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A HIERARCHICAL STRUCTURAL MODEL OF ASSESSING INNOVATION AND PROJECT PERFORMANCE

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Abstract

Research in construction innovation highlights construction industry as having many barriers and resistance to innovations and suggests that it needs champions. This paper addresses this issue and presents a hierarchical structural model to assess the impact of the role of the project manager (PM) on the levels of innovation and project performance. The model adopts the structural equation modelling technique and uses the survey data collected from PMs and project team members working for general contractors in Singapore. The model fits well to the observed data, accounting for 24%, 37%, and 49% of the variance in championing behaviour, the level of innovation, and project performance respectively. The results of this study show the importance of the championing role of PMs in construction innovation. However, in order to increase their effectiveness, such a role should be complemented by their competency and professionalism, tactical use of influence tactics, and decision authority. Moreover, senior management should provide adequate resources and a sustained support to innovation and create a conducive environment or organizational culture that nurtures and facilitates the PM’s role in the construction project as a champion of innovation.

Keywords: champions, project manager, innovation, organizational climate

Introduction

Companies achieve competitive advantages through acts of innovation—by differentiating their products and/or services and making this strategy as an alternative to cost competition (Porter, 1990; Slaughter, 1998). Furthermore, innovation becomes essential for project success by achieving sponsor goals. While innovation in construction is often driven by problems encountered during the execution of the project, it can also be a process in which organizations or individuals are driven by a desire to improve performance.

However, there are many barriers and limitations to construction innovations. Attributes such as scale, complexity, and durability of the facilities, together with the organizational and socio-political contexts subsequently influence the nature, development, and implementation of innovation (Slaughter, 1998). The construction industry is also known for conservatism; professionals cling to an accepted industry practice and norms in fulfilling client’s need; changes are taken as a threat, and slack resources are rarely permitted (Nam and Tatum, 1997). Moreover, construction projects also have a significant co-ordination and integration problems due to extreme specialization of functions and/or involvement of various professions (Nam and Tatum, 1992a).

Research in construction innovation indicates that an organizational climate that is supportive towards innovation fosters successful innovation (Tatum, 1989). Nevertheless, organizations need enthusiastic and committed individuals so-called “champions” in the innovation process (e.g., Roberts and Fusfeld, 1981; Nam and Tatum, 1992a, 1997; Winch, 1998). This calls for the active role of the key individuals to manage innovation in construction. However, it is not clear who these individuals are and how their role is manifested in a construction project environment. Moreover, the role of key individuals as champions who can exert great influence in the process of construction innovation has been mostly neglected (Nam and Tatum, 1997). In addition, the role of innovation champion in a project-based process such as construction can be different (Tatum, 1989). Despite a number of innovation-related studies in the past, only few of them have examined innovation at a project level and, there is still a lack of empirical research done in this area.

The premise of this paper is that the role of the project manager (PM) in construction project is essentially that of a champion to enable innovation on site and improve project performance. Several individual and situational factors may also significantly affect the PM’s championing role and its effectiveness and influence directly and/or indirectly the level of innovation and project performance. For this purpose, the research used a hierarchical structural model to explain the relationships between the different factors. This research argues that PMs’ championing is manifested in their behaviours, i.e., championing behaviour, hereinafter used interchangeably with championing. Championing behaviour is defined as the PM’s observable actions directed towards seeking, stimulating, supporting, carrying, and promoting innovation in the project.

Based on the definitions found in the literature (Van de Ven, 1986; Damanpour, 1991), this paper defines innovation as the generation, development, and implementation of ideas that are new to an organization and that has practical or commercial benefits. This definition also encompasses adoption and implementation of products or processes developed outside the organization.

Theoretical framework

Research in the field of organizational behaviour has identified two main groups of variables (individual and situational) that influence individual job behaviour (Bresnen *et* al., 1986; Dulaimi and Langford, 1999). Figure 1 represents the model that will be used to develop the research's hypotheses and for the analysis of the data. Individual variables such as the PM's education and experience and other personality-related traits represent what PMs bring to the situation. Meanwhile, situational variables (e.g., decision authority, organizational climate for innovation, project complexity, and project size) are related to the project and organizational situation and the context. The hypotheses associated with the model are discussed below.

<<Insert Figure 1 about here>>

Problem solving style

The problem solving style is one's preferred or characteristic pattern of creativity, problem solving, and decision-making (Kirton, 1976). 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). 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 end 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 site. We thus hypothesize:

Hypothesis 1: The degree to which PMs’ problem solving style is innovative is positively related to their championing behaviour and the level of innovation on site.

Given the lack of theoretical explanations, we consider the test of the relationship between problem solving style and project performance exploratory; thus, no specific hypothesis is posited.

Influence tactics

The theoretical as well as empirical research supports the use of influence tactics by a champion as part of innovation and issue selling process (Dutton and Ashford, 1993; Howell *et al.*, 1998). Frost and Egri (1991) argue that successful champions are able to influence important players in their organizations to envision the strategic importance of their ideas. Researchers have identified a host of influence tactics that champions tend to engage. However, four tactics identified as rational persuasion, inspirational, consultation, and coalition building may be the most appropriate for champions in influencing targets in their organization to implement major strategies, including innovations (Yukl and Falbe, 1990; Yukl and Tracey, 1992; Lee and Sweeney, 2001). The literature cited also indicates that the four tactics are equally used with the subordinates, peers or superiors to achieve objectives such as assign work; change behaviours; get assistance, support, and personal benefits.

Few would dispute the fact that PMs need technical, administrative as well as social skills to effectively sell new ideas in the project. Apart from that, 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 would require PMs to use a variety of influence tactics to convince inter- and/or intra-organizational participants of the merits of innovation and to secure their overwhelming support in its implementation. Following the discussions, we thus hypothesize:

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

Organizational climate for innovation

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 basically refers to the organizational climate for innovation that is often described in terms of psychological climate. The psychological climate is a multi-dimensional construct that can be conceptualized and operationalized at the individual level (Koys and DeCotiis, 1991). It 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 and Sells, 1981; Scott and Bruce, 1994).

The signals project team members receive from the organization about the expectations for innovation may play a crucial role in activating or inhibiting innovation. The conduct by which organizations signal an expectation for innovation is by providing resources and support for innovation (Kanter, 1988; Amabile, 1997). The supportive organizational climate in construction may include acknowledgement of and reward for creativity; tolerance of risk, failure, and mistakes; commitment of necessary resources (manpower, money, information, and time); innovative culture that values innovation and change, and clear strategic vision of the company, among others.

It is therefore argued that the perception of the project environment in terms of support for innovation and resource supply may encourage PMs to engage in a host of championing activities; such perception would also play a vital role in fostering innovative practices. The above 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 and the level of innovation on site.

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

Decision authority of the project manager

The delegation of autonomy and decision authority to the PM may be the most important factor for success of innovation as 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). Arguably, PMs who have enough authority and decision power would presumably have sufficient control over their projects, and are likely to exhibit 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 as PMs will see such decisions as their decisions and try harder to make them succeed. This is also true, in part, due to the sense of authority and responsibility the PM would have when s/he is involved in a decision-making process. Thus we posit that:

Hypothesis 5: The decision authority of PMs is positively related with their championing, the level of innovation, and project performance.

Outcomes of championing and the level of innovation

Available research in construction provides little evidence relating PM's championing and the level of innovation with project performance. However, the literature investigating the relationships between championing and innovation 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 the construction projects is arguably initiated to address challenges, opportunities, and problems encountered at work to meet project objectives or to improve performance. If PMs were convinced of the merits 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, and so forth.

Since construction companies have 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 site operations. Nam and Tatum (1997) and Toole (2001) note 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. We thus hypothesize:

Hypothesis 6: PM's championing will be positively related to the level of innovation on site and project performance.

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

Other variables

We have included several other variables (factors) that may influence championing, the level of innovation, or both in testing the hypothesized model. The individual factors considered in the structural model are the PM's job tenure and education. Research suggests 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 research model framework, in particular, the volume of innovative ideas to be generated during the construction. It is also known that construction projects provide numerous opportunities for innovation, because technical challenges on a construction project generally demand innovative methods for improved performance.

Methods

This research used survey questionnaires and interviews to collect the necessary data. The survey items for some of the measures, which are more specific to this research, are presented in the appendix.

Survey measures

PM's education (coded as 1 = Diploma, 2 = Bachelors, 3 = Masters, and 4 = PhD) was measured by asking PMs the highest degree they had earned. *The job tenure* 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 a PM. We standardized each respondent's score on each of these three experience factors and took the average in order to measure the job tenure.

The size of the project was measured in terms of two highly correlated variables, contract value and project duration. We calculated a score by standardizing the PM's response to each of the variables and averaging them to represent a proxy for the size of the project.

The complexity of the project was measured using a single item by asking PMs to rate the perceived complexity of the project on a scale of 1 (not complex at all) to 7 (very complex).

Problem solving style was measured using 32 items of the KAI (Kirton, 1976) that uses a five-point scale format asking the respondents to state the degree of difficulty to each of the 32 items. Theoretically, the KAI scores may range from 32 to 160 with the mean score of 96. Scoring is arranged so that adaptors get low scores and innovators get high scores. Cronbach's alpha for this measure was .92.

Influence tactics was measured by 13 items based on the work of Kipins *et al.* (1980) and Yukl and Falbe (1990). PMs were asked to indicate how often they used each of the influence tactics on a scale of 1 to 5. Cronbach's alpha for the construct was .73.

Organizational climate for innovation was measured, using 22 items developed and validated by Scott and Bruce (1994). 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' containing six items measures the degree to which resources were perceived as adequate in the project (Scott and Bruce, 1994)). We made minor changes to some items so as to make them suitable for the current research. Cronbach's alpha for the support for innovation in this study was .80. For the resource supply, it was .70.

Decision-making authority was measured on the basis of the scale developed by Dulaimi (1991). Cronbach's alpha for this scale in this study was .86.

PM's championing behaviour was assessed using 33 items on a five-point scale. The authors 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 championing behaviour of the PM.

Project performance was measured by 12 subjective items. This research argues that our measure is comprehensive and captures traditional project performance indicators as well as innovation induced outcomes. Cronbach's alpha for the measure was .87.

The level of innovation was measured using three items developed by Lewis-Beck (1977) to assess the innovativeness of the project. The construct, which was slightly modified by the authors, reflects the degree of innovative practices adopted on site. Cronbach's alpha for the measure was .75.

The negatively worded items in the level of innovation and organizational climate for innovation measures were reverse coded in the data file to enable consistency in the interpretation of the results. The reliability of all the measures was ensured as the Cronbach's alpha for each construct was equal to and/or greater than .70, a generally accepted minimum value.

Data collection procedure

The data was collected in Singapore from June to September 2002. A list of construction projects was identified and communication was established with the contractors undertaking the projects requesting them to participate in the research. Survey forms were then hand delivered to 67 ongoing projects in Singapore; some of them were in a stage of completion.

In each project, our survey required the PM and three of the project team members that included practitioners such as engineers, managers, 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. Altogether, 32 PMs and 94 project team members from 32 projects, comprising 25 local and 7 foreign medium- and large-sized companies, responded to the survey. Table 1 provides general characteristics of the projects where the study was conducted.

We used different survey forms for PMs and their team members. PMs' response made possible the researchers to assess project characteristics, their use of influence tactics, problem solving style, decision-making authority and other personal characteristics. Meanwhile, project team members' response enabled the research team to assess PM's championing, organizational climate for innovation, project performance, and the level of innovation on site.

It is reasonable to expect a less precise evaluation of project performance indicators before the actual completion of the project. However, we feel that good performing projects are likely to perform well in every aspect from the beginning. In addition, through various information sources such as monthly progress reports, project meetings, overtime work, schedule pressure, just to name a few, project participants can be expected to provide a fair evaluation of the project on criteria such as the time and schedule performance.

<<Inset Table 1 about here>>

Data analysis

Pattern of PM's championing

To ascertain the valid measure of championing behaviour and identify its pattern 33 items of the construct were subjected to principal components analysis (PCA). The Kaiser-Meyer-Oklin measure of sampling adequacy (KMO) was .87, exceeding the recommended value of .6 and the Barlett's Test of Sphericity was significant (p = .000), supporting the factor analysis. PCA revealed the presence of six components with eigenvalues exceeding 1. An inspection of the component matrix, however, revealed that most of the items loaded on three factors. Interpretation of the scree plot also suggested that three factors should be extracted.

The three-factor solution explained 59.7% of the variance in championing behaviour construct. Only those items that loaded strongly on a single factor with loadings greater than .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 Cronbach's alpha for the construct was .93. The three factors were interpreted as follows:

- Leads the innovation process (Factor 1, 11 items) — This factor, which explained 22.85% of the variance in 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, 6 items) — This factor explaining 20.7% of the variance in championing displays the PM's commitment in the innovation by taking risk, showing confidence and conviction.
- Stimulates for innovation (Factor 3, 4 items) — This factor, which explained 16.15% of the variance in championing, represents the PM's action towards promoting innovative ideas in the project.

Structural equation modelling

Structural equation modelling (SEM) was used to examine the hypothesized model. We used SIMPLIS syntax in LISREL 8.52 to estimate the parameters. However, in this model, all constructs were operationalized into a single/composite or summed scaled indexes, resulting in one indicator per construct. Bentler and Chou (1987) suggest that the ratio of sample size to an estimated parameters should be between 5:1 and 10:1. The 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.

Researchers (e.g., Williams and Hazer, 1986; Scott and Bruce, 1994) have also used single and/or composite indicators of latent variables in the SEM analysis. 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 model using multiple indicators. In this paper, 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 for each construct and, their respective error terms were fixed to 1 minus alpha as suggested by Williams and Hazer (1986).

In our study, education and project complexity measures were single-item measures; the project size and job tenure were composite measures. A single indicator with summed scaled index represented the remaining constructs. We assumed no measurement error for the measure of education. Cronbach's alpha for the job tenure and size of the project was each set at .95; for the project complexity, it was fixed at .90.

Results

Descriptive statistics, intercorrelations, and covariances for all study variables are presented in Table 2. All model tests were based on the covariance matrix and used maximum likelihood estimation as implemented in LISREL (Jöreskog and Sörbom, 1993). The exogenous variables were allowed to co-vary in the estimation of the model.

<<Insert Table 2 about here>>

The fit statistics for the hypothesized model indicated that the model fits the data. The chi-square was 9.65 (df = 9, *p* = .38, ns), indicating a good fit between the data and the model. Other fit indices for the overall model were: goodness of fit index (GFI) = .98, adjusted goodness of fit index (AGFI) = .86, normed fit index (NFI) = .97, non-normed fit index (NNFI) = .98, incremental fit index (IFI) = 1.00, comparative fit index (CFI) = 1.00, and relative fit index (RFI) = .77 also indicating an acceptable fit of the model to the data. The model accounted for 24%, 37% and 49% of the variance in championing behaviour, the level of innovation, and project performance respectively.

Standardized parameter estimates for the hypothesized model with corresponding standard error of estimate and t value are presented in Table 3. Figure 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 at .05 significance level was 18.30 and the obtained value {9.02} was less than the critical value {18.30}, we conclude that there is no significant difference between the two models (Kelloway, 1998).

<<Insert Table 3 about here>>

<<Insert Figure 2 about here>>

Discussion

The study has provided the empirical evidence that the PM as a champion for innovation in construction has multiple roles. This perhaps 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.

The PM can influence construction innovation in a number of ways. For instance, the leadership of the PM provides direction and leads the project team to attaining project 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. The PM 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, the PM, to some extent, could act as a pressure agent forcing team members to increase their efforts towards innovation. This would arise when the team members were not paying attention to the development of new ideas to address project challenges, as it is often difficult to channel and direct individuals' action thresholds to pay attention to the needs and opportunities; only crises, dissatisfaction, tension, or significant external stress stimulate individuals to act (Van de Ven, 1986).

Finally, PMs need to exhibit commitment in the innovation process by expending their energy, taking responsibility and reasonable amount of risk. Since 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 the PM's 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.

Turning to the research hypotheses, results of this study have partially supported Hypothesis 1 as no significant path from problem solving style to championing was observed. The mean KAI score for PMs in this research is 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 are 87.98, 81.06, and 91.03 respectively. The mean KAI score and an equivalent score for each of the three sub-constructs are all less than the empirical mean score of 95, indicating that PMs have an adaptive problem solving style. The result is not surprising in that construction work environment normally insists on conformity, reliability, efficiency, and operating within present practices and procedures.

The research provided the evidence that the PM's innovative problem solving style would contribute 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 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 go beyond established organizational policies and practices might trigger an increased risk on the 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.

Despite a significant correlation, no support was found for the significant relationship between influence tactics and championing. 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 2 that influence tactics strongly correlated with decision authority, which also correlated significantly with championing. However, when the effect of decision authority was removed, the correlation between influence tactics and championing was negligible. It appears to suggest 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. Some of the PMs revealed that they used their authority to influence subordinates to get the work done, as they wished while seeking support from other project stakeholders and securing adequate resources from the head office.

The structural model partially supports Hypothesis 3 as the perceived degree of support for innovation is significantly related only to the level of innovation. Hypothesis 4, which postulated that resource supply is positively related with championing and the level of innovation, was supported from the analysis. It appears that PMs tend to focus more on 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 have also referred to the very tight schedule and the undue emphasis on cost-cutting measures that impeded their actual ability to innovate. Some of the PMs even pointed to the economic recession, lowest bidding practices, and very short project duration as hindrances 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.

The research results partially supported Hypothesis 5. Despite a high beta coefficient, the relationship between decision authority and championing was less significant owing to the high standard error, but the relationship is as hypothesized. 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 from the fact that other factors that were beyond the control of the PM might have mediated such a relationship. For instance, frequent change order, design changes, incomplete design, and default of a subcontractor, just to name a few, would adversely affect project performance. We also tested the possibility that decision-making authority (DMA) would probably have an influence on project performance above some threshold level (3.5 in this case). We divided mean DMA scores for the subjects into two categories (≤ 3.5 and > 3.5) and ran separate regression tests. It was observed that DMA significantly predicted project performance (r = .365; R^2 = .133; beta = .365; p = .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 = .049; R^2 = .002; beta = .049; p = .731, ns).

Our hypothesis regarding positive relationship of championing with the level of innovation and project performance was partially supported as we found that only project performance was strongly related to championing. One possible explanation for the lack of significant relationship between championing and the level of innovation is 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 increase in the level of innovation on site would help to increase project performance, was supported at .10 significance level. It is also possible that there is a time lag in the realization of innovation. The separate regression analyses of the level of innovation with each of the project performance indicators suggested that innovative practices had less effect on cost and schedule but it had significant impact on other performance indicators. This 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.

Conclusion

This paper presented a hierarchical structural model of innovation and project performance, focusing on individual and situational factors and the PM's championing behaviour. The model was tested, using a survey data conducted with PMs and their project team members working for general contractors in Singapore. The model accounted for 24%, 37%, and 49% of the variance in championing, the level of innovation, and project performance respectively.

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 order to increase the innovative practices on site. However, such a role should be complemented by PM's competency and professionalism, adequate resource supply, and by providing autonomy and decision authority to the PM. The research results suggested that construction organizations should foster innovation on projects by creating proper organizational climate — the support for innovation and resource supply — and by creating an environment or culture that is conducive to nurture and facilitate the PM's role as a champion of innovation. The study also suggested that innovative practices could increase organizational effectiveness and bring long-term benefits to the construction firms. This has an important implication for construction organizations to move forward with an innovative mindset.

This research has provided insights and contributed to current knowledge of innovation in construction through an empirical study. We feel, however, that a more rigorous and exhaustive analysis is needed to further examine the dynamics of construction innovation and refine the relationships among the variables. Our future work will address this issue further that was not possible to be included in this paper due to space limitation.

The limitations of this study are due to small samples used, cross-sectional research design, and the possibility of partiality in the selection of team members. In addition, the data collection relied on responses based on perceptions rather than actual practices and the PM's self-reporting might have exposed such results to bias. This study recommends future research to be conducted in diverse settings and project environment for cross comparisons and further development of the framework in order to draw more robust conclusions. Further research is also needed to explore an identification of the factors that drive or motivate individuals in construction for innovation and the mechanism that perpetuates it.

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Appendix: Survey Measures

Influence tactics

Please indicate how often you use the following strategies in your work on this project (1 = never, 2 = seldom, 3 = occasionally, 4 = frequently, 5 = almost always).

- I provide evidence to show that proposed innovation is likely to succeed.
- I write a detail plan that justifies innovative ideas.
- I explain why the requested assistance from the top management is important for innovation.
- I use logic to convince project parties.
- I carefully explain to the project team members the reasons for my request.
- I tell what I am trying to accomplish and ask others if they know a good way to do it.
- I encourage project team members to express any concerns or doubts about the innovation proposed.
- I involve the project team members in the planning/decision-making process so that he or she will do what I want.
- I describe a proposed task or activity with enthusiasm and conviction, that it is important and worthwhile.
- I appeal to the team members' values, ideals and aspirations when proposing new ideas.
- I obtain the support of my team members to back up a plan or proposal.
- I obtain the support of my co-workers to persuade others to provide assistance.

- I get help in persuading another person from one of his/her project team member.

Decision-making authority

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? (1 = virtually no influence, 2 = little influence, 3 = some influence, 4 = a good deal of influence, 5 = a very great deal of influence).

- The sequence of work activities
- The use of particular methods of construction
- The organization of work of your own staff and manpower
- The use of materials and equipment
- The organization of sub-contractors’ work
- Modifying or changing existing design and drawings
- Modifying or changing existing cost plans
- The recruitment of workers employed directly by your firm to this site
- The selection criteria of sub-contractors

Championing behaviour

Please indicate the extent to which the ‘Project Manager’ displays the following behaviours in promoting new ideas and innovative work on this site (1 = not at all, 2 = once in a while, 3 = sometimes, 4 = fairly often, 5 = frequently).

- Seeks out new technologies, process, techniques, and /or product ideas
- Maintains a network of contacts
- Seeks differing perspectives when solving problems

- Gets others to look at problems from many different angles
- Challenges the way it has been done before as the only answer
- Expresses confidence in what the innovation can do and achieve
- Enthusiastically promotes the advantages of new ideas and solutions
- Pushes innovation actively and vigorously
- Shows optimism about the success of innovation
- Shows tenacity in overcoming obstacles
- Accepts responsibility for the results
- Gives top priority to getting results
- Co-ordinates and brings together the key individuals
- Gets the necessary resources (e.g., people, time, dollar) to implement new ideas, technology and/or solutions
- Backs the people involved
- Builds trust
- Gets the problems into the hands of those who can solve them
- Gets support from the top level
- Accepts feedback
- Sets up harmonious and cooperative working environment amongst parties
- Keeps project stakeholders involved in the process

Levels 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? (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree).

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

Project performance

To what extent do you perceive the project has achieved or will achieve the following outcomes? (1 = not at all, 2 = just a little, 3 = moderate amount, 4 = quite a lot, 5 = a great deal).

- Facilitate learning within the project
- Enable continuous improvement
- Enhance client satisfaction
- Enhance the image of the company
- Enable competitive advantages to the company
- Retain talents with the company
- Finish project on time
- Finish project within the budget
- Promote better safety practices
- Increase the level of productivity on this project
- Lead to improved project team satisfaction
- Enable and motivate innovation on this site

Table 1 Profiles of the 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 S$)	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

Table 2 Descriptive statistics, intercorrelations and covariances for the study variables

	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.

Table 3 Standardized path estimate for the 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 *

* $p < 0.10$
** $p < 0.05$
*** $p < 0.01$

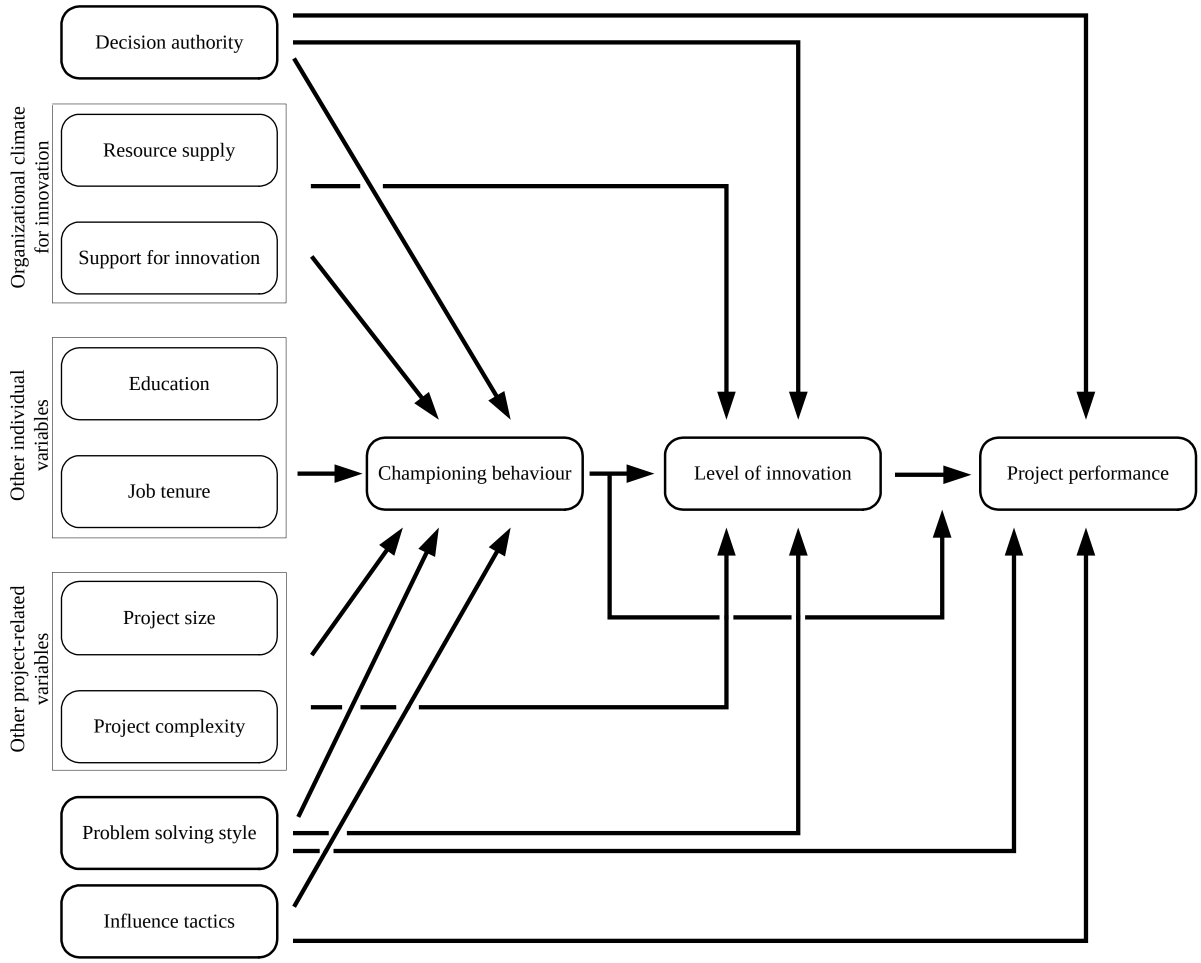

Figure 1 A hierarchical structural model of innovation and project performance

Project performance

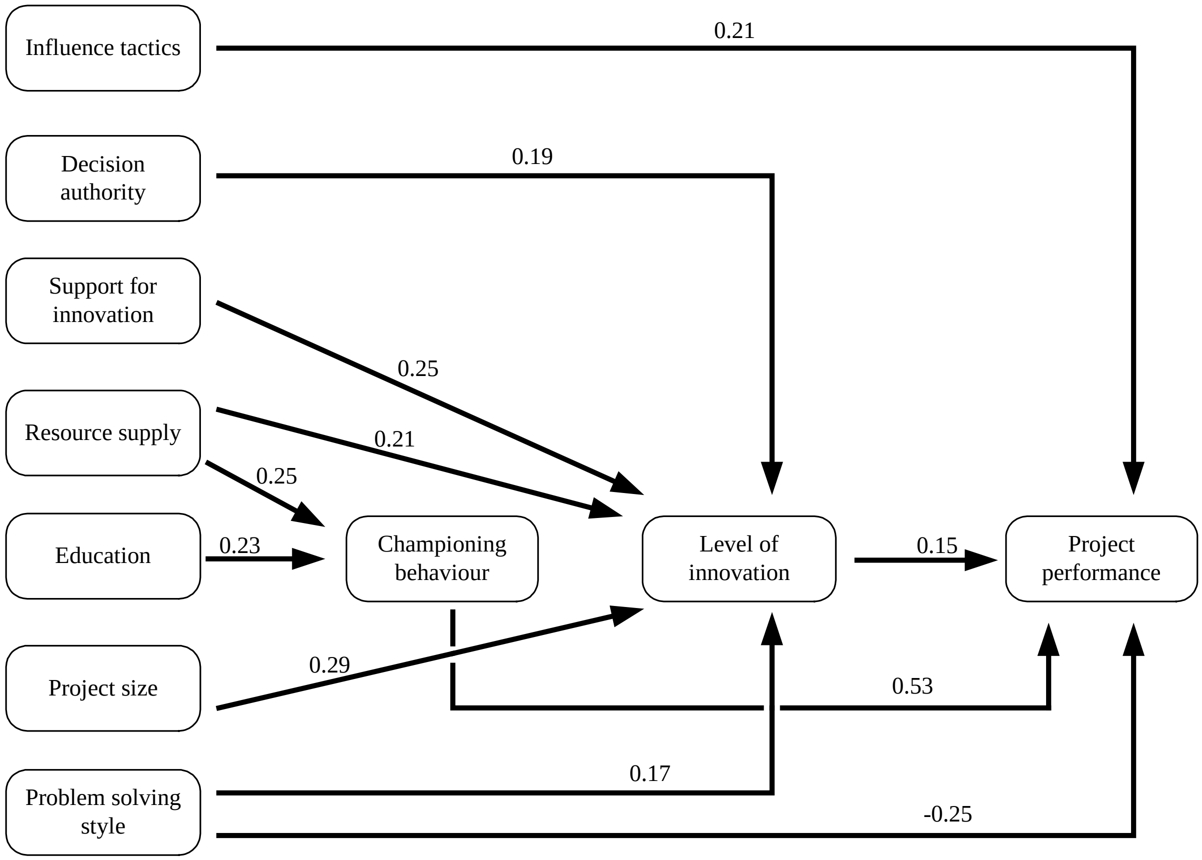

Figure 2 Revised model with non-significant paths deleted