Procurement-Related Critical Factors for Briefing in Public-Private Partnership Projects: Case of Hong Kong

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Abstract: Public private partnerships (PPPs) are widely used for construction project procurement. However, the briefing stage of PPP projects has been largely overlooked, although it has a far-reaching influence throughout the project lifecycle. In response, this is rectified by exploring the critical factors involved. A set of 15 procurement-related factors are first identified from the existing literature. Then the effects of four background variables on the factors are tested with Hong Kong government data by an exploratory factor analysis extracting four major dimensions. The relationships between these dimensions and background variables indicate the need to take the background variables into account when ranking the factors. The ranking of the factors is then obtained by considering their weighted importance. Finally, the final practical value of the results is discussed. **DOI: 10.1061/(ASCE)ME.1943-5479.0000352.**

Author keywords: Critical factors; Procurement; Briefing stage; public private partnership; Factor analysis; Hong Kong.

Introduction

Projects that require private companies in "design, financing, construction, ownership and/or operation of a public sector utility or service" are called public-private partnership (PPP) projects (Akintoye et al. 2003).

Decisions made in the early stages of a project have a far-reaching influence on the remainder of its cycle (Gray 2008, pp. 21–57), synonymous with the terms architectural programming and program (Yu 2006). The briefing stage in Hong Kong is an early stage that greatly influences a project and collects views from all stakeholders.

The briefing process identifies and clarifies the client's objectives and requirements of the procurement (Wood and Ellis 2005). As an effective and efficient briefing stage is expected, by both public and private sectors, accurate information is needed of client requirements to make sound and timely decisions (Tang and Shen 2013). A good briefing process helps stakeholders form good relations and make valuable decisions for a project. Poor briefing, on the other hand, restricts the exchange of information and clarification of requirements, wasting time and delaying the whole project process. As a result, briefing needs to be well-prepared and structured (Tang et al. 2013). The Abdel Aziz (2007) analysis of United States guidelines for the successful implementation of PPPs indicates that briefing decisions, such as the delivery system to use, provide the greatest benefits to the public or users. Rebeiz (2012) uses a build-own-operate-transfer (BOOT) illustrative case study to show how important is increasing the pool of potentially interested (and qualified) foreign construction firms and investors in the briefing stage for the ultimate success of PPP projects.

Since the importance of the briefing stage in PPP projects has been largely overlooked (Kelly 2003), this paper explores the critical factors in successful PPP project briefing. Specifically, the paper identifies the critical success factors for effective and efficient briefing in PPP projects. A mathematical model is developed to rank the factors to identify their relative importance levels. Suggestions are then be made on ways of improving the briefing stage of both public and private sectors.

Initially, the briefing stage is described of both conventional projects and PPP projects, focusing on the influencing factors from the literature review for further analysis. In the Research Method section, a questionnaire survey is described that collected public sector opinions on the critical factors involved. The questionnaire contains two parts, as follows: (1) background information concerning the project, and (2) extracted critical factors. A factor analysis of the data and examination of how background variables affect the critical factors is then presented. Finally, the factors are ranked with the aid of a mathematical model.

Procurement Factors in Briefing

There are many forms of PPP, such as the outright privatization of previously state-owned industries (Ahadzi and Bowles 2004) and contracting out of services (Tang et al. 2010). The latter includes refuse collection and cleaning by private firms (Robinson and Scott 2009), and the use of private finance in the provision of social infrastructure (Carrillo et al. 2006). Public-private partnerships in the United States are defined as contractual agreements between a public agency and a private sector entity, to allow for greater private sector participation in the delivery and financing of transportation projects (FHWA 2007).

The U.K. Construction Industry Board (CIB 1997, p. 5) defines briefing as "the process by which a client informs others of his

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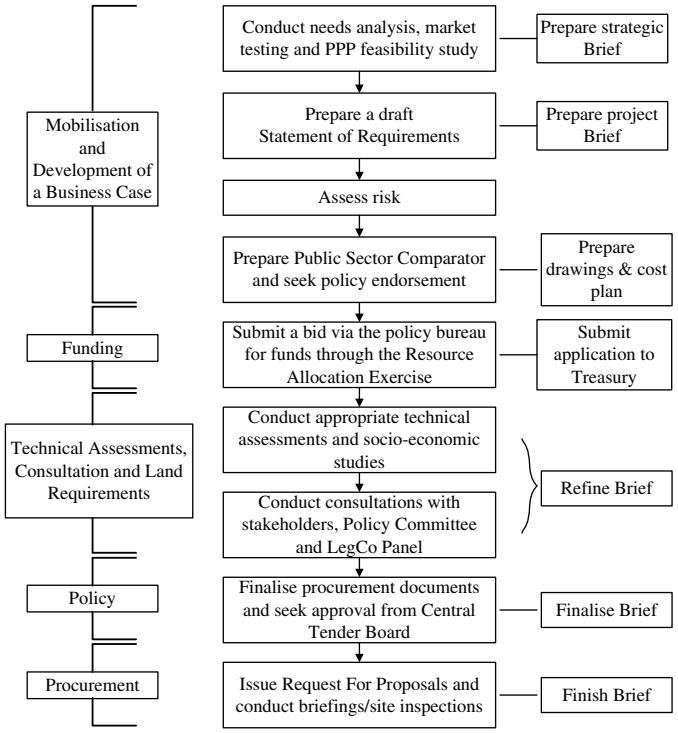

Fig. 1. Structure of the PPP briefing stage (adapted from EUD 2008)

or her needs, aspirations and desires, either formally or informally, whilst a brief is a formal document which sets out a client's requirements in detail."

Kelly and Duerk (2002) assert that a more process-oriented definition is one of gathering, analyzing, and synthesizing information needed in the building process, in order to inform decision-making and decision implementation. In the United States, architectural programming approaches include design-based architectural programming, knowledge-based architectural programming, agreement-based architectural programming, and value-based architectural programming (Hershberger 1999).

Fig. 1 summarizes the PPP briefing structure (Efficiency Unit Department 2008). The central column consists of briefing steps which give an introduction on what to do during the briefing, while the left-hand column indicates the deliverables for the whole stage. Some deliverables involve more than one step. For example, the first deliverable, to assemble and develop a business case, consists of the first four steps. The right-hand column represents the timeline of the briefing stage and process for writing a brief. The briefing session in PPP projects occurs approximately halfway through the bid preparation period (CIB 1997). This allows the government's potential transaction advisors to consider which elements of the project need clarifying before finalizing their bids.

Kelly et al. (1992) argue that the major weakness of the current briefing guide is that real assistance to clients and designers is too general and implicit. Similarly, the case studies and industrial survey of Kamara and Anumba (2001) investigate the briefing process to identify the limitations of current practice, and find that the general framework for briefing is inadequate. Kelly and Duerk (2002) also note that mandatory design guides do not adequately consider the requirements of either the public sector or large corporate organizations. Outdated or irrelevant design guides may lead to inappropriate or even incorrect design decisions. Each project has a specific briefing stage and the briefing for one project is never repeated for other projects. A regular review of the lessons learned from previous briefings and checking the progress of ongoing briefings should be key characteristics involved. Also, exposing hidden agendas by clear representation and recording of project goals is an important function of brief writing.

Comparing the briefing stages of conventional and PPP projects, some procurement-related steps not in conventional projects are needed in PPP project briefing. For example, preparing a public sector comparator (PSC) is one of these steps. A PSC is the estimated, risk-adjusted cost of delivering a project, expressed in terms of the net present cost to the government, and using a discounted cashflow analysis to adjust the future value of the expected cashflow to a common reference date. This enables a comparison with bids and makes allowance for the cost of government borrowing (EUD 2008). The Papajohn et al (2011) examination of U.S. transportation found the government should consider the key legal issues impacting on PPPs to include procurement, financing, project characteristics, and legal authority of the owner, in addition to a political environment favoring PPPs. Meng et al. (2011) use three case studies in China to identify critical success factor (CSFs) for transfer-operate-transfer urban water supply projects, some of which make the procurement process more effective and efficient. Regan et al. (2011) examine whether the current volatility and uncertainty of capital markets in Australia affects the feasibility of privately financed infrastructure, and specifically the PPP method of procurement. Ho and Hsu (2014) use game theoretic analysis to help project owners choose better bid compensation strategies. Cruz and Marques (2014) find that alternative methodologies for calculating the discount rate and different assumptions can lead to completely different results, biasing the final decision. Finally, Ye et al. (2013) examine procurement systems under China's unique culture and social background, and identify the key factors considered in compiling tender prices.

These issues show that it is crucial to identify the critical factors that affect its success as this will benefit both public and private sectors in PPPs in the briefing stage. This paper therefore focuses on these factors in relation to procurement. In all, 15 procurement-related factors are identified based on the existing literature. These factors have been tested in previous studies for their importance in the PPP approach and briefing stage, and are summarized in Table 1. For example, Leung et al. (2008) recommend that formal briefing sessions and regular formal meetings influence project success and participant satisfaction. The Yu et al. (2008) Hong Kong questionnaire survey found significant implications for construction industry practitioners in producing their guidelines for the briefing process, and for writers in drafting how-to briefing guides. CIB (1997) suggest that clear and agreed objectives, carefully thought-out requirements, and other factors are critical, while Blyth and Worthington (2001) also identify defining the process, timely decision taking, and other key areas as essential to briefing success. Lee and Schaufelberger (2014) use case studies in East Asia and the Pacific to identify factors such as government interference, conflict of interest among parties, delays in government agency support, and political force majeure, must be identified at the briefing stage of build-operate-transfer (BOT) project development and manage them through contractual agreements (and financial arrangements), clearly specified in the terms and conditions.

Research Method

Data Collection

A questionnaire survey was conducted from March 2009 to May 2009 to collect public-sector opinions on the importance of each of the 15 factors in PPP project briefing. The pilot study

Table 1. Procurement-Related Factors of Briefing Stages in PPPs

Procurement-related factors	Remarks	Factors adopted from these references
Clear goals and objectives	Briefing is a process which should have a clear goal and/or objectives	CIB (1997), Gurgun and Touran (2014)
Experience of the brief writer	Experienced person is needed to develop a brief	Yu et al. (2008)
Clear end user requirements	Brief needs to elucidate the end user requirements	CIB (1997), Kelly and Duerk (2002)
Development of a framework agreed by the key parties	During briefing, the process involved in formulating the brief needs to be agreed by the key parties	Kamara and Anumba (2001), Leung et al. (2008)
Control of process	Public sector should lead throughout the briefing process	Leung et al. (2008), Blyth and Worthington (2001)
Adequate time for briefing	Briefing should be allocated sufficient time for its conduct	Leung et al. (2008), Blyth and Worthington (2001)
Consensus building	Consensus of the brief; contents amongst the various stakeholders needs to be developed during the briefing stage	Yu et al. (2008)
Proper priority setting	Prioritization of decisions to be made should be agreed by the key parties in briefing	Yu et al. (2008)
Time for freezing of brief documents	Schedule should be set for the completion of the brief	Blyth and Worthington (2001)
Flexibility of briefs to cater for changes	Sufficient flexibility in briefs should be provided to allow possible future changes	Yu et al. (2008)
Good record of decisions made	Decisions made should be recorded in detail	Yu et al. (2008), Wang (2014)
Identification of client requirements	Client requirements should be identified during briefing	CIB (1997), Kelly and Duerk (2002)
Thorough understanding of client requirements	Client requirements should be thoroughly understood	CIB (1997); Kelly and Duerk (2002)
Feedback from completed projects	Feedback from completed projects is needed to improve briefing	Yu et al. (2008)
Clear and precise briefing documents	Clear and precise brief should be available at the end of the briefing	Yu et al. (2008)

involved three interviews, with two interviewees being officers in Hong Kong (HK) government departments and one from a local construction company. All interviewees have over 10 years' working experience in the construction industry and have been involved in PPP projects at least once. Only those who had work experience of PPP projects in Hong Kong Special Administrative Region (HKSAR) government departments were selected for the survey sample (Cheung and Chan 2011). Overall, 500 questionnaires were sent out and 122 responses were collected, yielding a response rate of 24.4%. Returns were received by respondents from the architectural services department, buildings department, drainage services department, efficiency unit, environmental protection department, highways department, and transport department. All these departments have had experience with PPP projects.

The questionnaire comprises two sections, as follows: (1) in the first section, background information on the type of the PPP project, the nature of the PPP project, role played in the PPP project and experience in the PPP project, was requested; and (2) the second section, the procurement-related factors which might affect the success of briefing were rated on a scale of 1–5 (Zarkada-Fraser and Skitmore 2000), where 1 represents strongly disagree and 5 represents strongly agree. A five-point Likert scale is in common use for research of this kind as it is simple enough to answer, and yet still provides sufficient information concerning different degrees of the same attribute (Chan et al. 2011; Yeung et al. 2008). Respondents answered the questionnaire based on a particular PPP project in which they had participated in Hong Kong.

Preliminary Findings

Among the different types of PPP projects, about one-third of the respondents had worked on road projects (34%); next are drainage projects (30%), waste transfer stations (13%), theme parks (9%), tunnels (7%), schools (5%), and rail projects (2%). Of the four different natures of projects, slightly more than half of the projects involved refurbishment (53%); next are new build (34%), and schemes comprising both new build and refurbishment (13%). In terms of roles played in PPP projects, 51 respondents are engineers (42%); next are client representatives (23%), administrators (10%), contract managers (8%), surveyors (7%), financial managers (5%), architects (2%), and contractors/suppliers (3%).

The bulk of respondents (77%) were not directly involved in briefing, leaving 23% of respondents directly involved in briefing. Despite this, their active involvement in a project is expected to provide useful data. This applies especially when briefing is perceived to be part of the inception stage of a project, as professionals who work on later stages of a project should be able to provide opinions on how to improve the briefing stage for the benefit of these later stages.

For example, an engineer involved only in the later stages of a project, such as the maintenance stage after the concession period when PPP projects are delivered back to the host government, may wish to correctly record the decisions made and change the contents of the brief, to save cost and avoid dissension (Yuan et al. 2012a, b, 2013). For another example, a client representative not involved in the briefing stage may identify missing client requirements and/or misunderstandings, when the concept or detail design is completed, and want to clearly identify (and fully understand) the client requirements during the briefing stage to save project time. Soomro and Zhang (2013) investigate the actions and decisions of private-sector partners by evaluating 35 failed transportation PPPs around the world, and suggest a better understanding of partners' actions (and decisions), and their influence on project success, would be beneficial at the briefing stage.

Table 2. Rotated Component Matrix

Factors	Component 1	2	3	4
Adequate time for briefing	0.685	—	—	—
Good record of decisions made	0.507	—	—	—
Identification of client requirements	0.671	—	—	—
Thorough understanding of client requirements	0.684	—	—	—
Time for freezing of brief documents	—	0.578	—	—
Flexibility of briefs to cater for changes	—	0.576	—	—
Feedback from completed projects	—	0.764	—	—
Clear and precise briefing documents	—	0.775	—	—
Clear goal and objectives	—	—	0.695	—
Experience of the brief writer	—	—	0.778	—
Clear end user requirements	—	—	0.672	—
Control of process	—	—	0.481	—
Development of a framework agreed by the key parties	—	—	—	0.653
Consensus building	—	—	—	0.708
Proper priority setting	—	—	—	0.777

Note: Extraction method, principal component analysis; rotation method, varimax with Kaiser normalization. Rotation converged in six iterations.

Data Analysis and Discussion

Factor Analysis

An exploratory factor analysis was conducted to identify the latent dimensions that affect the briefing stage. The purpose of this was to reduce the amount of work needed to test the effect of background variables on the factors (as described in the next section). The total percentage of variance explained was used to determine the number of components involved (Chan and Lee 2008). This was obtained by principal component analysis with varimax rotation to generate factor loadings for the extracted components.

Prior to the factor analysis, the data samples were analysed to check their appropriateness. The Kaiser-Meyer-Olkin (KMO) test and Barlett's test were conducted. The KMO measure of sampling adequacy examines whether the partial correlations among variables are small (Khazanchi 2005). The KMO test value should be greater than 0.5 for a satisfactory factor analysis to proceed. Bartlett's test of sphericity determines whether the correlation matrix is an identity matrix, which would indicate that the factor model is inappropriate. The null hypothesis should be rejected prior to factor analysis. The test results indicate that the KMO measure was above the threshold of satisfaction (0.755), while the significance value of Bartlett's test was sufficiently small (0.000). Therefore, both measures support the undertaking of a factor analysis.

A total of four dimensions were extracted from the factor analysis with Eigenvectors greater than 1 and accounting for 61% of the common variance (Table 2). The scree plot was also indicates that the contributions are relatively low after the fourth component. This is consistent with the preceding conclusion that the four dimensions offer a reasonable summary of the data. Each dimension consists of a set of factors. According to Hair et al. (1998), the item-total correlation should exceed 0.5 for identifying significant loading. From Table 3, the loadings for all 15 factors exceed 0.500 ($p < 0.01$) with the sole exception of one factor with a factor loading of 0.481, which was still included in the subsequent analysis since it is only marginally significant in exploratory research (Hair et al. 1998).

The four extracted dimensions were labeled as follows:

1. Client requirements and decisions for briefing contains the following four factors (shown with their factor loadings): (1) adequate time for the briefing process (0.685), (2) good record of decisions made (0.507), (3) identification of client requirements (0.671), and (4) thorough understanding of client requirements (0.684);
2. Briefing documentation and flexibility contains the following four factors: (1) time for freezing of brief documents (0.578), (2) flexibility of briefs to cater for changes (0.576), (3) feedback from completed projects (0.764), and (4) clear and precise briefing documents (0.775);
3. Clear briefing process and control contains the following four factors: (1) clear goal and objectives (0.695), (2) experience of the brief writer (0.778), (3) clear end user requirements (0.672), and (4) control of process (0.481); and
4. Stakeholders' involvement in briefing contains the following three factors: (1) development of a framework agreed by the key parties (0.653), (2) consensus building (0.708), and (3) proper priority setting (0.777).

The means, SDs, Cronbach alpha, and correlations are presented in Table 4. The means indicate that the respondents rated clear briefing process and control (4.41) the highest; next are clients' requirements and decisions for briefing (4.08), briefing documentation

Table 3. Total Variance Explained

Component	Initial Eigenvalues Total	Variance (%)	Cumulative (%)	Extraction sums of squared loadings Total	Variance (%)	Cumulative (%)	Rotation sums of squared loadings Total	Variance (%)	Cumulative (%)
1	4.985	33.235	33.235	4.985	33.235	33.235	2.468	16.451	16.451
2	1.586	10.570	43.806	1.586	10.570	43.806	2.468	16.450	32.901
3	1.433	9.553	53.359	1.433	9.553	53.359	2.114	14.093	46.994
4	1.147	7.645	61.004	1.147	7.645	61.004	2.102	14.010	61.004
5	0.997	6.644	67.648	—	—	—	—	—	—
6	0.924	6.161	73.809	—	—	—	—	—	—
7	0.750	5.000	78.809	—	—	—	—	—	—
8	0.639	4.260	83.070	—	—	—	—	—	—
9	0.565	3.764	86.833	—	—	—	—	—	—
10	0.472	3.148	89.981	—	—	—	—	—	—
11	0.435	2.898	92.878	—	—	—	—	—	—
12	0.317	2.116	94.995	—	—	—	—	—	—
13	0.301	2.006	97.001	—	—	—	—	—	—
14	0.258	1.721	98.723	—	—	—	—	—	—
15	0.192	1.277	100.000	—	—	—	—	—	—

Note: Extraction method, principal component analysis.

Table 4. Correlations, Means, and SDs

Variables	Mean	SD	1	2	3	4	5	6	7	8
Type of PPP projects	—	—	—	—	—	—	—	—	—	—
Nature of PPP projects	—	—	−0.04	—	—	—	—	—	—	—
Role in PPP projects	—	—	−0.16	−0.02	—	—	—	—	—	—
Experience in PPP projects	—	—	−0.16	−0.04	0.33[a]	—	—	—	—	—
Client's requirements and decisions for briefing	4.08	0.52	−0.02	−0.10	0.10	0.18[b]	0.73[c]	—	—	—
Briefing documentation and flexibility	3.90	0.53	0.13	−0.29[a]	0.22[b]	0.22[b]	0.49[a]	0.73[c]	—	—
Clear briefing process and control	4.41	0.48	0.10	−0.11	0.22[b]	0.24[a]	0.40[a]	0.38[a]	0.66[c]	—
Stakeholders' involvement in briefing	3.82	0.54	0.13	−0.09	0.24[a]	0.18[b]	0.35[a]	0.46[a]	0.26[a]	0.68[c]

[a]$p < 0.01$, $n = 122$.
[b]$p < 0.05$.
[c]Coefficient alpha values.

and flexibility (3.90), and stakeholders' involvement in briefing (3.82).

In order to test the extent to which the corresponding factors measure the dimension, an internal consistency reliability test was conducted. A Cronbach alpha value was computed for each dimension. The alpha coefficients ranged from 0.66 to 0.73, which were all greater than 0.6, indicating acceptable and good internal consistency reliability (Zhang 2006). Moreover, two-tailed Spearman rank correlations between the four dimensions were computed to test the relationship between dimensions. The correlation matrix (Table 4) indicates that the four dimensions were significantly related to each other. In general, the analysis supports the existence of four distinct but correlated components of the critical factors.

Effect of Background Variables on the Four Extracted Dimensions

The effect of the background variables on the four dimensions was investigated, for if they exert a considerable influence on the factors, then their effect should be included in estimating the relative levels of importance of the factors. Four background variables were used, as follows: (1) type of PPP project (e.g., road project and drainage project), (2) nature of PPP project (e.g., refurbishment and new build), (3) role in PPP projects (e.g., engineers and client representatives), and (4) experience of PPP projects (directly involved in briefing and nondirectly involved in briefing). These variables are basic and essential for analyzing the effects of the critical factors. Since these categorical variables involve different numbers of groups, they were tested with different statistical methods.

From the analysis, no background variable affects the extracted dimension termed client requirement and decision for briefing. This means that illustrating the client requirements well is considered in the same way by all respondents, no matter what their background. Other results are as follows:

- Three types of PPP projects [(1) building, (2) infrastructure, and (3) specific projects] were investigated. An ANOVA test was used and results indicate that type of PPP project did not significantly relate to all dimensions.
- As there were three different natures of PPP projects, the ANOVA test was again employed and the results indicate that nature of PPP project does significantly affect both the dimensions of (1) briefing documentation and flexibility ($p = 0.007$), and (2) stakeholders' involvement in briefing ($p = 0.023$).
- The variable termed the experience in PPP projects is a dichotomous variable, so a t-test was adopted. The results indicate that experience in PPP projects significantly affects the three dimensions of (1) briefing documentation and flexibility ($p = 0.023$), (2) clear briefing process and control ($p = 0.017$), and (3) stakeholders' involvement in briefing ($p = 0.018$).
- The two roles of (1) professional group, and (2) management group, being dichotomous, were subject to t-tests. These showed that role in PPP projects also significantly affects the three dimensions of (1) briefing documentation and flexibility ($p = 0.005$), (2) clear briefing process and control ($p = 0.011$), and (3) stakeholders' involvement in briefing ($p = 0.009$).

Factor Ranking

Sample Visualization Method

Since three of the four background variables exert a significant influence on the four factor dimensions, their effect needs to be considered when identifying the importance of the original factors. In view of this, a sample visualization method is developed to estimate the weighted importance of the 15 factors. The method is described next.

Suppose there are N respondents, where $N = 122$. Each respondent is denoted as $\mathbf{x_i} = (x_{i,1}, x_{i,2}, \ldots, x_{i,d}) \in R^d$, which is a dimensional vector. Each dimension is an item with values ranging from 1 to 5. The class labels used in pattern recognition (Hastie et al. 2008) are defined based on the indicator of different variables, i.e., the options mentioned previously. These variables are used to help distinguish between different data samples. Suppose there are C classes, and the label of $\mathbf{x}_i$ is l_i. Linear discriminate analysis (LDA) produces a linear projection matrix $\mathbf{W} \in R^{d \times m}$ to project the original data onto lower-dimensional data

$$\mathbf{y}_i = \mathbf{W}^{\mathrm{T}}\mathbf{x}_i \tag{1}$$

where $\mathbf{y}_i \in R^m$ = m-dimensional vector; $\mathbf{W}$ = linear projection matrix; d = number of dimensions of the original data space; m = reduced number of dimensions.

To estimate $\mathbf{W}$, two scatter matrices are introduced, which are the (1) within-class scatter matrix $\mathbf{S}_w$, and (2) between-class scatter matrix $\mathbf{S}_b$

$$\mathbf{S}_w = \sum_{i=1}^{C} \sum_{x_j:l_j=i} (\mathbf{x}_j - \mathbf{m}_i)(\mathbf{x}_j - \mathbf{m}_i)^{\mathrm{T}} \tag{2}$$

$$\mathbf{S}_b = \sum_{i=1}^{C} (\mathbf{m}_i - \mathbf{m})(\mathbf{m}_i - \mathbf{m})^{\mathrm{T}} \tag{3}$$

where $\mathbf{m}_i$ = mean of class i; $\mathbf{m}$ = mean of all data samples; $\mathbf{S}_w$ measures the intraclass *variances*; and $\mathbf{S}_b$ measures the interclass

variances. The optimization of the projection matrix $\mathbf{W}$ is obtained by finding a lower-dimensional space to simultaneously maximize the between-class scatter and minimize the within-class scatter. Compared with principal component analysis, which is based on the total variances ($\mathbf{S}_w + \mathbf{S}_b$), LDA projects the data sample with most discriminative directions (Bishop 2006). This means that the projected data have the property such that samples with the same label have a clustering property in the projected space. Visualization then helps to identify classes with similar levels of importance but different working experiences. The optimization criterion is formulated as

$$\mathbf{W}^* = \arg \max_{\mathbf{W} \in R^{d \times m}} \text{tr}[(\mathbf{W}^{\text{T}} \mathbf{S}_w \mathbf{W})^{-1} (\mathbf{W}^{\text{T}} \mathbf{S}_b \mathbf{W})] \tag{4}$$

where tr represents the trace of the matrix. The solution to this criterion has been proven to be the m largest Eigenvectors of the matrix $\mathbf{S}_w^{-1} \mathbf{S}_b$ and the optimal value of the criterion is the sum of the corresponding largest Eigenvalues (Hastie et al. 2008).

Projection Result

Since each vector $\mathbf{x}_i$ is used to represent a sample, the similarity between two samples $\mathbf{x}_i$ and $\mathbf{x}_j$ can be represented by a function of Euclidean distance. The smaller the Euclidean distance between the two samples, the more similar they are. Therefore, researchers can also make use of the Euclidean distance between two projected vectors (1), $\mathbf{y}_i$ and (2) $\mathbf{y}_j$, to approximately represent the similarity. Although this may lose some information, it does not affect the use of the two-dimensional (2D) plane to visualize the clustering property.

The visualization results are shown in Fig. 2. The horizontal and vertical axes represent the scale value of the projected coordinate system. The scale value is a weighted combination of original factor values. The weighting scheme is determined by the projection matrix $\mathbf{W}$. In Fig. 2, shows the clustering properties of the samples, i.e., the samples with the same class label projected onto nearby places. Since all the original rating values are normalized to zero mean and uniform variance, many of the samples cluster around zero.

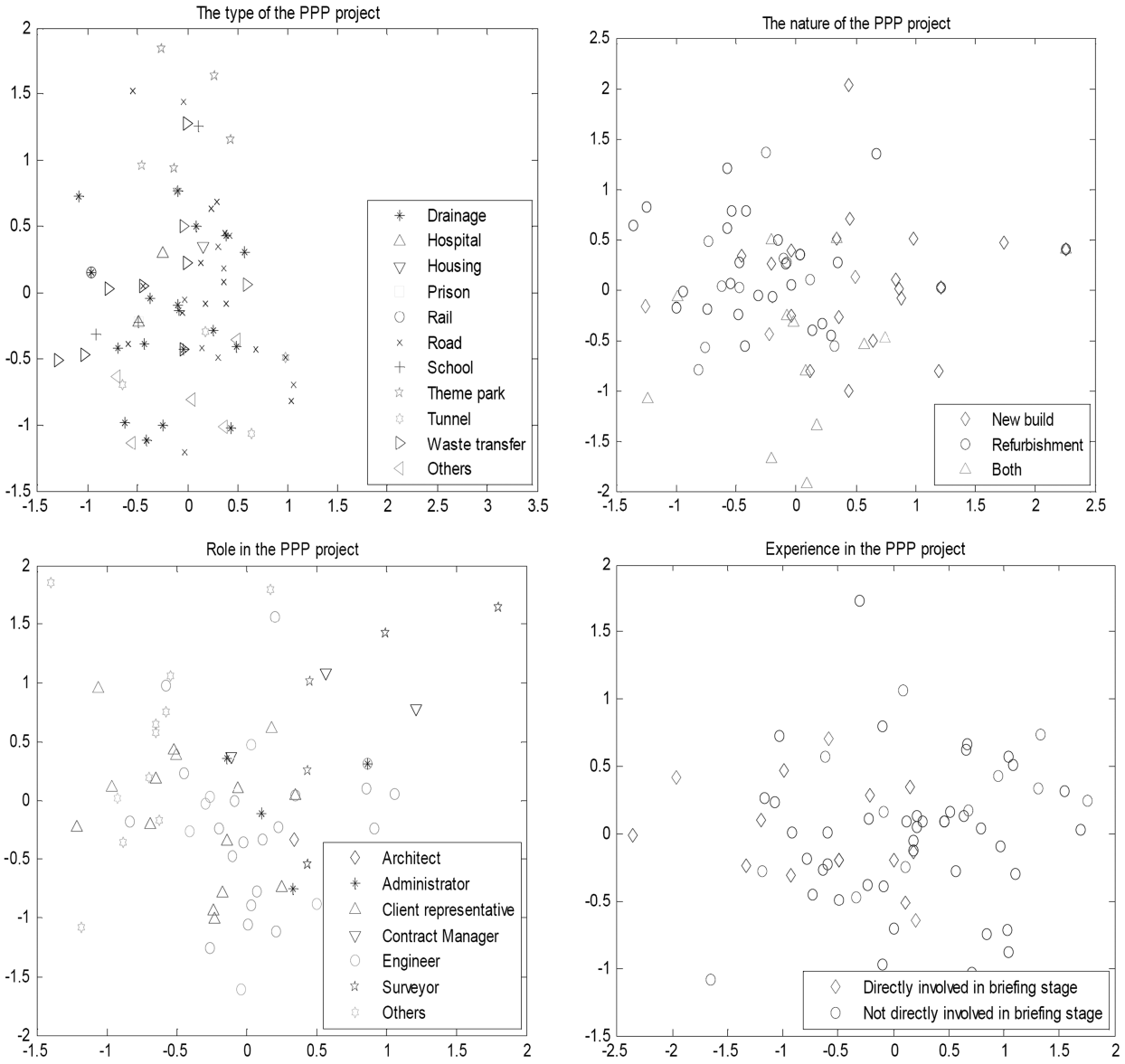

Fig. 2. Projection results of background variables

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Ranking of Key Factors

By inspecting the 2D visualization of the samples, most of the samples are located approximately on a Gaussian distribution near the zero point. To reduce the influence of those clustered away from zero, a class-mean based ranking method is developed. A function of class mean and the total data mean is used to weight the factor agreement values. In particular, the weighting for data $\mathbf{x}_i$ in background variable k is calculated as

$$w_{l_i}^k = \exp\left[-\frac{1}{2}(\mathbf{m}_{l_i}^k - \mathbf{m}^k)^{\mathrm{T}}\left(\sum^k\right)^{-1}(\mathbf{m}_{l_i}^k - \mathbf{m}^k)\right] \quad (5)$$

where k = indicator of different background variables, ranging from 1–4 to represent (1) type of PPP project, (2) nature of PPP project, (3) role in PPP project, and (4) experience of PPP projects, respectively; l_i is the class label for $\mathbf{x}_i$; $\mathbf{m}_{l_i}^k$ = mean of class l_i in background variable k; $\mathbf{m}^k$ = total data mean of the background k; and $\sum^k$ = total data covariance matrix which is calculated based on all the data samples over background k, so that

$$\sum^k = \frac{1}{N-1}\sum_{i=1}^{N}(\mathbf{x}_i^k - \mathbf{m}^k)(\mathbf{x}_i^k - \mathbf{m}^k)^{\mathrm{T}} \quad (6)$$

where $\mathbf{x}_i^k$ = vector composed of the factors of data $\mathbf{x}_i$ in background k; and the weighting coefficient is just the exponential term of a multivariate Gaussian distribution

$$\frac{1}{(2\pi)^{d/2}}\frac{1}{|\sum^k|^{1/2}}\exp\left[-\frac{1}{2}(\mathbf{m}_{l_i}^k - \mathbf{m}_k)^{\mathrm{T}}\left(\sum^k\right)^{-1}(\mathbf{m}_{l_i}^k - \mathbf{m}^k)\right] \quad (7)$$

ignoring the constant term. Moreover, the weighting ranges from 0–1. Therefore, if the class mean $\mathbf{m}_{l_i}^k$ in background variable k is distant from the total data mean $\mathbf{m}^k$, a small weighting is given to the samples with that background variable option. Contrarily, if the experience class $\mathbf{m}_{l_i}^k$ in experience type k is near the total data mean $\mathbf{m}^k$, a large weight is given since the samples of that background variable represent the majority of the collected data. Similar weighting schemes have been widely used in nonparametric kernel methods (Schölkopf and Smola 2001), neural network-based machine learning (Bishop 1995), and manifold approximation (Belkin and Niyogi 2005).

Based on the weighting of each background variable option, the weighting for each data sample $\mathbf{x}_i$ is defined as

$$w_{\mathbf{x}_i} = \frac{1}{4}\sum_{k=1}^{4} w_{l_i}^k = \frac{1}{4}(w_{l_i}^1 + w_{l_i}^2 + w_{l_i}^3 + w_{l_i}^4) \quad (8)$$

where $w_{l_i}^k$ = weight for $\mathbf{x}_i$ with class label l_i in background variable k. Therefore, if a data sample is in the majority of all of the four background variables, it is allocated a large weighting in calculating the final ranking.

With the weighting value for each data sample, the final ranking score for item j is

$$r_j = \sum_{i=1}^{N} w_{\mathbf{x}_i} x_{i,j} = w_{\mathbf{x}_1} x_{1,j} + w_{\mathbf{x}_2} x_{2,j} + \cdots + w_{\mathbf{x}_N} x_{N,j} \quad (9)$$

The results are shown in the Table 5 and discussed in the next section.

Table 5. Ranking Scores of Procurement-Related Factors

Factors	Weighted scores	Means
Clear goals and objectives	3.193	4.410
Clear end user requirements	3.191	4.418
Experience of the brief writer	3.187	4.410
Thorough understanding of client requirements	3.067	4.213
Good record of decisions made	2.956	4.066
Identification of client requirements	2.941	4.041
Adequate time for briefing	2.888	3.984
Flexibility of briefs to cater for changes	2.837	3.918
Time for freezing of brief documents	2.821	3.902
Clear and precise briefing documents	2.819	3.893
Feedback from completed projects	2.806	3.869
Development of a framework agreed by the key parties	2.797	3.877
Proper priority setting	2.751	3.787
Consensus building	2.745	3.787
Control of process	2.561	3.533

Discussion

Table 5 lists the ranking of factors related to procurement in the PPP briefing stage according to public-sector opinions. The scores presented are lower than the mean values of factors. This is because the scores were calculated in a different way. Therefore, the weighted scores and the mean values cannot be directly compared. Only the ranks based on the two methods can be compared. The two ranking orders are not the same when the four background variables are taken into consideration. However, the rank estimated by the sample visualization method is more accurate and reliable.

As shows in Table 5, clear goals and objectives are ranked first (3.1932); next is clear end users requirements (3.1914). Therefore, in order to maximize the benefit to be obtained from a project, the briefing should provide clear goals and objectives in the form of clear instructions from the client (Abdel Aziz 2007). End users of the project may have specific requirements. Unfortunately, these requirements are not always made known in the briefing process. Thus, the client has the responsibility to make sure that all the user groups' requirements are heard (Blyth and Worthington 2001).

In third and fourth place are experience of the brief writer (3.1869) and thorough understanding of client requirements (3.0674). Briefing documents specify all the requirements demanded by a project. Brief writers therefore play an important role in capturing all these requirements in a clear overall picture for project stakeholders, including clients and designers (Hyams 2001). On the other hand, the needs and requirements of all stakeholders should also be included in a comprehensive manner in stating the required end product (Kamara and Anumba 2001). For example, site, environmental, and regulatory requirements should be combined when specifying design requirements

Good record of decisions made occupies fifth place in the ranking list (2.9563). The reasons for its importance are similar to those of experience of the brief writer. Decisions should be clearly recorded in the brief documents by the brief writer for later use. There are many well-known techniques, such as computer-aided tools, that can help in keeping these records (Tang et al. 2010).

Conclusions

The briefing stage is important for all construction projects, especially PPP-type projects, which are more complex because of the increased numbers, involvement and responsibilities of

stakeholders, and the longer periods involved. Better briefing can save both time and value in the later stages of projects.

The purpose of the paper is to identify the critical success factors for the briefing stage of PPP projects. The most important factor is clear goals and objectives. This reminds both the public sector and the private sector of their roles at this stage. The same result is also found in research on conventional projects, and means that both conventional projects (and PPP projects) need to provide clear goals (and objectives) in their briefing stages. The main findings also highlight the need for clarity, experience and understanding these critical success factors. Statistical and mathematical analyses of the data from different Hong Kong government departments regarding the significance of the 15 procurement-related factors also provide the following results:

- The KMO test supports the conclusion that the survey data are adequate for factor analysis;
- Factor analysis establishes four dimensions of briefing stage procurement, as follows: (1) clients' requirements and decisions for briefing, (2) briefing documentation and flexibility, (3) clear briefing process and control, and (4) stakeholders' involvement in briefing (also, the effect of four background variables on the four dimensions was tested and partially supported);
- Validity analysis and reliability analysis confirm the quality of the questionnaire survey, the soundness of the factor analysis, and the internal consistency of the procurement-related factors; and
- A new mathematical model, namely the sample visualization method, adopted from Gaussian distribution was used to add weights generated by the four background variables to estimate the weighted ranking scores of factors.

The briefing stage of PPP projects has been largely overlooked to date in terms of its importance, although decisions made at this stage have a far-reaching influence throughout the project lifecycle. A set of 15 procurement-related factors affecting the success of the briefing stage is first identified based on the existing literature. Then the effects of the four background variables on the factors are tested for the first time with a sample of data from government departments in Hong Kong. The results support the view that the background variables should be taken into account when ranking the factors, which suggests that factor analysis should not be used as the only way to analyze questionnaire survey data on this topic.

The literature review concerns the briefing stage and relevant procurement studies. A statistical analysis is then conducted in order to obtain solid and credible analysis results. The practical value of the analysis is that the findings facilitate all stakeholders in attending and collaborating in the briefing to increase the value of PPP projects. As the briefing stage is usually led by the public sector, the public sector can use these CSFs to prepare the briefing while obtaining private sector benefits as benchmarks in attending and collaborating at the briefing stage.

The limitation of the research reported in this paper is that only factors related to procurement issues and the success of PPP briefing through the perspective of perceptions of PPP practitioners were studied. For further research, these factors could be used in real cases by government departments. In theoretical terms, there are other aspects which impact on the success of briefing stages, such as stakeholder-related, risk-related, and finance-related issues (Tang et al. 2010). Likewise, in practice, these factors should be studied and tested in later research in order to develop a more comprehensive picture of what is needed to improve PPP briefing. Case studies focusing on how proper attention to these factors would have improved the performance of previous PPP projects should also be a subject of further study. The findings of this paper need to be tested by studies of briefing in real PPP projects in order to verify the relevance of the analyzed briefing factors for the success of entire PPP projects.

In summary, the main findings highlight the need for clarity, experience and understanding of what is needed for PPP projects, and how these needs are represented and documented. Although the respondents of the questionnaire survey are drawn from the Hong Kong public sector, these findings facilitate all stakeholders in attending and collaborating in briefings so as to increase the value of PPP projects. This is likely to contribute to the success of an effective and efficient briefing stage of the majority of PPP-type construction projects worldwide.

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