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Development of a partnering performance index (PPI) for construction projects in Hong Kong: a Delphi study

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Over the past decade, research studies on benefits, critical success factors, difficulties, process, conceptual and theoretical models of construction partnering have been ubiquitous in the construction management discipline. In fact, there is adequate evidence that an increasing number of client organizations are adopting a partnering approach to undertake their building and construction projects both locally and worldwide during the last decade. With the perceived benefits that partnering brings about, research into Key Performance Indicators (KPIs) to evaluate the success of partnering projects in construction becomes vital as it can help set a benchmark for measuring the performance level of partnering projects. However, although there are some related studies and papers on this research area, few, if any, comprehensive and systematic studies focus on developing a comprehensive, objective, reliable and practical performance evaluation model for partnering projects. A model has been developed using the Delphi survey technique to objectively measure the performance of partnering projects in Hong Kong based on a consolidated KPIs' conceptual framework previously developed for partnering projects. Four rounds of Delphi questionnaire survey were conducted with 31 construction experts in Hong Kong. The results reveal that the top seven weighted KPIs to evaluate the success of partnering projects in Hong Kong were: (1) time performance; (2) cost performance; (3) top management commitment; (4) trust and respect; (5) quality performance; (6) effective communications; and (7) innovation and improvement. A statistically significant consensus on the top seven weighted KPIs was also obtained. Finally, a composite Partnering Performance Index (PPI) for partnering projects in Hong Kong was derived to provide an all-round assessment of partnering performance. Different partnering projects can now be assessed on the same basis for benchmarking purposes. Construction senior executives and project managers can thus use the Index to measure, evaluate and improve the performance of their partnering projects to strive for construction excellence. Although the PPI was developed locally in Hong Kong, the research method could be replicated in other parts of the world to produce similar indices for international comparison. Such an extension would aid the understanding of managing partnering projects across different geographic locations.

Keywords: Key Performance Indicators (KPIs), Partnering Performance Index (PPI), Delphi method, Delphi study, Hong Kong

Introduction

There are plenty of research studies on benefits, critical success factors, difficulties, process, conceptual and theoretical models of partnering in construction over the last decade. For instance, the Construction Industry Institute (1991 and 1996) stated that in a partnering arrangement, the problems of disputes, claims and litigation could be greatly reduced through open communication and improved working relationship. Abudayyeh (1994) opined that partnering reduces

the risk of budget overruns because of improved cost control. However, many parties do not trust other parties because of past experiences and fear for the unknown and change (Larson, 1995). In fact, it is very difficult to change the myopic thinking of project parties. Cook and Hancher (1990) and the Construction Industry Institute (1991) considered that project participants may find it difficult to share the risk fairly in the partnering process because they try to take full advantage of the partnering spirit to reduce their own risk. For partnering to work, the parties involved

must have mutual trust towards the other partners and it is essential to 'open' the boundaries of the relationship because it could relieve tension and enhance adaptability, information exchange and joint problem solving and promise better outcomes (Mohr and Spekman, 1994; Cheng *et al.*, 2000). A number of process, conceptual and theoretical models of construction partnering have also appeared in the last decade. For example, Latham (1994) introduced the project partnering process, which mainly included the decision to use partnering, the first partnering workshop and the follow-up workshops, while Crane *et al.* (1999) created a model called 'Objectives, Goals, Strategies, Measures' (OGSM) to exemplify the systematic selection of project measures for monitoring partnering performance.

In fact, an increasing number of client organizations have been observed to introduce a partnering approach to their building and construction works both locally and internationally (Chan *et al.*, 2002) during the last decade. With the merits that the partnering approach derives (Construction Industry Institute, 1991; Li *et al.*, 2000), research into Key Performance Indicators (KPIs) to evaluate the success of partnering projects in construction becomes all the more important because it can help develop a benchmark for measuring the performance of partnering projects. However, although some related studies and papers have been documented on this research area (Crane *et al.*, 1999; Cheung *et al.*, 2003; Bayliss *et al.*, 2004; Chan *et al.*, 2004 and 2006), few, if any, comprehensive and systematic studies focus on formulating a comprehensive, objective, reliable and practical performance evaluation model for partnering projects. It is thus difficult for construction senior executives and project managers to objectively evaluate the performance level of their partnering projects. The research question for this study is to find out whether there exists a set of KPIs which can be used to comprehensively, objectively, reliably and practically measure the partnering performance of construction projects in Hong Kong.

A previous study of the research team has developed a consolidated conceptual framework encompassing 25 various measures for assessing the performance of partnering projects in construction. The 25 performance measures were classified into four major categories, as follows:

(1) Result-oriented objective measures:

- Time performance
- Cost performance
- Profit and financial objectives
- Scope of rework
- Safety performance

- Environmental performance
- Productivity
- Pollution occurrence

(2) Result-oriented subjective measures:

- Quality performance
- Professional image establishment
- Client's satisfaction
- Customer's satisfaction
- Job satisfaction
- Innovation and improvement

(3) Relationship-oriented objective measures:

- Litigation occurrence and magnitude
- Dispute occurrence and magnitude
- Claim occurrence and magnitude
- Introduction of facilitated workshop

(4) Relationship-oriented subjective measures:

- Trust and respect
- Effective communications
- Harmonious working relationships
- Long-term business relationship
- Top management commitment
- Employee's attitude
- Reduction of paperwork

The consolidated conceptual framework was developed first by a comprehensive and critical literature review on performance measures for partnering projects in construction (Table 1), and then followed by verification through 17 demonstration projects using the partnering approach (24 demonstration projects in total including seven non-partnering ones), which were derived from the Hong Kong Demonstration Projects Committee (Table 2). The committee, which was set up in Hong Kong in 2003, comprises around 25 leading industrial practitioners within the Hong Kong construction industry with many diverse roles and responsibilities, including private property developers, architects, structural and civil engineers, building services engineers, government departments, major contracting organizations and subcontracting organizations (HKCI, 2003, available at www.hkci.org). In fact, partnering projects need different KPIs from construction projects in general. The reasons behind this were stated by Crane *et al.* (1999) and Cheung *et al.* (2003). Crane *et al.* (1999) introduced three types of measures for partnering projects. Two of them, result measures and relationship measures, are crucial to measure the performance of partnering projects. They defined result measures as 'hard' measures based on performance, such as cost, schedule, quality and safety.

Crane *et al.* (1999) argued that since result measures tell the decision maker little or nothing about the

Table 1 Summary of literature review on performance measures to evaluate the success of partnering projects in construction

KPIs for partnering projects in construction	Crane <i>et al.</i> (1999)	Chan <i>et al.</i> (2001)	Zhao (2002)	Cheung <i>et al.</i> (2003)	Bayliss <i>et al.</i> (2004)	Cheng and Li (2004)	Chan <i>et al.</i> (2004, 2006)	Total no. of citations for each KPI identified
1. Construction time/time variation/programme	✓	✓	✓	✓	✓		✓	6
2. Cost/capital cost/construction cost/budget	✓	✓	✓	✓	✓		✓	6
3. Quality	✓	✓		✓	✓		✓	5
4. Claim occurrence/claim magnitude		✓		✓	✓		✓	4
5. Effective communications	✓		✓	✓	✓			4
6. Accident/incident rate/safety	✓			✓	✓		✓	4
7. Environmental issue/number of environmental complaints			✓	✓	✓		✓	4
8. Trust and respect	✓		✓	✓				3
9. Harmonious working relationships		✓				✓		2
10. Litigation occurrence/litigation magnitude	✓						✓	2
11. Dispute occurrence/dispute magnitude		✓					✓	2
12. Customer satisfaction			✓			✓		2
13. Profit and financial objectives			✓					1
14. Scope of rework	✓							1
15. Productivity			✓					1
16. Innovation and improvement			✓					1
17. Pollution occurrence/pollution magnitude							✓	1
18. Professional image establishment							✓	1
19. Employee's attitude			✓					1
Total number of KPIs identified from each publication	8	6	10	8	7	2	10	51

condition of the environment in which the performance is attained, a partnering relationship must make use of relationship measures to achieve a greater degree of foresight and realize the benefits of increased time to react to problems in the relationship. Cheung *et al.* (2003) also pointed out that hard measures alone do not provide a clear picture of partnering performance, as partnering is about cooperative working relationships between contracting parties. They also suggested that it is necessary to use relationship measures to assess the behavioural aspects of partnering. Crane *et al.* (1999) defined relationship measures as 'soft' measures and they are used to track the activities and effectiveness of the partnering working team. Examples of the

relationship measures include: (1) internal communication; (2) external communication; (3) meeting effectiveness; (4) worker morale; (5) internal trust; (6) external trust; (7) internal leadership; (8) external leadership; (9) accomplishment of objectives; (10) utilization of resources; (11) problem solving; (12) creativity and synergy; (13) timely evaluation and appropriate response; (14) definition and adherence to roles and responsibilities; (15) continuous improvement; and (16) teamwork. On the other hand, both the result and relationship measures can be divided into objective and subjective measures. The first group uses mathematical formulae to calculate the respective values. Examples include time performance, cost

Table 2 Key Performance Indicators (KPIs) for 17 demonstration projects using partnering approach in Hong Kong

	Safety	Quality/high quality	Anticipated delay/programme	Effective communications/teamwork	Profit/financial objective	Environmental performance/environmental protection/waste reduction	Cost/savings	Successful project/elevated project image/professional image establishment	Innovation	Relationships/improved relationship	Team of next project/long-term relationship	Job satisfaction	Trust/respect	Client's satisfaction	Top management commitment	Reduction of paperwork	Partnering workshop	Total number of KPIs identified from each project
The Orchards	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓					11
Three Pacific Place	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						11
Cambridge House	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓					11
Po Lam Road Phase 1	✓	✓	✓	✓	✓	✓		✓	✓			✓		✓				10
Tsim Sha Tsui Station Modification Works	✓	✓	✓	✓	✓		✓		✓		✓	✓	✓					10
Chater House	✓	✓			✓	✓	✓			✓		✓		✓		✓		9
Choi Yuen Phase 2	✓	✓	✓	✓	✓	✓		✓			✓							8
Stonecutters Bridge	✓	✓	✓		✓	✓		✓	✓	✓								8
Grand Promenade	✓		✓	✓			✓	✓		✓		✓	✓					8
Hong Kong Museum of Coastal Defence	✓	✓	✓	✓	✓			✓					✓					7
Tradeport Hong Kong Logistics Centre	✓			✓	✓	✓	✓	✓	✓									7
Design and Build of Improvement to Castle Peak Road	✓		✓		✓	✓				✓								5
Lok Ma Chau Viaduct	✓	✓	✓				✓							✓				5
Tseung Kwan O Technology Park		✓	✓	✓											✓		✓	5
East Hall Extension of Passenger Terminal Building of the HK International Airport	✓	✓	✓				✓											4
One Peking Road	✓			✓		✓			✓									4
Tseung Kwan O Area 73A Phase 2	✓	✓				✓												3
Total no. of citations for each KPI identified	16	13	13	11	11	10	9	9	8	5	5	5	5	3	1	1	1	125

performance, safety performance and productivity. The other group uses subjective opinions and personal judgment of the project stakeholders. Examples include quality, trust and effective communications.

A model has been established using the Delphi survey technique to objectively measure the performance of partnering projects in Hong Kong. A composite Partnering Performance Index (PPI) for partnering projects has been compiled. By doing so, the performance of different partnering projects can be compared and assessed objectively. Four rounds of Delphi questionnaire survey were launched with 31 construction experts in Hong Kong. The selected experts were either industrial practitioners equipped with rich hands-on experience in partnering projects or prominent academics with demonstrated research experience in construction partnering. The iterations of the Delphi exercise enable the experts both to select the most appropriate KPIs for partnering projects in Hong Kong, and to provide ratings to each KPI. A more reliable result could thus be achieved. A statistically significant consensus on the weighting of each KPI was also sought from the 31 experts. The Delphi technique was used first to select a series of the most important KPIs for partnering projects in Hong Kong and second to obtain suitable ratings to each identified KPI. Finally, a series of weighted KPIs were developed from the Delphi questionnaires. The findings of this Delphi study will be discussed in this paper, followed by highlighting the significance and limitations of the study. It is of interest to note that since project partnering is still dominant in the Hong Kong construction industry when compared with strategic partnering, the model developed is mainly applied to project partnering. A significant difference between project partnering (relationship established for a single project) and strategic partnering (a long-term commitment beyond a discrete project) is that the former is for a single project (Construction Industry Institute, 1991; Li *et al.*, 2000; McGeorge and Palmer, 2002; Walker *et al.*, 2002) but the latter involves at least two projects (Bennett and Jayes, 1998; Li *et al.*, 2000).

Background of the Delphi technique

The Delphi concept was developed from the American defence industry (Chan *et al.*, 2001). A study entitled 'Project Delphi' was conducted by the Rand Corporation for the US Air Force in the early 1950s related to the use of expert opinion (Helmer, 1967a, b; Robinson, 1991). The Delphi method involves the selection of procedures for suitable experts, development of appropriate questions to be put to them, and

analysis of their responses (Cabanis, 2001; Outhred, 2001). The process is typically carried out by remote correspondence, such as mailed questionnaires and e-mail, rather than involving face-to-face group discussions. This enables all Delphi survey participants to respond individually and reduces the impact of group dynamics on the resulting consensus (Manoliadis *et al.*, 2006). The method is based on the judgment of the selected experts, and does not rely on previous historical data being available. In addition, the method is typically intended to provide a judgment or opinion on the specific subject area, rather than producing a quantifiable measure or result. Because of this, the method can easily work well in new areas that are frequently subject to unpredictable forces, which are not easily quantifiable in most of the cases (Manoliadis *et al.*, 2006).

Chan *et al.* (2001) considered that the Delphi method can be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal with complicated problems. Delphi is primarily a communication device that is applied when the consensus of experts on an uncertain issue, often intangible, is desired (Linstone and Turoff, 1975). It is generally conducted by several rounds interspersed with group opinion and information feedback in the form of relevant statistical data. The three key features of the Delphi method, as mentioned by Dickey and Watts (1978) and Adnan and Morledge (2003), are (1) anonymity; (2) iteration with controlled feedback; and (3) statistical response. Generally, the number of rounds ranges from two to seven and the number of participants varies between 3 and 15 (Rowe and Wright, 1999; Adnan and Morledge, 2003). The desired outcome is that, by using an iterative forecasting procedure on reaching the final round, the experts will have achieved unanimity on the issues put before them (Manoliadis *et al.*, 2006). The Delphi approach also offers a fringe advantage in situations where it is vital to define areas of uncertainty or disagreement among experts (Chan *et al.*, 2001). In these examples, Delphi can highlight topics of concern and assess uncertainty in a quantitative manner. The major difficulties of the Delphi method, however, lie in maintaining high level of response and in reaching and implementing a consensus (Robinson, 1991; Chan *et al.*, 2001).

Research method: the Delphi survey

Literature related to performance measures for partnering projects in construction was comprehensively

reviewed, which led to the development of a conceptual framework encompassing 25 various measures to evaluate the success of partnering projects. Four rounds of Delphi questionnaire survey were conducted to develop a series of weighted KPIs for measuring the performance of partnering projects through leading industrial practitioners in Hong Kong. By doing so, different partnering projects can be assessed and compared objectively based on a composite Partnering Performance Index (PPI) to measure their project performance. Face-to-face interviews were launched with leading industrial practitioners to verify the validity of the identified KPIs.

The Delphi technique is the primary research tool adopted in this study. In fact, the Delphi approach has been increasingly adopted in many complex areas in which a consensus is needed to be reached (Chan *et al.*, 2001), for example: (1) the development of residential areas (Anatharajan and Anataraman, 1982); (2) theory and design application (Corotis *et al.*, 1981); (3) bridge condition rating and effects of improvements (Saito and Sinha, 1991); (4) procurement selection (Chan *et al.*, 2001); and (5) sustainable development (Manoliadis *et al.*, 2006). The Delphi method is a highly formalized method of communication that is designed to extract the maximum amount of unbiased information from a panel of experts (Chan *et al.*, 2001). Therefore, it is appropriate to adopt the Delphi method to obtain a series of weighted KPIs to evaluate the success of partnering projects in construction because it is a rather subjective and new area of research.

Format of Delphi rounds

Manoliadis *et al.* (2006) stated that the key issues in preparing a Delphi study were: (1) the definition of experts and their selection; (2) the number of rounds; and (3) the questionnaire structure (i.e. number of questions) in each study round. The Delphi method used in this research comprised four rounds. In the first round of the Delphi questionnaire, the respondents were asked to select a minimum of five to a maximum of 10 KPIs from a consolidated conceptual framework of 25 various measures of partnering success identified from the literature. In Round 2 of the Delphi survey, respondents were provided with the consolidated results from Round 1 and were invited to reconsider their options to see if they would like to adjust their original choice. In the third round of questionnaire, respondents were requested to provide ratings on the top seven weighted KPIs (the top seven KPIs have been selected for further study based on a criterion that all of them were selected by at least 50% of experts) based on a five-point Likert scale to evaluate the success of partnering projects. While analysing the data, the focus

ought to be on the opinion of the group rather than of individuals. Therefore, a concordance analysis measuring the consistency of the experts' responses over successive rounds of the Delphi questionnaire was used. In Round 4 of the Delphi questionnaire, respondents were provided with the consolidated results from Round 3. They were asked to reconsider the ratings of each of the top seven KPIs to see if they would like to adjust their original ratings in the light of the consolidated results. The consistency of the results of Rounds 3 and 4 were analysed and compared by the Kendall's Concordance Analysis statistically.

Selection of expert panel

The success of the Delphi method depends principally on the careful selection of the panel members (Chan *et al.*, 2001). A group of experts was selected to determine the KPIs of partnering projects in Hong Kong. As the information solicited requires in-depth knowledge and sound experience about KPIs for partnering projects, a purposive approach was adopted to select this group of experts (Bryman, 1996; Morgan, 1998; Edmunds, 1999; Chan *et al.*, 2001; Manoliadis *et al.*, 2006). The following three criteria were devised in order to identify eligible participants for this study:

- Criterion 1: Having extensive working experience in partnering projects in Hong Kong.
- Criterion 2: Having current/recent and direct involvement in the management of partnering projects in Hong Kong.
- Criterion 3: Having a sound knowledge and understanding of partnering concepts.

In order to obtain the most valuable opinions, only practitioners/academics who met all the selection criteria were considered. A total of 39 practitioners/academics were identified and invited to participate in this study. The selected experts represent a wide spectrum of construction professionals in Hong Kong, with eighteen from the private sector, eight from the public sector, six from the infrastructure sector, and seven from the academic sector. The composition of this group of experts provides a balanced view for the Delphi study.

Four rounds of Delphi questionnaires

Round 1 of the Delphi questionnaire: selecting the most vital KPIs

Format

The first round of Delphi questionnaire (see Appendix A) was sent to the group of panel members by both

mail and e-mail in early September 2005. The invitation letter explained the aim of the research, and the experts were informed that there would be a total of four rounds of questionnaires in the proposed survey. In this round, the identified 39 experts were asked to select a minimum of five to a maximum of 10 out of 25 KPIs that they believed to be the most important KPIs to evaluate the success of partnering projects (the respondents were encouraged to propose additional KPIs for partnering projects in Hong Kong if deemed appropriate). However, only about half of the experts completed the questionnaire in two weeks' time. An e-mail was therefore sent to remind all the experts who had not yet returned their completed questionnaires within the stipulated deadline, followed up by a phone call. Finally, 31 responses were collected and eight experts withdrew from the study in mid-October 2005. The main reason for their dropping out was the heavy commitment of their current workload.

Results and analysis

Table 3 shows the indication of relative importance of each KPI by the 31 experts. Similar to Chan *et al.* (2001), only KPIs which have been selected by 50% of experts or above will be selected for further consideration. Seven (7) KPIs met this criterion in the first round of the study. The top seven KPIs were: (1) time performance; (2) cost performance; (3) quality performance; (4) trust and respect; and effective communications (equal frequencies for both); (6) harmonious working relationships; and top management commitment (equal frequencies for both). In addition, five new KPIs which had not been identified from the literature were suggested by the panel of experts. They included: (1) method of procurement and time for closing of final account; (2) job efficiency and reliability; (3) minimizing impact on operations; (4) commitment of staff at work level; and (5) good public relations. However, they were not selected for further study since they did not meet the 50% cut-off criterion.

Round 2 of the Delphi questionnaire: reassessing the selected KPIs

Format

Similar to Round 1 of the Delphi survey, the second round of the Delphi questionnaire (see Appendix B) was forwarded to the group of panel members by both mail and e-mail in mid-October 2005. In this round, the results of Round 1 were consolidated and presented and the experts were requested to reconsider whether

they would like to change any of their original choices in the light of the consolidated results from Round 1. Similar to Round 1, only about half of the experts completed the questionnaire within two weeks. An e-mail was then issued to remind all the experts who had not yet returned their completed forms, followed up by a phone call. Finally, they all completed the questionnaire in mid-November 2005.

Results and analysis

Table 4 shows the relative importance of each KPI assessed by the 31 experts after their second thoughts. It should be pointed out that 'harmonious working relationships', originally rated as one of the top seven KPIs in Round 1, was dropped out and replaced by 'innovation and improvement'. The descending order of the top seven KPIs was slightly changed as follows: (1) time performance; (2) cost performance; (3) quality performance; (4) trust and respect; (5) top management commitment; (6) effective communications; and (7) innovation and improvement.

Round 3 of the Delphi questionnaire: ratings obtained from experts

Format

In the third round of the Delphi questionnaire (see Appendix C), experts were asked to provide ratings on the top seven KPIs based on a five-point Likert scale to evaluate the success of partnering projects. In addition, the five-point Likert scale, ranging from 1 = least important, 2 = slightly important, 3 = important, 4 = very important, to 5 = most important, is used because the dimension for measuring KPIs should be unipolar, referring to different degrees of the same attribute, but not bipolar, referring to the presence of opposite attributes (Schwarz, 1996). Similar to Rounds 1 and 2, only about half of the experts completed the questionnaire within two weeks. An e-mail was sent to remind those experts who had not returned their completed questionnaires in time, and followed up by a phone call. Finally, they all completed the questionnaire in mid-December 2005.

Results and analysis

A statistical analysis was performed on the 31 questionnaires received in which the mean ratings for the top seven KPIs were computed. A preliminary series of weighted KPIs was developed based on the mean ratings advocated by the 31 experts. Each KPI was measured using a score between 1 and 5, with 1 representing 'least important' and 5 representing 'most important' for each KPI to assess the success of

Table 3 Result of Round 1 of the Delphi questionnaire

	Total Frequency	Percentage	Rank
KPIs for partnering projects in Hong Kong			
<i>Time performance</i> Referring to the time variation of a project, such as ahead of schedule, on schedule or behind schedule	28	90.32	1
<i>Cost performance</i> Referring to the total cost of a project, such as within budget, on budget or over budget	27	87.10	2
<i>Quality performance</i> Referring to the quality of a project, such as high quality, average quality or low quality	26	83.87	3
<i>Trust and respect</i> Referring to level of trustfulness and respectfulness among different project stakeholders	20	64.52	4
<i>Effective communications</i> Referring to level of effective cooperation, communication and teamwork at all levels	20	64.52	4
<i>Harmonious working relationships</i> Referring to developing harmonious working relationships among all project stakeholders at all levels	16	51.61	6
<i>Top management commitment</i> Referring to level of senior management commitment on supporting partnering approach	16	51.61	6
<i>Innovation and improvement</i> Referring to number of new initiatives for improvement introduced (e.g. construction techniques, procurement) in a project	15	48.39	8
<i>Client's satisfaction</i> Referring to level of satisfaction for the client organization on participating a project	13	41.94	9
<i>Safety performance</i> Referring to accident rate of a project, such as low accident rate, average, or high accident rate	10	32.26	10
<i>Profit and financial objectives</i> Referring to the profitability of a project, such as high profit, break even or serious loss	9	29.03	11
<i>Dispute occurrence and magnitude</i> Referring to dispute numbers and amounts of a project	9	29.03	11
<i>Customer's satisfaction</i> Referring to level of satisfaction for the end-users on a project	8	25.81	13
<i>Productivity</i> Referring to the amount of resource input to complete a given task	8	25.81	13
<i>Scope of rework</i> Referring to the scale of rework of a project, such as very little rework, average rework, or much rework	7	22.58	15
<i>Long-term business relationship</i> Referring to building up long-term business relationships with other contracting parties involved in a project	7	22.58	15
<i>Reduction of paperwork</i> Referring to level of paperwork reduction of a project, such as high level of paperwork reduction or low level of paperwork reduction.	7	22.58	15
<i>Environmental performance</i> Referring to number of complaints received caused by environmental problems of a project	6	19.35	18
<i>Claim occurrence and magnitude</i> Referring to claim numbers and amounts of a project	5	16.13	19
<i>Employee's attitude</i> Referring to employee's attitude towards the implementation of partnering approach of a project	5	16.13	19
<i>Introduction of partnering workshop</i> Referring to whether a project uses a structured or unstructured approach towards implementing partnering	5	16.13	19
<i>Professional image establishment</i> Referring to the degree of pride and reputation of each contracting party enhanced by the successful completion of a project	4	12.90	22

Table 3 (Continued.)

KPIs for partnering projects in Hong Kong	Total Frequency	Percentage	Rank
<i>Litigation occurrence and magnitude</i>	2	6.45	23
Referring to litigation numbers and amounts of a project			
<i>Job satisfaction</i>	2	6.45	23
Referring to level of individual job satisfaction and career development opportunities			
<i>Good public relations</i>	2	6.45	23
<i>Method of procurement and timing for closing of final account</i>	1	3.23	26
<i>Job efficiency and reliability</i>	1	3.23	26
<i>Minimizing impact on operations</i>	1	3.23	26
<i>Commitment of staff at work level</i>	1	3.23	26
<i>Pollution occurrence</i>	0	0.00	30

Table 4 Result of Round 2 of the Delphi questionnaire

KPIs for partnering projects in Hong Kong	Total frequency	Percentage	Rank
Time performance	30	96.77	1
Cost performance	29	93.55	2
Quality performance	28	90.32	3
Trust and respect	24	77.42	4
Top management commitment	20	64.52	5
Effective communications	19	61.29	6
Innovation and improvement	17	54.84	7
Harmonious working relationships	15	48.39	8
Client's satisfaction	13	41.94	9
Safety performance	10	32.26	10
Profit and financial objectives	8	25.81	11
Dispute occurrence and magnitude	8	25.81	11
Productivity	6	19.35	13
Customer's satisfaction	6	19.35	13
Scope of rework	5	16.13	15
Long-term business relationship	5	16.13	15
Reduction of paperwork	5	16.13	15
Environmental performance	4	12.90	18
Claim occurrence and magnitude	4	12.90	18
Good public relations	2	6.45	20
Introduction of partnering workshop	2	6.45	20
Method of procurement and timing for closing of final account	1	3.23	22
Employee's attitude	1	3.23	22
Professional image establishment	1	3.23	22
Job satisfaction	1	3.23	22
Job efficiency and reliability	1	3.23	22
Minimizing impact on operations	1	3.23	22
Commitment of staff at work level	0	0.00	28
Litigation occurrence and magnitude	0	0.00	28
Pollution occurrence	0	0.00	28

partnering projects. The weighting for each of the top seven KPIs was computed by using the following equation (Chow, 2005):

$$W_{KPIa} = \frac{M_{KPIa}}{\sum_g M_{KPIg}} \text{ for } a = 1 \quad (1)$$

where:

W_{KPIa} represents the weighting of a particular top seven KPI;

M_{KPIa} represents the mean ratings of a particular top seven KPI;

$\sum_g M_{KPIg}$ represents the summation of mean ratings of all the top seven KPIs.

Table 5 shows the top seven KPIs together with their corresponding weightings. They are: (1) time performance, with the weighting of 0.167; (2) cost performance, with the weighting of 0.161; (3) top management commitment, with the weighting of 0.148; (4) quality performance, with the weighting of 0.147; (5) trust and respect, with the weighting of 0.142; (6) effective communications, with the weighting of 0.131; and (7) innovation and improvement, with the weighting of 0.104. In order to compile a composite indicator to evaluate the success of partnering projects, a Partnering Performance Index (PPI) is developed which can be represented by the following formula:

$$\begin{aligned} \text{PPI} = & 0.167 \times \text{time performance} \\ & + 0.161 \times \text{cost performance} \\ & + 0.148 \times \text{top management commitment} \\ & + 0.147 \times \text{quality performance} \\ & + 0.142 \times \text{trust and respect} \\ & + 0.131 \times \text{effective communications} \\ & + 0.104 \times \text{innovation and improvement} \end{aligned} \quad (2)$$

The PPI is composed of the top seven weighted KPIs identified in the Round 3 of the Delphi questionnaire

and the coefficients are their individual weightings, which are calculated by their individual mean ratings divided by the total mean ratings. The Index is derived based on the assumption that this is a linear and additive model. It is logical and valid to derive this linear and additive model because the correlation matrix as shown in Table 6 reveals that the top seven weighted KPIs are not highly correlated with each other at 5% significance level (more than half of them are even insignificantly correlated with each other). In addition, the units of measurement for the top seven weighted KPIs are different so it is not likely to have any multiplier effect between them. Though it seems more sophisticated to use a non-linear model to fit the data obtained, overfitting is a common problem with non-linear models especially when the sample size is not sufficiently large (Neter *et al.*, 2005; Weisberg, 2005). That is why a linear, but not non-linear model is recommended if the relationship among variables is not proved to be non-linear. In fact, a linear model is assumed to be a linearized model of an unknown non-linear model if it really exists (Morrison, 1991; Griffiths, 1993). Practically speaking, it is simpler and easier to use this model to measure the partnering performance of construction projects in the Hong Kong construction industry.

In order to obtain a measure of consistency, a statistical test was applied involving the calculation of the Kendall's Coefficient of Concordance (W) for the KPIs provided by the 31 experts (Chan *et al.*, 2001) with the aid of the Statistical Packages for Social Sciences (SPSS) computer software. If the Concordance Coefficient is equal to 1, it means that all the experts rank the KPIs identically. In contrast, if the Concordance Coefficient is equal to 0, it means that all the experts rank the KPIs totally differently. Table 5 also shows that Kendall's Coefficient of Concordance (W) for the rankings of the top seven weighted KPIs was 0.249, which was statistically significant at 1% level. The null hypothesis that the respondent's ratings within the group are unrelated to

Table 5 Result of Round 3 of the Delphi questionnaire

KPIs for partnering projects in Hong Kong	Mean rating	Rank	Corresponding weighting
Time performance	4.48	1	0.167
Cost performance	4.32	2	0.161
Top management commitment	3.97	3	0.148
Quality performance	3.94	4	0.147
Trust and respect	3.81	5	0.142
Effective communications	3.52	6	0.131
Innovation and improvement	2.81	7	0.104

Notes:

Number (n) = 31. Kendall's Coefficient of Concordance (W) = 0.249. Level of significance = 0.000.

For 'Mean rating': 1 = least important and 5 = most important.

Table 6 Correlation matrix among the top seven weighted KPIs (for Round 3 of the Delphi survey)

Correlation matrix	Time performance	Cost performance	Quality performance	Trust and respect	Top management commitment	Effective communications	Innovation and improvement
Time performance	1	0.505**	0.551**	-0.347	-0.248	-0.241	-0.138
Cost performance		1	0.520**	-0.411*	-0.261	-0.388*	-0.242
Quality performance			1	-0.360*	-0.418*	-0.129	0.172
Trust and respect				1	0.682**	0.674**	0.249
Top management commitment					1	0.550**	0.248
Effective communications						1	0.547**
Innovation and improvement							1

Notes: ** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

each other would have to be rejected. Therefore, it can be concluded that a significant amount of agreement among the respondents within the group of panel experts is found.

Round 4 of the Delphi questionnaire: reassessing the weighted KPIs

Format

For Round 4 of the Delphi survey (see Appendix D), the experts were provided with the consolidated results obtained in Round 3. The average ratings of the 31 experts for each KPI and the respondent's own ratings in Round 3 were provided. The respondents were asked to reassess their ratings in the light of the mean scored by the 31 experts. The final round questionnaire was distributed to the same group of panel experts both by mail and e-mail in mid-December 2005. Similar to

the previous rounds, an e-mail was forwarded to remind all the experts who did not return the questionnaire in time, followed up by a phone call. Finally, they all completed the questionnaire in mid-January 2006.

Results and analysis

Most experts had reconsidered their ratings provided in the previous round and had made adjustments to their ratings. The consistency of the experts' weightings was again computed using SPSS package to calculate the Kendall's Coefficient of Concordance (W). Table 7 shows that there is no change for the order of their mean ratings except that 'trust and respect' is changed from the fifth rank to the fourth rank. In addition, their corresponding weightings are similar to those of Round 3. It also reveals that the consistency of the experts' rankings for the top seven weighted KPIs was improved

Table 7 Comparisons of Rounds 3 and 4 of the Delphi questionnaire

KPIs for partnering projects in Hong Kong	Round 3			Round 4		
	Mean rating	Rank	Corresponding weighting	Mean rating	Rank	Corresponding weighting
Time performance	4.48	1	0.167	4.55	1	0.167
Cost performance	4.32	2	0.161	4.35	2	0.160
Top management commitment	3.97	3	0.148	4.10	3	0.150
Quality performance	3.94	4	0.147	3.90	4	0.143
Trust and respect	3.81	5	0.142	3.90	4	0.143
Effective communications	3.52	6	0.131	3.58	6	0.131
Innovation and improvement	2.81	7	0.104	2.90	7	0.106
Number (n)		31			31	
Kendall's Coefficient of Concordance (W)		0.249			0.290	
Level of significance		0.000			0.000	

Notes: For 'Mean rating': 1 = least important and 5 = most important.

by 16.5% to 0.29, which was also statistically significant at 1% level.

$$\begin{aligned}
 \text{PPI} = & 0.167 \times \text{time performance} \\
 & + 0.160 \times \text{cost performance} \\
 & + 0.150 \times \text{top management commitment} \\
 & + 0.143 \times \text{quality performance} \\
 & + 0.143 \times \text{trust and respect} \\
 & + 0.131 \times \text{effective communications} \\
 & + 0.106 \times \text{innovation and improvement}
 \end{aligned} \quad (3)$$

Similar to the Index derived in Equation 2, this PPI is composed of the top seven weighted KPIs identified in Round 4 of the Delphi questionnaire and the coefficients are their individual weightings, which are calculated by their individual mean ratings divided by the total mean ratings. As with the previous Index, this Index is derived based on the assumption that this is a linear and additive model. The correlation matrix as indicated in Table 8 manifests that the top seven weighted KPIs are not highly correlated with each other at 5% significance level (more than half of them are even insignificantly correlated with each other). Therefore it is valid to assume this linear and additive model.

Discussion and validation of research findings

The research findings indicate that the top seven weighted KPIs for partnering projects in Hong Kong emphasize project success, relationships and people. Traditionally, project success is measured by project performance in terms of time, cost and quality (Chan and Chan, 2004). The findings are consistent in this

regard because time performance, cost performance and quality performance take the first, second and fourth positions respectively in this research study. On the other hand, the findings stress relationships and people. There is no doubt that three of the top seven weighted KPIs, including: (1) trust and respect; (2) effective communication; and (3) innovation and improvement, are important goals pursued by many of the project stakeholders who procure partnering projects. The results are also in line with the previously reviewed literature on KPIs for partnering projects and the Hong Kong demonstration projects using the partnering approach. It should be added that the Delphi method by its inherent nature serves as a self-validating mechanism because individual experts are given chances to reassess their scores with reference to the consolidated mean scores as assessed by other experts. By using the Delphi method, the maximum amount of unbiased and objective information can be obtained from the panel of experts. Since the sample size is specified and appropriate for this Delphi study, the results of the study can be reasonably generalized based on the sample.

Significance and limitations of the study

There is ample evidence that an increasing number of client bodies are applying a partnering approach to launch their building and construction works (Chan *et al.*, 2003). With the perceived partnering benefits, research into Key Performance Indicators (KPIs) for partnering projects is vital because it can help boost a wider application through identifying critical success factors for partnering projects and developing a best practice framework for implementation. However, there are few, if any, comprehensive research studies into the study of

Table 8 Correlation matrix among the top seven weighted KPIs (for Round 4 of the Delphi survey)

Correlation matrix	Time performance	Cost performance	Quality performance	Trust and respect	Top management commitment	Effective communications	Innovation and improvement
Time performance	1	0.464**	-0.193	0.414*	-0.181	-0.213	-0.166
Cost performance		1	-0.231	0.528**	-0.416*	-0.416*	-0.278
Quality performance			1	-0.271	0.804**	0.426*	0.205
Trust and respect				1	-0.256	-0.121	0.185
Top management commitment					1	0.571**	0.273
Effective communications						1	0.495**
Innovation and improvement							1

Notes: ** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

KPIs to evaluate the success of partnering projects. Therefore, the development of a series of weighted KPIs becomes essential. In fact, without a general consensus on how to measure the performance level of partnering projects, it is quite difficult for construction senior executives and project managers to allocate their resources in the best way because their decisions are very often made by perceived intuition, and they cannot be sure whether the actions taken are correct or not. The proposed performance evaluation model provides an objective basis for measuring the performance of partnering projects. The PPI not only enhances the understanding of clients, contractors and consultants in running a successful partnering project, but also it sets a solid base for industrial practitioners to measure, evaluate and monitor the performance of their individual partnering projects at completion. In addition, the PPI helps set a benchmark for measuring the performance of partnering projects within an organization and the construction industry so that this can help improve the partnering performance of construction projects through proper project monitoring and control. It also provides valuable insights into developing a strong and comprehensive base for further research, for example, identifying critical success factors for implementing partnering and then developing a best practice framework for partnering. A similar research method (a comprehensive literature review together with several rounds of Delphi questionnaire survey) can also be extended to develop a comprehensive, objective, reliable and practical performance evaluation model for partnering projects internationally and other similar types of projects, such as alliancing projects, relational contracting projects and public-private partnerships projects.

However, it is worth noting that different assessors may have their own semantic interpretation on each KPI. For example, an assessor may use 'Percentage of conformance to the specifications' to measure quality performance while another assessor may adopt 'Number of non-conformance reports generated per month' to measure it. Even if a mutually agreed set of linguistic interpretations exists, its qualitative nature could lead to subjective judgment instead of evidence-based consideration. Thus, it is desirable to identify suitable quantitative interpretations/indicators (QIs) for each KPI so as to avoid any possible discrepancies in interpreting the meaning of each KPI and provide objective evaluation results based on quantitative evidence. By incorporating these indicators into the evaluation process, assessors could perform their evaluation based on quantitative evidence.

Nevertheless, having a set of QIs cannot fully eliminate the subjectivity of evaluation. To remedy this deficiency, fuzzy quantitative requirements (FQRs) pertinent to each QI should be identified. However,

defining the QR of each performance level by a single figure is insufficient. For instance, a 1% reduction in project duration may represent 'average performance' while a 5% reduction in project duration may denote 'good performance'. Should a partnering project be classified as 'average' or 'good' in terms of time performance in case of a 3% reduction in project duration? Therefore, it is more appropriate to establish a well-defined range of QRs for each QI against different performance levels. For example, a partnering project that is ahead of schedule by 3% to 8% could be regarded as 'good' on the QI 'Variation of actual completion time expressed as a percentage of finally agreed completion time'. The development of appropriate QIs and ranges of QRs for each QI identified in this study has been completed and the overall research outcomes will be disseminated via subsequent publications.

Conclusion

The topic of Key Performance Indicators (KPIs) in construction has been discussed for many years, but there are not many comprehensive and systematic studies on partnering projects. This study has applied the Delphi survey technique to develop a model to objectively measure the performance of partnering projects in the Hong Kong construction industry. The descending order of the top seven weighted KPIs identified were found to be: (1) time performance, with the weighting of 0.167; (2) cost performance, with the weighting of 0.160; (3) top management commitment, with the weighting of 0.150; (4) quality performance, with the weighting of 0.143; (5) trust and respect, with the weighting of 0.143; (6) effective communications, with the weighting of 0.131; and (7) innovation and improvement, with the weighting of 0.106. The KPIs' framework for partnering projects helps develop a composite index and set a benchmark for measuring the performance of partnering projects in Hong Kong. Different partnering projects can then be evaluated and compared objectively based on this Partnering Performance Index (PPI) established. As a result, construction senior executives and project managers can use this Index to measure, monitor and upgrade the performance of their partnering projects. It also deepens the current body of knowledge and understanding of both academics and practitioners in the construction industry to achieve outstanding partnering performance. Since the model was developed locally in Hong Kong, further research should be conducted in other geographical locations to seek their similarities and differences by adopting the same research method for international comparisons.

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References

- Abudayyeh, O. (1994) Partnering: a team building approach to quality construction management. *ASCE Journal of Management in Engineering*, 10(6), 26–9.
- Adnan, H. and Morledge, R. (2003) Application of Delphi method on critical success factors in joint venture projects in the Malaysian construction industry, Paper presented at the CITC-II Conference, Hong Kong, 10–12 December.
- Anatharajan, T. and Anataraman, V. (1982) Development of residential areas: Delphi technique for decision making. *International Journal for Housing Science and Its Application*, 6(4), 329–41.
- Bayliss, R., Cheung, S.O., Suen, H.C.H. and Wong, S.P. (2004) Effective partnering tools in construction: a case study on MTRC TKE contract 604 in Hong Kong. *International Journal of Project Management*, 22(3), 253–63.
- Bennett, J. and Jayes, S. (1998) *The Seven Pillars of Partnering: A Guide to Second Generation Partnering*, Thomas Telford, London.
- Bryman, A. (1996) *Quantity and Quality in Social Research*, Routledge, London.
- Cabanis, K. (2001) Counseling and computer technology in the new millennium—an internet Delphi study, available at <http://scholar.lib.vt.edu/theses/available/etd-03072001.175713> (accessed).
- Chan, A.P.C. and Chan, A.P.L. (2004) Key Performance Indicators (KPIs) for measuring construction success. *Benchmarking: An International Journal*, 11(2), 203–21.
- Chan, A.P.C., Yung, E.H.K., Lam, P.T.I., Tam, C.M. and Cheung, S.O. (2001) Application of Delphi method in selection of procurement systems for construction projects. *Construction Management and Economics*, 19, 699–718.
- Chan, A.P.C., Chan, D.W.M. and Ho, K.S.K. (2002) An analysis of project partnering in Hong Kong. Research Monograph, Department of Building and Real Estate, The Hong Kong Polytechnic University.
- Chan, A.P.C., Chan, D.W.M. and Ho, K.S.K. (2003) An empirical study of the benefits of construction partnering in Hong Kong. *Construction Management and Economics*, 21(5), 523–33.
- Chan, A.P.C., Chan, D.W.M., Fan, L.C.N., Lam, P.T.I. and Yeung, J.F.Y. (2004) *A Comparative Study of Project Partnering Practices in Hong Kong*, Research Report No. 2, Construction Industry Institute, Hong Kong.
- Chan, A.P.C., Chan, D.W.M., Fan, L.C.N., Lam, P.T.I. and Yeung, J.F.Y. (2006) Partnering for construction excellence: a reality or myth? *Building and Environment*, 41(12), 1924–33.
- Cheng, E.W.L., Li, H. and Love, P.E.D. (2000) Establishment of critical success factors for construction partnering. *ASCE Journal of Management in Engineering*, 16(2), 84–92.
- Cheung, S.O., Suen, H.C.H. and Cheung, K.K.W. (2003) An automated partnering monitoring system: Partnering Temperature Index. *Automation in Construction*, 12(3), 331–45.
- Chow, L.K. (2005) Incorporating fuzzy membership functions and gap analysis concept into performance evaluation of engineering consultants: Hong Kong study, unpublished PhD thesis, Department of Civil Engineering, The University of Hong Kong, HKSAR.
- Collin, J. (2002) *Measuring the Success of Building Projects: Improved Project Delivery Initiatives*, Report for the Queensland Department of Public Works, Australia.
- Construction Industry Institute (CII) (1991) *In Search of Partnering Excellence*, Publication No.17-1, Report CII, Austin, TX.
- Construction Industry Institute (CII) (1996) *Partnering: Models for Success*, Partnering Task Force Report, Construction Industry Institute, Australia.
- Cook, E.L. and Hancher, D.E. (1990) Partnering: contracting for the future. *ASCE Journal of Management in Engineering*, 6(4), 431–46.
- Corotis, R., Fox, R. and Harris, J. (1981) Delphi methods: theory and design load application. *ASCE Journal of the Structural Division*, 107(6), 1095–1105.
- Crane, T.G., Felder, J.P., Thompson, P.J., Thompson, M.G. and Sanders, S.R. (1999) Partnering measures. *ASCE Journal of Management in Engineering*, 15(2), 37–42.
- Dickey, J. and Watts, T. (1978) *Analytic Techniques in Urban and Regional Planning*, McGraw-Hill, New York.
- Edmunds, H. (1999) *The Focus Group Research Handbook*, NTC Business Books.
- Griffiths, H.B. (1993) *Mathematics of Models: Continuous and Discrete Dynamics Systems*, Ellis Horwood Ltd, New York.
- Helmer, O. (1967a) *Systematic Use of Expert Opinions*, The Rand Corporation, Santa Monica, CA.
- Helmer, O. (1967b) *Analysis of the Future: The Delphi Method*, The Rand Corporation, Santa Monica, CA.
- Hong Kong Construction Industry (HKCI) (2003) *Hong Kong Demonstration Projects*, available at www.hkci.org (accessed).
- KPI Working Group (2000) *KPI Report for the Minister for Construction*, Department of the Environment, Transport and the Regions, London.
- Larson, E. (1995) Project partnering: results of study of 280 construction projects. *ASCE Journal of Management in Engineering*, 11(2), 30–35.
- Latham, M. (1994) *Constructing the Team*, Final Report of the Government/Industry Review of Procurement and Contractual Arrangements in the UK Construction Industry, HMSO, London.

- Li, H., Cheng, E.W.L. and Love, P.E.D. (2000) Partnering research in construction. *Engineering, Construction and Architectural Management*, 7(1), 76–92.
- Linstone, H. and Turoff, M. (1975) *The Delphi Method: Techniques and Applications*, Addison-Wesley, Reading, MA.
- Manoliadis, O., Tsolas, O. and Nakou, A. (2006) Sustainable construction and drivers of change in Greece: a Delphi study. *Construction Management and Economics*, 24(2), 113–20.
- McGeorge, D. and Palmer, A. (2002) *Construction Management New Directions*, 2nd edn, Blackwell Science, Oxford.
- Mohr, J. and Spekman, R. (1994) Characteristics of partnering success: partnering attributes, communication behaviour, and conflict resolution techniques. *Strategic Management Journal*, 15(2), 135–52.
- Morgan, D.L. (1998) *The Focus Group Guidebook*, Focus Group Kit 1, Sage, Beverly Hills, CA.
- Morrison, F. (1991) *The Art of Modeling Dynamics Systems: Forecasting for Chaos, Randomness and Determinism*, John Wiley & Sons, New York.
- Neter, J., Kutner, M., Nachtsheim, C. and Wasserman, W. (2005) *Applied Linear Statistical Models*, 5th edn, McGraw-Hill.
- Outhred, G.P. (2001) The Delphi method: a demonstration of its use for specific research types, in *Proceedings of the RICS Foundation, Construction and Building*.
- Robinson, J.B.L. (1991) Delphi technology for economic impact assessment. *Journal of Transportation Engineering*, 117(3), 335–349.
- Rowe, G. and Wright, G. (1999) The Delphi technique as a forecasting tool: issues and analysis. *International Journal of Forecasting*, 5, 353–75.
- Saito, M. and Sinha, K. (1991) Delphi study on bridge condition rating and effects of improvements. *Journal of Transportation Engineering*, 117(3), 320–34.
- Schwarz, N. (1996) *Cognition and Communication: Judgmental Biases, Research Methods, and the Logic of Conversation*, Lawrence-Erlbaum, Mahwah, NJ.
- Walker, D.H.T., Hampson, K. and Peters, R. (2002) Project alliancing vs project partnering: a case study of the Australian National Museum Project. *Supply Chain Management: An International Journal*, 7(2), 83–91.
- Weisberg, S. (2005) *Applied Linear Regression*, 3rd edn, John Wiley & Sons.
- Zhao, F. (2002) Measuring inter-organizational partnership: the challenge of cultural discrepancy, in *Proceedings of the 3rd International Conference on Theory & Practice in Performance Measurement*, Boston.

Appendix A

A survey of developing a series of Key Performance Indicators (KPIs) to evaluate the success of a partnering project (Round One Delphi Survey)

Guidance on completion

Thank you very much for participating in this research survey by making the best use of your expertise in

providing valuable opinions on identifying Key Performance Indicators (KPIs) to evaluate the success of a partnering project. Below are the 25 KPIs identified from previous research studies, and you are encouraged to insert additional attributes in the last row if deemed appropriate. Please select a minimum of 5 to a maximum of 10 Key Performance Indicators (KPIs) by giving ticks in the appropriate spaces, which you believe are the most vital KPIs to evaluate the success of a partnering project. Before completing this questionnaire, the following note on Key Performance Indicators (KPIs) may act as a useful reference.

Note:

Key Performance Indicators (KPIs)

The purpose of the Key Performance Indicators (KPIs) is to enable measurement of project and organizational performance through the construction industry. This information can then be used for benchmarking purposes, and will be a key component of any organization's move towards achieving best practice (The KPI Working Group, 2000). Collin (2002) advocates that the process of developing KPIs involved the consideration of eight factors. Five of them are listed as follows:

- (1) KPIs are general indicators of performance that focus on critical aspects of outputs or outcomes;
- (2) Only a limited, manageable number of KPIs is maintainable for regular use;
- (3) The systematic use of KPIs is essential as the value of KPIs is almost completely derived from their consistent use over a number of projects;
- (4) Data collection must be made as simple as possible;
- (5) A large sample size is required to reduce the impact on project specific variables. Therefore, KPIs should be designed to be used on every project.

References

- Collin, J. (2002) *Measuring the Success of Building Projects: Improved Project Delivery Initiatives*, Report for the Queensland Department of Public Works, Australia.
- The KPI Working Group (2000) *KPI Report for the Minister for Construction*, Department of the Environment, Transport and the Regions, London.

Round One Delphi survey (Please select a minimum of 5 but a maximum of 10 KPIs by giving ticks in the appropriate spaces)

Name of Respondent: _____

Position in your organization: _____

Key Performance Indicators (KPIs) for partnering projects	Your options
1. Time performance Referring to the time variation of a project, such as ahead of schedule, on schedule, or behind schedule	_____
2. Cost performance Referring to the total cost of a project, such as within budget, on budget or over budget	_____
3. Profit and financial objectives Referring to the profitability of a project, such as high profit, break even or serious loss	_____
4. Quality performance Referring to the quality of a project, such as high quality, average quality, or low quality	_____
5. Scope of rework Referring to the scale of rework of a project, such as very little rework, average rework, or much rework	_____
6. Productivity Referring to the amount of resource input to complete a given task	_____
7. Harmonious working relationships Referring to developing harmonious working relationships among all project stakeholders at all levels	_____
8. Long-term business relationships Referring to building up long-term business relationships with other contracting parties involved in a project	_____
9. Trust and respect Referring to level of trustfulness and respectfulness among different project stakeholders	_____
10. Litigation occurrence and magnitude Referring to litigation numbers and amounts of a project	_____
11. Dispute occurrence and magnitude Referring to dispute numbers and amounts of a project	_____
12. Claim occurrence and magnitude Referring to claim numbers and amounts of a project	_____
13. Effective communications Referring to level of effective cooperation, communication, and teamwork at all levels	_____
14. Reduction of paperwork Referring to level of paperwork reduction of a project, such as high level of paperwork reduction or low level of paperwork reduction	_____
15. Safety performance Referring to accident rate of a project, such as low accident rate, average, or high accident rate	_____
16. Environmental issues Referring to number of complaints received caused by environmental problems of a project	_____
17. Pollution occurrence Referring to number of pollution occurrences of a project	_____
18. Professional image establishment Referring to the degree of pride and reputation of each contracting party enhanced by the successful completion of a project	_____
19. Client's satisfaction Referring to level of satisfaction for the client organization on participating a project	_____
20. Customer's satisfaction Referring to level of satisfaction for the end-users on a project	_____
21. Job satisfaction Referring to level of individual job satisfaction and career development opportunities	_____
22. Employee's attitude Referring to employee's attitude towards the implementation of partnering approach of a project	_____
23. Innovation and improvement Referring to number of new initiatives for improvement introduced (e.g. construction techniques, procurement) in a project	_____
24. Introduction of partnering workshop Referring to whether a project uses a structured or unstructured approach towards implementing partnering	_____
25. Top management commitment Referring to level of senior management commitment on supporting partnering approach	_____
16. Others (Please specify)	_____

Appendix B

A survey of developing a series of Key Performance Indicators (KPIs) to evaluate the success of a partnering project (Round Two Delphi Survey)

Guidance on completion

Below are the results of Round 1 of the above study. The average percentage score of all experts is given in column (1). Your Round 1 option selections are given in column (2).

It is of interest to the research study to learn whether, with further thought, you would make any changes to your Round 1 option selections. Hence I would be most grateful if you would again select a minimum of 5 to a maximum of 10 Key Performance Indicators (KPIs) which you believe are the most vital to evaluate the success of a partnering project.

Round Two Delphi Survey

Name of Respondent: _____

Position in your organization: _____

Key Performance Indicators (KPIs) for partnering projects	% of experts in Round One	Your options in Round One	Your options in Round Two
1. Time performance	90.32	_____	_____
2. Cost performance	87.10	_____	_____
3. Quality performance	83.87	_____	_____
4. Trust and respect	64.52	_____	_____
5. Effective communications	64.52	_____	_____
6. Harmonious working relationships	51.61	_____	_____
7. Top management commitment	51.61	_____	_____
8. Innovation and improvement	48.39	_____	_____
9. Client's satisfaction	41.94	_____	_____
10. Safety performance	32.26	_____	_____
11. Profit and financial objectives	29.03	_____	_____
12. Dispute occurrence and magnitude	29.03	_____	_____
13. Customer's satisfaction	25.81	_____	_____
14. Productivity	25.81	_____	_____
15. Scope of rework	22.58	_____	_____
16. Long-term business relationships	22.58	_____	_____
17. Reduction of paperwork	22.58	_____	_____
18. Environmental performance	19.35	_____	_____
19. Claim occurrence and magnitude	16.13	_____	_____
20. Introduction of partnering workshop	16.13	_____	_____
21. Employee's attitude	16.13	_____	_____
22. Professional image establishment	12.90	_____	_____
23. Litigation occurrence and magnitude	6.45	_____	_____
24. Job satisfaction	6.45	_____	_____
25. Good public relations	6.45	_____	_____
26. Method of procurement and timing for closing of final account	3.23	_____	_____
27. Job efficiency and reliability	3.23	_____	_____
28. Minimizing impact on operations	3.23	_____	_____
29. Commitment of staff at work level	3.23	_____	_____
30. Pollution occurrence	0.00	_____	_____

Appendix C

A survey of developing a series of Key Performance Indicators (KPIs) to evaluate the success of a partnering project (Round Three Delphi Survey)

Guidance on completion

Below are the results of Round 2 of the above study. The average percentage score of all experts is given in column (2).

It is of interest to this Round Three Delphi Survey to study how you give ratings on the top-7 Key

Performance Indicators (KPIs) based, this time, on the 5-point Likert scale to evaluate the success of partnering projects.

Round Three Delphi Survey

(Please give ratings for each of the top-7 KPIs from 1=least important, 2=slightly important, 3=important, 4=very important, to 5=most important)

Name of Respondent: _____

Position in your organization: _____

Key Performance Indicators (KPIs) for partnering projects	% of experts in Round Two	Your ratings in Round Three (from 1=least important to 5=most important)
1. Time performance	96.67	_____
2. Cost performance	93.33	_____
3. Quality performance	90.00	_____
4. Trust and respect	76.67	_____
5. Top management commitment	63.33	_____
6. Effective communications	60.00	_____
7. Innovation and improvement	53.33	_____
8. Harmonious working relationships	46.67	_____
9. Client's satisfaction	43.33	_____
10. Safety performance	33.33	_____
11. Profit and financial objectives	23.33	_____
12. Dispute occurrence and magnitude	23.33	_____
13. Productivity	20.00	_____
14. Customer's satisfaction	20.00	_____
15. Scope of rework	16.67	_____
16. Long-term business relationships	16.67	_____
17. Reduction of paperwork	16.67	_____
18. Environmental performance	13.33	_____
19. Claim occurrence and magnitude	13.33	_____
20. Good public relations	6.67	_____
21. Introduction of partnering workshop	6.67	_____
22. Method of procurement and timing for closing of final account	3.33	_____
23. Employee's attitude	3.33	_____
24. Professional image establishment	3.33	_____
25. Job satisfaction	3.33	_____
26. Job efficiency and reliability	3.33	_____
27. Minimizing impact on operations	3.33	_____
28. Litigation occurrence and magnitude	0.00	_____
29. Commitment of staff at work level	0.00	_____
30. Pollution occurrence	0.00	_____

Appendix D

A survey of developing a series of Key Performance Indicators (KPIs) to evaluate the success of a partnering project (Round Four Delphi Survey)

Guidance on completion

Below are the results of Round 3 of the above study. The average ratings of all experts are given in column (2). Your Round 3 ratings are given in column (3).

It is of interest to the research study to learn whether, with further thought, you would make any changes to

your Round 3 ratings. Hence I would be most grateful if you would again give ratings on the top-7 Key Performance Indicators (KPIs) based on the 5-point Likert scale to evaluate the success of partnering projects.

Round Four Delphi Survey

Name of Respondent: _____
Position in your organization: _____

Please give ratings from 1=least important, 2=slightly important, 3=important, 4=very important, and 5=most important)

Key Performance Indicators (KPIs) for partnering projects	Average ratings of experts in Round Three	Your ratings in Round Three	Your ratings in Round Four
1. Time performance	4.48	_____	_____
2. Cost performance	4.32	_____	_____
3. Top management commitment	3.97	_____	_____
4. Quality performance	3.94	_____	_____
5. Trust and respect	3.81	_____	_____
6. Effective communications	3.52	_____	_____
7. Innovation and improvement	2.81	_____	_____