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Quantity Surveyors' Perception of Cost Impact Factors in Hong Kong Civil Engineering Projects

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Abstract: Project cost is an important concern in any construction project. Although there has been a lot of studies on factors affecting the cost of construction projects, there seems no consensus as what cost factors have direct influence on the cost of civil engineering projects. This study therefore aims to bridge the current knowledge gap by examining quantity surveyors' perception of the factor structure among nineteen costing attributes identified based on literature review. Questionnaire was used to elicit responses from quantity surveyors working in the Hong Kong construction industry. Principal component analysis is conducted to extract the factor structure of the cost attributes and the attributes are grouped into three factor components, namely the contract management factor, the project management factor and the monetary value factor. Understanding these cost impact factors could be crucial in managing civil engineering projects, since it allows the project stakeholders and quantity surveyors to take precautionary steps to identify the cost management problems and areas for improvement and could even help to avoid cost deviations in engineering projects.

Keywords: Hong Kong, Cost Attributes, Civil Engineering Projects, Principal Component Analysis

I. INTRODUCTION

The traditional philosophy of managing construction projects places great emphasis on the time, cost and quality management. Construction projects are considered as successful when they are completed within specified cost, time and quality [1]. However, the studies conducted by Flyvbjerg et al. [2] and Mahamid and Bruland [1] demonstrate that cost overrun or cost deviations are common in engineering projects. Whilst there is no disagreement about the consequences of cost deviations or cost overruns, much of the difference in opinions arises from the magnitude influencing the factors on project cost. Researchers [3], [4] in the past have identified various items/attributes that affect project cost. Albeit, the study about the items affecting project cost is no new field, however, it is unfortunate that those studies are area specific or project specific and mostly come from developed countries and are based on researchers' experience on completed projects. Moreover, there is no consensus on what the cost factors are that would directly influence the cost of engineering projects and whether they are predictable or not predictable in the project outlay. This will however affect the accuracy of the project cost, particularly when there are numerous high risk items and uncertainties in the project. Thus, a deep understanding of how project costs are incurred is vital for the overall success in project cost management and ascertaining those factors working constantly in the cost field.

The objectives of this paper are to ascertain the cost impact factors affecting civil engineering project cost and to understand the latent properties of these factors. An exploratory approach is employed to investigate the research area. Literature review and personal interviews with experienced construction professionals are conducted to generate a list of cost attributes that affect engineering project cost. By adopting the attributes in the questionnaire survey, quantitative data is collected from quantity surveyors through professional institution. The data collected is analyzed by the principal component analysis (PCA) to examine the cost impact factor structure among the cost attributes identified in the analysis and to determine the grouping of the attributes. With a better understanding of the critical factors affecting civil engineering project cost, it is hoped that appropriate strategies can be devised for project cost assessment. Limitations of this research are also presented in order to enhance the originality of the paper.

II. LITERATURE REVIEW

Project cost is generally referred as construction cost. It can be viewed differently at different timelines for an engineering project. From the perspective of cost consultants or quantity surveyors, project cost is administered in two stages, the pre-contract stage and the post contract stage. At tendering stage, construction project cost is seen to be divided into pre-tendering and post-tendering stage. This division is offered because it is critical to the client to confirm the budget for the construction works and to the contractor to confirm business [5]. As the usual client for engineering projects is the government, a pre-tender estimate has to be established and approved before tendering and contracted out. This is generally known to quantity surveyors as the pre-contract stage. Once a contract is awarded, the cost

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monitoring function is based on the contract price and this is known as the post contract stage, including finalizing the cost at project completion at a later date [5]. It is not uncommon to find cost deviations at the pre-contract stage and cost overrun at the post-contract stage, while many studies relate to project cost have been conducted on cost impact factors aiming at identifying factors and/or attributes affecting/determining the magnitude of project cost [3] [6] [7]. Generally, the attributes that affect project cost can be grouped into several factors, including project issue, estimator-attribute, and construction, contract, economic, environmental and political factors.

Akinci and Fisher [3] distinguish the factors affecting project cost into three dimensions, namely cost estimate, final cost and contract specific dimensions. The cost estimate dimension includes the estimator-attribute factors, and design and project specific factors which have high cost impact on project cost estimate. The items that include in the two factors include the estimator's biases, vagueness in scope, design complexity, project size and such like. Regarding the final cost dimension, Akinci and Fisher [3] distinguish the factors that affect the final cost and have classified them into two major groups: construction specific factors as well as economic and political environment-specific factors. The construction specific factors refer to unknown geological conditions, weather conditions and client- and sub-contractor-generated risk attributes. The economic and political environment-specific factors are about the economic and political risks such as the price fluctuation, high inflation rate, change in exchange rate, political instability and taxation changes etc. The contract specific dimension refers to the type of contract adopted in the project and the contract clauses included in the contract. The use of different types of contract would affect the allocation of risk between the owner and the contractor. Moreover, it is considered that the contract clauses may also result in ambiguity and disputes between project parties, which will lead to decrease in cost effectiveness in the project [3]. However, there is no explanation as to how the above factors are generated, nor any validation of the significance of those factors/items included in the dimension. The validity of the proposed factors is thus questionable.

Trost and Oberlender [8] establish a predictive model to determine project cost. Factor analysis is conducted to group 45 variables into 11 orthogonal factors. Ordinary least square regression analysis is then performed on the 11 factors and their factor scores are used to predict the project cost and assess its accuracy. Of the 11 factors, 5 are found to be significant in determining project cost: process design, team experience and project information, time allowed to prepare the estimate, site requirements and bidding and labor estimate. Subsequently, Chan and Park [9] argue that the application of the ordinary regression analysis approach in the study tends to produce coefficient estimator that will perform poorly in the presence of multi-collinearity and surface due to high correlation among a group of variables. In addition, the variance of the ordinary least squares estimator becomes inflated, which results in the low possibility of the estimator being close to the true value of the regression coefficient [9].

The study of Chan and Park [9] points out that the construction project cost is affected by a number of factors as the industry is multi-disciplinary and its work is done by a lot of parties. In the study, a total of 57 variables/determinants are classified into 3 broad categories, pertaining to (1) project design, complexity and time, (2) professional level of the project team; and (3) contractor's competency for extracting components that contribute to project cost. The factor analysis result shows that the factors affecting construction project cost are project-specific factors and those reflecting the characteristics of the project team, including technological and project design requirements preset by the client and the consultants, contractor's expertise and management ability; and the client's desired level of construction sophistication. However, there is a lack of description and explanation about how the factors are generated whereas the questionnaire respondents are identified from building projects.

Warsame [7] have enhanced researchers' understanding of the cost impact factors by systematizing the attributes that influence project costs into four factors, namely project-specific factor, client and contractor-related factor, competition and market condition, and macroeconomic and political factors. The project-specific factor contains attributes that are related to the project issues such as the size, quality and complexity of the project. The items that include in the client and contractor-related factor are about the procurement method selected, contractor-client relationship etc. The competition and market condition comprises attributes that are difficult to control by the client and the contractor but can have a high impact on the costs and mark-up, such as the level of competition and market condition [7]. Macroeconomic and political factor includes items about the economic situation and political issues such as inflation, interest rate fluctuation and government regulations. On the other hand, there is not any explanation as to how the above factors are generated, nor any validation of the significance of those factors/items included in the dimension. The validity of the proposed factors is thus questionable.

Similar variables and factors have also been found as affecting project related cost in other studies. For instance, Kaming et al. [10] applies the factor analysis, and extract "factors" or "components" out of the original variables that influence project construction cost: environment, cost data and inflation. Akintoye [6] presents 24 variables that affect project cost estimation and has found that most of them also have impact on the final project cost. The variables are grouped under seven factors, namely project complexity, technological requirements, project information, project team requirement, contract requirement, project duration and market requirement. Williams [11] findings show that the quality and constructability of the project design, contractor management techniques, project location and macroeconomic conditions have influence on the price of the project during construction. In Iyer and Jha [12] study about factors affecting cost performance of Indian construction projects, it is found that a number of variables, including the conflicts between project participants, poor project specific attributes, holistic socio-economic relations and climate conditions, aggressive contractor competition and short bid preparation time would have impact on the project cost. Elhag et al. [4] in their analysis of factors affecting tendering cost state that the client priority on construction time, contractor's planning capability, procurement methods, market conditions as well as the level of construction activity would have impact on the project tendering cost. The research results of Elhag et al. [4] indicate that the technological and project design, the contractor's expertise and management ability, and the client's desired level of construction sophistication all play a role in determining the cost of the project. Recently, Chan [13] examines factors that influence construction project overhead expenses. Using the factor analysis approach, the 27 variables identified from the Delphi method are extracted into 8 factors: contractor's design requirement, regional economic condition, financial and insurance charges, project complexity, procurement arrangement, site layout, stakeholders' interest and project duration.

Drawing on the ongoing discussion, it is undeniably factual that, a project cost depends not only on a single factor but a group of attributes/items that are related to the characteristics of the project and to the construction team as well as the market conditions. Despite these enormous contributions, it is not clear in the literature about the specific cost attributes that affect project cost in civil engineering projects. On the other hand, taking lead from previous studies by related scholars such as Akinci and Fischer [3]; Akintoye [6]; Iyer and Jha [12] and Warsame [7] etc. and from preliminary interviews with experienced professionals, a list of 12 cost attributes that affecting project cost besides external influencing factors are firstly identified, namely "inflation rate", "exchange rate", "the profit margin", "the tender negotiation process", "tender pricing or contractor's pricing", "valuation of variation", "assessment of claims", "the negotiation process taken at the post-contract stage", "re-measurement of provisional quantities", "revaluation of provisional sums and prime cost sums", "the negotiation process taken at the final account stage", and "the overall settlement of the final account", which are generally focused on the calculation of the project cost at different timelines. The views on external influencing factor are varied and are later verified and expanded into 7 items. They are "site location", "programme", "procurement strategy", "contract management", "market conditions", "contractor's workload" and "technology". Though the list of attributes identified may not be exhaustive due to the vast magnitude and fragmented nature of the construction industry, the list covered attributes pertaining to influence the magnitude of project cost in a large variety of construction projects shown in the literature [3, 6, 7, 14]. The list of cost attributes forms the backbone of the survey instrument in the following section.

III. Research Design And Methodology

A. Quantitative Method

In this study, both the existing literatures as well as the opinion of the experienced construction professionals are taken into account for identifying the 19 cost attributes that may affect the civil engineering project cost in the questionnaire. Quantitative approach with questionnaire survey was then adopted to collect the primary data from a large number of quantity surveyors. The questionnaire survey is considered as an appropriate tool for this study as it is the most popular and cost effective means to collect information about attitudes, opinions and behaviors [15] and is widely used by researchers in the construction management discipline. Quantity surveyors were selected as the target respondents as they are responsible for cost management functions in construction projects. The questionnaire survey under internet-link was sent to the targeted respondents (i.e. quantity surveyors) by e-mail through relevant professional and associated institutions in Hong Kong. The respondents could fill in the questionnaire directly by click in the internet-link.

Although justification has been made for looking at the 19 variables as the underlying attributes that affect project cost, it was not clear which of the variables would measure the same underlying effect. In the questionnaire survey, the sequence of the cost attributes was randomly oriented. The respondents (quantity surveyors) were asked to respectively indicate whether they agree the 19 cost attributes have high impact on project cost in civil engineering projects on a 5-point likert-type scale ranging from strongly disagree (1) to strongly agree (5). Before the main survey was conducted, the questionnaire was pre-tested for comprehensibility by consulting a few experienced quantity surveyors and academics in the university.

The analytical tool selected was aimed to explore the latent characteristics and highlight the grouping of the 19 variables identified. Principal Component Analysis (PCA) was conducted to reduce the factor structures of the cost attributes, which will be discussed in the next section.

B. Qualitative Method

Following the questionnaire survey, semi-structured interviews were conducted with ten experienced practitioners who had wide knowledge of project cost management as to supplement the quantitative results obtained from the questionnaire survey. The main method for identifying interviewees was through the contact obtained from the questionnaire survey respondents. All the interviewees were experienced quantity surveyors and have more than 20 years working experience in the construction industry. It was believed that the semi-structured interviews could also help to provide a better understanding about the latent properties of the factors identified in the quantitative findings. The profiles of the interviewees are listed in the following table.

TABLE I
PROFILE OF INTERVIEWEES

Interviewees	Position Level	Company Nature
1	Former QS Director	Quantity Surveying Consultant
2	Former QS Director	Quantity Surveying Consultant
3	Professor	Tertiary Institution
4	QS Director	Engineering Consultant
5	QS Director	Engineering Consultant
6	Quantity Surveyor	Quantity Surveying Consultant
7	Senior Contracts Administration Manager	Engineering Consultant
8	Senior Resident Quantity Surveyor	Contractor
9	Quantity Surveyor	Engineering Consultant
10	Quantity Surveyor	Client/Development Office

IV. THE RESEARCH ANALYSIS

When the survey is closed, a total of 165 responses were collected. The data collected are analyzed statistically using IBM SPSS 19.0. The following is the research results obtained from the questionnaire responses.

A. Demographic Information of Survey Respondents

A preliminary descriptive analysis is provided for the understanding of the background of the survey respondents. Table 2 presents the characteristics of survey respondents with respect to their demographic information.

TABLE II
DEMOGRAPHIC INFORMATION OF SURVEY RESPONDENTS

Items	Label	Frequency	Percentage
Working Fields	QS Consultant	38	23.0%
	Civil Engineering Consultant	17	10.3%
	Contractor	56	33.9%
	Client	34	20.7%
	Others	17	10.3%
	Not answered	3	1.8%
Nature of Works	Civil Engineering	44	26.7%
	Building	64	38.8%
	Building and Civil Engineering	49	29.7%
	Not Answered	8	4.8%
Working Position Level	Policy making (planning) level	14	8.5%
	Project management (group of projects) level	63	38.2%
	Project (single project) level	81	49.1%
	Not Answered	7	4.2%
Company Attribute	Public	16	9.7%
	Semi-public	6	3.6%
	Private	53	32.2%
	Not Answered	90	54.5%
Working experience in the profession (Years)	1-3 years	7	4.2%
	3-5 years	1	0.6%
	5-7 years	2	1.2%
	7-10 years	4	2.4%
	More than 10 years	63	38.2%
	Not Answered	88	53.4%

A number of characteristics are identified from the demographic information of the survey respondents. Except for those respondents who do not answer the questions, a high portion of the respondents (more than 38%) have more than 10 years working experience in the profession. More than 32% of the respondents are working in the private sector. However, nearly 50% of the respondents are working with a single project only. In addition, a high portion of the respondents (around 40%) involves in building projects, rather than civil engineering projects in the last three years. The number/percentage of respondents working with contractors and consultants are nearly the same; whilst more than 20% of the respondents are working for the client.

B. Factor Analysis (Principal Component Analysis) (PCA)

In this study, the PCA technique is used to examine the factor structure among the cost attributes and determine the grouping of the related attributes in the analysis. It is because the technique is useful for finding the underlying structure of related variables and ideal for reducing a large number of variables into a more easily understood framework [8, 16, 17, 18]. The tool is widely used by researchers of different disciplines to identify and interpret non-correlated clusters of variables [8, 19, 20]. To ensure the validity of the factors, some pertinent issues such as the reliability of the survey instrument (cost attributes), the adequacy of sample size and the suitability of the items are addressed before the analysis is conducted.

The reliability of the cost attributes is related to the internal consistency of the attributes included in the measurement, which is obtained through the Cronbach's reliability test. The Cronbach's alpha is a value commonly used to depict the degree to which the attributes in the measurement scale to "indicate" the construct [18]. Typically, the scale with a threshold value of 0.70 is regarded as having acceptable internal consistency [21, 22].

Following the reliability analysis, the data is subjected to the Kaiser-Meyer-Olkin (KMO) and Barrtlett's Test which measures the sampling adequacy - in factor analysis [23]. KMO test measures whether the distribution of values is adequate for conducting factor analysis [23]. It is expressed as an index ranges from "0" to "1". Scholars [18, 23] suggest that the threshold KMO value should be greater than 0.70 if the sample size is adequate for factor analysis. The sample that has a KMO value between 0.50 and 0.70 is marginal while lower than 0.50 is considered to be unsuitable for factor analysis [23]. The Barrlett's Test of Sphericity is a Chi-square test, which measures the multivariate normality of the variables. The test examines the probability that the correlation matrix is an identity matrix [18, 24]. Result with a significant level of less than 0.05 is considered suitable for carrying out the factor analysis.

The results of the reliability of cost attributes, sample size adequacy and population matrix are provided as follows:

TABLE III
RELIABILITY STATISTICS OF THE COST ATTRIBUTES

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.940	.941	19

The alpha value of 0.940 in Table 3 indicates that the cost attributes achieve a high level of reliability for factor analysis. Table 4 shows that the test result of KMO is 0.814, indicating that the sample size is more than adequate for factor analysis. The Barrlett's test of Sphercity is also significant, suggesting that the population is not an identity matrix, of which the research instrument is suitable for factor analysis.

TABLE IV
KMO AND BARRLETT'S TEST FOR THE COST ATTRIBUTES

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.814
Bartlett's Test of Sphericity	Approx. Chi-Square	726.928
	df	171
	Sig.	.000

After satisfying all the necessary requirements, factor analysis is conducted for the cost attributes by using PCA with varimax rotation. This rotation method is used as it seeks to maximize the variance of the factor loadings by making high loadings higher and low loadings lower on each factor [18]. The eigenvalue is a measure of how a standard variable contributes to the principal components [25]. As a general rule applied in most factor analysis results, the extracted components having the eigenvalues of 1.0 are considered as significant contributing factors and those having less than 1.0 can therefore be ignored [16, 23, 25].

Regarding the factor structure issue, a clear component structure is present when a variable has significant factor loading (loading > 0.50) on one component only [22]. Dogbegah et al. [17] recommended checking for two strange situations, namely complex structures among variables and components that have one variable loading on them. Complex variables refer to that having significant factor loading on more than one component, which also make interpretation of the output difficult. When a complex structure exists, the variable that has significant loading on more than one component has to be eliminated and the remaining variable has to rotate again for the factor result loading. The loading specified is used to express the influence of each variable to the particular component. In addition to examining whether complex structure exists among the variables, the researcher also has to examine the factor loading as to check for components that have more than one variable loading on them, otherwise the component is eliminated for further analysis. The rotated component matrix of the cost attributes are provided in Table 5 as follows:

TABLE V
ROTATED COMPONENT MATRIX

Cost Attributes	Component		
	1	2	3
11 The negotiation process taken at final account stage	.862	.302	.074
12 The overall settlement of the final account	.831	.267	.126
7 Assessment of claims	.798	.309	.190
6 Valuation of variations	.797	.347	.224
8 The negotiation process taken at post-contract stage	.754	.252	.260
9 Re-measurement of provisional quantities,	.751	.036	.329
10 Re-valuation of provisional sums and prime cost sums	.703	.042	.409
1 Inflation rate	.205	.808	-.024
14 Programme	.140	.743	.168
19 Technology	.118	.695	.369
2 Exchange rate	.260	.690	-.014
17 Market conditions	.101	.621	.416
16 Contract management	.505	.531	.338
4 The tender negotiation process	.523	-.058	.714
15 Procurement strategy	.204	.392	.693
18 Contractor's workload	.192	.452	.681
5 Tender pricing or contractor's pricing (whatever method)	.529	-.019	.666
3 The profit margin	.517	.413	.539
13 Site location	.163	.471	.519

Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; a. Rotation converged in 10 iterations.

TABLE VI
REVISED KMO AND BARRLETT'S TEST FOR THE COST ATTRIBUTES

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.782
Bartlett's Test of Sphericity	Approx. Chi-Square	545.208
	Df	105
	Sig.	.000

The KMO value of 0.782 in Table 6 indicates that the sample size is adequate for factor analysis for the remaining cost attributes. The Barrlett's test of Sphercity is also significant, suggesting that the population is not an identity matrix and is suitable for factor analysis.

Table 7 shows that when the rule of an eigenvalue greater than 1.0 is applied, 3 components are extracted in the factor analysis. The cumulative of total variance explained has been accounted for 69.921% of the variation in the data set, which fulfills the criterion of factors explaining at least 50% of the variation. The variance explained by Component 1, 2 and 3 are 32.650%, 21.37% and 15.901% respectively.

A check on Table 5 shows that the three components obtained from the varimax rotation has more than one variable loading on them, thus all the 3 components can be kept in the analysis. However, when looking into details of the 3 components, it is found that 4 items (Item 3, 4, 5 and 12) have significant loading on more than one component. The significant loading of 4 items on 2 components expresses the influence of each original variable within the two components. Thus, the 4 items are excluded from the cost attributes and the remaining research instruments (i.e. remaining cost attributes) have to be rotated again for the factor analysis result.

TABLE VII
TOTAL VARIANCE EXPLAINED OF THE COST ATTRIBUTES

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.363	49.084	49.084	7.363	49.084	49.084	4.897	32.650	32.650
2	2.022	13.481	62.565	2.022	13.481	62.565	3.205	21.370	54.020
3	1.103	7.356	69.921	1.103	7.356	69.921	2.385	15.901	69.921
4	.913	6.084	76.005						
5	.762	5.083	81.088						
6	.634	4.224	85.312						
7	.511	3.404	88.716						
8	.426	2.837	91.553						
9	.364	2.426	93.979						
10	.255	1.701	95.680						
11	.236	1.572	97.252						
12	.139	.924	98.175						
13	.123	.820	98.995						
14	.086	.571	99.566						
15	.065	.434	100.000						

Extraction Method: Principal Component Analysis

The next stage is about the interpretation of the PCA results and the examination of the factor structure in the factor analysis. Table 8 shows that a clear component structure is present in the analysis as all variables have significant factor loading (loading > 0.50) on one factor component only. A check on Table 8 also shows that the three components obtained from the varimax rotation has more than one variable loading on them, thus all the 3 components are retained for data interpretation.

TABLE VIII
ROTATED COMPONENT MATRIX

Cost Attributes	Component 1	Component 2	Component 3
11 The negotiation process taken at final account stage	.861	.111	.282
12 The overall settlement of the final account	.824	.089	.304
7 Assessment of claims	.811	.292	.166
6 Valuation of variations	.802	.279	.258
9 Re-measurement of provisional quantities,	.794	.195	-.007
8 The negotiation process taken at post-contract stage	.774	.282	.163
10 Re-valuation of provisional sums and prime cost sums	.764	.268	-.016
18 Contractor's workload	.290	.830	.097
15 Procurement strategy	.309	.738	.081
17 Market conditions	.152	.707	.318
14 Programme	.139	.668	.401
19 Technology	.167	.666	.405
13 Site location	.217	.636	.303
2 Exchange rate	.196	.140	.825
1 Inflation rate	.166	.266	.769
11 The negotiation process taken at final account stage	.861	.111	.282
12 The overall settlement of the final account	.824	.089	.304
7 Assessment of claims	.811	.292	.166
6 Valuation of variations	.802	.279	.258

Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; a. Rotation converged in 5 iterations.

The remaining is about the interpretation of the 3 principal components extracted. It is instructive to note that the 15 retained cost attributes are summarized into 3 new uncorrelated factors that explain 69.921% of the total variance in the variables included in the components. However, as this paper adopts only exploratory approach involving a large number of cost attributes, the interpretation of the principal components has become a considerable challenge in this study. Another challenge posed by the PCA is that the combination of the variables that load high on a component is difficult to interpret and to explain their pattern, as the analysis indicates only the relationship between individual component and the variable. As such, the interpretation of factors involves a certain amount of inventiveness and imagination [26, 27]. In the next section, the assessment and naming of each component is based on the understanding of the content and relationship among the variables.

V. Discussion Of Factor Analysis Results

Based on the critical examination of the variables in each factor/component, an appropriate collective label is given to each extracted factor/component so as to reflect the correlation of all the variables within. Factor 1 is named as contract management factor; factor 2 is named as project management factor and factor 3 is named as monetary value factor. Referring to the findings obtained in preceding studies and opinions collected from the semi-structured interviewees, the meaning of the three extracted factors are interpreted as follows according to the descending order of variance explained by each factor.

A. Contract Management Factor

The first principal component (factor) in Table 6 reports high factor loadings for a group of variables (cost attributes), namely “The negotiation process taken at final account stage”, “The overall settlement of the final account”, “Assessment of claims”, “Valuation of variation”, “Re-measurement of provisional quantities”, “The negotiation process taken at post-contract stage” and “Re-valuation of provisional sums and prime cost sums”. These variables account for 32.65% of the variance explained as shown in Table 5. Subsequently, examining critically the latent characteristics of the variables, the factor is named as “contract management factor”. This factor is easy to interpret, in the sense that with the complex, dynamic and challenging nature of civil engineering projects, contract management is exceptionally important in this type of project and its performance would affect project productivity, quality and budget significantly. For instance, Ibbs and Ashley [28] point out that the ambiguity and disputes between project parties in a number of contract clauses (including workmanship variation, work variation order and cost reporting and control etc.) affects project performance, cost, schedule and quality. Similarly, in the study of 204 construction contracts in Italy, Tagliaventi [29] points out that the contract clauses define how a project is measured (e.g. variation work and works under provisional and prime cost sum) and how risks are allocated between the parties involved. Hence, it is essential that the contract-specific issues would determine the magnitude of the total cost of the project. The interview results also confirm the questionnaire findings of which most of the respondents have pointed out that a number of matters of contract administration are cost significant, including payment, valuation, variations and claims, loss and expenses issue and final account settlement etc. Since the contract issues of a project determines the condition under which the project will be let and the amount of work to be valuated, it is not surprising that the contract management factor has been found as a cost impact factor in civil engineering projects.

B. Project Management Factor

Factor 2 accounts for 21.37% of the total variance (see Table 5). As demonstrated in Table 6, the factor consists of “contractor’s workload”, “procurement strategy”, “market conditions”, “site location” and “programme” and “technology”. It is noteworthy that these variables are loaded on the same factor, which is related to the construction project subject matter. Without difficulty, the factor is labeled as “project management factor”, and the interpretation that follows. Contractor’s workload and market conditions are found to have high impact on project cost in a number of studies. For instance, Akintoye [6] study findings show that that the contractor’s workload and trends in market condition have implications on the resource cost and mark-up determination for the project and consequently, the whole project costing. Moreover, Elhag et al. [4] also point out in his study that market conditions have a clear effect on tender prices, and particularly on mark-up and profit margins of a particular construction project. In the analysis of construction cost in Sweden, Warsame [7] found that the contractor’s workload is a function of the number of contractors in the market, which inherently influences the costs of inputs and the level of final construction cost. Warsame [7] also points out that the market condition would have high impact on final project cost as it determines how a project initial cost get estimated and the level of final construction costs derived, usually long after the estimated date.

Considering the procurement strategy, although it is argued by some researchers [4, 30] that the attribute itself has little relationship with the construction cost of the project, it is expected that this attribute has some implication on the contractual arrangement, which affects the risk allocation and thus the final project cost. Site location also has implication on project cost as site located in remote area may encounter more problems such as the unforeseen geological condition, delivery of resources and restriction of access to site [31] [32] [33]. In addition, the work programme is also considered as important in project cost as this information is essential to plan the construction activities and resource requirements accurately at the project construction stage. Inaccurate estimation of the materials and manpower would subsequently affects project performance, cost and schedule. Some of the interview respondents also mentioned that problems or negative effects (such as time overrun) may arise when less attention has been paid to monitor the work programme, which will in turn affects the final project cost. Technology is of particular importance in project cost as it determines the equipment and construction methods that can be used for construction projects. Some interview respondents also support that the "technology" used in construction is important in engineering project cost because of the project complexity usually found in many of constructing engineering works.

C. Monetary Value Factor

Factor 3 consists of two cost variables: exchange rate and inflation rate, which accounts 15.901% of the total variance (see Table 5). This factor is named as "monetary value" and the interpretation follows. Both exchange rate and inflation rate affect the financial performance of a construction project as the two variables will contribute for the unprecedented price strikes in vital construction labour and materials such as steel, copper and cement etc., which have an enormous impact on the overall cost of the project. For example, inflation causes price escalation in concrete will obviously lead to an increase in the total concrete cost of a project. Whilst the economic and financial factor plays a role in project cost, its significance varies with the country in which construction is taken place and with the project duration [3]. This factor is especially important when the project takes place in countries where there is economic instability or with project of long duration. For instance, in the study of North Sea platform projects, Hetland [34] has found that the projects normally take 3 to 5 years for completion and inflation alone already represents about 27% of the total project cost, which is also one of the major reasons for project cost overrun. Similarly, Kaming et al. [10] also state that there is cost overrun on high-rise projects in Indonesia because of the unpredicted inflation in the past few years of which the price of the cement itself has already increased by more than 70%.

VI. Conclusion And Recommendation

Project cost is an important concern in any construction project. The significant cost deviations in civil engineering projects nowadays has placed emphasis on the need for construction professionals to understand the magnitude of the factors on influencing the project cost. Taking lead from previous studies and discussions with experienced construction professionals, nineteen cost attributes that affect civil engineering project cost are identified. PCA is adopted to extract the factor structure of these attributes. The analysis results show that the cost attributes can be distinguished into three factors, namely contract management factor, project management factor and monetary value factor. This also forms the basis for improving the cost management of engineering projects in Hong Kong. The originality and value of the paper is manifested in the use of the principal component analysis to provide an understanding into the grouping of the various cost attributes and expound three cost impact factors in civil engineering projects.

The contribution of this paper is twofold. First, it represents the idea of context-driven research that identifies the cost impact factors in the provision of civil engineering projects to address the dynamic nature of the industry. Second, the findings draw an implication of focus in assisting the project stakeholders and quantity surveyors to perform cost management functions better in civil engineering projects. This is achieved through the grouping of the factor components. The recognition of these factor component groupings, representing the important cost attributes in engineering works, implies that the three factors should be considered carefully in managing engineering project cost. It is believed that an improved understanding portrayed in this study would enable the development of strategies, methods and tools for managing those costing items in civil engineering projects. In addition, categorization of the cost attributes under different principal factors allows practitioners to assess the associated risks with reference to the project characteristics and environment and to make necessary adjustments, thereby performing better cost management functions. This is also envisioned to help the project stakeholders and quantity surveyors to understand the dynamics of cost deviations in civil engineering projects. On the other hand, this research, like others, also had limitations in its conduct and scope. This paper is to be seen largely as exploratory research and confirmatory research on the scope is required in terms of the methodological aspect. Moreover, a large sample size to be used instead of the relatively small sample size could have been better for the use of the factor analysis to be robust. However, this does not nullify the conclusions drawn, given that the necessary tests has obtained favorable results for the analysis to proceed. These limitations also provide the basis for future research recommendations. Future research to explore the right probes of how those cost factors in civil engineering projects can be worked out would be important for improving the predictability of project cost and enhancing the project cost accuracy.

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