Factor Analysis of Public Clients' Best-Value Objective in Public–Privately Partnered Infrastructure Projects

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Abstract: Best value is the ultimate goal of the public client in infrastructure development through public–private partnerships (PPPs). A best-value approach necessitates a sound best-value source selection methodology, which encourages creativity and innovation from the private sector and allows the public sector to make a right tradeoff between cost and noncost criteria in tender evaluation. Through a factor analysis of the relative significance of the best-value contributing factors (BVCFs) based on a previous questionnaire survey of international PPP experts, this paper has determined the major common dimensions of the public clients' best-value objective in infrastructure development and the key BVCFs that measure each of these dimensions. Statistical tests confirm the adequacy and quality of the survey, the soundness of the factor analysis and the internal consistency of the BVCFs, and they also indicate that the public, private, and academic sectors consider BVCFs rather similarly. The establishment of the best-value objective dimensions and the BVCFs that measure each of these dimensions would direct and concentrate the efforts of the private sector in crafting innovative project delivery models to offer the best value, the public sector in efficiently evaluating project proposals to award a defensible contract, and the consequently formed PPPs in continuously enhancing the best-value objective through long-term contractual arrangements.

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Introduction

Public–private partnerships (PPPs) are contractual relationships between public and private sectors in infrastructure development. The Canadian Council for Public Private Partnerships (2004) defines PPP as "a cooperative venture between the public and private sectors, built on the expertise of each partner that best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards." PPPs have been practiced worldwide in both developed and developing countries with multiple objectives including promoting infrastructure development, reducing costs, increasing construction and operation efficiencies, and improving service quality by incorporating private sector knowledge, expertise, and capital. These PPPs span a spectrum of contractual models from straight contracting out to outright privatization with increasing responsibilities and risks allocated to the private sector. However, no matter which PPP model is used, the regulatory control remains the responsibility of the public sector, which determines the kind of public works and services to be acquired and the quality and cost requirements on the delivery of such works and services, and takes necessary remedial actions for substandard performance (National Council for Public–Private Partnerships 2002 and 2003).

The public client often uses a best-value source selection (BVSS) methodology in choosing the private sector partner for the provision of specific public works and services through PPPs. The BVSS encourages creativity and innovation from interested private parties in meeting the requirements of a public project and provides the public client flexibility to select a project proposal that offers the best value. However, the BVSS process is often subject to wide criticism from private sector participants and even government contracting specialists who claim that the BVSS is usually subjective, used with broad discretion to award a public contract, and many times less than fair. Nonetheless, the courts have considered the challenges to the BVSS methodology and the legal decisions have upheld the BVSS as long as the public client documents its reasons for the tradeoff between cost and noncost criteria (Mickaliger 2001). Therefore, it is very important for the public client to develop an appropriate BVSS methodology, which will facilitate the private sector in effectively developing innovative proposals for improved project delivery and the public sector in efficiently conducting sound proposal evaluation, which meets the requirements of the legal decisions and consequently can withstand any protest proceeding after a contract award.

Three critical issues need to be adequately addressed in the development of an appropriate BVSS methodology: (1) the public client's best-value objective in the acquisition of public works and services; (2) best-value source selection criteria; and (3) best-value source selection methods. This paper focuses on the first issue, in which factor analysis is used (1) to determine the major dimensions of the public client's best-value objective and (2) to identify key factors [hereinafter referred to as best-value contributing factors (BVCFs)] that contribute to each dimension of the public client's best-value objective. The establishment of the best-value dimensions and the corresponding BVCFs would direct and

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concentrate the efforts of the private sector in crafting innovative project delivery models to offer the best value, the public sector in efficiently evaluating project proposals for a defensible contract award, and the consequently formed PPP in continuously enhancing the best value through long-term contractual arrangements.

Best-Value Source Selection Perspective

Best-Value Source Selection Methodology and Its Challenges

The essence of a sound BVSS methodology lies in: (1) the establishment of the major dimensions of the best-value objective of the public client in the acquisition of works and services and the identification of key BVCFs that measure each of these best-value objective dimensions; (2) the determination of a set of cost and noncost evaluation criteria that effectively "predict" the private sector participants' capability and their potential contributions to the public client's best-value objective; and (3) the development of a sound multicriterion tender evaluation method that ensures the right "tradeoff" between cost and noncost criteria and facilitates the comparison and ranking of alternative project proposals such that a defensible contract is awarded to the right private sector partner, whose proposal is perceived to be able to maximize the outcome of the project under consideration.

The BVSS has been increasingly used in various types of PPPs in worldwide procurement of public works and services in order to address the multiobjectives of public clients in formulating such partnerships with the private sector and the radical realignment of risks, responsibilities, and awards among project participants. The BVSS allows tradeoff between cost and noncost criteria and thus enables the government to select a higher priced project proposal instead of the lowest priced one provided that the increased benefits merit the additional costs. This encourages creativity and innovation from interested private parties in meeting the requirements of a public project and provides the public client flexibility to select a project proposal that offers the best value.

However, the BVSS is open to wide criticism by many contracting specialists from both the private and public sectors and often faces challenges from the private sector (Mickaliger 2001). Companies often struggled with the BVSS decisions of the public client and wondered: (1) how the public client derived its decision based on the cost and noncost criteria; (2) what were the discriminators that led to their nonselection; (3) how the public client determined that the value perceived was worth the cost difference between the source selection finalists; (4) whether they had received fair evaluations during a BVSS process, or if the public client used the BVSS to ensure the party of its choice received the business; and (5) if the public client conducted a thorough analysis and fully documented the source selection decision (Mickaliger 2001).

Best-Value Objective

Best value means the maximum achievable outcome from the development of an infrastructure project. Value includes tangible, intangible, intrinsic, and extrinsic aspects. Time, cost, image, aesthetics/appearance, operation and maintenance, managerial, safety and environmental aspects are all elements of the best value (Gransberg and Ellicott 1997). Best-value emphasizes quality, efficiency/effectiveness, value for money and performance standards (Akintoye et al. 2003). The priority of these value elements depends on the client's business requirements and the particular attributes of the specific project under consideration, and the achievability of the best-value elements depends on available resources of the client.

The best-value objective in a BVSS approach to the delivery of a particular infrastructure project should reflect the public client's overall strategic plan and mission objectives. This is confirmed by the US Government Performance and Results Act of 1993, which requires federal agencies to establish and manage to mission-related performance objectives. Defining the specific project to be procured in terms of how it supports and improves these mission-based performance objectives facilitates the public client in establishing a clear relationship of the particular project to the client's overall business and in developing an innovative PPP model where these objectives are grounded in the project's budget and program documents and performance measures. This ensures that the public and private sectors have a common vision of the project under consideration and work in partnership toward shared objectives.

Best-Value Source Selection Criteria

The public client's best-value objective should be translated into an appropriate set of effective evaluation criteria that measure a private sector party's capability and predict its potential level of contributions to the public client's best-value objective. The criteria should be unambiguous. This not only provides transparency in the award process, but also avoids unnecessary complications resulting from tradeoffs between offers on multiple criteria by competing bids (Estache and Carbajo 1996). The criteria and their weighting should also be justified. Otherwise, the best-value objective of the public client may be impaired in addition to the possible protests filed by unsuccessful tenderers. Therefore, actual project data need to be collected and correlated to the completed project value, and sensitivity analysis conducted to determine the appropriate value of the technical weighting and the cost weighting in order to achieve the "real" best value through an equitable BVSS process (Molenaar and Johnson 2003).

Zhang (2005) has developed a four-package evaluation criterion set for PPP projects in general. The four packages are: (1) financial; (2) technical; (3) safety, health, and environmental; and (4) managerial. Statistical analyses of the responses from a structured questionnaire survey of international experts on the relative weighting of the four packages and the relative significance of the criteria within each package have concluded that the four-package criterion set may be used as a common set of evaluation criteria for PPP projects in general, and be tailored for a specific PPP project by making appropriate adjustments to reflect the uniqueness of the project, such as the type and scope of the project, the PPP model chosen, and the allocation of responsibilities and risks among project participants.

Best-Value Source Selection Methods

A number of tender evaluation methods for PPP projects are currently in use. These include the simple scoring method, net present value (NPV) method, multiattribute analysis, Kepner–Tregoe decision analysis technique, two envelope method, NPV method+scoring method, and binary method+NPV method. Zhang (2004) provides a brief discussion of these methods. The binary method, simple scoring method and two-envelope method

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Table 1. Best-Value Contributing Factors for Public–Private Partnerships in General (Zhang 2006)

BVCFs	Remarks
Transfer of risks related to construction, finance, and operation	Public clients take a variety of risks in traditional procurements of works and services. Transfer to the Private sector of risks that are better managed by them will increase project development efficiency.
Reducing the size of public borrowing via off-balance sheet financing	In off-balance sheet transaction, lenders look primarily to the project's revenues for repayment and to its assets as collateral for their loan. They have no recourse or only limited recourse to the general funds or assets of project sponsors.
Benefits to local economy	This refers to the offers in alternative tender proposals that benefit local economic development.
Early project completion/ product or service delivery	There is a substantial time value to the customers related to the early availability of products/ services.
Acquisition of a fully completed and operational facility	Public sector may not have various resources required for the development of a project even if they have an urgent need of it. Resources from the private sector can lead to a fully completed and operational facility.
Low project life cycle cost	The integration of finance, design, construction and operation in a single source, the concessionaire, facilitates the achievement of a low life-cycle cost of the project.
Reduced public administrative costs	Great costs are incurred in the administration of public works procured in a traditional way, especially in dealing with those risks that may be better controlled by the private sector.
Reduced disputes and claims	PPPs reverse the overfragmentation of functions in a traditional design–bid–build contract that often leads to divergent if not confrontational agendas of the multiple participants, providing a great potential of reduced disputes and claims.
Low tariffs/tolls	The level of tariffs/tolls measures the cost to use the facilities of the project. It also determines the profit level of the concessionaire. Improved efficiency makes possible of low level of tariffs/ tolls.
Long project life span	Longer life span means longer period availability of products or service. For a PPP project with a specific concession period, longer span means longer remaining service period after transfer of the project to the client.
Optimized resources utilization	This increases project development efficiency, reduces costs and makes possible better offers to the public.
Additionality (acquisition of facilities that would otherwise not be built by the public sector)	This refers to projects developed as a result of unsolicited project proposals. When there is an initiative for PPPs in a public organization, private developers may go to this organization for possible PPP projects with their proposals.
Utilization of private managerial skills and technologies	Utilization of skills and technologies that are not available from the public sector enhances project development process, increases efficiency and reduces costs.
Environment friendly	Environmental issues become increasingly important, and are one of the key assessment areas in tender evaluation.
Transfer of technologies	This facilitates the operation and management of the current project beyond the concession period, and the development of new projects.
Increased project development and operation efficiencies	This makes possible low life-cycle project costs.
Improved constructability and maintainability	Constructability and maintainability are two important issues to be considered in design. Single source point in PPP projects encourages adequate attention paid to these two issues.
Additional financial sources for priority projects	This refers to the public money to be shifted from the PPP project to other important projects.
Technical innovation	A single source point encourages technical innovation and consequent improved project development.
Additional facilities/services beyond client requirements	The concessionaire may provide additional facilities beyond public client's requirements in a competitive tendering process.
Modular and repeatable design/construction	This facilitates the public client to develop similar projects in the future.

may be more appropriate for small and simple projects. For projects in which technical issues are not a problem and there exists proven construction technology, the NPV method may be more suitable. For complex projects, the multiattribute analysis and the Kepner–Tregoe decision analysis technique may be more fitting. Furthermore, financial aspects are the most important issue that needs to consider in PPPs. Hence, the financial package is usually assigned a much higher weight than other evaluation packages, and the NPV method is often used in conjunction with other evaluation methods to enhance the appraisal of financial aspects. Zhang (2005) recommends that the weights for: (1) financial; (2) technical; (3) safety, health, and environmental; and (4) managerial packages be 40, 25, 20, and 15% of the total weights.

Best-Value Contributing Factors

Best-Value Objective

One problem related to the BVSS methodology is that the public client often does not have clear objectives and priorities in infra-

Table 2. BVCFs Indicated as Statistically Different at 5% Level of Significance

Public and private	Public and academic	Private and academic
Benefits to local economy	No BVCF is statistically different.	Benefits to local economy
Environment friendly		Reduced public administrative costs
Additionality—acquisition of facilities that would otherwise not be built by the public sector		Additional facilities/ services beyond client requirements
		Transfer of technologies

structure development through PPPs. The demands of the public client as listed in the request for proposals are often "wish lists" instead of being sensible objectives (Akintoye et al. 2003). This often impairs the project development process. The client should clearly define its objectives and establish their relative importance and make sure the private sector shares these objectives. The probability of successful project delivery increases dramatically when both sectors have a common vision of the project to be developed.

Best-Value Contributing Factors

As mentioned in a previous section, the best value includes many value elements. The priority of these elements depends on the client's overall business requirements and the particular attributes of the specific project, and their achievability on the available resources of the client. To generalize the common dimensions of the public client's best-value objective in infrastructure development through PPPs, the BVCFs that different public clients believe contribute most to the best-value objective of infrastructure projects under their management need to be identified and analyzed.

The writer has conducted a research to identify the BVCFs for PPP infrastructure projects in general. A number of BVCFs have been identified through the study of many project delivery models in international public infrastructure development, including traditional design–bid–build model and various PPP models such as the build–own–operate–transfer and develop–operate–transfer. These BVCFs are screened by drawing in the opinions and comments of worldwide PPP experts and experienced practitioners from the public, private, and academic sectors, and after which, 21 key BVCFs remained, which are listed in Table 1 (Zhang 2006).

Significances of Best-Value Contributing Factors

The relative significances of the 21 key BVCFs have been determined through a structured questionnaire survey of the opinions of international experts in PPPs. In this survey, respondents were requested to indicate the significances of the 21 BVCFs on a scale of 0–5 (with "0" being "not applicable" "1" being "not significant" "2" being "fairly significant" "3" being "significant" "4" being "very significant," and "5" being "extremely significant"). Forty six respondents returned complete questionnaires. They are from 42 different organizations/institutions in a number of countries and regions, including Australia, Hong Kong Special Administrative Region of China, India, Japan, Peru, the Philippines, Mainland China, Malaysia, Singapore, South Africa, Thailand, United Kingdom and the United States. Twenty nine respondents are from the industry (12 from public clients and quasi-government organizations, hereinafter referred to as the public sector; and 17 from private companies, hereinafter referred to as the private sector) and 17 from academic organizations, hereinafter referred to as the academic sector. Many of the respondents are from organizations that have rich experiences in PPP projects. Statistical analysis of the relative significances of the 21 key

Table 3. Mann Whitney U Test Results for BVCFs between Public and Academic Sectors

BVCFs	Asymp. significance (2-tailed)	Exact significance [2*(1-tailed significance)]
Early project completion/product or service delivery	0.050	0.059[a]
Long project life span	0.922	0.945[a]
Additional facilities/services beyond client requirements	0.679	0.732[a]
Low tariffs/tolls	0.070	0.090[a]
Low project life-cycle cost	0.122	0.146[a]
Benefits to local economy	0.225	0.260[a]
Environment friendly	0.843	0.873[a]
Utilization of private managerial skills and technologies	0.919	0.945[a]
Technical innovation	0.478	0.507[a]
Transfer of technologies	0.939	0.423[a]
Improved constructability and maintainability	0.860	0.873[a]
Optimized resources utilization	0.480	0.507[a]
Modular and repeatable design/ construction	0.981	0.982[a]
Additional finance sources for priority projects	0.091	0.110[a]
Increased project development and operation efficiencies	0.357	0.397[a]
Transfer of risks related to construction, finance and operation	0.607	0.645[a]
Acquisition of a fully completed and operational facility	0.959	0.982[a]
Reduced public administrative costs	0.386	0.423[a]
Reduced disputes and claims	0.622	0.664[a]
Reducing the size of public borrowing via off balance-sheet financing	0.918	0.942[a]
Additionality—acquisition of facilities that would otherwise not be built by the public sector	0.145	0.165[a]

[a]Not corrected for ties.

Table 4. KMO and Bartlett's Test for All BVCFs

Kaiser–Meyer–Olkin measure of sampling adequacy	Bartlett's test of sphericity: Approximate chi square	DOF[a]	Significance
0.405	584.553	210	0.000

[a]DOF=degree of freedom.

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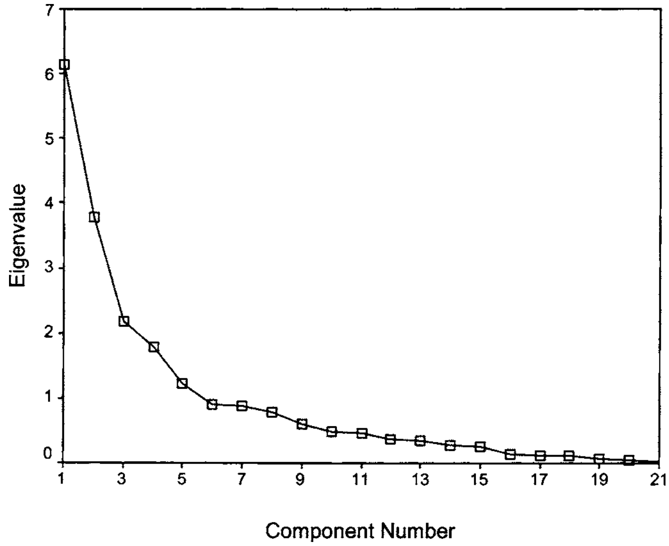

Fig. 1. Scree plot for factor analysis of all BVCFs

BVCFs shows that these BVCFs are important and should be considered in a best-value approach to PPPs in infrastructure development (Zhang 2006).

Agreement on Best-Value Contributing Factors Across Sectors

There is a need to examine the level of agreement between respondents from the public, private, and academic sectors in the rating of the significances of the BVCFs. This is done by conducting a Mann Whitney *U* test (please read George and Mallery 2000 for details) to determine whether the mean significance of each BVCF is equal across the public, private and academic sectors. The hypotheses are as follows:

H_o = mean significance of each BVCF is equal between any two sectors

H_a = mean significance of each BVCF is different between any two sectors

The statistic of the Mann Whitney *U* test is *U*, which is compared to a table of critical values based on the sample size of each group. If the value of *U* exceeds its critical value at some significance level (usually 0.05) it means that there is evidence to reject the null hypothesis and accept the alternative hypothesis. The test results are summarized in Table 2. Six out of the 21 BVCFs, 29%%, are indicated as statistically different in terms of mean significance at the 95% level of confidence between public and private sectors and/or between the private and academic sectors. The six BVCFs are "benefits to local economy," "environment friendly," "reduced public administrative costs," "additional

Table 5. Total Variance Explained by Extracted Major Components (all BVCFs)

	Initial eigenvalues			Rotation sums of squared loadings		
Component	Total	% of variance	Cumulative (%)	Total	% of variance	Cumulative (%)
1	8.004	31.890	31.890	3.589	17.090	17.090
2	4.366	17.398	49.287	3.394	16.161	33.251
3	2.488	9.911	59.199	3.158	15.039	48.291
4	2.264	9.022	68.221	2.500	11.905	60.195
5	1.302	5.188	73.409	2.268	10.801	70.996

Table 6. Rotated Component Matrix for All BVCFs

Best-value contributing factors	Component 1	2	3	4	5
Early project completion/ product or service delivery	0.469	—	—	—	—
Long project life span	—	0.718	—	—	—
Additional facilities/services beyond client requirements	—	0.654	—	—	—
Low tariffs/tolls	—	0.595	—	—	—
Low project life cycle cost	—	0.666	—	—	—
Benefits to local economy	—	0.563	—	—	—
Environment friendly	—	0.691	—	—	—
Utilization of private managerial skills and technologies	—	—	—	0.832	—
Technical innovation	—	—	—	0.741	—
Transfer of technologies	—	0.596	—	—	—
Improved constructability and maintainability	—	—	0.905	—	—
Optimized resources utilization	—	—	0.894	—	—
Modular and repeatable design/construction	—	—	0.824	—	—
Additional finance sources for priority projects	—	—	—	—	0.759
Increased project development and operation efficiencies	—	—	—	0.547	—
Transfer of risks related to construction, finance and operation	—	—	—	—	0.523
Acquisition of a fully completed and operational facility	0.716	—	—	—	—
Reduced public administrative costs	0.896	—	—	—	—
Reduced disputes and claims	0.800	—	—	—	—
Reducing the size of public borrowing via off-balance sheet financing	0.796	—	—	—	—
Additionality—acquisition of facilities that would otherwise not be built by the public sector	—	—	—	—	0.719

Table 7. KMO and Bartlett's Test for Agreeable BVCFs

	Bartlett's test of sphericity		
Kaiser–Meyer–Olkin measure of sampling adequacy	Approximate chi square	DOF[a]	Significance
0.647	295.150	105	0.000

[a]DOF = degree of freedom.

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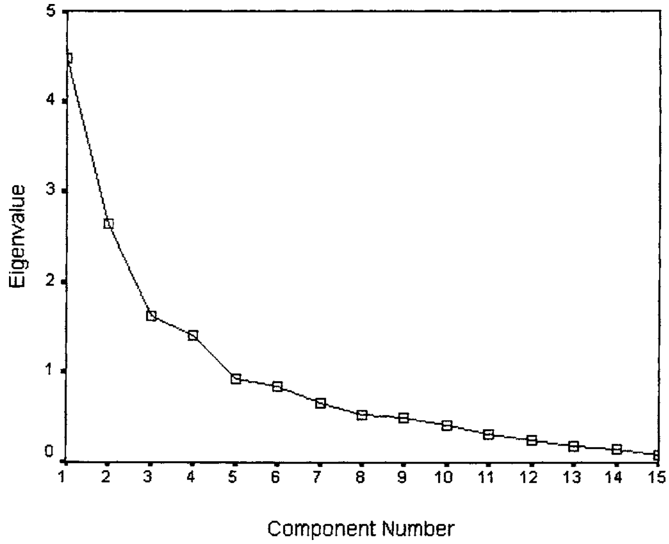

Fig. 2. Scree plot for factor analysis of agreeable BVCFs

facilities/services beyond client requirements," "transfer of technologies," and "additionality—acquisition of facilities that would otherwise not be built by the public sector." Table 3 shows the results of the Mann Whitney *U* test for BVCFs between public and academic sectors. It is seen that no BVCF is statistically different between these two sectors. That 71% of the BVCFs are similarly selected by public, private, and academic sectors indicates that the three sectors consider BVCFS rather similarly in determining the best-value objective of a PPP project.

Factor Analysis of Best-Value Contributing Factors

Adequacy for Factor Analysis

The survey data should be examined to see whether it is appropriate to use factor analysis by conducting the Kaiser–Meyer–Olkin (KMO) test and/or the Barlett's test of sphericity. The two tests indicate the strength of the relationship among variables and provide a minimum standard that should be passed before a factor analysis is conducted. The KMO measure of sampling adequacy is an index for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients. Its value should be greater than 0.5 for a satisfactory factor analysis to proceed. The Bartlett's test of sphericity examines the null hypothesis that the correlation matrix is an identity matrix (that is, the variables in the population correlation matrix are uncorrelated), which would indicate that the factor model is inappropriate.

Table 8. Total Variance Explained by Extracted Major Components (Agreeable BVCFs)

	Initial eigenvalues			Rotation sums of squared loadings		
Component	Total	% of variance	Cumulative (%)	Total	% of variance	Cumulative (%)
1	4.471	29.808	29.808	3.017	20.115	20.115
2	2.646	17.642	47.449	2.974	19.828	39.944
3	1.616	10.776	58.225	2.280	15.197	55.141
4	1.407	9.383	67.607	1.870	12.466	67.607

Table 9. Rotated Component Matrix for Agreeable BVCFs

	Component			
Best-value contributing factors	1	2	3	4
Early project completion/product or service delivery	0.533	—	—	—
Long project life span	—	—	0.733	—
Low tariffs/tolls	0.680	—	—	—
Low project life cycle cost	—	—	0.645	—
Utilization of private managerial skills and technologies	—	—	0.696	—
Technical innovation	—	—	0.629	—
Improved constructability and maintainability	—	0.849	—	—
Optimized resources utilization	—	0.843	—	—
Modular and repeatable design/construction	—	0.774	—	—
Additional finance sources for priority projects	—	—	—	0.704
Increased project development and operation efficiencies	—	—	—	0.575
Transfer of risks related to construction, finance and operation	—	—	—	0.772
Acquisition of a fully completed and operational facility	0.759	—	—	—
Reduced disputes and claims	0.764	—	—	—
Reducing the size of public borrowing via off-balance sheet financing	0.729	—	—	—

Basic Steps of Factor Analysis

Factor analysis is a statistical approach that can be used to verify the conceptualization of a hypothesis by analyzing interrelationships among a large number of variables and to explain these variables in terms of their common underlying dimensions by condensing the information contained in a number of original variables into a smaller set of dimensions with a minimum loss of information. Factor analysis can also be used to determine the relative importance amongst these dimensions. There are four basic steps for factor analysis: (1) generation of the correlation matrix; (2) extraction of initial factors; (3) rotation and interpretation; and (4) construction of scales or factor scores for further analyses. Please refer to Zeller and Carmines (1980) and Pett et al. (2003) for details on how to conduct a factor analysis.

Factor Analysis for All BVCFs

Table 4 shows the results of the KMO and Bartlett's tests for all of the 21 BVCFs. The KMO measure is 0.405, indicating the data are not adequate for factor analysis. The observed significance level of the Bartlett's test of sphericity is 0.000, which is small enough to reject the null hypothesis and supports a factor analysis for the data. The two tests draw opposite conclusions regarding whether a factor analysis is appropriate. Nonetheless, a factor analysis is conducted for all of the 21 BVCFs.

The principal components and orthogonal rotation are used to

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Table 10. Comparison of Components Extracted for All BVCFs and Agreeable BVCFs Only

(a) Factor analysis for all best value contributing factors				
Objective (component) I: Exploring private finance initiatives for enhanced infrastructure development	Objective (component) II: Maximizing the benefits to the public sector	Objective (component) III: Improving construction engineering and management process	Objective (component) IV: Utilizing private sector technologies and managerial skills for innovations and improved efficiencies	Objective (component) V: Improving the scope for private sector participation to promote the development of priority and other needed projects
Early project completion/ product or service delivery Acquisition of a fully completed and operational facility Reduced public administrative costs Reduced disputes and claims Reducing the size of public borrowing via off balance-sheet financing	Long project life span Additional facilities/ services beyond client requirements Low tariffs/tolls Low project life cycle cost Benefits to local economy Environment friendly Transfer of technologies	Improved constructability and maintainability Optimized resources utilization Modular and repeatable design/construction	Utilization of private managerial skills and technologies Technical innovation Increased project development and operation efficiencies	Additional finance sources for priority projects Transfer of risks related to construction, finance and operation Additionality-acquisition of facilities that would otherwise not be built by the public sector
(b) Factor analysis for agreeable best value contributing factors				
Objective (component) 1: Exploring private finance initiatives for enhanced infrastructure development	Objective (component) 2: Improving construction engineering and management process	Objective (component) 3: Utilizing private sector technologies and managerial skills for innovative and cost-effective project procurement	Objective (component) 4: Improving the scope for private sector participation to promote the development of priority and other needed projects	—
Early project completion/ product or service delivery Low tariffs/tolls Acquisition of a fully completed and operational facility Reduced disputes and claims Reducing the size of public borrowing via off balance-sheet financing	Improved constructability and maintainability Optimized resources utilization Modular and repeatable design/construction	Long project life span Low project life cycle cost Utilization of private managerial skills and technologies Technical innovation	Additional finance sources for priority projects Increased project development and operation efficiencies Transfer of risks related to construction, finance and operation	—

extract highly correlated BVCFs into a small number of major components (dimensions) of the best-value objective of the public client. Fig. 1 shows the scree plot of the factor analysis for all of the 21 BVCFs. The scree plot graphs the eigenvalue against the number of components. Each successive component accounts for decreasing amounts of the total variance. Five principal components are extracted by specifying eigenvalues (i.e., the variances of the principal components) greater than 1. As shown in Table 5, the five extracted components cumulatively explain 70.996% of the total variance.

Table 6 is the rotated component matrix, in which to make the output easier to read absolute values less than 0.5 are suppressed. Each row of Table 6 contains component loadings, the correlations between each variable (BVCF), and the component (the dimension of the best-value objective). The component loadings indicate which BVCF belongs to which component. The first component has the largest variance and therefore can explain the problem most effectively. The second component is independent of the first component and contains as much of the remaining information in all BVCFs as possible, and so on. After examination of the meanings of the BVCFs that belong to each component, the five components are renamed, respectively, "Objective I: exploring private finance initiatives for enhanced infrastructure development," "Objective II: maximizing the benefits to the public sector," "Objective III: improving construction engineering and management process," "Objective IV: utilizing private sector technologies and managerial skills for innovations and improved efficiencies," and "Objective V: improving the scope for private sector participation to promote the development of priority and other needed projects."

Factor Analysis for Agreeable BVCFs

As discussed in a previous section, six out of the 21 BVCFs are nonagreeable among the public, private, and academic sectors. It is meaningful to rerun the factor analysis using only the 15 agreeable BVCFs. Table 7 shows the results of the KMO and Bartlett's tests. The KMO measure of 0.647 and the 0.000 significance level of the Bartlett's test indicate that a factor analysis is appropriate for the 15 agreeable BVCFs.

Fig. 2 shows the scree plot of the factor analysis for the 15 agreeable BVCFs. Four principal components are extracted by specifying a minimum initial eigenvalue of 1. As shown in Table 8, the four extracted components cumulatively explain 67.607% of the total variance. Table 9 shows the rotated component matrix (absolute values less than 0.5 are suppressed). After examination

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Table 11. Pearson Correlations for Component 1 in Factor Analysis for Agreeable BVCFs

		Early project completion/ product or service delivery	Low tariffs/ tolls	Acquisition of a fully completed and operational facility	Reduced disputes and claims	Reducing the size of public borrowing via off-balance sheet financing
Early project completion/product or service delivery	Pearson correlation	1.000	0.187	0.368	0.420[b]	0.122
	Sig. (2-tailed)	—	0.218	0.013	0.004	0.432
	N	45	45	45	45	44
Low tariffs/tolls	Pearson correlation	0.187	1.000	0.420[b]	0.320[a]	0.347[a]
	Sig. (2-tailed)	0.218	—	0.004	0.032	0.021
	N	45	45	45	45	44
Acquisition of a fully completed and operational facility	Pearson correlation	0.368[a]	0.420[b]	1.000	0.533[b]	0.520[b]
	Sig. (2-tailed)	0.013	0.004	—	0.000	0.000
	N	45	45	45	45	44
Reduced disputes and claims	Pearson correlation	0.420[b]	0.320[a]	0.533[b]	1.000	0.549[b]
	Sig. (2-tailed)	0.004	0.032	0.000	—	0.000
	N	45	45	45	45	44
Reducing the size of public borrowing via off-balance sheet financing	Pearson correlation	0.122	0.347[a]	0.520[b]	0.549[b]	1.000
	Sig. (2-tailed)	0.432	0.021	0.000	0.000	—
	N	44	44	44	44	44

[a]Correlation is significant at the 0.05 level (2-tailed).
[b]Correlation is significant at the 0.01 level (2-tailed).

of the meanings of the BVCFs that belong to each component, the four components are renamed respectively as "Objective 1: exploring private finance initiatives for enhanced infrastructure development;" "Objective 2: improving construction engineering and management process;" "Objective 3: utilizing private sector technologies and managerial skills for innovative and cost-effective project procurement," and "Objective 4: improving the scope for private sector participation to promote the development of priority and other needed projects."

A comparison of the extracted components of the factor analyses using all BVCFs and only the agreeable BVCFs is shown in Table 10.

Table 12. Pearson Correlations for Component I in Factor Analysis for All BVCFs

		Long project life span	Additional facilities/ services beyond client requirements	Low tariffs/tolls	Low project life cycle cost	Benefits to local economy	Environment friendly	Transfer of technologies
Long project life span	Pearson correlation	1.000	0.506[a]	0.334[b]	0.426[a]	0.062	0.434	0.610[a]
	sig. (2-tailed)	—	0.000	0.025	0.004	0.686	0.003	0.000
	N	45	45	45	44	45	45	44
Additional facilities/services beyond client requirements	Pearson correlation	0.506[a]	1.000	0.280	0.421[a]	0.369[b]	0.430[a]	0.440
	sig. (2-tailed)	0.000	—	0.063	0.004	0.013	0.003	0.003
	N	45	45	45	44	45	45	44
Low tariffs/tolls	Pearson correlation	0.334[b]	0.280	1.000	0.543[b]	0.326[b]	0.370[b]	0.185
	sig. (2-tailed)	0.025	0.063	—	0.000	0.029	0.012	0.230
	N	45	45	45	44	45	45	44
Low project life cycle cost	Pearson correlation	0.426[a]	0.421[a]	0.543[a]	1.000	0.263	0.446[a]	0.322[b]
	sig. (2-tailed)	0.004	0.004	0.000	—	0.084	0.002	0.035
	N	44	44	44	44	44	44	43
Benefits to local economy	Pearson correlation	0.062	0.369[b]	0.326[b]	0.263	1.000	0.568[a]	0.369
	sig. (2-tailed)	0.686	0.013	0.029	0.084	—	0.000	0.014
	N	45	45	45	44	45	45	44
Environment friendly	Pearson correlation	0.434[a]	0.430[a]	0.370[b]	0.446[a]	0.568[a]	1.000	0.511[a]
	sig. (2-tailed)	0.003	0.003	0.012	0.002	0.000	—	0.000
	N	45	45	45	44	45	45	44
Transfer of technologies	Pearson correlation	0.610[a]	0.440[a]	0.185	0.322[b]	0.369[b]	0.511[a]	1.000
	sig. (2-tailed)	0.000	0.003	0.230	0.035	0.014	0.000	—
	N	44	44	44	43	44	44	44

[a]Correlation is significant at the 0.01 level (2-tailed).
[b]Correlation is significant at the 0.05 level (2-tailed).

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Table 13. Reliability Analysis for BVCFs

All BVCFs	Cronbach alpha	Agreeable BVCFs	Cronbach alpha
BVCFs measuring Objective I	0.8439	BVCFs measuring Objective 1	0.7506
BVCFs measuring Objective II	0.8236	BVCFs measuring Objective 2	0.8651
BVCFs measuring Objective III	0.8651	BVCFs measuring Objective 3	0.7397
BVCFs measuring Objective IV	0.7318	BVCFs measuring Objective 4	0.6766
BVCFs measuring Objective V	0.6403		

Validity and Reliability

Validity

Validity analysis examines whether what is expected to be measured is measured. This means that, if the BVCFs grouped in a particular component collectively explain the client's best-value objective in that dimension, they should significantly correlate with one another. Here, Pearson bivariate correlation analysis is conducted to examine whether relationships between BVCFs exist to ensure validity. According to the Pearson's table, the critical values that need to be surpassed to achieve significance for the two-tailed test for a sample of size 46 are around 0.288 and 0.372 for the 0.05 and 0.01 levels, respectively. Pearson bivariate correlation analysis shows that most of the BVCFs that measure a specific dimension of the client's best-value objective are correlated to one other, and therefore, they (or most of them) do measure the best value in that dimension. Tables 11 and 12 show the correlations between BVCFs grouped in component 1 in factor analysis for agreeable BVCFs only and for all BVCFs, respectively. Correlations between BVCFs grouped in other components are not provided due to the limitation of space.

Reliability

The internal consistency is examined to ensure at a certain level that the scale (0–5) for measuring the relative significance of the BVCFs yield the same result over time. This aims at finding the reliability coefficient based on the average correlation among BVCFs and on the number of BVCFs. Cronbach alpha (please read George and Mallery 2000 for details) is performed to test the internal consistency reliability of the scale. Table 13 shows the values of Cronbach alpha for BVCFs that measure different dimensions of the public client's best-value objective. The values are all greater than 0.6, indicating acceptable and good internal consistency reliability.

Conclusions

Public–private partnerships have been practiced worldwide and they span a spectrum of contractual models from straight contracting out to outright privatization with increasing responsibilities and risks allocated to the private sector. Best-value objective should be the ultimate goal of the public client in such PPPs. This necessitates BVSS methodology, which encourages creativity and innovation from the private sector and provides the public sector flexibility to choose a project proposal that offers the best value. However, the BVSS is subject to wide criticism and sometimes faces strong challenges from private companies because it is often used with broad discretion to award a public contract. Therefore, there is a need to develop an impartial, equitable, and thorough BVSS methodology, based on which a defensible contract award decision can be made.

Key BVCFs for PPP infrastructure projects in general have been identified and their relative significance determined in a previous study based on international PPP practices and the knowledge, expertise and experience of worldwide PPP experts and experienced practitioners. Factor analysis of these BVCFs has determined the major common dimensions of the public client' best-value objective in infrastructure development through PPPs and the BVCFs that measure each of these dimensions. The Mann Whitney *U* test shows that the public, private, and academic sectors consider BVCFs rather similarly, and the KMO test, Bartlett's test, validity, and reliability analyses confirm the adequacy (at least for the agreeable BVCFs) and quality of the survey, the soundness of the factor analysis, and the internal consistency of the BVCFs that measure each dimension of the client's best-value objective.

The establishment of the best-value objective dimensions and their corresponding BVCFs would direct and concentrate the efforts of the private sector in crafting innovative project delivery models to offer the best value, the public sector in efficiently evaluating project proposals to award a defensible contract, and the consequent public–private partnership in continuously enhancing the best value through long-term contractual arrangements.

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