the PM is leadership. The PM as a leader needs to coordinate with project team members and project entities and get their support and involvement in the innovation process. The second factor relates to the PM's commitment in the innovation process by taking risk, showing confidence, and conviction. The third factor is a PM's role as a stimulator for innovation that promotes innovative ideas on the project.

- The results indicated that the PM's multifaceted role in championing construction innovation has a significant influence in achieving project goals and objectives and in increasing the innovative practices on site.

- Another important finding of this research is a high degree of positive association observed between PM's education and championing behaviour.

- The supportive organizational climate was perceived as the most important factor for innovation, as indicated by the survey results. In addition to a sustained organizational support, providing autonomy and decision authority to the PM are equally important for the successful implementation of innovation, which was confirmed by the current study and from previous research as well (Nam and Tatum, 1997).

- The research results showed that the extent of resource supply in a project significantly impacted the championing role of the PM.

- The PM's use of influence tactics contributed significantly to project performance. The survey results also suggested that consultation, inspirational, and rational persuasion are frequently used influence tactics (strategies) by PMs while coalition tactic is less often used.

- The PM's championing was also found to have been significantly influenced by size of the project. This is an indication that an organization should recognize the opportunity to innovate working on a large project by facilitating the role of the PM.

- The research results indicated that an increased level of innovation could positively impact on project performance. However, the level of innovation on a project was perceived as having less effect on the cost and schedule performance. But other project performance indicators such as organizational learning, competitive advantages to the company, productivity, client satisfaction, project team satisfaction, and safety practices were perceived significantly enhanced by the level of innovation in the project. Thus innovation may provide long-term benefits to the company.

- The research results also indicated that many projects were lacking in the application of innovative practices, especially the projects constructed by local companies. Companies should therefore emphasize to increase innovation in their project. For average performing ones, there could always be opportunities and room for improvement.

- It was found that projects procured by foreign contactors had a higher level of innovation than their local counterparts. In addition, design & build contracts were found to be more innovative than a traditional design-bid-build contract. Also, private contracts ranked significantly higher in innovation than public projects. Furthermore the level of innovation for industrial projects was higher than the residential ones.

6.2 Strategies for Construction Firms

Based on the research findings, the following strategies are suggested for construction firms to help them to increase the level of innovation on construction projects and achieve desired project outcomes.

- Construction organizations should foster innovation on projects by creating proper organizational climate or culture that is conducive to nurture and facilitate the PM's role as a champion for innovation. This may also require change in the mindset and preference of the construction firms in order to transfer traditional family-owned business towards the knowledge-based, innovative and growth-oriented enterprises. In particular any change must be viewed as an opportunity for improvement, not as a risk.

- The significance of "resource supply" and "support for innovation" factors in innovation, as indicated by the research results, implies that the level of innovation on construction sites can be increased by adequate provision of resources and support for innovation. Therefore, senior managers should provide moral support and show evidence of their commitment to innovation, which may include, among others, the acknowledgement of and reward for creativity; tolerance of risk, failure, and mistakes; culture that values innovation and change; and clear strategic vision of the company.

- Since PMs are driven more by the availability of adequate resources in a project, senior management may therefore respond to this by ensuring that the necessary fund, materials, information, and personnel are committed to support the innovation effort of the PM.

- PMs should be given enough authority and decision power so that they can have sufficient control on the project. Also, as PMs understand well the project environment or context and the level of expertise to be required in the project, it is important that the PM be involved in the selection and recruitment of project team members.

- At the company level, policy priority should be given to a recruitment of influential, well-qualified and competent PM possessing effective leadership skills.

- Also companies should enhance the professionalism of the PM and project team members by providing them with the necessary training and skills. In addition, it is suggested that an organization should retain the talents and champions, as they are the key strength of an innovative organization. It is also recommended that companies should create repositories of project knowledge for organizational learning and subsequent use in future projects. This may be even more important for a country such as Singapore, which is progressing towards the knowledge-based economy.

- Moreover, it will be in the best interest of an organization to recognize the innovation opportunities in a particular project and the drivers and motives of project participants in order to create an environment that would unearth their innovative behavior. This would require that organizations restructure the environment and/or programs to facilitate innovation on construction projects without sacrificing project objectives.

6.3 Limitations of the Study and Recommendations for Further Study

This research has provided insights and contributed to current knowledge of innovation in construction through an empirical study. However, there were a number of limitations. The limitations of the current research offer opportunity for further research. The methodology used in this research was cross-sectional. Data collected using a longitudinal study may explain the causality of variables. Second, only 24% of the variation in championing behaviour was explained by the variables posited in the model. There may be other variables that influence championing behaviour and thus needs further investigation. A third limitation is that project team members who participated in the study were not independently chosen; they were selected by the respective PM. This might have introduced some bias in a response.

Additional limitation to this study is that influence tactics were assessed based on the PM's self-reports, which possibly could have introduced self-serving bias. This could be avoided through an assessment of the independent source such as the PM's subordinates and superiors. A fifth limitation of this study is that project performance indicators were assessed subjectively by project team members. The evaluation from the PM's seniors in the organization or even from the client could possibly provide a better assessment of the project performance indicators.

To the best of this author's knowledge, there is paucity of empirical research in construction innovation at the project level. In particular, research investigating the role of the PM as a champion of innovation is very limited. This study recommends future research be conducted in diverse settings and project environment for cross comparisons and for further development of the framework in order to draw more robust conclusions. Construction projects by nature are transient and dynamic. As such they are influenced by a large number of organizational and project-related situational factors. It is suggested that future work should consider an array of such factors. Innovation is essentially a dynamic process. As a result, an innovative behaviour of the PM and project participants can considerably change during the process of innovation. Therefore, future research should also consider this dynamic aspect of construction innovation.

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APPENDIX A.1: QUESTIONNAIRE FOR PROJECT MANAGERS

Dear Respondent:

This questionnaire is intended to be answered by a Project Manager, or anyone with similar title, who has the sole responsibility for the day-to-day management of this project.

Section 1: Individual Profile

1. What is your highest academic qualification?

☐ Diploma ☐ Bachelor's ☐ Master's ☐ PhD

Other (Please specify) ____________________

2. Your Age (optional): _______yrs

3. Job Experience:

In the construction industry ________________yrs

In the current company ________________yrs

As a project manager ________________ yrs

4. Membership of Professional Bodies:

☐ SISV ☐ SIA ☐ IES ☐ ACES ☐ SPM ☐ SIBL

Other (Please specify) ____________________

Section 2: Your Company Particulars

Please provide your company particulars.

1. Status of Company: ☐ Local ☐ Foreign ☐ Local-foreign J/V

2. Years of operation in the Construction Industry: ____________________

3. Main Activity: ☐ Building ☐ Civil Engineering ☐ Piling

Other (Please specify)____

4. Average Annual Turnover over the last three years: S$ ______________________________

5. The company's current BCA Registration Category:

Work head: _______________ Financial Grade: _______________

Section 3:The Particulars for this Project

Please answer the following questions based on your current project.

1. Name of the Current Project: ____

2. Contract Type: ☐ Design & Build ☐ Turnkey ☐ Design-Bid-Build

Other (Please specify)________________________________

3. Contract Value: S$ _______________ **Project Duration**: ___________(months)

4. Number of sub-contractors & specialist contractors currently involved on site: ____________

5. Complexity of the project: Please indicate the extent to which you believe the work on this project is complex by circling the appropriate number on the following 7-point scale, where 1 = not complex at all and, 7 = very complex.

1 2 3 4 5 6 7

6. Project Category: ☐ Public ☐ Private ☐ Mixed

7. Pricing Provision: ☐ Lump sum contract ☐ Cost reimbursable/cost plus contract

☐ Unit price/BQ contract Other (Please specify) ____________

8. Conditions of Contract:

☐ SIA Standard Form of Bldg Contract ☐ ICE Contract

☐ PSSCOC ☐ FIDIC

Other (Please specify) ____________________________

9. Type of Construction: ☐ Residential ☐ Commercial ☐ Industrial

☐ Infrastructure Other (Please specify): ___________________

10: When do you expect work in this project to finish?

(a) ☐ Ahead of Contract Program (b) ☐ Behind Contract Program

(c) ☐ On Contract Program

If your answer is (a) or (b) by how many weeks ____

If your answer is (b), how many weeks do you think are authorized by the client? _____________

11: What is the estimated Final Cost will be? S$ ____

12: If there is an overrun in cost, how much do you think is authorized by client? S$ _____________

13: What is the size (number) of your project management team on this site? ____________________

14: How long have your project team spent together in similar projects including the current project?____________________ Months

15: Your project team selected from: ☐ Within the firm ☐ Outside the firm ☐ Mixed

Section 4: Working Climate

Describe the working climate in your current project using the following statements. Please indicate your response by circling the appropriate number.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

1	Creativity is encouraged here.	1	2	3	4	5
2	Our ability to function creatively is respected by the leadership of the company.	1	2	3	4	5
3	Around here, people are allowed to try to solve the same problems in different ways.	1	2	3	4	5

4	The main function of members in this project is to follow orders, which come down through formal channels.	1	2	3	4	5
5	Around here, a person can get in a lot of trouble by being different.	1	2	3	4	5
6	Our company can be described as being flexible and continually adapting to changes.	1	2	3	4	5
7	A person can't do things that are too different around here without provoking anger.	1	2	3	4	5
8	The best way to get along in this project is to think the way the rest of the group does.	1	2	3	4	5
9	People around here are expected to deal with problems in the same way.	1	2	3	4	5
10	Our company is open and responsive to change.	1	2	3	4	5
11	The people in charge around here usually get credit for other's ideas.	1	2	3	4	5
12	In this project, we tend to stick to tried and true ways.	1	2	3	4	5
13	This place seems to be more concerned with the status quo than with change.	1	2	3	4	5
14	The reward system here encourages innovation.	1	2	3	4	5
15	This project publicly recognizes those who are innovative.	1	2	3	4	5
16	The reward system here benefits mainly those who don't rock the boat.	1	2	3	4	5
17	Assistance in developing new ideas is readily available.	1	2	3	4	5
18	There are adequate resources devoted to innovation in this project.	1	2	3	4	5
19	There is adequate time available to pursue creative ideas here.	1	2	3	4	5
20	Lack of funding to investigate creative ideas is problem in this project.	1	2	3	4	5
21	Personnel shortages inhibit innovation in this project.	1	2	3	4	5
22	This project gives me free time to pursue creative ideas during the workday.	1	2	3	4	5

Section 5: Influence Strategies

Please indicate how often you use the following strategies in your work on this project.

Never	Seldom	Occasionally	Frequently	Almost Always
1	**2**	**3**	**4**	**5**

1	I provide evidence to show that proposed innovation is likely to succeed.	1	2	3	4	5
2	I write a detailed plan that justifies my ideas.	1	2	3	4	5
3	I explain why the requested assistance from the top management is important for the innovation.	1	2	3	4	5
4	I use logic to convince project parties.	1	2	3	4	5
5	I carefully explain to the project team members the reasons for my request.	1	2	3	4	5
6	I tell what I am trying to accomplish and ask others if they know a good way to do it.	1	2	3	4	5
7	I encourage project team members to express any concerns or doubts about the innovation proposed.	1	2	3	4	5
8	I involve the project team members in the planning/decision making process so that he or she will do what I want.	1	2	3	4	5
9	I describe a proposed task or activity with enthusiasm and conviction, that it is important and worthwhile.	1	2	3	4	5
10	I appeal to the team member's values, ideals, and aspirations when proposing new ideas.	1	2	3	4	5
11	I obtain the support of my team members to back up a plan or proposal.	1	2	3	4	5
12	I obtain the support of my co-workers to persuade others to provide assistance.	1	2	3	4	5
13	I get help in persuading another person from one of his/her project team member.	1	2	3	4	5

Section 6: Problem Solving Style

Imagine that you have been asked to present, consistently and for a long time, a certain image of yourself to others.

Please state the degree of difficulty you feel you will have in presenting such an image on this project by circling the appropriate number.

Very Easy	Easy	Neither Easy nor Hard	Hard	Very Hard
1	**2**	**3**	**4**	**5**

1	Has original ideas	1	2	3	4	5
2	Promotes and encourages multiple new ideas	1	2	3	4	5
3	Being stimulating	1	2	3	4	5
4	Copes with several new ideas at the same time	1	2	3	4	5
5	Will always think of something when stuck.	1	2	3	4	5
6	Prefers to create new ideas than improve on existing one	1	2	3	4	5
7	Has fresh perspective on old problems	1	2	3	4	5
8	Often risks doing things differently	1	2	3	4	5
9	Likes to vary set routines at a moment’s notice	1	2	3	4	5
10	Prefers to work on one problem at a time	1	2	3	4	5
11	Can stand out in disagreement against group	1	2	3	4	5
12	Needs the stimulation of frequent change	1	2	3	4	5
13	Prefers changes to occur gradually	1	2	3	4	5
14	Being thorough	1	2	3	4	5
15	Masters all details painstakingly	1	2	3	4	5

16	Is methodical and systematic	1	2	3	4	5
17	Enjoys detailed work	1	2	3	4	5
18	Is a steady plodder (working steadily and slowly)	1	2	3	4	5
19	Being consistent	1	2	3	4	5
20	Imposes strict order on matters within own control	1	2	3	4	5
21	Fits readily into the system	1	2	3	4	5
22	Conforms	1	2	3	4	5
23	Readily agrees with the project team at work	1	2	3	4	5
24	Never seeks to bend or break the rules	1	2	3	4	5
25	Never acts without proper authority	1	2	3	4	5
26	Being prudent (sensible and careful) when dealing with authority	1	2	3	4	5
27	Likes the protection of precise instructions	1	2	3	4	5
28	Being predictable	1	2	3	4	5
29	Prefers colleagues who never "rock the boat"	1	2	3	4	5
30	Likes bosses and work patterns which are consistent	1	2	3	4	5
31	Works without deviation in a prescribed way	1	2	3	4	5
32	Holds back ideas until obviously needed	1	2	3	4	5

Section 7: Influence in Decision Making

In your experience of managing and directing work on this site, how much influence would you say you have had in decisions made about the following?

Please answer all statements by circling the appropriate number.

Virtually no Influence	Little Influence	Some Influence	A Good Deal of Influence	A Very Great Deal of Influence
1	**2**	**3**	**4**	**5**

1	The sequence of work activities on site	1	2	3	4	5
2	The use of particular methods of construction on this site	1	2	3	4	5
3	The organization of work of your own staff and manpower	1	2	3	4	5
4	The use of materials and equipment on site	1	2	3	4	5
5	The organization of sub-contractor's work on site	1	2	3	4	5
6	Modifying or changing existing design and drawings	1	2	3	4	5
7	Modifying or changing existing cost plans	1	2	3	4	5
8	The recruitment of workers employed directly by your firm to this site	1	2	3	4	5
9	The selection criteria of sub-contractors	1	2	3	4	5

Section 8: Level of Innovation

In your experience of working on this site to what extent do you agree that the following statements are true descriptions of the work on this site?

Please answer all statements by circling the appropriate number

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	**2**	**3**	**4**	**5**

1	This project is a little bit behind in utilizing the most adequate equipment and materials.	1	2	3	4	5
2	This project has not introduced any new construction methods or techniques.	1	2	3	4	5
3	This project is very behind in the application of new ideas in the planning, organizing and management of work on site.	1	2	3	4	5

APPENDIX A.2: QUESTIONNAIRE FOR PROJECT TEAM MEMBERS

Dear Respondent:

This questionnaire is intended to be answered by project team members who have been working closely with the Project Manager on this project.

Name of the current project: ____

Your job title in the current project: ______________________________________

Section 1: Working Climate

Describe the working climate in your current project using the following statements.

Please indicate your response by circling the appropriate number.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

1	Creativity is encouraged here	1	2	3	4	5
2	Our ability to function creatively is respected by the leadership of the project	1	2	3	4	5
3	Around here, people are allowed to try to solve the same problems in different ways	1	2	3	4	5
4	The main function of members in this project is to follow orders, which come down through formal channels	1	2	3	4	5
5	Around here, a person can get in a lot of trouble by being different	1	2	3	4	5

6	This company can be described as flexible and continually adapting to changes	1	2	3	4	5
7	A person can't do things that are too different around here without provoking anger	1	2	3	4	5
8	The best way to get along in this project is to think the way the rest of the group does	1	2	3	4	5
9	People around here are expected to deal with problems in the same way	1	2	3	4	5
10	This company is open and responsive to change	1	2	3	4	5
11	The people in charge around here usually get credit for other's ideas	1	2	3	4	5
12	In this project, we tend to stick to tried and true ways	1	2	3	4	5
13	This place seems to be more concerned with the status quo than with change	1	2	3	4	5
14	The reward system here encourages innovation	1	2	3	4	5
15	This project publicly recognizes those who are innovative	1	2	3	4	5
16	The reward system here benefits mainly those who don't rock the boat	1	2	3	4	5
17	Assistance in developing new ideas is readily available	1	2	3	4	5
18	There are adequate resources devoted to innovation in this project	1	2	3	4	5
19	There is adequate time available to pursue creative ideas here	1	2	3	4	5
20	Lack of funding to investigate creative ideas is problem in this project	1	2	3	4	5
21	Personnel shortages inhibit innovation in this project	1	2	3	4	5
22	This project gives me free time to pursue creative ideas during the workday	1	2	3	4	5

Section 2: Project Manager Behaviour

Describe the behaviour of the Project Manager on this site in promoting new ideas and innovative work.

Please indicate your response by circling the appropriate number.

Not at all	Once in a while	Sometimes	Fairly often	Frequently
1	**2**	**3**	**4**	**5**

1	Seeks out new technologies, process, techniques, and /or product ideas	1	2	3	4	5
2	Recognizes the opportunities for improvement	1	2	3	4	5
3	Generates creative ideas and solutions	1	2	3	4	5
4	Experiments with ideas and solutions	1	2	3	4	5
5	Maintains a network of contacts	1	2	3	4	5
6	Keeps informed of related developments that occur outside the organization through journals, conferences, colleagues, and other companies	1	2	3	4	5
7	Seeks differing perspectives when solving problems	1	2	3	4	5
8	Gets others to look at problems from many different angles	1	2	3	4	5
9	Challenges the way it has been done before as the only answer	1	2	3	4	5
10	Suggests new ways of looking at how to complete an assignment	1	2	3	4	5
11	Expresses confidence in what the innovation can do and achieve	1	2	3	4	5
12	Enthusiastically promotes the advantages of new ideas and solutions	1	2	3	4	5
13	Pushes innovation actively and vigorously	1	2	3	4	5
14	Shows optimism about the success of innovation	1	2	3	4	5
15	Takes the risks necessary to make innovations happen	1	2	3	4	5
16	Articulates the compelling vision of the future of innovation	1	2	3	4	5
17	Doesn't give up when others say it cannot be done	1	2	3	4	5
18	Persists in the face of obstacles, large or small	1	2	3	4	5
19	Knocks down barriers to the innovation	1	2	3	4	5
20	Shows tenacity in overcoming obstacles	1	2	3	4	5
21	Accepts responsibility for the results	1	2	3	4	5
22	Gives top priority to getting results	1	2	3	4	5
23	Co-ordinates and brings together the key individuals	1	2	3	4	5
24	Gets the necessary resources (people, time, dollar) to implement new ideas, technology, and/or solutions	1	2	3	4	5
25	Backs the people involved	1	2	3	4	5

26	Builds trust	1	2	3	4	5
27	Gets the problems into the hands of those who can solve them	1	2	3	4	5
28	Gets support from the top level	1	2	3	4	5
29	Accepts feedback	1	2	3	4	5
30	Makes improvements/adjustments based on feedback received	1	2	3	4	5
31	Convinces several organizations outside the contractor's firm of implementing innovative ideas	1	2	3	4	5
32	Sets up harmonious and cooperative working environment amongst parties	1	2	3	4	5
33	Keeps project stakeholders involved in the process	1	2	3	4	5

Section 3: Project Performance

To what extent do you perceive the behaviour of the Project Manager on this site would help to achieve the following outcomes?

Please answer all items by circling the appropriate number.

Not at all	Just a little	Moderate amount	Quite a lot	A great deal
1	**2**	**3**	**4**	**5**

1	Facilitate learning within the project	1	2	3	4	5
2	Enable continuous improvement	1	2	3	4	5
3	Enhance client satisfaction	1	2	3	4	5
4	Enhance the image of the company	1	2	3	4	5
5	Enable competitive advantages to the company	1	2	3	4	5
6	Retain talents with the company	1	2	3	4	5
7	Finish project on time	1	2	3	4	5
8	Finish project within budget	1	2	3	4	5
9	Promote better safety practices	1	2	3	4	5

10	Increase the level of productivity on this project	1	2	3	4	5
11	Lead to improved project team satisfaction	1	2	3	4	5
12	Enable and motivate innovation on this site	1	2	3	4	5

Section 4: Level of Innovation

In your experience of working on this site to what extent do you agree that the following statements are true descriptions of the work on this site?

Please answer all statements by circling the appropriate number

Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
1	**2**	**3**	**4**	**5**

1	This project is a little bit behind in utilizing the most adequate equipment and materials.	1	2	3	4	5
2	This project has not introduced any new construction methods or techniques.	1	2	3	4	5
3	This project is very behind in the application of new ideas in the planning, organizing and management of work on site.	1	2	3	4	5

APPENDIX B: RELATED PUBLICATIONS

Refereed Journal Papers

Park, M., **Nepal, M. P.** and Dulaimi, M. F. (2004) Dynamic modelling for construction innovation. ASCE, *Journal of Management in Engineering*, scheduled to publish in the October 2004 issue.

Dulaimi, M. F., **Nepal, M. P.** and Park, M. (2004) A hierarchical structural model of assessing innovation and project performance. *Construction Management and Economics*, paper accepted in February 2004, waiting for publication.

Refereed Conference Paper

Nepal, M. P. and Park, M. (2003) Championing behavior of project manager: determinants and outcomes. In Ofori, G. and Ling, F. Y. Y. (Eds.), Proceedings of *Knowledge Construction, The Joint International Symposium of CIB Working Commissions W55, W65 and W107* (Vol. 2, pp. 747-758), Singapore.