Factors affecting effectiveness and efficiency of analyzing stakeholders' needs at the briefing stage of Public Private Partnership projects

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Abstract

The briefing stage is of utmost importance to public private partnership (PPP) projects as it conveys the major message regarding what stakeholders need. However, stakeholders' needs are not often stated clearly at the briefing stage. In considering this, the current paper aimed at analyzing the key stakeholders' needs that should be known by project participants. Eighteen factors related to stakeholders' needs were identified based on literature and interviews. The importance of these factors was rated using a questionnaire survey in Hong Kong. Also, it was expected that some background

variables should be taken into account when rating these factors. Therefore, other than using simple rating methods, a custom-made weighted ranking method was developed, which could enable an estimation of the weighted importance of stakeholder-related factors. In this research, four background variables were identified and their effects on the aspects such as type and nature of a PPP project, role in a PPP project, and experience working in a PPP project were examined. In order to group the factors, an exploratory factor analysis was conducted and four dimensions were extracted. The relationship of these dimensions with the four background variables were then tested by means of either t-test or ANOVA. Results indicate that the four background variables were important in ranking the aspects. After incorporating the effect of the four background variables, the weighted importance of the 18 factors was analyzed with the weighted ranking method. Finally, discussion about the rank order of the factors is provided.

Keywords: Critical factors; Briefing stage; Public private partnership; Stakeholder; Construction management; Factor analysis.

1. Introduction

Public Private Partnership (PPP) is widely used in the construction industry worldwide, and was studied by many researchers. One of the specific characteristics of PPP projects is that they have more stakeholders than other types of projects (Tang et al., 2010).

Construction briefing is the process by which a client informs others of his 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. The meetings at the briefing stage are the first time that key stakeholders meet each other and express clear requirements. Good stakeholder relationships will benefit the process of briefing while bad stakeholder relationships will hinder it (Yang et al., 2011). So this study is conducted to identify and examine the critical factors which relate stakeholders that affect the effectiveness and efficiency of briefing in PPP projects.

The paper starts with a description of the background of PPP and briefing stage, especially concerning the stakeholder aspect. Then the rationale behind the design of a questionnaire survey is explained. This collected the public sector's opinions to identify the critical factors of the briefing stage in PPP projects. The section of factor analysis presents the examination of how background variables may affect the critical factors. A mathematical model was developed to rank the factors in order to identify their importance level. At the end of the paper, the conclusions are summarized, and suggestions given to both public and private sectors to improve the briefing stage concerning the stakeholder aspect.

2. Briefing stage and stakeholders in PPP projects

As a term commonly used in Hong Kong, briefing is the process to define and articulate client requirements for a construction project. Significant decisions are also made in this process. Delivery of construction projects and effectiveness to achieve stated

objectives are critically influenced by briefing, so it is important to get it right. In the PPP project the briefing defines the scope of the project and its relationship with the institutions' other activities. Normally, the briefing session in PPP projects is set for approximately halfway through the bid preparation period. The situation for stakeholders in PPP projects is more complicated than the situation in conventional projects. Several aspects about stakeholders, for example, the relationship between organizations within the public and private sectors, experiences of doing PPP projects, and so on, are perceived to be crucial to the success of PPP projects because poor stakeholder management would easily lead to misunderstanding and conflict (Aaltonen, 2011). Therefore, the research presented in this paper has mainly focused on exploring what factors influence stakeholder aspects in the briefing stage.

Some aspects of stakeholders in PPP projects have already been widely studied by researchers. For example, by conducting an industry-wide survey study, Chan et al. (2003), found that the most significant benefits obtained from the use of partnering in PPP projects were 'improved relationships amongst project participants' and 'improved communication amongst project participants'. Consoli (2006) found through interviews that various needs of stakeholders, contractual arrangements, and different philosophical standpoints created friction between the involved parties. Apparently, friction is the major cause of poor relationships.

Through a Malaysian case study, Abdul-Aziz (2001) claimed that once privatization has taken place, re-involvement of the public sector should be avoided as much as possible, because of the latter's lack of expert experience and possible social impact of the project. This is particularly relevant in the case of the injection of new funds.

Researchers have also related the relationship issue to contractor selection. For choosing suitable contractors, researchers have not only suggested benchmarking the ‘best’ selection practices, but have also emphasized ‘innovative’ contractor selection approaches to be used by large public clients, in which the relationship issue is always regarded as a key criterion. For example, Palaneeswaran and Kumaraswamy (2000a,b) made a comparative overview to formulate a ‘cooperative’ and ‘non-competitive’ conceptual benchmarking model to identify the core aspects for selecting a suitable bidder in order to achieve the best ‘value for money’.

The success factors of how to create win–win relations were studied, since 'a fair deal' is what project parties should achieve. The strengths of both successful approaches and those lessons learned from less successful or abortive projects were identified. For example, Zhang (2004a, b) carried out a knowledge-mining process to draw experiences and lessons learned from international PPP practices and to refine experiential and expert knowledge underlying the subconscious decision-making process in the field of project financing. He developed five main critical success factors (CSFs) (favourable investment environment, economic viability, reliable concessionaire consortium with strong technical strength, sound financial package, and appropriate risk allocation via reliable contractual arrangements) for a win–win relationship, each of which included a number of successful sub-factors.

From the above literature, 18 factors which may affect stakeholder relationships in PPP project were found. For example, the Construction Industry Board (1997) summarized that trusting relationships among stakeholders were important to the briefing stage. Blyth and Worthington (2001) mentioned that clear and comprehensive

communication was a key aspect in briefing. The research presented in this paper will examine whether these factors have the same level of importance in the briefing stage in PPP projects.

Table 1. Stakeholder-related factors of briefing in PPP projects

Factors	Explanations
Experience of the client	The client should have related experience of briefing.
Clear management structure	The client needs a clear management organization structure for briefing.
Knowledge of client's responsibility	Knowledge of the client's responsibility is needed.
Skillful guidance and advice from project manager	Project manager should give appropriate guidance and advice during briefing.
Holding workshops for stakeholders	Workshops for stakeholders should be held regularly.
Good facilitation	Good facilitation of briefing should be given to stakeholders.
Selection of briefing team	Briefing team needs proper participant selection.
Clarity of roles of stakeholders	Roles of stakeholders should be clarified clearly.
Sufficient consultation with stakeholders	Briefing needs sufficient consultation with stakeholders.

Experience of stakeholder group	Stakeholders' experience of attending briefing should be considered.
Balance of the needs/requirements of different stakeholders	Needs/requirements of different stakeholders need to be balanced.
Knowledge of consultants	Knowledge of consultants should be considered.
Knowledge of statutory and lease control of the project	Knowledge of statutory and concession period control of the project are needed in briefing.
Team commitment	Team commitment should be clear.
Honesty	Honesty among stakeholders is critical for briefing.
Openness and trust	Openness and trust should be built among stakeholders.
Open and effective communication	Briefing needs open and effective communication.
Agreement of brief by all relevant parties	Agreement on the brief should be obtained among all relevant parties.

3. Research method

3.1 Data collection

A questionnaire survey (sample is shown in Appendix A) was carried out amongst seven HKSAR government departments which had work experience of PPP projects. These departments included: Architectural Services Department, Buildings Department, Drainage Services Department, Efficiency Unit, Environment Protection Department, Highways Department, and Transport Department. Respondents answered the questionnaire based on a particular PPP project in Hong Kong that they had participated in. Overall, 122 responses were collected and the response rate was 24.4%. The questionnaire consisted of two sections. In the first section, background information, mainly the type of the PPP project, the nature of the PPP project, the role in the PPP project and the experience in the PPP project, was elicited. In the second section, the stakeholder-related factors which might affect the success of briefing in PPP projects were rated on a scale of 1-5, where 1 represents “strongly disagree” and 5 represents “strongly agree”.

3.2 Methods used in this study

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 required

to test the effect of background variables on the factors, which was conducted in the next section. In this study, the principle component analysis with varimax rotation was computed to generate factor loadings for the extracted components. In total, 18 factors were included in the analysis.

Since three of four background variables exerted significant influence on the four factor dimensions, their effect needs to be considered when identifying the importance level of the original factors. In view of this, a sample visualization method is developed to estimate the weighted importance of the 18 factors.

Projection methods have been widely used in visualizing data samples in high-dimensional space. Principle component analysis (PCA) is one of the most famous methods that have been used to project the high-dimensional data onto a low-dimensional space. Interestingly, the relationship between PCA and factor analysis has been studied by Lawley (1953) and Anderson (1963), and a comprehensive introduction of factor analysis can be found from the book by Everitt (1984). The motivation of PCA is to project original data (which are represented as high-dimensional vectors) to the coordinates with maximal variances, while the motivation of FA is to describe variability of differences between original high-dimensional vectors and the projected lower-dimensional vectors. When the difference terms in FA are assumed having the same variance, FA becomes essentially equivalent to PCA. Both FA and PAC make an assumption that the original data are Gaussian distributed and the projected variables are also Gaussian.

Another category of visualization methods is multidimensional scaling (MDS) (Cox et al., 2000; Borg and Groenen 2005). The motivation of MDS is to visualize high-

dimensional vectors on a 2D plane, which uses the geometric distance to approximate some pre-defined distances, e.g. the Euclidean distance based on original vectors or the graph-theoretic distance. In the classical case which using a linear projection approximation to the Euclidean distance, MDS also equals to PCA.

In this work, the collected samples have some category information, which can be considered to affect the final factor ranking results. Therefore, a new method to visualize the samples is required to show the specific differences among the categorized samples. Linear discriminant analysis (LDA) (Duda et al., 2000; Bishop, 2006; Hastie et al., 2008) is a natural way to handle such kind of data associated with class labels. Thus, it is adopted to visualize the categorized samples. Consequently, a ranking formulation based on the visualization results is essentially derived to re-define the ranking values of the factors.

3.3 Preliminary findings

The background variables of the sample were presented in this section. From Table 2-5, the percentages of variables are presented. Note that the bulk of respondents (77%) were not directly involved in briefing, leaving the remaining 23% of respondents who were directly involved. Even though the majority of respondents were not directly involved, their active involvement in a project should still provide useful data for this survey. Our rationale is that when briefing is perceived to be part of the inception stage of a project, professionals who work for other stages of a project should be able to provide opinions on how to improve the briefing stage.

Table 2. The type of PPP projects

The type of PPP projects	Frequency	Percentage
Road	41	33.6
Drainage	36	29.5
Waste transfer station	16	13.1
Theme park	11	9.0
Tunnel	8	6.6
School	6	4.9
Rail	4	3.3
Total	122	100.0

Table 3. The nature of PPP projects

The nature of PPP projects	Frequency	Percentage
Refurbishment	64	52.5
New build	41	33.6
Scheme comprising both new build and refurbishment	17	13.9
Total	122	100.0

Table 4. The role in PPP projects

The role in PPP projects	Frequency	Percentage
Engineer	51	41.80
Client representative	28	22.95
Administrator	12	9.84
Contract Manager	10	8.20
Surveyor	9	7.38
Financial manager	6	4.92
Architect	3	2.46
Contractor/Supplier	3	2.46
Total	122	100.0

Table 5. The experience in PPP projects

The experience in PPP projects	Frequency	Percentage
Directly involved in briefing	28	23.0
Indirectly involved in briefing	94	77.0
Total	122	100.0

4. Methods of data analysis

4.1 Factor analysis

Before the factor analysis, the data samples were examined to check their appropriateness. Both the Kaiser-Meyer-Olkin (KMO) test and Barlett's test were conducted. The Kaiser-Meyer-Olkin 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 tests whether the correlation matrix is an identity matrix, which would indicate that the factor model is inappropriate. The test results indicate that KMO measure was above the threshold of satisfaction (=0.728), while the significance value of Bartlett's test was sufficiently small (=0.000). Both of them supported the undertaking of factor analysis.

A total of four dimensions were extracted from factor analysis with eigenvectors greater than one and accounted for 63% of the common variance. A scree plot was also performed to indicate that the contributions were 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 in this paper. The loadings for all 18 factors exceeded 0.500 ($p < 0.01$) except for two factors that had loading value of 0.496 and 0.486. These

factors were still included in this research since they were considered to be marginally significant in an exploratory research (Hair et al. 1998).

The four extracted dimensions were labeled as follows (shown in Table 6):

- The label “stakeholder commitment and ability for briefing” contains the following factors (shown with their factor loadings): team commitment (0.755), experience of the client (0.654), experience of stakeholder group (0.651), holding workshops for stakeholders (0.629), clear management structure (0.605), knowledge of clients business (0.579), skillful guidance and advice from project manager (0.557), knowledge of statutory and lease control of the project (0.539). These factors were associated with process requirements for briefing;
- The label “stakeholder leadership in briefing” contains the following factors (shown with their factor loadings): clarity of roles of stakeholders (0.825), selection of briefing team (0.739), sufficient consultation with stakeholders (0.563), agreement of brief by all relevant parties (0.543), knowledge of consultants (0.496), and honesty (0.486). These factors were associated with consultancy by stakeholders to briefing;
- The label “stakeholder ethics for briefing” contains the following factors (shown with their factor loadings): openness and trust (0.744) and open and effective communication (0.700). These factors were associated with ethical requirements for briefing;
- The label “stakeholder facilitation in briefing” contains the following factors (shown with their factor loadings): balance of the needs requirements of different

stakeholders (0.818) and good facilitation (0.504). These factors were associated with facilitation to stakeholders.

The means, standard deviations, Cronbach alpha, and correlations are presented in Table 7. The means indicate that respondents rated the highest on stakeholder ethics for briefing (4.06), followed by stakeholder consultancy to briefing (3.92), stakeholder ability for briefing (3.81), and stakeholder facilitation in briefing (3.79).

Table 6. Rotated Component Matrix(a)

Factors	Component			
	1	2	3	4
Team commitment	0.755			
Experience of the client	0.654			
Experience of stakeholder group	0.651			
Holding workshops for stakeholders	0.629			
Clear management structure	0.605			
Knowledge of clients business	0.579			
Skillful guidance and advice from project manager	0.557			
Knowledge of statutory and lease control of the project	0.539			
Clarity of roles of stakeholders		0.825		
Selection of briefing team		0.739		
Sufficient consultation with stakeholders		0.563		

Agreement of brief by all relevant parties	0.543		
Knowledge of consultants			
	(0.496)		
Honesty			
	(0.486)		
Openness and trust		0.744	
Open and effective communication		0.700	
Balance of the needs/requirements of different stakeholders			0.818
Good facilitation			0.504

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

[Insert Table 7. here]

In order to test the extent to which the corresponding factors measure the dimension, the internal consistency reliability test was conducted. A Cronbach alpha value was computed for each dimension. The alpha coefficients ranged from 0.533 to 0.803, indicating acceptable and good internal consistency reliability (Zhang 2006). Moreover, two-tailed Spearman rank correlations between the four dimensions were computed to test for the relationship between dimensions. The correlation matrix (in Table 7) indicates that the four dimensions were significantly related to each other in the predicted direction.

In general, the analysis supports the existence of four distinct but correlated components of the critical factors.

4.2 Effect of background variables on the four extracted dimensions

Effect of the background variables on the four dimensions was worth investigating. If the background variables exert considerable influences on the factors, then their effect should be included in estimating the importance level of the factors. In this study, there were four background variables: “the type of PPP projects”, “the nature of PPP projects”, “the role in PPP projects”, and “the experience in PPP projects”. Since these categorical variables possessed different number of groups, they were tested with different statistical methods:

- Originally, there were 11 types of PPP projects. Due to the lack of data in some of these types, transformation of data was needed to combine some types together. Finally, three types were developed, which were “specific projects”, “infrastructure”, and “building”. Therefore, ANOVA test was used here. The results indicate that “the type of PPP projects” significantly affected the dimension of “stakeholder ability for briefing” ($p=0.016$).
- As there were three different natures of PPP projects, ANOVA test was employed. The results indicate that “nature of PPP projects” did not significantly relate to all dimensions.

- The variable “the experience in PPP projects” was a dichotomous variable, so t-test was adopted. The results indicate that this variable did not significantly relate to all dimensions.
- Similarly, there were 9 roles originally, so transformation was undertaken to develop 2 roles which were “professional” group and “management” group. For a dichotomous variable, t-test was used. The results indicate that “the role in PPP projects” significantly affected the dimension of “stakeholder facilitation in briefing” (p=0.026).

5. Factor ranking results

5.1 Sample Visualization Method

The method used in this paper is described hereinafter.

Suppose there are N respondents, where N is 122 in this paper. Each respondent is denoted as $\mathbf{x}_i = (x_{i,1}, x_{i,2}, ..., x_{i,d}) \in R^d$, which is a d dimensional vector. Each dimension is an item with values ranging from 1 to 5. The class label used in pattern recognition (Duda et al. 2000; Bishop 2006; Hastie et al. 2008) are defined based on the indicator of different variables, i.e. the options mentioned above. These variables are used to help distinguish different data samples. LDA finds a linear projection matrix $\mathbf{W} \in R^{d \times m}$ to project the original data to lower-dimensional data

$$\mathbf{y}_i = \mathbf{W}^T \mathbf{x}_i \quad (1)$$

where $\mathbf{y}_i \in R^m$ is an m dimensional vector. The criterion as well as the solution to the optimization problem for obtaining $\mathbf{W}$ are presented in Appendix B.

5.2 Projection Result

Since we use each vector $\mathbf{x}_i$ 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, we can also make use of the Euclidean distance between two projected vectors $\mathbf{y}_i$ and $\mathbf{y}_j$ to approximately represent the similarity. Although it may lose some information, it does not affect to use 2D plane to visualize the clustering property.

The visualization results are shown in Fig. 1. The horizontal and vertical axes represent the scale value of 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. 1, most of the samples show their clustering properties, i.e. the samples with the same class label are projected onto near places. Since all the original rating values are normalized as zero mean and uniform variance, most of the samples ride on the region around zero point. There are some clusters very near the zero point, and there are also clusters far away from the zero point.

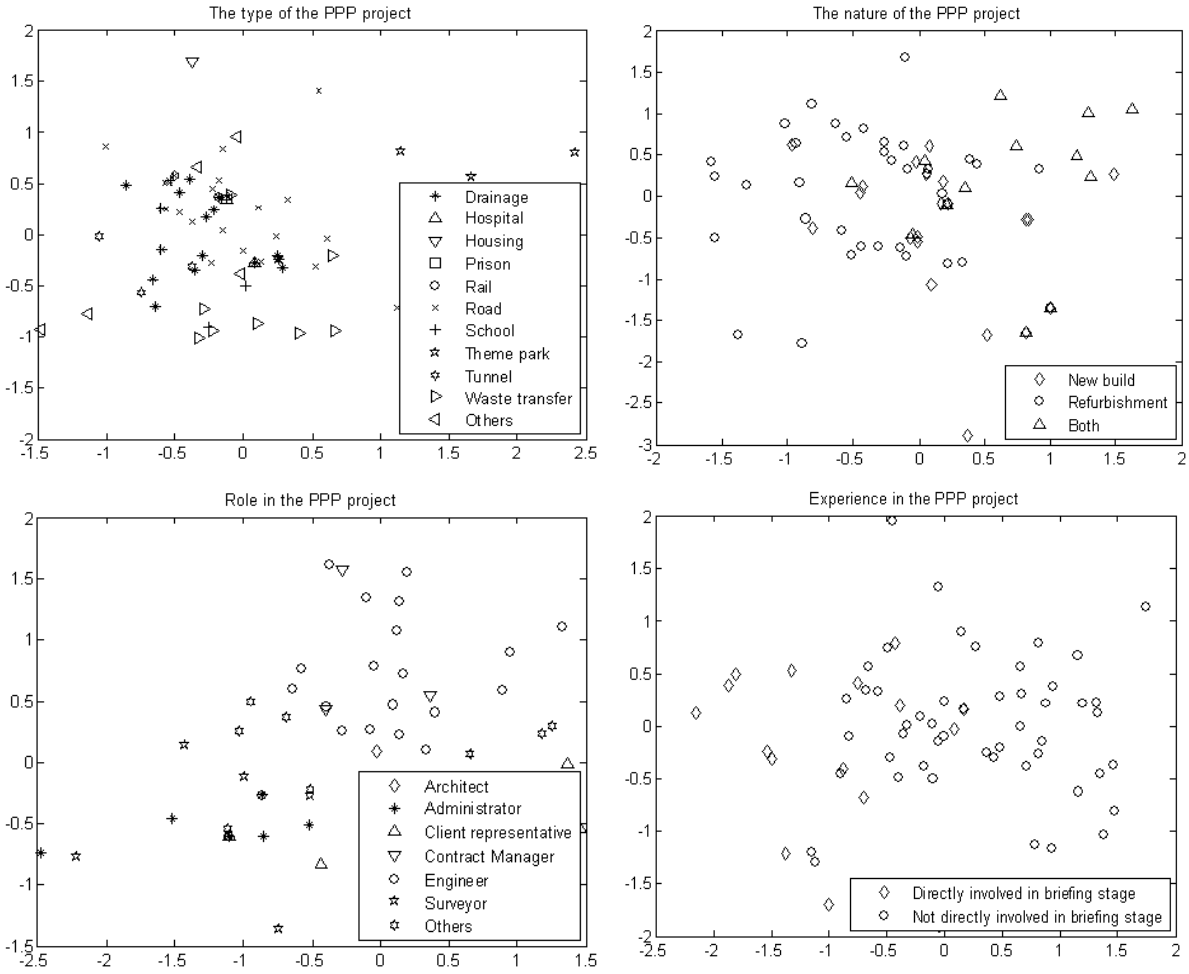

Fig. 1. Projection results of background variables

5.3 Ranking of Key Factors

Based on the observation in the 2D visualization of samples, we can see that most of the samples approximately ride on a Gaussian distribution near zero point. However, some samples are far from the center. To reduce the influence of far away clustered data samples, a class-mean based ranking method is developed to sort the factors. A function

of class mean and the total data mean is used to weight the factor agreement values. Particularly, the weight for data $\mathbf{x}_i$ in background variable k is calculated as:

$$\begin{aligned} w_{l_i}^k &= \exp\left(-\frac{1}{2}\left(\mathbf{m}_{l_i}^k - \mathbf{m}^k\right)^T \boldsymbol{\Sigma}^{-1} \left(\mathbf{m}_{l_i}^k - \mathbf{m}^k\right)\right) \\ &= \exp\left(-\frac{1}{2}\left(\mathbf{m}_{l_i}^k - \mathbf{m}\right)^T \boldsymbol{\Sigma}^{-1} \left(\mathbf{m}_{l_i}^k - \mathbf{m}\right)\right) \end{aligned} \tag{2}$$

where k is the indicator of different background variables, ranging from 1 to 4 to represent “the type of the PPP project”, “the nature of the PPP project”, “the role in the PPP project” and “the experience form in the PPP project” respectively. l_i is the class label for $\mathbf{x}_i$. $\mathbf{m}_{l_i}^k$ is the mean of class l_i in background variable k. $\mathbf{m}^k = \mathbf{m}$ is the total data mean. $\boldsymbol{\Sigma}$ is the total data covariance matrix which is calculated based on all the data samples

$$\boldsymbol{\Sigma} = \frac{1}{N-1}\sum_{i=1}^{N}(\mathbf{x}_i - \mathbf{m})(\mathbf{x}_i - \mathbf{m})^T \tag{3}$$

The explanation of the relationship between the weight and Gaussian distribution is given in Appendix C.

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

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

where $w_{l_i}^{k}$ is the weight for $\mathbf{x}_i$ with class label l_i in background variable k. This means that if a data sample is in the majority of all of the four background variables, it is added a large weight to compute the final ranking.

With the weight value for each data sample, the final ranking score for item j is calculated as:

$$r_j = \sum_{i=1}^{N} w_{\mathbf{x}_i} x_{i,j} = w_{\mathbf{x}_1} x_{1,j} + w_{\mathbf{x}_2} x_{2,j} + \ldots + w_{\mathbf{x}_N} x_{N,j} \quad (5)$$

The results are shown in the Table 8.

5.4 Discussion of Ranking Results

Table 8 lists the ranking order of factors related to stakeholders in the PPP briefing stage from public-sector opinions. It is noted that the scores presented are lower than the mean values of factors. It is because the scores were calculated based on a totally different method. Therefore, the weighted scores and the mean values could not be directly compared. Only the ranks based on the two methods could be compared. It is clear that the two ranking orders were not the same when the four background variables were taken into consideration. The rank estimated based on the sample visualization method is more accurate and reliable.

Table 8. Ranking Scores of Factors

Factors	Weighted Scores	Means
Open and effective communication	2.735	4.090
Skillful guidance and advice from project manager	2.711	4.057
Knowledge of consultants	2.700	4.057
Openness and trust	2.677	4.025
Clarity of roles of stakeholders	2.657	3.984
Knowledge of clients business	2.650	3.951
Honesty	2.613	3.918
Knowledge of statutory and lease control of the project	2.596	3.885
Agreement of brief by all relevant parties	2.594	3.910
Selection of briefing team	2.590	3.893
Team commitment	2.583	3.852
Sufficient consultation with stakeholders	2.572	3.877
Clear management structure	2.490	3.730
Good facilitation	2.473	3.713
Balance of the needs/requirements of different stakeholders	2.468	3.697
Experience of the client	2.464	3.680
Holding workshops for stakeholders	2.386	3.566
Experience of stakeholder group	2.380	3.574

As shown in Table 8, “open and effective communication” ranked in first place (=2.735), followed by “skillful guidance and advice from project manager” (=2.711). An ethics of care offers an alternative underpinning that more adequately recognizes the interests and hears the voice of internal and external stakeholders (Smyth, 2008). So from views of the public sector, open and effective communication is the most important factor during the briefing stage. Project manager has responsibility to give initial advice and undertake feasibility exercises to help the client appreciate the nature of their site or building (Salisbury, 1998). So the project manager with skillful guidance and advice will lead a smooth briefing.

“Knowledge of consultants” ranked the third place (=2.700). Consultants may manage teamwork, collaboration, face to face contact and effective communication structures during the briefing stage. So the public sector wants the consultants to have these abilities to help briefing process. “Openness and trust” listed in the fourth place (=2.677). As measures of closeness and collaboration in the partnerships, two ways of trust were used: (1) self-interested trust, based upon seeking win-win outcomes centring upon a minimal range needed for an exchange, managing a transaction and working together and (2) socially orientated trust, based upon self-love (Smyth, 2008). The fifth place in the ranking list was “clarity of roles of stakeholders” (=2.657). In order to understand the various interested parties in the project, all types of stakeholders should be identified and represented during the early stages of the project (Kelly et al. 2004).

It seems that the public sector do not care about the experience of attending briefing of stakeholder group (=2.380). Because some of stakeholders in briefing are end users and/or other parties, so they do not strict all stakeholders have attended briefing stages

before. For “holding workshops for stakeholders” (=2.386), the public sector think special workshops which train stakeholders how to do briefing are not that necessary because the purpose of the briefing stage is to clarify all needs of clients. It is not to train stakeholders to do briefing and each project is unique to do a very standard way to briefing stages.

6. Conclusions

PPP is widely used in many construction projects worldwide. The KMO test supports the conclusion that survey data are adequate for factor analysis. Factor analysis establishes four dimensions of stakeholders involved in the briefing stage: “stakeholder ability for briefing”, “stakeholder consultancy to briefing”, “stakeholder ethic for briefing”, and “stakeholder facilitation 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 stakeholder-related factors. A mathematical model adopted from Gaussian distribution was used to add a weight generated by the four background variables to estimate the weighted ranking scores of factors. Mathematical analysis concludes that the 18 factors are different in their importance level in making briefing successful.

The limitation of research presented in this paper is all factors tested are related stakeholders and all data were collected from the public sector in Hong Kong. Future research will be carried on into two parts. First, the factors presented here will be tested

in real cases by working with related government departments. Secondly, there are other aspects which have impacts on the success of briefing such as factors of risk and finance (Tang et al., 2010) which should be studied and tested in future research in order to have a more comprehensive picture on how to improve PPP in the briefing stage.

Although the responses of this questionnaire survey are from the public sector, the findings in this research may facilitate all stakeholders in attending and making collaboration in briefing so as to increase the value of PPP projects. Because all factors tested in the paper are related stakeholders, other stakeholders should learn the preference of the public sector. This will contribute to an effective and efficient briefing of PPP-type construction projects.

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Appendix A: Sample of the questionnaire

Section A – Background Information
Please answer this section with reference to your previous experience in a particular ***PPP project*** *that you have participated in Hong Kong.*

1. The type of the PPP project:
☐ Cable car ☐ Drainage ☐ Hospital ☐ Housing
.
.
.

2. The nature of the PPP project:
☐ New build ☐ Refurbishment (including renovation, extension etc.)
.
.
.

3. Your role in the PPP project:
☐ Architect ☐ Administrator ☐ Engineer ☐ Contract Manager
.
.
.

4. Your experience in the PPP project:
☐ Directly involved in briefing stage ☐ Not directly involved in briefing stage

Section B – Stakeholder-related factors affecting effectiveness and efficiency of briefing stage in Public Private Partnership Projects in the construction industry
Those writing on the subject of briefing have made the following statements. Please indicate your level of agreement/disagreement for each statement.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1) The client should have related experience of briefing.	☐	☐	☐	☐	☐
2) The client needs a clear management organization structure for briefing.	☐	☐	☐	☐	☐
3) Knowledge of the client's responsibility is needed.	☐	☐	☐	☐	☐
4) Project manager should give appropriate guidance and advice during briefing.	☐	☐	☐	☐	☐
5) Workshops for stakeholders should be held regularly.	☐	☐	☐	☐	☐

Appendix B: Estimation of Projection Matrix

Suppose there are C classes, and the label of $\mathbf{x}_i$ is l_i. To estimate $\mathbf{W}$, two scatter matrices are introduced, which are the within-class scatter matrix $\mathbf{S}_w$ and between-class scatter matrix $\mathbf{S}_b$:

$$\mathbf{S}_w = \sum_{i=1}^{C} \sum_{\mathbf{x}_j : l_j = i} (\mathbf{x}_j - \mathbf{m}_i)(\mathbf{x}_j - \mathbf{m}_i)^T \tag{6}$$

$$\mathbf{S}_b = \sum_{i=1}^{C} (\mathbf{m}_i - \mathbf{m})(\mathbf{m}_i - \mathbf{m})^T \tag{7}$$

where $\mathbf{m}_i$ is the mean of class i, and $\mathbf{m}$ is the mean of all data samples. $\mathbf{S}_w$ measures the intra-class variances and $\mathbf{S}_b$ measures the inter-class variances. The optimization of the projection matrix $\mathbf{W}$ is to find a lower-dimensional space to simultaneously maximize the between-class scatter and minimize the within-class scatter. Compared with PCA, 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 make the projected data have the property where the samples with the same label will show clustering property in the projected space. Then the visualization will help to find similar classes with similar voting but different working experiences. The optimization criterion is formulated as:

$$\mathbf{W}^* = \arg \max_{\mathbf{W} \in R^{d \times m}} tr\left(\left(\mathbf{W}^T \mathbf{S}_w \mathbf{W} \right)^{-1} \left(\mathbf{W}^T \mathbf{S}_b \mathbf{W} \right) \right) \tag{8}$$

Here tr represents the trace of a 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 optimizal value of the criterion

is the sum of the corresponding largest eigenvalues (Duda et al., 2000; Bishop, 2006; Hastie et al., 2008).

Appendix C: Explanation of Ranking Weight

We can see that the weighting coefficient is just the exponential term of a multivariate Gaussian distribution

$$\frac{1}{(2\pi)^{d/2}}\frac{1}{|\boldsymbol{\Sigma}|^{1/2}}\exp\left(-\frac{1}{2}\left(\mathbf{m}_{l_i}^{k}-\mathbf{m}\right)^{T}\boldsymbol{\Sigma}^{-1}\left(\mathbf{m}_{l_i}^{k}-\mathbf{m}\right)\right) \qquad (9)$$

which ignores the constant term. Moreover, the weight has the property of ranging from 0 to 1. If the class mean $\mathbf{m}_{l_i}^{k}$ in background variable k is far away from the total data mean $\mathbf{m}$, a small weight 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 $\mathbf{m}$, a large weight is given, since the samples in options of that background variable represent the majority of the collected data. Similar weighting scheme has been widely used in non-parametric kernel methods (Schölkopf and Smola, 2001), neural network based machine learning (Bishop, 1995), and manifold approximation (Belkin and Niyogi, 2008).

Table 7. Correlations, Means, and Standard Deviations

	Variables	Mean	S. D.	1	2	3	4	5	6	7	8
1	the type of PPP projects	—	—	—	—	—	—	—	—	—	—
2	the nature of PPP projects	—	—	-0.043	—	—	—	—	—	—	—
3	the role in PPP projects	—	—	-0.158	-0.023	—	—	—	—	—	—
4	the experience in PPP projects	—	—	-0.155	-0.035	0.339[b]	—	—	—	—	—
5	stakeholder commitment and ability for briefing	3.813	0.513	0.250[b]	0.083	0.027	0.110	(0.803)	—	—	—
6	stakeholder leadership in briefing	3.916	0.448	0.048	-0.038	0.148	0.117	0.391[b]	(0.748)	—	—
7	stakeholder ethics for briefing	4.057	0.469	-0.037	0.043	-0.076	-0.030	0.276[b]	0.413[b]	(0.742)	—
8	stakeholder facilitation in briefing	3.787	0.424	-0.073	0.004	0.103	0.213[a]	0.555[b]	0.263[b]	0.329[b]	(0.533)

Note: Parentheses in the diagonal cells are coefficient alpha values.

[a]$p<0.05$.

[b]$p<0.01$, n=122.