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Risk ranking and analysis in target cost contracts: Empirical evidence from the construction industry

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Abstract

The construction industry is often characterized by the traditional adversarial working relationships between contracting parties. There has been a strong call for applying target cost contracts to align the interest of owners and contractors together. By doing so, it aims to achieve a win-win situation under a partnering arrangement within the construction industry. Even though a multitude of research studies have been undertaken on target cost contracts (TCC) or guaranteed maximum price (GMP) contracts, not many of them have focused on the risk management and analysis of these procurement strategies. This paper aims to identify, rank and compare the key risk factors encountered with these forms of procurement based on an empirical questionnaire survey geared towards the clients, contractors and consultants in Hong Kong. Despite the limited number of completed TCC and GMP (TCC/GMP) construction projects in Hong Kong, the chosen sample was perceived to be truly representative of the survey population. A four-level data analysis framework was applied in this paper, including descriptive statistics, Kendall's concordance test, Spearman's rank correlation test and Mann-Whitney U Test. The research findings showed that the client group, contractor group and consultant group are in general agreement on the impact of individual risks. The identification of the key risk factors and their relative significance are important in the risk management of target cost contracts and guaranteed maximum price projects, which, if properly done, would enhance the value for money throughout the whole procurement process. This research study also helps various key project stakeholders to equip with better knowledge and understanding of TCC/GMP scheme by paying close attention to those

high-risk factors and then the implementation of appropriate risk mitigation measures in a proactive manner.

Keywords: Risk management; Risk analysis; Construction industry; Target cost contracts; Guaranteed maximum price contracts; Hong Kong

1. Introduction

The construction industry is conventionally fraught with the adversarial working relationships between contracting parties, particularly in case of competitive fixed-price lump-sum contracts (Kaka et al., 2008). The rationale of applying the traditional procurement approach is often questioned by industry review reports worldwide (Latham, 1994; Egan, 1998; Construction Industry Review Committee, 2001). Target Cost Contracts (TCC) and Guaranteed Maximum Price (GMP) contracts (being a variant of TCC), which align the individual objectives of various contracting parties together, would be appropriate procurement models to encourage more co-operative working culture and partnering spirit within the construction industry (Construction Industry Review Committee, 2001). TCC has often been practised in construction projects with a high level of risks (Broome and Perry, 2002). The identification of risks is a significant task for all major contracting parties across all building and civil engineering projects, since the owners may be interested in knowing which risk factors will generate significant impacts on the projects concerned.

Although both TCC and GMP contracts have been implemented in different parts of the world for several years, not all projects procured with these contractual arrangements have been equally successful in terms of performance outcomes. For example, Chan et al. (2010a) reported on a case study of metro station modification and extension works in Hong Kong completed with significant savings in both time and cost by introducing the TCC procurement strategy. However, Rojas and Kell (2008) stated that the final construction cost of 75% of school projects investigated in the northwest of the United States exceeded the GMP value, while the same phenomenon was found in about 80% of non-school projects. These findings did not support the notion that GMP was really a guarantor of construction cost, and generated a strong motive to launch this study by capturing the lessons learned from previous TCC/GMP contracts.

An extensive desktop search indicated that there is a lack of published literature on the risk assessment and analysis of TCC/GMP projects worldwide, especially in the Hong Kong context. In response to this knowledge gap, the objectives of this paper are to identify and rank the key risk factors associated with TCC/GMP construction projects and to compare the perceptions of risk assessment amongst the clients, contractors and consultants.

The determination of key risk factors and the assessment of their relative importance are essential in the risk management of those TCC/GMP contracts and in enhancing the cost effectiveness of the whole procurement process. This research study helps equip different major project stakeholders, including but not limited to employers, contractors and consultants with the necessary knowledge and understanding to focus on those high-risk factors and implement effective risk mitigation measures in a proactive manner. This study is expected to benefit both academic researchers and industrial practitioners in documenting the key risk factors of TCC/GMP projects, providing more empirical evidence by adding to the growing body of knowledge and establishing a sound foundation for further research such as an international comparison of risk assessment with this kind of projects.

2. What are TCC and GMP?

The National Economic Development Office (1982) based in the United Kingdom considered that "target cost contracts specify a 'best' estimate of the cost of the works to be carried out. During the course of the works, the initial target cost will be adjusted by agreement between the client or his nominated representative and the contractor to allow for any changes to the original specifications". According to Trench (1991), target cost contracting scheme is a contractual arrangement under which the actual cost of completing the works is evaluated and compared with an estimate or a target cost of the works, the differences within a cost band are shared between the client and the contractor based on a pre-determined share ratio. Wong (2006) shared a similar view that the contractor is paid the actual cost for the work done during the contract stage. When the final construction cost, termed as the final total cost, differs from the initial target cost, the variance would be spilt between the employer and the contractor based on a pre-determined gain-share/pain-share ratio as stated in the contract.

GMP is a type of contract works that is more suitable when the design is based on conventional means. However, the scope of works is not clear for fixed-price bidding at the time of contract award (Saporita, 2006). The American Institute of Architects (2001) regarded GMP as a sum established in an agreement between a client and a contractor as the cap of overall project cost to be paid by the client to the contractor for performing specified works on the basis of cost of labour and materials plus overhead and profit. The contractor receives a prescribed sum, along with a share of any savings to the client under this procurement approach. If the cost of the work exceeds the assured maximum, the contractor bears the excessive costs (Walker et al. 2000). Under this situation, a ceiling price is established, and the contractor is responsible for any additional costs (Gould and Joyce, 2003). However, the project is often started with considerable unknowns, and the quality and scope of work may be sacrificed at the expense of GMP value (Gould, 2005).

3. Previous research studies on TCC/GMP schemes

There exists a vast amount of research which focuses on TCC as well as GMP contracts. For example in Australia, Walker et al. (2002) presented a case study of the Australian National Museum procured with a TCC approach. An agreement on a risk and reward formula where an open-book accounting regime was adopted in this case study. This arrangement tied the objectives of both contracting parties together, since this provision encouraged more co-operative behaviours between project team members. Davis and Stevenson (2004) conducted ten interviews and found that price certainty, faster construction and achieving a teamwork approach to project delivery are the perceived major benefits of GMP. Whilst a lack of common understanding of GMP, a lack of standard form of contract for GMP, and the minimization of capital cost at the expense of running costs, were regarded as primary barriers to launching GMP in Australia. Ross (2006) introduced a three-prong compensation framework when applying TCC in alliancing. The owner and non-owner participants jointly develop the scope of project and agree on a target cost and performance targets. The non-owner participants are reimbursed for: (1) actual cost on the works and project-specific overheads; (2) fee to cover normal profit and corporate overheads; and (3) pre-agreed share of gain/pain, depending on the actual outcomes compared with the pre-agreed targets.

In the United Kingdom, Perry and Barnes (2000) proposed methods of tender evaluation for TCC to reduce the scope of manipulation of tenders and increase the possibility of contract being awarded to tenderers with the lowest final price. Their study also suggested that the contractor's gain-share/pain-share ratio should not be set at lower than 50%. Nicolini et al. (2000) explored two successful cases of applying TCC within the United Kingdom construction industry. The project participants opined that there were less adversarial working relationships and cost reduction was achieved by adopting innovative ideas. Pryke and Pearson (2006) reported from their case study on the application of GMP rather than the standard form of building contract. They claimed that this GMP form of contractual arrangement instigated a change in contractor's attitude towards financial control of variations. Badenfelt (2008) launched a series of interviews with eight construction clients and eight contractors in Sweden to investigate the selection of share ratios under TCC, followed by a case study. He advocated that the "relational" factors should be considered during the selection and negotiation of share ratios in TCC. It was found that the selection of share ratio is affected by long-term relations, previous experience of working together and contract design.

In the United States, Arditi and Yasamis (1998) conducted a survey with resident engineers and contractor's superintendents involved in 13 cases with incentive/disincentive contracts. All respondents working for contractors and more than half of the engineers respondents shared a common perception that the associated incentive/disincentive projects would have taken longer project duration to complete when compared with projects having contracts without incentive/disincentive provisions. Kaplanogu and Arditi (2009) launched another survey with the top 400 construction companies and their findings confirmed that pre-project peer reviews were necessary and important to GMP or lump-sum contracts within the United States. This study revealed that the benefits of pre-project peer review in construction companies included: (1) minimizing the risk of underestimating the cost of projects; (2) evaluating the schedule; (3) reviewing conditions of contracts concerned; and (4) preventing making bad bargains from the contractor's perspective. Rojas and Kell (2008) compared the cost growth performance of construction at risk between GMP form of procurement and traditional design-bid-build methods in construction projects in Pacific Northwest. Their findings indicated that there was no significant statistical difference between the two project delivery methods on change in construction cost and the project costs exceeded the GMP in 18 out of 24 school projects. The final construction cost exceeded the GMP in nearly 80% of the non-school projects investigated. The above findings suggested that the GMP may not be effective in controlling cost growth and deviated from some traditional expectations.

Interestingly, several research papers in this area so far has been devoted to identifying the benefits and difficulties, the operational mechanism, share ratio and overall performance of TCC and GMP projects. However, few (if any) research studies have been carried out to determine the key risk factors and analyze the risk management of these forms of procurement. This finding derived from previous literature review reinforces the objectives of this research study.

4. Research methodology

4.1 Literature review

A pilot questionnaire survey was designed to explore the key risk factors encountered with TCC/GMP construction projects. The pilot questionnaire was developed based on the risk factors documented in previous research studies by Bernhard (1988), Ahmed et al. (1998), Al-Subhi Al-Harbi Kamal (1998), Ahmed et al. (1999), Broome and Perry (2002), Haley and Shaw (2002), Rahman and Kumaraswamy (2002), Cheng (2004), Fan and Greenwood (2004), Oztas and Okmen (2004), Sadler (2004), Environment, Transport and Works Bureau (2005), Li et al. (2005), Tang (2005), Hong Kong Housing Authority (2006), Shen et al. (2006), Ng and Loosemore (2007), Chan et al. (2007a), Chan et al. (2007b), Yew (2008), together with seven structured interviews with experienced industrial practitioners with abundant hands-on practical experience in those TCC/GMP procurement approaches undertaken by the authors (Chan et al., 2010b). The interviewees suggested that nature of variations, change in scope of work, quality and clarity of tender documents, unforeseen ground conditions, fluctuation of materials price, and approval from regulatory bodies for alternative cost saving designs were the key risk factors associated with TCC/GMP contracts in Hong Kong. The results of pilot survey enabled the development and fine-tuning of the empirical research questionnaire.

4.2 Pilot questionnaire survey

Only those "key" risk factors identified from the face-to-face structured interviews are highlighted herein due to the limitation of length in this paper. "Nature of variations" was considered to be the most common risk factor inherent with TCC/GMP contracts in Hong Kong. That is, whether an architect/engineer instruction should be classified either as a TCC/GMP variation which would be liable to adjust the agreed GMP value (or target cost value) in contract or as a design development change. This finding echoes the commentary made by both Chan et al. (2007a) and Fan and Greenwood (2004) that the nature of variation can be a main source of disputes in TCC/GMP schemes.

The second key risk factor as perceived by the interviewees was "Quality and clarity of tender documents". The contract document comprising the tender documents is a fundamental tool for risk allocation. If there exist errors, omissions or discrepancies within the contract document at the outset of the project, they would give rise to a huge number of intractable disputes or conflicts and unnecessary contract variations during the post-contract stage. Yew (2008) shared a similar perception that contractors are bound to take all of the risks under TCC/GMP contracts, including errors and omissions in tender documents in Singapore.

The third significant contractual risk reported is "Change in scope of work". Disputes may arise due to the changes in scope of work (Tang and Lam, 2003). Since unexpected change in scope of work due to changing user's requirements may generate a considerable number of TCC/GMP variations (Fan and Greenwood, 2004), it would prolong the overall development programme as well as incur significant cost escalations to the project. Besides, the extent of design development changes would also be difficult to define. Improper handling of these issues may provoke adversarial disputes and thus diminish the mutual trust and partnering relationship developed within the project team (Sadler, 2004).

"Unforeseen ground conditions" was discerned as a key physical risk factor associated with the TCC/GMP procurement approach. This finding is similar to that reported by Shen (1997) suggesting that unexpected ground conditions constitute a key risk factor leading to project delay in Hong Kong.

As for economic risks, "Fluctuation in materials price" was regarded as one of the key risk factors encountered in adopting TCC/GMP form of procurement. It is a common practice of the Hong Kong construction industry to insert the Special Conditions of Contract to delete the fluctuation clause in the General Conditions of Contract in the private sector (i.e. the fluctuation of materials prices is at contractor's risk). One representative from the contractor side commented that his company suffered a loss due to the sharp increase in materials price in 2008, even though a fluctuation clause was applicable to his project which was a public housing development. It is logical to deduce that the contractors engaged in the private sector building projects, who had committed themselves to fixed price contracts also suffered losses of this nature.

"Approval from regulatory bodies for alternative cost saving designs" was considered as a key design risk factor. When the main contractor comes up with an alternative proposal, he has to submit its design proposal to regulatory bodies for verification and approval. If the contractor is not familiar with the practice and operation of those regulatory bodies, this certainly increases the difficulty in obtaining design approval from the relevant unit. Such delay of this approval process would discourage the main contractor from contributing his expertise by proposing alternative designs and hence hindering the benefits of using TCC or GMP contractual arrangement.

4.3 Empirical questionnaire survey

The survey form consisted of four parts. The first part was about respondents' personal profiles. The second part focused on the risk assessment in terms of the perceived level of severity and likelihood of occurrence of the 34 listed risk factors in relation to TCC/GMP construction projects with a five-point Likert scale where 1 denoted "very low" and 5 denoted "very high" for severity and a seven-point Likert scale where 1 denoted "very very low" and 7 denoted "very very high" for likelihood. The respondents were also requested to choose the party best capable to manage each of the key risks elicited. The third part was related to some recommended risk mitigation measures for TCC/GMP construction projects. The fourth part was optional and the respondents were welcome to express their personal preference on future application of TCC or GMP contractual arrangement with their supporting reasons. However, only the survey findings regarding the risk assessment of the 34 key risk factors (including severity and likelihood) are reported and discussed in this paper. Respondents were also requested to list out and score any other unmentioned risks derived from their personal experience but no new items were obtained from them. The results of other parts will be duly documented and disseminated in other publications in near future due to length limitation.

A total of 300 self-administered blank survey forms were distributed to construction professionals associated with the Hong Kong construction industry. The target survey respondents were first identified from previous research studies in TCC/GMP in Hong Kong undertaken by the authors (Chan et al., 2007a). A snowball sampling technique was employed in this study due to the limited number of TCC/GMP projects completed in Hong Kong. According to Tashakkori and Teddlie (2003), snowball sampling involves using informants which would be useful in the study. Respondents are selected by using the expert judgment of the researcher or some available resources identified by the researcher. With a purposive sample, the researcher is likely to glean the genuine opinions of the target population. Questionnaires were dispatched to those representatives from the clients, main contractors and consultants engaged in those TCC/GMP construction projects between March and April

of 2009 via postal mail. And they were requested to pass the questionnaires to their in-house project team members with direct hands-on experience in TCC/GMP projects concerned and colleagues with basic understanding of TCC/GMP operational mechanism to fill in the questionnaires. As all of the key active players in adopting TCC/GMP had been included in the questionnaire survey, it was considered that their opinions and perceptions could substantially represent the TCC/GMP project pool in Hong Kong over the past decade of 1998-2007. Hence, the chosen sample was regarded as truly representative of the survey population given the scarce number of construction projects procured with the TCC/GMP approach in Hong Kong (about 20 as cited by Chan et al., 2007a). The similar snowball sampling technique was also applied in the field of construction management research by Lu and Yan (2007) to study the benefits of construction partnering in Mainland China where partnering was not popular at that time.

A total of 141 valid and duly completed survey forms were returned in June of 2009, representing a response rate of 47%. Among these 141 responses, 47 respondents declared that they had "No hands-on experience in procuring TCC/GMP construction projects" and they were advised not to complete the survey forms and returned the forms for record. The remaining 94 respondents either had acquired hands-on experience in procuring TCC/GMP projects or they declared to have basic understanding of the underlying principles of TCC/GMP schemes even though without the direct exposure to TCC/GMP contracts before.

Therefore, only the data and perceptions obtained from these 94 responses were used for further data analysis. Although only 94 samples were collected, the number of samples was considered adequate and representative when compared with other similar studies on risk management in construction. For example, 35 responses were obtained in Kartam and Kartam (2001)'s questionnaire survey on risk management in the Kuwaiti construction industry; 92 survey responses were collected by Rahman and Kumaraswamy (2005) on joint risk management in Hong Kong and 70 responses were collected in El-Sayegh (2008)'s research on risk assessment and risk allocation in the construction industry of the United Arab Emirates. In addition, Table 1 shows that the target survey respondents covered all the known TCC and GMP construction projects completed up to 2007 and hence the results of this study are regarded as sufficient, valid and representative of the whole project population concerned.

In view of the possible disparities in perceptions among survey respondents with different roles, they were divided into three major groups for further data analysis according to their roles involved in the projects (i.e. client group, contractor group and consultant group). Table 2 summarizes the personal profiles of survey respondents.

Some of the survey respondents (39 out of a total of 94) did not have direct hands-on experience in TCC/GMP projects (but have obtained basic understanding of the underlying principles of TCC/GMP scheme) and they were classified as the non-experienced group. Experienced group were those who have participated in TCC/GMP projects before.

Independent two-sample t-test was applied to test the agreement on the risk assessment of each listed risk factor between the experienced group and non-experienced group as adopted by Ke et al. (2010). The result of the statistical test indicated that there are no statistically significant differences on the risk assessment of each of the risk factors of TCC/GMP projects between the experienced group and non-experienced group. It was concluded that the two sets of opinion data can be lumped together for further analysis and the survey findings are regarded as being consistent, reliable and representative.

Table 1. Selected TCC/GMP cases for the research in Hong Kong (Adapted from Chan et al., 2007b)

	Project name	Project nature	TCC/GMP	Covered in this study?
1.	Chater House	A prestigious rental commercial development in Central	GMP	Yes
2.	1063 King's Road	A rental commercial development in Quarry Bay	GMP	Yes
3.	Alexandra House Refurbishments	A prestigious rental commercial development in Central	GMP	Yes
4.	Tradeport Hong Kong Logistics Centre	A commercial logistics hub for the Asia region at Chek Lap Kok	GMP	Yes
5.	York House	A rental commercial redevelopment in Central	GMP	Yes
6.	The Orchards	A twin tower residential development in Quarry Bay	GMP	Yes
7.	One Island East	A 70-storey Grade A Office Tower	GMP	Yes
8.	Three Pacific Place	A prestigious rental commercial development in Wanchai	GMP	Yes
9.	Australian International School	A private educational building	GMP	Yes
10.	Tseung Kwan O Technology Park	A private technology park	GMP	Yes
11.	Hong Kong Park	A public recreational park	GMP	Yes
12.	Public Housing Development at Eastern Harbour Crossing Site Phase 4	A public rental housing development in Yau Tong as a pilot study project	Modified GMP	Yes
13.	DHL Asia Hub	A private express cargo sortation and delivery terminal building	GMP	Yes
14.	Tseung Kwan O Railway Extension	13 civil engineering contracts, 4 building services contracts as well as 17 electrical and mechanical contracts	TCC	Yes
15.	Tsim Sha Tsui Metro Station Modification Works (MTRC Contract C4420)	Tsim Sha Tsui Metro Station Modification Works	TCC	Yes
16.	Tung Chung Cable Car Project	A sightseeing transportation facility including civil and building works	TCC	Yes

Table 2. Personal profiles of survey respondents

Category	Respondents	
	Frequency	%
Role		
Client Organization	33	35.1
Main Contractor	22	23.4
Architectural Consultant	2	2.1
Engineering Consultant	3	3.2
Quantity Surveying Consultant	19	20.2
Project Management Consultant	2	2.1
Subcontractor	2	2.1
Academic	9	9.6
Others	2	2.1
Grouping by Role		
Client	33	35.1
Contractor	27	28.7
Consultant	34	36.2
Experience Level		
Below 5 years	17	18.1
5-10 years	11	11.7
11-15 years	11	11.7
16-20 years	12	12.8
Over 20 years	43	45.7

5. Approach of data analysis

Tam et al. (2007) launched a survey on quality risks in the foundation works of public housing projects with construction professionals in Hong Kong and classified them into three groups: architect, engineer and surveyor. The concordance of mean values of risk impact between the three groups was tested with the one-way ANOVA test (F-test) for multiple samples. However, no two-group comparison was carried out in the study. El-Sayegh (2008) investigated the risk assessment and risk allocation within the UAE construction industry using the relative importance index and Spearman's rank correlation test as the primary tools of data analysis, and no analysis was conducted to identify the particular items which account for significant differences in perceptions between groups of respondents. A similar approach was applied in a study by Shen et al. (2001) about risk assessment for construction joint ventures in Mainland China. The current study is an attempt to take a further step forward in research of risk assessment and a four-level data analysis approach was adopted as illustrated in Figure 1. At the first level, the individual risk factors are ranked in descending order of the mean scores on the perceived risk impact to identify the important risk factors. This indicates an overall picture of the perceptions of different respondents on the risk impact. At the second level, the agreement of respondents' perceptions within a particular group is checked by the Kendall's concordance analysis. At the third level, the association on the rankings of risk factors between any two groups is verified using the Spearman's rank correlation test. At the fourth level, the Mann-Whitney U test is applied to enable two-group comparisons to identify if there is any individual risk factor on which different perceptions between any two groups of respondents are placed. It should be emphasized that the chosen sample was found to be truly representative of the survey population although the number of completed TCC/GMP construction projects in Hong Kong is quite limited.

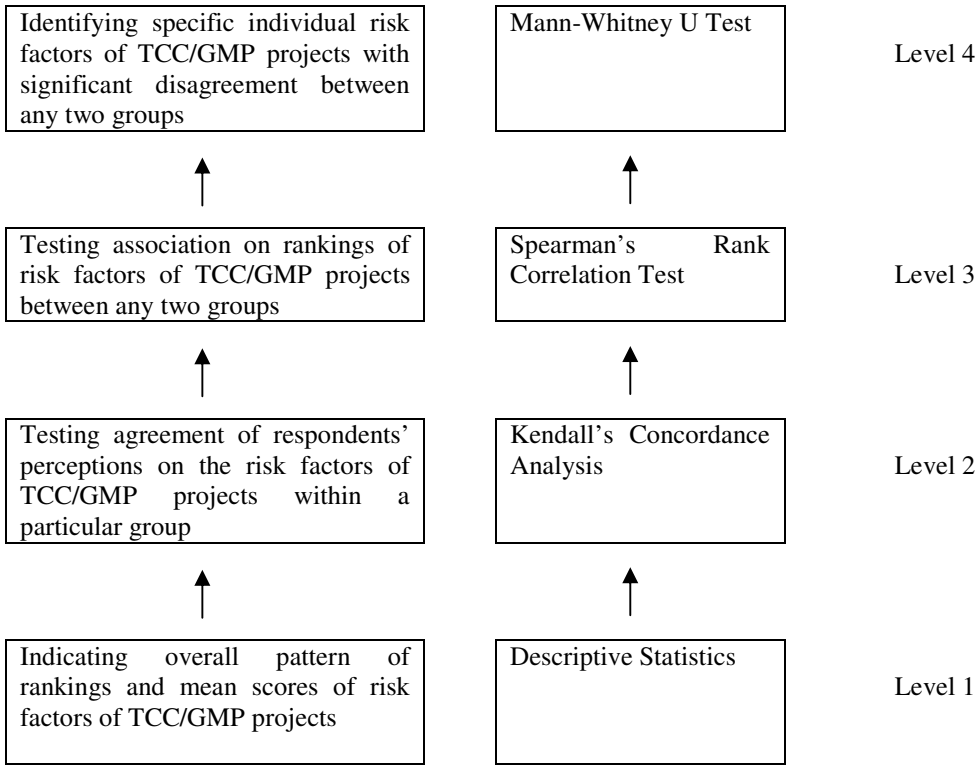

Figure 1. Four-level data analysis framework for this study

6. Statistical tools employed

The various statistical techniques used in this study are described below.

6.1 Kendall's concordance test

The Kendall's coefficient of concordance (W) was used to measure the agreement of different respondents on their rankings of risk factors based on mean values within a particular survey group. This statistical test aims to ascertain whether the respondents within a particular group respond in a consistent manner or not (Kvam and Vidakovic, 2007). The value of W ranges from 0 to 1, where 0 reveals perfect disagreement and 1 reveals perfect agreement. A significant value of W (p-value < 0.05) can reject the null hypothesis that there is a complete lack of consensus amongst the respondents within one group on the ranking of risk factors (Chan, 1998).

6.2 Spearman's rank correlation test

The Spearman's rank correlation coefficient is a statistical tool to test the strength of relationship between the rankings of two groups (El-Sayegh, 2008). This technique has been widely applied in construction management research involving ranking exercise. For example, Wong et al. (2000) adopted this technique to test if there was any correlation on the rankings of project specific criteria in civil engineering works and building works by clients in the United Kingdom. Odeh and Battaineh (2002) used this tool to test the association on the rankings by contractors and consultants on the causes of delay to construction projects.

The level of association between any two respondent groups on their rankings of various risk factors inherent with TCC/GMP schemes was measured by the Spearman's rank correlation coefficient (r_s) (Fellows and Liu, 2008). The coefficient, r_s , ranges between –1 and +1. A value of +1 indicates a perfect positive correlation, while a value of –1 indicates a perfect negative correlation. For a positive correlation, if the ranking on one group is increased, the ranking for the other group is also increased. In contrast, for a negative correlation, if the ranking on one group is increased, the ranking for the other group is decreased, and vice versa. If r_s is approaching to zero, it means that there is no relationship between the two groups on the variable under study (Kottegoda, 1997). If r_s was statistically significant at a pre-determined 0.05 significance level (i.e. p-value < 0.05), then the null hypothesis that no significant correlation between the two groups on the rankings can be rejected. It can be concluded that there is significant association between the two groups on the ranking exercise.

6.3 Mann-Whitney U test

The Mann-Whitney U test is a non-parametric test which is applied in hypothesis testing involving two independent variables (Gibbons and Chakraborti, 2003). If the result of this test is significant (p-value < 0.05), it means that there is a statistically significant difference between two sample medians (Sheskin, 2007). It is applied to test if there is any statistically significant difference in median values between two groups. Three paired comparisons between various respondent groups (i.e. client vs contractor, contractor vs consultant and client vs consultant) were undertaken in this study. The same technique was applied by Zhang (2005) to the selection of private sector partners under public-private partnership (PPP) arrangement and by Yu et al. (2008) for the comparison of the perceptions on variables of

construction project briefing of project managers and architects between Hong Kong and western countries. The Mann-Whitney U test was employed to test the null hypothesis that "there is no statistically significant difference between the two populations so they have the same median for the same risk factor" and the medians can be represented by mean ranks (Sheskin, 2007).

Null hypothesis: There is no statistically significant difference between the two populations so they have the same median for the same risk factor.
$H_0 : \theta_1 = \theta_2$
Alternative hypothesis: There is a statistically significant difference between the two populations so they have different medians for the same risk factor.
$H_a : \theta_1 \neq \theta_2$

Level of significance (α) for testing these hypotheses is set at 0.05. The results can be interpreted by the Z-values and p-values. When the p-value is less than 0.05, H_0 is rejected and thus it can be concluded that the median values of a certain risk of TCC/GMP between the two respondent groups are significantly different from each other.

7. Research findings and discussions

It is generally accepted that the impact of a risk is calculated by the product of its level of severity and likelihood of occurrence (Cox and Townsend, 1998; Bunni, 2003; Garlick, 2007). Shen et al. (2001) applied a similar approach to the calculation of the significance scores for the 58 risks encountered with joint ventures in Mainland China. Zou et al. (2007) used this approach for the computation of the significance index scores for risk factors inherent with construction projects in Mainland China. Roumboutsos and Anagnostopoulos (2008) adopted the same method to assess the risks associated with public-private partnership schemes in their survey for construction sector, public sector and financial sector in Greece. The same method of analysis was adopted in this paper. Risks are assessed based on the mean values of their impacts (i.e. the product of severity ranking and likelihood ranking). It should be noted that the selected sample could truly represent the TCC/GMP project pool in Hong Kong as all the major project team members involved in those completed TCC/GMP construction projects had been included in the questionnaire survey. In order to add value to this study and enhance the quality of this paper, the survey results derived were compared with the published findings of other forms of contractual arrangements (e.g. fixed-price lump-sum contracts) wherever deemed appropriate,

7.1 Overall ranking of the risk factors of TCC/GMP

Based on the survey results, the risk factors were ranked in the descending order of mean scores for their perceived impact indicated in Table 3 with the top 10 most important risks in bold font. It is indicated that "Change in scope of work" was perceived as the most significant risk amongst the 34 risks identified on the survey form. Change in scope of work is more common in TCC/GMP as the scope is not totally defined in many cases of TCC/GMP projects in Hong Kong (Chan et al., 2007a). This finding echoes a recent study by Olawale and Sun (2010) suggesting that design changes were considered to be the most important factor inhibiting the ability of industrial practitioners in time and cost control in their questionnaire survey. Another earlier research launched by Cox et al. (1999) in the United Kingdom also revealed that change in employers' requirements was one of the most frequently cited reasons for design changes in their cases explored.

"Insufficient design completion during tender invitation" was perceived to be the second most significant risk associated with TCC/GMP schemes. Due to the very tight schedule of project development, the design is immature during tender invitation in many projects within the local construction industry. It is inevitable for the architect/engineer to issue variation orders at the post-contract stage. Olawale and Sun (2010) pointed out that lack of clear distinction between design development and design change lead to intractable arguments between contracting parties if a change is actually a design change or a design development without time and cost compensations under contract. Yew (2008) held a similar view that disputes may arise at the post-contract stage as to whether the refinement and development of the project design which amounts to an enhancement of the original design intent or a change in employer's requirements constituting a variation and a change in GMP.

As may be observed, "Unforeseeable design development risks at tender stage" was viewed as the third most important risk factor encountered with TCC/GMP contracts. The contractor has to abide by the contract sum to develop the partially completed design at tender stage. In other words, the contractor has to abide by a fixed contract sum to complete works which are not well defined. If the contractor underestimates the quantities needed during the stage of design development which is included in tender sum, it would probably suffer from a monetary loss. Yew (2008) opined that the contractors were usually bound to take all risks associated with GMP agreements including shortcomings of originally tendered design schemes. Davis Langdon and Seah (2004) commented that agreeing on the GMP value too early based on incomplete design information is risky for both employer and contractor. Fan and Greenwood (2004) suggested that design development is a grey area under GMP schemes and a source of contractual disputes. Oztas and Okmen (2004) opined that clients should develop a set of comprehensive clients' requirements in tender documents to avoid unnecessary subsequent design changes. This risk may arise from the insufficient tendering period for the contracts concerned, so the tenderers may not have full knowledge about the scope of work and potential pitfalls embedded in the conditions of contract.

"Errors and omissions in tender document" was discerned as the fourth most significant risk inherent with TCC/GMP schemes. The contract document comprising the tender documents is a fundamental tool for risk allocation. If there exist errors, omissions or discrepancies within the contract document at the outset of the project, they would give rise to a huge number of intractable disputes or conflicts and unnecessary contract variations during the post-contract stage. One interviewee with contracting background reported that the contractor had to cover the risk of inaccuracy of firm quantities in the Bills of Quantities for his project, for which his company finally incurred a loss (Chan et al., 2010b). Yew (2008) shared a similar perception that contractors are bound to take all of the risks under TCC/GMP contracts, including errors and omissions in tender documents in Singapore.

"Exchange rate variations" was discerned as the fifth most significant risk encountered with TCC/GMP schemes. However, Tam et al. (2007) reported that the same risk was considered as a minor one in their study in Hong Kong. Seemingly, the finding may be due to the fact that the respondents concerned more with exchange rates in the time of financial crisis over recent months.

Table 3. Impacts of risk factors encountered with TCC/GMP schemes by all survey respondents

ID	Risk factor	Mean	Rank
5	**Change in scope of work**	**16.41**	**1**
17	**Insufficient design completion during tender invitation**	**15.46**	**2**
20	**Unforeseeable design development risks at tender stage**	**14.54**	**3**
6	**Errors and omissions in tender document**	**14.51**	**4**
21	**Exchange rate variations**	**14.49**	**5**
29	**Unforeseeable ground conditions**	**14.25**	**6**
1	**Actual quantities of work required far exceeding estimate**	**13.97**	**7**
32	**Lack of experience of contracting parties throughout GMP/TCC process**	**13.91**	**8**
22	**Inflation beyond expectation**	**13.81**	**9**
3	**Unrealistic maximum price or target cost agreed in the contract**	**13.76**	**10**
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor	13.51	11
7	Difficult for main contractor to have back-to-back GMP/TCC contract terms with nominated or domestic subcontractors	13.31	12
26	Global financial crisis	13.19	13
18	Poor buildability / constructability of project design	13.11	14
2	Delay in resolving contractual disputes	13.11	15
9	Loss incurred by main contractor due to unclear scope of work	13.07	16
16	Delay in work due to third party	12.64	17
28	Inclement weather	12.43	18
8	Inaccurate topographical data at tender stage	12.40	19
19	Little involvement of main contractor in design development process	12.36	20
15	Selection of subcontractors with unsatisfactory performance	12.17	21
31	Difficult to obtain statutory approval for alternative cost saving designs	12.16	22
33	Impact of construction project on surrounding environment	12.15	23
12	Poor quality of work	12.07	24
11	Technical complexity and design innovations requiring new construction methods and materials from main contractor	11.92	25
23	Market risk due to the mismatch of prevailing demand of real estate	11.86	26
24	Change in interest rate on main contractor's working capital	11.33	27
34	Environmental hazards of constructed facilities towards the community	11.17	28
13	Delay in availability of labour, materials and equipment	11.03	29
25	Delayed payment on contracts	10.81	30
30	Change in relevant government regulations	10.80	31
10	Difficult to agree on a sharing fraction of saving / overrun of budget at pre-contract award stage	10.72	32
14	Low productivity of labour and equipment	10.09	33
27	Force Majeure (Acts of God)	8.66	34

7.2 Agreement of respondents within each survey group

The results of the mean risk impacts of the 34 risks by all respondents, the client group, contractor group and consultant group, together with the results of Kendall's concordance analysis are presented in Table 4. As the number of factors is greater than seven (34 factors in this case), the values of chi-square are to be tested with the critical values obtained from a

table in Siegel and Castellan (1988), instead of considering the value of W. The actual values of chi-square within the client group and contractor group are larger than the critical values from the table (Siegel and Castellan, 1988) and the p-values are all less than 0.05. The null hypothesis that "the respondents' sets of rankings within a certain group are unrelated (independent) to each other" is therefore rejected for these two groups of respondents. This statistical result implies that there is a statistically significant agreement amongst the respondents within the client group and contractor group during the ranking exercise of risks encountered with TCC/GMP construction projects. However, the null hypothesis cannot be rejected for the consultant group since the actual value of chi-square is smaller than the critical value of chi-square from table. This result may be explained by the fact that the consultant group respondents come from different professions such as quantity surveyors, architectural consultants and engineering consultants. Each profession may have differing concerns about the impact of risks.

Table 4. Rankings and results of Kendall's concordance test of risk factors encountered with TCC/GMP construction projects

ID	Risk factor	All respondent group		Client group		Contractor group		Consultant group	
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
5	Change in scope of work	16.41	1	15.61	2	18.22	1	15.66	1
17	Insufficient design completion during tender invitation	15.46	2	15.94	1	16.19	4	14.35	2
20	Unforeseeable design development risks at tender stage	14.54	3	13.90	10	16.30	3	13.65	4
6	Errors and omissions in tender document	14.51	4	14.90	5	16.00	6	12.88	10
21	Exchange rate variations	14.49	5	13.77	11	16.15	5	13.78	3
29	Unforeseeable ground conditions	14.25	6	14.03	9	15.30	8	13.55	5
1	Actual quantities of work required far exceeding estimate	13.97	7	14.10	8	15.69	7	12.44	15
32	Lack of experience of contracting parties throughout TCC/GMP process	13.91	8	14.58	6	14.33	14	12.87	12
22	Inflation beyond expectation	13.81	9	15.16	4	14.81	10	11.66	23
3	Unrealistic maximum price or target cost agreed in the contract	13.76	10	15.32	3	13.22	19	12.69	13
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor	13.51	11	14.55	7	14.44	12	11.65	24
7	Difficult for main contractor to have back-to-back TCC/GMP contract terms with nominated or domestic subcontractors	13.31	12	11.42	25	16.56	2	12.41	16
26	Global financial crisis	13.19	13	13.70	13	12.70	22	13.13	7
18	Poor buildability / constructability of project design	13.11	14	12.90	16	14.85	9	11.81	21
2	Delay in resolving contractual disputes	13.11	15	12.71	17	13.88	16	12.88	10
9	Loss incurred by main contractor due to unclear scope of work	13.07	16	11.83	22	14.59	11	12.94	9
16	Delay in work due to third party	12.64	17	11.94	21	12.41	24	13.53	6
28	Inclement weather	12.43	18	11.32	26	13.67	18	12.45	14
8	Inaccurate topographical data at tender stage	12.40	19	13.06	14	12.56	23	11.63	25
19	Little involvement of main contractor in design development process	12.36	20	11.65	24	13.78	17	11.84	20
15	Selection of subcontractors with unsatisfactory performance	12.17	21	12.00	20	11.26	28	13.09	8
31	Difficult to obtain statutory approval for alternative cost saving designs	12.16	22	10.90	27	13.96	15	11.84	19

33	Impact of construction project on surrounding environment	12.15	23	11.74	23	14.41	13	10.58	31
12	Poor quality of work	12.07	24	13.77	12	10.11	32	12.06	18
11	Technical complexity and design innovations requiring new construction methods and materials from main contractor	11.92	25	12.19	19	12.96	20	10.78	30
23	Market risk due to the mismatch of prevailing demand of real estate	11.86	26	12.96	15	11.85	26	10.91	28
24	Change in interest rate on main contractor's working capital	11.33	27	12.20	18	10.42	30	11.25	26
34	Environmental hazards of constructed facilities towards the community	11.17	28	10.55	28	12.81	21	10.38	32
13	Delay in availability of labour, materials and equipment	11.03	29	10.42	30	10.30	31	12.25	17
25	Delayed payment on contracts	10.81	30	9.55	32	11.15	29	11.75	22
30	Change in relevant government regulations	10.80	31	9.52	33	12.15	25	10.90	29
10	Difficult to agree on a sharing fraction of saving / overrun of budget at pre-contract award stage	10.72	32	10.47	29	11.81	27	10.03	34
14	Low productivity of labour and equipment	10.09	33	10.42	30	8.33	33	11.25	26
27	Force Majeure (Acts of God)	8.66	34	8.43	34	7.22	34	10.13	33
	Number (N)	81		27		25		29	
	Kendall's Coefficient of Concordance (W)	0.075		0.114		0.138		0.057	
	Actual Calculated Value of Chi-square	200.392		101.506		113.889		54.508	
	Critical Value of Chi-square from table	67.985		67.985		67.985		67.985	
	Degree of freedom (df)	33		33		33		33	
	Level of Significance	0.000		0.000		0.000		0.011	
	H_0 = Respondents' sets of rankings are unrelated (independent) to each other within each group. Reject H_0 if the actual value of chi-square is larger than the critical value from table								

7.3 Agreement of respondents between any two survey groups

The level of agreement amongst the respondents on the ranking exercise was tested via the Spearman's rank correlation test as indicated in Table 5. The results showed that the null hypotheses that no significant correlation between clients-contractors, clients-consultants and contractors-consultants on the rankings of TCC/GMP risk factors can be rejected. This reflects significant correlations on the perceptions of the risk impacts encountered with the TCC/GMP projects between any two respondent groups.

Table 5. Results of Spearman's rank correlation test on the risk factors encountered with TCC/GMP construction projects between respondent groups

Comparison of rankings	r_s	Significance level	Conclusion
Client's ranking vs Contractor's ranking	0.607	0.000	Reject H_0 at 1% significance level
Client's ranking vs Consultant's ranking	0.552	0.001	Reject H_0 at 1% significance level
Contractor's ranking vs Consultant's ranking	0.562	0.001	Reject H_0 at 1% significance level

H_o = No significant correlation on the rankings between two groups
H_a = Significant correlation on the rankings between two groups
Reject H_o if the actual significance level (p-value) is less than the allowable value of 5%

7.4 Results of Mann-Whitney U test

The next step of data analysis is to conduct the Mann-Whitney U test to identify the particular risks in which any two groups of respondents hold different perceptions on the level of severity and likelihood of occurrence of those risks concerned. The same test was applied in Roumboutsos and Anagnostopoulos (2008)'s study to compare the risks associated with public-private partnership schemes between construction and public sectors; between construction and financial sectors; and between public and financial sectors. A similar statistical technique has been used to compare the perceptions between Hong Kong and western respondents on construction project briefing (Yu et al., 2008); and to compare the perceptions of financial criteria between different groupings (Zhang, 2005). The results of the Mann-Whitney U tests for severity, likelihood and risk impact (i.e. the product of severity and likelihood) are presented in Table 6.

The client group and contractor group held different views towards the severity of the two risks "Exchange rate variations" and "Change in relevant government regulations". These findings may reflect the fact that since it is the contractor, who is the builder by nature, to procure materials, if the exchange rate fluctuates, the contractor would probably suffer from a loss, since most materials for construction, such as water pipes and electrical wires, are procured from other countries. Regarding the risk "Change in relevant government regulations", since the construction site is under the management of contractor, but not the client, the contractor respondents would provide a higher rating on the severity of "Change in relevant government regulations". In fact, such changes would generate financial implications to them.

The contractor group provided a higher rating on the severity of "Impact of construction project on surrounding environment" than the consultant group. Similar to the factors discussed before, this result may be due to the fact that the contractor is the party operating the construction site. Therefore, the contractor is probably accountable to the impact, such as noise and pollution generated from construction site to the environment nearby. However, the consultant group probably does not have such a perception as their daily works are more related to paperwork and documentation.

In addition, both the client group and consultant group assigned high ratings to the severity of "Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor". The finding may be attributed to the fact that the consultant group is independent of the interest of client and contractor. They may be less sensitive to this risk which is directly related to the profit of client. On the other hand, the client organizations are profit-driven, it is not surprising for them to rate a higher severity on this risk than the consultant group.

To compare the likelihood of risk occurrence, the contractor perceived that the risk of "Difficult for main contractor to have back-to-back TCC/GMP contract terms with nominated or domestic subcontractors" is more likely to occur than the consultant group. One of the possible reasons is that the contractors are the party to make subcontracts with specialist subcontractors. Thus, they may face a lot of problems with having back-to-back contracts with TCC/GMP arrangement, but the consultant group does not. In contrast, the consultant group provided a higher rating on the likelihood of "Low productivity of labour and equipment" because the consultant group may be responsible for supervising the progress of

construction works, and they may perceive that productivity is a prime concern over their daily work.

Moreover, the client group regarded "Inflation beyond expectation" as more likely to materialize than the consultant group. Similar to "Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor", the consultant group is impartial and independent of the profit of clients; they may be less sensitive to the occurrence of inflation beyond expectation.

To compare the overall risk impact of 34 key risks, the contractor group rated a higher impact on "Difficult for main contractor to have back-to-back TCC/GMP contract terms with nominated or domestic subcontractors" than the client group. This may be due to the difference in role playing in the construction project development of contractor who has a direct contractual link with all subcontractors. Similarly, the client group perceived a greater impact on "Poor quality of work"; it is because the clients themselves are possibly the end-users of the buildings. If the quality of work is not as good as expected, the client will suffer a lot. Statistical differences in perception on risk impacts of "Low productivity of labour and equipment" and "Inflation beyond expectation" are noted. Since the risk impact is the product of risk severity and risk likelihood in this survey, statistical differences in perception on the risk impact may be detected when statistical differences in either risk severity or risk likelihood are found.

8. Conclusions and further research

An empirical questionnaire survey was conducted in Hong Kong to address the risk assessment for TCC/GMP construction projects, contributing to the new knowledge base of risk assessment under this kind of projects in the Eastern world. The key risk factors associated with TCC/GMP contracts were identified according to their values of risk impacts. The top five risk factors were found to be: (1) Change in scope of work; (2) Insufficient design completion during tender invitation; (3) Unforeseeable design development risks at tender stage; (4) Errors and omissions in tender document; and (5) Exchange rate variations. The Kendall's concordance analysis revealed that the client group and contractor group held a significant agreement on the ranking exercise. The Spearman's rank correlation test indicated that all of the three respondent groups (i.e. client group, contractor group and consultant group) shared a general association on the rankings of the 34 risks identified from the questionnaire survey. The Mann-Whitney U tests reflected that there were statistically significant differences in perceptions of 8 risks out of 34 risks. The prevailing conclusion is that such differences in perceptions are mainly due to the roles played by different contracting parties under the construction development (e.g. the contractor group rated a higher score on the severity of exchange rate variations, since the contractor is the party to procure materials throughout the entire construction process).

Table 6. Results of the Mann-Whitney U test on the risk factors encountered with TCC/GMP construction projects (Asymp. Sig < 0.05)

ID	Risk factor	Risk severity			Risk likelihood			Risk impact		
		Client-Contractor	Contractor-Consultant	Client-Consultant	Client-Contractor	Contractor-Consultant	Client-Consultant	Client-Contractor	Contractor-Consultant	Client-Consultant
4	Disagreement over evaluating the revised contract price after submitting an alternative design by main contractor			0.046						
7	Difficult for main contractor to have back-to-back TCC/GMP contract terms with nominated or domestic subcontractors					0.038		0.042		
12	Poor quality of work							0.033		
14	Low productivity of labour and equipment					0.029			0.036	
21	Exchange rate variations	0.045								
22	Inflation beyond expectation					0.015				0.022
30	Change in relevant government regulations	0.049								
33	Impact of construction project on surrounding environment		0.035							

It is widely accepted that risk management is vital to project success in construction. The research findings from this study are particularly useful in the field of risk management in construction, considering that a scarcity of research has been conducted on the risk aspects in implementing TCC/GMP contracts. However, the scope of study is limited to Hong Kong, which nevertheless has an internationalized construction market. Further research can be launched to compare the research findings in Hong Kong with those in both Australia and the United Kingdom where those procurement strategies are more developed and mature. In addition, the identified risk perceptions only concern the respondents' attitudes towards risk assessment of TCC/GMP schemes. This does not provide any insights into the possible changes over the different stages of project development. This may be an area for further research as it forms the basis for ensuring value of money in construction project procurement.

Since all the key project stakeholders in applying TCC/GMP had been covered in the questionnaire survey, their perceptions and opinions substantially represent the TCC/GMP project population in Hong Kong over the past decade of 1998-2007. Hence, the chosen sample was regarded as truly representative of the survey population. Limitations of the research study lie in the conclusions drawn being indicative rather than conclusive, as merely 94 completed survey questionnaires were received and analyzed owing to a limited number of TCC/GMP construction projects in Hong Kong. Notwithstanding, the survey findings would be valuable for future studies in this area.

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References

Ahmed, S.M., Ahmed, R. and De Saram, D.D. (1998). Risk management in management contracts. *Asia Pacific Building and Construction Management Journal*, 4(1), 23-31.

Ahmed, S.M., Ahmad,R. and Saram, D.D. (1999). Risk management trend in the Hong Kong construction industry: a comparison of contractors and owners perceptions. *Engineering, Construction and Architectural Management*, 6(3), 225-234.

Al-Subhi Al-Harbi Kamal M. (1998). Sharing fractions in cost-plus-incentive-fee contracts. *International Journal of Project Management*, 16(2), 73-80.

Arditi, D. and Yasamis, F. (1998) Incentive/Disincentive Contracts: Perceptions of Owners and Contractors. *Journal of Construction Engineering and Management*, ASCE, 124(9), 361-373.

Badenfelt, U. (2008) The selection of sharing ratios in target cost contracts. *Engineering, Construction and Architectural Management*, 15(1), 54-65.

Bernhard, R.H. (1988). On the choice of the sharing fraction for incentive contracting, *Engineering Economist*, 33(3), 181-190.

Broome, J. and Perry, J. (2002) How practitioners set share fractions in target cost contracts. *International Journal of Project Management*, 20(1), 59-66.

Bunni, N.G. (2003) *Risk and Insurance in Construction*, 2nd Edition. London: Spon Press.

Chan, A.P.C. (1998) Perception on variations – a tale of three cities, *The Australian Institute of Quantity Surveyors Referred Journal*, 2(1), 42-54.

Chan, D.W.M., Chan, A.P.C., Lam, P.T.I., Lam, E.W.M. and Wong, J.M.W. (2007a) *An Investigation of Guaranteed Maximum Price (GMP) and Target Cost Contracting (TCC) Procurement Strategies in Hong Kong Construction Industry*. Research Monograph, Department of Building and Real Estate, The Hong Kong Polytechnic University, 152 pages, ISBN 978-962-367-593-2, October 2007, available at URL: http://repository.lib.polyu.edu.hk/jspui/handle/10397/2376.

Chan, D.W.M., Chan, A.P.C., Lam, P.T.I., Lam, E.W.M. and Wong, J.M.W. (2007b) Evaluating Guaranteed Maximum Price and Target Cost Contracting Strategies in Hong Kong Construction Industry. *Journal of Financial Management of Property and Construction*, 12(3), 139-149.

Chan, D.W.M., Lam, P.T.I., Chan, A.P.C. and Wong, J.M.W. (2010a). Achieving better performance through target cost contracts – The tale of an underground railway station modification project. *Facilities - Special Issue on Performance Measurement and Management in Facilities Management*, 28(5/6), 261-277.

Chan, D.W.M., Chan, A.P.C., Lam, P.T.I. and Chan, J.H.L. (2010b). Exploring the key risks and risk mitigation measures for guaranteed maximum price and target cost contracts in construction. *Construction Law Journal*, 26(5), 364-378.

Cheng, Rebecca L.L. (2004) *Investigation of the application of guaranteed maximum price in the Hong Kong construction industry*. Unpublished BSc(Hons) Dissertation in Construction Economics and Management, Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong, 58 pages.

Construction Industry Review Committee (2001) *Construct for Excellence*. Report of the Construction Industry Review Committee, Hong Kong SAR, 207 pages.

Cox, I.D., Morris, J.H.R. and Jared, G.E. (1999) A quantitative study of post contract design changes in construction. *Construction Management and Economics*, 17(4), 427-439.

Cox, A.W. and Townsend, M. (1998) *Strategic procurement in construction: towards better practice in the management of construction supply chains.* London: Thomas Telford.

Davis Langdon and Seah (2004) Guaranteed Maximum Price Contracts. *Executive Summaries for the practitioners*, 4(1), April 2004.

Davis, P.R. and Stevenson, D. (2004) Understanding and Applying Guaranteed Maximum Price Contracts in Western Australia, *Proceedings of the Australian Institute of Project Management 2004 National Conference, Perth, 10-12th October, 2004*. Australian Institute of Project Management, Perth.

Egan, J. (1998) *Rethinking Construction*. Department of the Environment Transport and Regions, London

El-Sayegh, S.M. (2008) Risk assessment and allocation in the UAE construction industry. *International Journal of Project Management*, 26(4), 431-438.

Environment, Transport and Works Bureau (ETWB) (2005) *Risk Management for Public Works – Risk Management User Manual*. Hong Kong: The HKSAR Government

Fan, A.C.W. and Greenwood, D. (2004) Guaranteed maximum price for the project? *Surveyors Times*, The Hong Kong Institute of Surveyors, March, 20-21.

Fellows, R. and Liu, A. (2008) *Research Methods for Construction*, 3rd Ed. Wiley-Blackwell.

Garlick, A.R. (2007) *Estimating risk: a management approach***.** Aldershot : Ashgate.

Gibbons, J.D. (1993) *Nonparametric Statistics: An Introduction*. Newbury Park, CA: Sage Publications, Inc.

Gibbons, J.D. and Chakraborti, S. (2003) *Nonparametric Statistical Inference*, 4th Ed. New York: Marcel Dekker, Inc.

Gould, E.F. (2005) *Managing the construction process: estimating, scheduling, and project control, 3rd Edition.* Upper Saddle River, New Jersey: Prentice Hall.

Gould, E.F. and Joyce, N.E. (2003) *Construction Project Management, 2nd Edition.* Upper Saddle River, New Jersey: Prentice Hall.

Haley, G. and Shaw, G. (2002). *Is "guaranteed maximum price" the way to go?* Hong Kong Engineer, January, 2002.

Hong Kong Housing Authority (2006). *Internal Guidelines for Guaranteed Maximum Price Contract Procurement Based on Private Sector Model*. The Hong Kong Housing Authority, The Hong Kong SAR Government, 19 pages

Kaka, A., Wong, C. and Fortune, C. (2008) Culture change through the use of appropriate pricing systems. *Engineering, Construction and Architectural Management*, 15(1), 66-77.

Kaplanogu, S.B. and Arditi, D. (2009) Pre-project peer reviews in GMP/lump sum contracts. *Engineering, Construction and Architectural Management*, 16(2), 175-185.

Ke, Y., Wang, S.Q., Chan, A.P.C. and Lam, P.T.I. (2010) Preferred risk allocation in China's public-private partnership (PPP) projects. *International Journal of Project Management,* 28(5), 482-492.

Kvam, P.H. and Vidakovic, B. (2007) *Nonparametric statistics with applications to science and engineering*. John Wiley & Sons.

Kottegoda, N.T. (1997). *Statistics, probability, and reliability for civil and environmental engineers*. New York : McGraw-Hill

Latham, M. (1994) *Constructing the Team*, Final Report of the Joint Government/Industry Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry, HMSO, London.

Li, B., Akintoye, A., Edwards, P.J. and Hardcastle, C. (2005) The allocation of risk in PPP/PFI construction projects in the UK. *International Journal of Project Management*, 23(1), 25-35.

Lu, S. and Yan, H. (2007) An empirical study on incentives of strategic partnering in China: Views from construction companies. *International Journal of Project Management*, 25(3), 241-249.

National Economic Development Office (1982) *Target cost contracts – a worthwhile alternative*, Civil Engineering Economic Development Committee, National Economic Development Office, London, United Kingdom.

Ng, A. and Loosemore, M. (2007) Risk allocation in the private provision of public infrastructure. *International Journal of Project Management*, 25(1), 66-76.

Nicolini, D., Tomkins, C, Holti, R. and Oldman, A. (2000) Can target costing and whole life costing be applied in the construction industry: Evidence from two case studies. *British Journal of Management*, 11(4), 303-324.

Odeh, A.M. and Battaineh, H.T. (2002). Causes of construction delay: traditional contracts. *International Journal of Project Management*, 20(1), 67-73.

Olawale, Y.A. and Sun, M. (2010) Cost and time control of construction projects: inhibiting factors and mitigating measures in practice, *Construction Management and Economics*, 28(5), 509-526.

Oztas, A. and Okmen O. (2004). Risk analysis in fixed priced design build construction projects, *Building and Environment*, 49(2), 229-237

Perry, J.G. and Barnes, M. (2000) Target cost contracts: an analysis of the interplay between fee, target, share and price. *Engineering, Construction and Architectural Management*, 7(2), 202-208.

Pryke, S. and Pearson, S. (2006) Project governance: case studies on financial incentives. *Building Research and Information*, 34(6), 534-545.

Rahman, M.M. and Kumaraswamy, M.M. (2002) Risk management trends in the construction industry: moving towards joint risk management, *Engineering Construction and Architectural Management*, 9(2), 131-151.

Rahman, M.M. and Kumaraswamy, M.M. (2005) Assembling integrated project teams for joint risk management. *Construction Management and Economics*, 23(4), 365-375.

Rojas, E.M. and Kell, I. (2008) Comparative analysis of project delivery systems cost performance in Pacific Northwest public schools. *Journal of Construction Engineering and Management*, *ASCE*, 134(6), 387-397.

Ross, J. (2006) *Project Alliancing Practitioners' Guide*. The Department of Treasury and Finance, State of Victoria, Melbourne.

Roumboutsos, A. and Anagnostopoulos, K.P. (2008) Public-private partnership project in Greece: risk ranking and preferred risk allocation. *Construction Management and Economics*, 26(7), 751-763.

Sadler, Michael C. (2004). *The use of alternative integrated procurement approaches in the construction industry*. Unpublished MBA Thesis in Construction and Real Estate, School of Construction Management and Engineering, The University of Reading, UK, 132 pages.

Saporita, R. (2006) *Managing risks in design and construction projects.* New York : ASME Press.

Septelka, D. and Goldblatt, S. (2005) *Survey of general contractor/construction management projects in Washington State*, Report to State of Washington Joint Legislative Audit and Review Committee, Seattle, Wash.

Shen, L.Y., Platten A. and Deng, X.P. (2006) Role of public private partnerships to manage risks in public sector projects in Hong Kong, *International Journal of Project Management,* 15(2), 101-107.

Shen, L.Y., Wu, G.W.C. and Ng, C.S.K. (2001) Risk assessment for construction joint ventures in China. *Journal of Construction Engineering and Management,* 127(1), 76-81.

Sheskin, D. (2007). *Handbook of parametric and nonparametric statistical procedures, 4th ed.* Boca Raton : Chapman & Hall/CRC

Siegel, S. and Castellan, N. J. (1988). *Nonparametric Statistics for the Behavioral Sciences.* McGraw-Hill, Inc.

Tam, V.W.Y., Shen, L.Y., Tam, C.M. and Pang, W.S.P. (2007) Investigating the intentional quality risks in public foundation projects: A Hong Kong study. *Building and Environment,* 42, 330-343.

Tang, W.Y. (2005) *An evaluation of the success and limitations of guaranteed maximum price in the Hong Kong construction industry*. Unpublished BSc(Hons) Dissertation in Construction Economics and Management, Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong, 45 pages.

Tashakkori,A and Teddlie, S (2003) *Handbook of mixed methods in social and behavioral research*. Oaks, CA : SAGE Publications

The American Institute of Architect (AIA) (2001). *The architect's handbook of professional practice, 13th Edition.* New York : J. Wiley.

Trench, David (1991) *On Target – A Design and Manage Target Cost Procurement System*. London Thomas Telford.

Walker, D.H.T., Hampson, K.D. and Peters, R (2000) *Relationship-based Procurement Strategies for the 21st Century*. AusInfo, Canberra, Australia, 112 pages, ISBN 064243079-9.

Walker, D.H.T, Hampson K.D and Peters, R. (2002) Project alliancing vs project partnering: a case study of the Australian National Project. *Supply Chain Management: An International Journal*, 7(2), 83-91.

Wong, A.K.D (2006) The application of a computerized financial control system for the decision support of target cost contracts. *Journal of Information Technology in Construction (ITcon)*, 11, Special Issue on Decision Support Systems for Infrastrucutre Management, 257-268.

Wong, C.H., Holt, G.D. and Cooper, P.A. (2000) Lowest price or value? Investigation of UK construction clients' tender selection process. *Construction Management and Economics*, 18(7), 767-774.

Yew, M. (2008) Guaranteed Maximum Price (GMP) Contracts in Singapore**.** *EC Harris Asia Commentary – January 2008*.

Yu, A.T.W., Shen, Q.P., Kelly, J. and Hunter, K. (2008) Comparative Study of the Variables in Construction Project Briefing/Architectural Programming. *Journal of Construction Engineering and Management,* 134(2), 122-138.

Zhang, X.Q. (2005) Criteria for selecting the private-sector partners in public-private partnerships. *Journal of Construction Engineering and Management,* 131(6), 631-644

Zou, P.X.W., Zhang, G. and Wang, J. (2007) Understanding the key risks in construction projects in China. *International Journal of Project Management*, 25(6), 601-614.