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Developing a Performance Measurement Index (PMI) for Target Cost Contracts in Construction: A Delphi Study

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Abstract: *There has exhibited an increasing trend of applying cost incentive contracts (including target cost contracts and guaranteed maximum price contracts), which tie the individual objectives of employers and service providers together to achieve more satisfactory project performance in construction. So it would be important to conduct research on the identification of key performance indicators (KPIs) as it can help decision makers to measure and benchmark the performance levels of these projects. Based on four rounds of Delphi questionnaire survey conducted with some relevant experienced industrial practitioners, this research study first identified the most important seven KPIs for evaluating the performance of target cost contracts (TCC) and guaranteed maximum price (GMP) contracts in the construction industry of Hong Kong, and second determined their suitable corresponding weightings by the Delphi expert panel. The top seven KPIs sought include: (1) Mutual trust between project partners; (2) Time performance; (3) Final out-turn cost exceeding the final contract target cost, or guaranteed maximum price value, or not; (4) Magnitude of disputes and conflicts; (5) Client's satisfaction on quality of completed work; (6) Time required for the settlement of final project account; and (7) Contractor's involvement in project design. The Kendall's concordance analysis indicated that there is a statistically significant consensus on the top seven KPIs. Finally, a statistical model for measuring the overall performance levels of TCC/GMP projects in the form of a composite performance measurement index (PMI) was derived to provide a single holistic assessment. Senior management and project managers can thus measure, evaluate and compare the performance levels of their own TCC/GMP projects for benchmarking purposes by applying the consolidated performance measurement model. Further research can be launched to adopting the same research methodology to different geographical locations where TCC/GMP schemes are more prevalent, such as the United Kingdom and Australia, to generate similar indices for international comparison between the East and the West.*

Keywords: Construction industry; Construction projects; Contract price; Hong Kong; Performance indicators, Project management; Target cost contracts

Introduction

There have been strong calls for change in procurement strategies worldwide, for example in the United Kingdom[1,2] and in Hong Kong[3], as a result of the adversarial working relationships inherent with the traditional procurement approach. Both 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 integrated procurement models to encourage more co-operative working culture and partnering spirit within the construction industry[4]. TCC and GMP (TCC/GMP) schemes have been practised in different parts of the globe for several years.

With the benefits that TCC/GMP schemes entail, research into the identification of those Key Performance Indicators (KPIs) best suited to evaluate the overall success of TCC/GMP projects becomes essential because this can assist in developing a benchmarking model for measuring the performance levels of these projects. However, there has manifested a lack of extensive and systematic empirical research into the performance measurement and assessment of TCC/GMP projects worldwide so far, especially in the Hong Kong context. It is thus difficult for senior executives and project managers objectively to assess the existing performance of their projects. Although a set of generic KPIs have been established within the construction industry at large[5], there may exist some "additional" KPIs unique to TCC/GMP projects which best reflect the performance outcomes due to the application of TCC/GMP contracts (e.g. trust and equity, teamwork effectiveness, dispute occurrence, or innovation and improvement). In response to this knowledge gap, the objectives of this article are to identify a series of key performance indicators (KPIs) to evaluate the performance of these procurement options and to determine their associated weightings.

The identification of KPIs for TCC/GMP contracts is essential for the continual improvement of project performance and in enhancing the cost effectiveness of the whole procurement process. This study aims to equip different major project stakeholders, including but not limited to employers, contractors and consultants, with the necessary knowledge and sound

[1] 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.
[2] Egan, J. (1998) *Rethinking Construction: Report of the Construction Task Force on the Scope for Improving the Quality and Efficiency of UK Construction*. London: Department of the Environment, Transport and the Regions.
[3] Construction Industry Review Committee (2001) *Construct for Excellence*. Report of the Construction Industry Review Committee, Hong Kong Special Administrative Region, 207 pages.
[4] Same as 3
[5] Collin, J. (2002) *Measuring the success of building projects – Improved project delivery initiatives*, Queensland Department of Public Works, Australia.

understanding of the KPIs associated with TCC/GMP schemes. This research study is expected to benefit both academic researchers and industrial practitioners in documenting the KPIs for TCC/GMP projects and the assessment of project performance. With the assistance of the developed PMI model, the performance levels of different TCC/GMP projects can now be assessed and compared objectively on the same basis for benchmarking purposes at project completion, or for project monitoring throughout the whole project life. It can also provide more empirical evidences by adding to the existing body of knowledge and establishing a sound foundation for further studies.

Definitions of TCC and GMP

According to Trench[6], the 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, any differences within a cost band being shared between the client and the contractor based on a pre-agreed sharing ratio. Hughes et al[7] suggested that TCC is often referred to as a gain-share/pain-share arrangement, in which the contracting parties specify an estimated cost (target cost) and sharing ratio which applies if the actual cost is higher or lower than the estimated cost. They also commented that TCC is justified to be adopted when: (1) the client is incentivised actively to help the contractor to seek cost-efficient solutions, and (2) the client deliberately chooses the same contractor for repeated business. Zimina et al[8] shared similar perception that a gain-share/pain-share mechanism is a distinguishing feature of this kind of contract. They also opined that the aim of TCC is to design a product (i.e. building) to a budget, rather than costing a design after it has been completed.

According to the American Institute of Architects (AIA)[9], GMP is 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. Masterman[10] defined GMP as an agreement which will reward the contractor for any savings made against the GMP and penalise him when this sum is exceeded as a result of his own mismanagement, or negligence. The contractor

[6] Trench, D. (1991) *On Target – A Design and Manage Target Cost Procurement System*. London: Thomas Telford.
[7] Hughes, W., Kwarwu, W. and Hillig, J.B. (2011) Contracts and Incentives in the Construction Sector, In: *Procuring Complex Performance*, Ed. Caldwell, N. and Howard, M., Taylor and Francis, United Kingdom.
[8] Zimina, D., Ballard, G. and Pasquire, C. (2012) Target value design: using collaboration and a lean approach to reduce construction cost, *Construction Management and Economics*, 30(5), 383-398.
[9] The American Institute of Architect (AIA) (2001) *The architect's handbook of professional practice, 13th Edition.* New York: John Wiley.

[10] Masterman, J.W.E. (2002) *Introduction to Building Procurement System, 2nd Edition*, London New York Spon Press.

receives a prescribed sum, along with a share of any savings to the client under this procurement approach. If the cost of the works 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 solely responsible for any additional costs[11].

According to Hughes et al[12], GMP is a TCC with an additional feature that the maximum amount to be paid by the employer is capped. Masterman[13] shared a similar view that GMP is a variant of TCC. Actually, TCC and GMP are grouped together in previous research studies for analysis. For example, Chan et al[14] conducted a detailed holistic empirical questionnaire survey to identify the perceived benefits, potential difficulties and suitability of adopting TCC/GMP contracts within the construction industry of Hong Kong. Moreover, Chan et al[15] launched several structured interviews to investigate the underlying motives, benefits, difficulties, success factors, risk factors and optimal project conditions for applying TCC and GMP schemes in Hong Kong. Mahesh[16] also looked into the strategies on how to enhance the value of TCC/GMP projects in construction and proposed a decision support framework for structuring the knowledge base so as to empower project managers to make more appropriate and informed choices in this kind of projects. Chan et al[17] reported on the major findings of a questionnaire survey on critical success factors during the implementation of TCC/GMP schemes in Hong Kong. In view of the similar nature of TCC and GMP contracts and their practices derived from previous research studies[18,19,20,21]. TCC and GMP are put together for subsequent analyses and discussions in this article.

[11] Gould, E.F. and Joyce, N.E. (2003) *Construction Project Management, 2nd Edition.* Upper Saddle River, New Jersey: Prentice-Hall.
[12] Same as 9
[13] Same as 12
[14] 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, retrieved from http://repository.lib.polyu.edu.hk/jspui/handle/10397/2376.
[15] 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.
[16] Mahesh, G. (2009) Gain/pain share and relational strategies to enhance value in target cost and GMP contracts, *unpublished PhD Thesis*, Department of Civil Engineering, The University of Hong Kong, Hong Kong.
[17] Chan D.W.M., Chan, A.P.C., Lam, P.T.I. and Wong, J.M.W. (2010a) Identifying the critical success factors for target cost contracts in the construction industry, *Journal of Facilities Management*, 8(3), 179-201.
[18] Same as 17
[19] Same as 19
[20] Chan, D.W.M., Lam, P.T.I., Chan, A.P.C. and Wong, J.W.M. (2010b) 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.
[21] Chan, J.H.L., Chan, D.W.M., Chan, A.P.C., Lam, P.T.I. and Yeung, J.F.Y. (2011c) Developing a fuzzy risk assessment model for guaranteed maximum price and target cost contracts in construction, *Journal of Facilities Management*, 9(1), 34-51.

Performance of TCC/GMP projects

Several scholars have expressed diverse opinions on the effectiveness of TCC/GMP schemes. Hughes et al[22] opined that the TCC form of procurement arrangement may not incentivise the contractor to save cost. However, Chan et al[23] reported on the key findings of eight face-to-face interviews and concluded that providing financial incentives for the contractor to achieve cost savings and innovate is one of the perceived benefits from the TCC/GMP contractual arrangements. It would be interesting to look into the performance outcomes of those construction projects employing TCC/GMP contracts worldwide.

In the United Kingdom, according to Mylius[24], the New Wembley Stadium in London, procured with the GMP form of contract, was opened in March 2007. It cost more than £757 million (over the original estimated budget of £200 million in 1996) and was opened almost two years behind schedule. Meng and Gallagher[25] investigated project performance in terms of cost performance, time performance and quality performance of 60 completed construction projects by means of a questionnaire survey in the United Kingdom and the Republic of Ireland. This paper concluded that, in terms of cost certainty, fixed-price contracts performed more satisfactorily than target cost contracts. 70% of projects administered with fixed-price contracts surveyed achieved cost savings, or were completed on budget, while only about 50% of projects procured with target cost contracts were completed under budget, or on budget.

In Australia, Hauck et al[26] undertook a case study via a series of interviews and found the National Museum of Australia, procured with TCC, achieved outstanding project performance in terms of time, cost and quality through collaborative project alliancing.

Besides, Rojas and Kell[27] studied around 300 school projects in the Northeast of the United States. The actual project cost exceeded the GMP value in 75% of the cases. In contrast, Bogus et al[28] conducted an analysis of the performance data of public water and wastewater

[22] Same as 9
[23] Same as 17
[24] Mylius, A (2007) Supply Management, *Building* (15 June 2007).
[25] Meng, X. and Gallagher, B. (2012) The impact of incentive mechanism on project performance, *Construction Management and Economics*, 30(4), 325-362.
[26] Hauck, A.J., Walker, D.H.T., Hampson K.D. and Peters, R.J. (2004) Project alliancing at National Museum of Australia – Collaborative process, *Journal of Construction Engineering and Management*, ASCE, 130(2), 143-152.
[27] 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.
[28] Bogus, S.M., Shane, J.S. and Molenaar, K.R. (2010) Contract payment provisions and project performance: an analysis of municipal water and wastewater facilities, *Public Works Management and Policy*, 15(1), 20-31.

facilities in the United States. Their study revealed that contracts using cost-plus fee with the GMP arrangement performed better in terms of cost and schedule when compared with those with lump-sum contracts.

In Hong Kong, Chan et al[29] launched a case study of an underground railway station modification and extension works project, procured with TCC, via several face-to-face interviews with relevant project participants and documentation analysis. Their findings indicated that the project achieved a cost saving of 5% and a time saving of 20%. Another case study of a private prestigious commercial development advocated that the GMP form of arrangement could align the individual objectives of different contracting parties together and the project achieved a cost saving of 15% and completed ahead of schedule by six days[30].

Key Performance Indicators (KPIs) in construction

Key Performance Indicator (KPI) is defined by Swan and Kyng[31] as a measure which indicates the performance of a project or a company against critical criteria. Cox et al[32] shared a similar view that KPIs can be defined as compilations of data measures for gauging the performance of a construction operation. The purpose of KPIs is enabling the measurement of project and organisational performance in the construction industry[33]. A plethora of research studies on KPIs within the construction industry is observed in the construction management literature. Table 1 gives a summary of the KPIs consolidated from some previous literature from 2000 to 2012. It was found that there is a considerable number of KPIs buried in different literature. The meanings of KPIs as highlighted in Table 1 are summarised and the number is condensed to 30 for easy reference.

In response to the Egan Report[34], the KPI Working Group[35] reported on the collective opinions on performance measurement of the construction industry in the United Kingdom. A total of 38 indicators grouped under six categories were suggested in the report for performance measurement of the whole supply chain in a construction project. It offered a flexible framework for different stakeholders' organisations along the entire supply chain (e.g. suppliers, subcontractors, main contractors, consultants, clients and the like) to adapt

[29] Same as 22
[30] Chan, D.W.M., Lam, P.T.I., Chan, A.P.C. and Wong, J.M.W. (2011a) Guaranteed maximum price (GMP) contracts in practice – A case study of a private office development project in Hong Kong, *Engineering, Construction and Architectural Management*, 18(2), 188-205.
[31] Swan, W. and Kyng, E. (2004) *An Introduction to Key Performance Indicators*, Centre of Construction Innovation, United Kingdom.
[32] Cox, R.F., Issa, R.J.A. and Ahren, D (2003) Management's perception of key performance indicators for construction, *Journal of Construction Engineering and Management,* ASCE, 129(2), 142-151.
[33] KPI Working Group (2000) *KPI Report for the Minister for Construction*, Department of Environment, Transport and the Region, London.
[34] Same as 4
[35] Same as 35

individual KPIs to suit their own specific needs. Cox et al[36] carried out a study on KPIs through a questionnaire survey with project managers and senior construction executives. It was discerned that the two groups of respondents held different views towards quality control and on-time KPIs. Project managers mainly focused on the project level, while senior executives tended to have a company-wide focus in the survey.

Swan and Kyng[37] introduced useful guidelines for benchmarking of construction projects, suggesting that once the requirements for a KPI system are put in place, it is important to determine which to measure. It was recommended that the number of KPIs should be limited from 8 to 12. Otherwise, the performance measurement exercise would become onerous and the collection of necessary data would also become a challenge. Moreover, the measures should be collected with a reason, if no action will be taken regardless of whether the KPIs are high, or low, they are not really "key" performance indicators. They further opined that the majority of performance measurement systems consist of a mixture of external benchmarks (e.g. safety and productivity) and internal benchmarks (e.g. time required for settling final project account). The inclusion of internal benchmarks would enable the user to compare among his own projects, but not at a national, or industry level.

Cheung et al[38] developed a web-based construction project performance monitoring system to assist project managers in exercising project monitoring. Eight project performance measure categories were identified for use in their performance monitoring system, including people, time, cost, quality, safety and health, environment, client's satisfaction and communication. The performance indicators and their corresponding measurements were established under each category in the system. Menches and Hanna[39] completed a research study on quantitative measurement of successful performance from project managers' views in the United States. They first conducted 55 interviews to investigate the definitions of project success from the project managers' perspective. A questionnaire survey was then launched to collect necessary and sufficient data and information to identify variables for inclusion in a performance measurement index. Lam et al[40] developed a project success index to benchmark the performance of construction projects procured with design-and-build procurement approach based on four KPIs (time, cost, quality and functionality). Data were collected from 40 design-and-build projects in Hong Kong and a project success index curve

[36] Same as 34
[37] Same as 33
[38] Cheung, S.O., Suen, H.C.H. and Cheung, K.K.W. (2004) PPMS: a web-based construction project performance monitoring system, *Automation in Construction*, 13(3), 361-376.
[39] Menches, C.L. and Hanna, A.S. (2006) Quantitative measurement of successful performance from the project manager's perspective, *Journal of Construction Engineering and Management,* ASCE, 132(12), 1284-1293.
[40] Lam, E.W.M., Chan, A.P.C. and Chan, D.W.M. (2007) Benchmarking the performance of design-build projects: development of project success index, *Benchmarking: An International Journal*, 14(5), 624-638.

was then established. According to Lam et al[41], construction companies could benchmark their own project performance levels against other counterparts by viewing their respective scores along the curve.

Jones and Kaluarachchi[42] generated a multi-dimensional benchmarking model for social house building innovation programme in the United Kingdom. The model gauged the performance of social housing provisions by integrating the demand and supply sides of the development process via the benchmarking model. Luu et al[43] established a conceptual framework for benchmarking the project management performance from contractors' perspective in Vietnam. A total of nine KPIs were provided to evaluate the contractors themselves and their capacity in their study. Case studies of three large contractors were used to verify the validity of the model. It was claimed that the model may be applied to other contractors with necessary minor modifications.

Tennant and Langford[44] scrutinised case studies of three construction companies comprising thirteen projects. Their findings advocated that the adoption of performance management systems can bring about several benefits to construction managers for project appraisal. Chan[45] applied the balanced scorecard approach to investigate the linkage between critical success factors and strategic thrusts defined in the Construction Industry Master Plan in Malaysia. It was indicated that the eight critical success factors and seven strategic thrusts included in the master plan generally cover the four perspectives of the balanced scorecard approach (i.e. financial perspective, customer perspective, internal perspective, as well as learning and growth perspective) with a strong emphasis on learning and growth.

A case study was launched by De Marco et al[46] to demonstrate the application of index-based estimate and logistic estimate for both cost estimate at completion (cost EAC) and time estimate at completion (TEAC) by means of an industrial building project in Turin, Italy. The results of their case study suggested that index-based estimates are a reliable source of information for project cost control, while time at completion is better estimated with logistic models. Toor and Ogunlana[47] conducted a questionnaire survey in Thailand on nine

[41] Same as 42
[42] Jones, K. and Kaluarachchi, Y. (2008) Performance measurement and benchmarking of a major innovation programme, *Benchmarking: An International Journal*, 15(2), 124-136.
[43] Luu, V.T., Kim, S.Y. and Huynh, T.A. (2008) Improving project management performance of large contractors using benchmarking approach, *International Journal of Project Management*, 26(7), 758-769.
[44] Tennant, S and Langford, D (2008) The construction project balanced score card. In: Dainty, A. (Ed) *Proceedings of the 24th Annual ARCOM Conference, 1-3 September 2008*, Cardiff, United Kingdom, Association of Researchers in Construction Management, 361-370.
[45] Chan, T.K. (2009) Measuring performance of the Malaysian construction industry, *Construction Management and Economics*, 27(12), 1231-1244.
[46] De Marco, A., Briccarello, D. and Rafele, C. (2009) Cost and schedule monitoring of industrial building project: case study, *Journal of Construction Engineering and Management*, ASCE, 135(9), 853-862.
[47] Toor, S.R. and Ogunlana, S.O. (2010) Beyond the 'iron triangle': stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects, *International Journal of Project*

KPIs for mega-sized infrastructure projects, and explored the significance of the KPIs from the viewpoints of different stakeholders (i.e. employers, contractors and consultants). Their findings revealed that KPIs other than time, cost and quality, such as safety, efficient use of resources, reduced conflicts and disputes and the like, become increasingly important. They also advocated that the construction industry is slowly shifting from the traditional performance measurement to a mix of both quantitative and qualitative performance measurements on those large-scale infrastructure projects. Haponava and Al-Jibouri[48] proposed a generic system for measuring project performance on the basis of a series of process-based KPIs related to both process completeness and process quality, at the pre-project stage, design stage and construction stage.

Performance measurement of TCC under NHS ProCure21+ Framework

The National Health Service (NHS) based in England adopted a NHS ProCure21+ Framework, in which the New Engineering Contract Version 3 (NEC3) Option C (Target Cost Contract with Activity Schedule) is used, for capital investment construction schemes[49]. A performance management system is introduced in the procurement framework. The KPIs included in the system cover six major areas of project performance: (1) time certainty; (2) cost certainty; (3) client's satisfaction (on products); (4) client's satisfaction (on services); (5) health and safety; and (6) defects. However, a huge amount of information and data have to be collected in order to compute the KPIs identified. For example, elemental cost breakdown is needed and the assessment of the Achieving Excellence Design Evaluation Toolkit (AEDET) has to be completed. In addition, TCC/GMP schemes are more well developed within the United Kingdom, while the development of TCC/GMP contracts in Hong Kong is still at a germinating stage. It would be interesting to compare the KPIs for TCC/GMP schemes in Hong Kong with those from the NHS ProCure21+ Framework, to see whether there exist any similarities or differences in the performance measurement systems between the two jurisdictions. Since the performance measurement framework of NHS ProCure21+ is client-driven and a multitude of information and data have to be entered into the assessment tool (e.g. cost data have to be inputted into the elemental cost analysis of the framework), it may be made more user-friendly and convenient to develop an overall performance index to indicate the performance levels of TCC/GMP projects, instead of comparing the project performance at individual KPI level. Taking an analogy, it would be more direct and holistic to assess the performance of a primary school student in terms of his/her overall score/position

Management, 28(3), 228-236.

[48] Haponava, T. and Al-Jibouri, S. (2012) Proposed system for measuring project performance using process-based key performance indicators, *Journal of Management in Engineering,* ASCE, 28(2), 140-149.

[49] NHS ProCure21+ Guide (2011), The ProCure21+ Guide, Available from URL: http://www.procure21plus.nhs.uk/guide (accessed on 25 July 2011).

in class (overall performance index), rather than the number of distinctions obtained from different individual subjects (individual KPIs).

Table 1: Summary of the Key Performance Indicators (KPIs) to evaluate the success of construction projects worldwide

		Key Performance Indicators (KPI)	KPI Working Group[50]	Nicolini et al[51]	Cox et al[52]	Swan and Kyng[53]	Cheung et al[54]	Menches and Hanna[55]	Lam et al[56]	Kaluarachchi and Jones[57]	Jones and Kaluarachchi[58]	Luu et al[59]	Rojas and Kell[60]	Tennant and Langford[61]	De Marco et al[62]	Toor and Ogunlana[63]	Chan et al[64]	Chan et al[65]	Haponava and Al-Jibouri[66]	***Total number of hits for each KPI identified***
			2000	2001	2003	2004	2004	2006	2007	2008	2008	2008	2008	2008	2009	2010	2010	2011	2012	
Time	1	Time for construction	√	√	√	√	√	√	√	√	√	√			√	√	√	√		14
	2	Time predictability – design and construction	√			√	√			√	√			√					√	7
	3	Time to rectify defects	√								√									2
Cost	4	Cost for construction	√		√	√	√	√	√	√	√	√			√	√				11
	5	Cost exceeding GMP / target cost or not		√									√				√	√		4
	6	Cost predictability – design and construction	√			√	√			√				√					√	6
	7	Occurrence and magnitude of disputes and conflicts							√							√	√	√		4

[50] Same as 35
[51] Nicolini, D. Holti, R. and Smalley, M. (2001) Integrating project activities: the theory and practice of managing the supply chain through clusters, *Construction Management and Economics*, 19(1), 37-47.
[52] Same as 34
[53] Same as 33
[54] Same as 40
[55] Same as 41
[56] Same as 42
[57] Kaluarachchi, Y.D. and Jones, K. (2008) Monitoring of a strategic partnering process: the Amphion experience, *Construction Management and Economics,* 25(10), 1053-1061.
[58] Same as 44
[59] Same as 45
[60] Same as 29
[61] Same as 46
[62] Same as 48
[63] Same as 49
[64] Same as 22
[65] Same as 19
[66] Same as 50

		Key Performance Indicators (KPI)	KPI Working Group[50]	Nicolini et al[51]	Cox et al[52]	Swan and Kyng[53]	Cheung et al[54]	Menches and Hanna[55]	Lam et al[56]	Kaluarachchi and Jones[57]	Jones and Kaluarachchi[58]	Luu et al[59]	Rojas and Kell[60]	Tennant and Langford[61]	De Marco et al[62]	Toor and Ogunlana[63]	Chan et al[64]	Chan et al[65]	Haponava and Al-Jibouri[66]	***Total number of hits for each KPI identified***
			2000	2001	2003	2004	2004	2006	2007	2008	2008	2008	2008	2008	2009	2010	2010	2011	2012	
	8	Cost of superstructure								√	√									2
	9	Development fee								√	√									2
	10	Consultant fee								√	√									2
	11	Cost per m^2			√															1
	12	Number of change orders generated	√				√	√												3
Quality	13	Quality					√		√									√	√	4
	14	Defects (Number / Severity)	√	√	√	√	√			√	√					√		√		9
	15	Quality issues at end of defect rectification period	√							√	√									3
	16	Quality management system										√								1
	17	Aesthetics							√	√										2
Satisfaction	18	Client's satisfaction	√			√				√	√	√		√					√	7
	19	Contractor's satisfaction								√	√									2
	20	Conformance to stakeholders' expectations								√				√		√	√	√	√	6
Health, Safety and Environment	21	Safety				√	√		√	√	√	√				√	√	√		9
	22	Reportable accidents	√	√			√											√		4
	23	Lost time accidents	√				√													2
	24	Environmental performance					√		√	√	√							√		5
	25	Quantity of waste generated					√			√	√							√		4

		Key Performance Indicators (KPI)	KPI Working Group[67]	Nicolini et al[68]	Cox et al[69]	Swan and Kyng[70]	Cheung et al[71]	Menches and Hanna[72]	Lam et al[73]	Kaluarachchi and Jones[74]	Jones and Kaluarachchi[75]	Luu et al[76]	Rojas and Kell[77]	Tennant and Langford[78]	De Marco et al[79]	Toor and Ogunlana[80]	Chan et al[81]	Chan et al[82]	Haponava and Al-Jibouri[83]	***Total number of hits for each KPI identified***
			2000	2001	2003	2004	2004	2006	2007	2008	2008	2008	2008	2008	2009	2010	2010	2011	2012	
Others	26	Contractor involvement								√	√						√	√	√	5
	27	Productivity performance			√	√	√													3
	28	Staff turnover			√															1
	29	Training days												√						1
	30	Profit predictability (project)	√			√														2
		Total number of KPIs identified from each publication	12	4	6	9	13	3	7	17	15	5	1	5	2	6	6	11	6	128

[67] Same as 35
[68] Nicolini, D. Holti, R. and Smalley, M. (2001) Integrating project activities: the theory and practice of managing the supply chain through clusters, *Construction Management and Economics*, 19(1), 37-47.
[69] Same as 34
[70] Same as 33
[71] Same as 40
[72] Same as 41
[73] Same as 42
[74] Kaluarachchi, Y.D. and Jones, K. (2008) Monitoring of a strategic partnering process: the Amphion experience, *Construction Management and Economics,* 25(10), 1053-1061.
[75] Same as 44
[76] Same as 45
[77] Same as 29
[78] Same as 46
[79] Same as 48
[80] Same as 49
[81] Same as 22
[82] Same as 19
[83] Same as 50

Research method: Delphi survey technique

The Delphi method is a systematic and interactive research technique to obtain the judgement of a group of experts on a specific topic[84]. Individual experts are requested to participate in two, or more rounds of structured surveys. An anonymous result summary of opinions and information feedback of the group of experts from the previous round in the form of relevant statistical data is provided to each of the experts, and they are invited to review the results and consider revising their original responses if deemed necessary. The objective of this process is to mitigate the variability of the responses and to achieve group consensus and correct value. By means of an iterative forecasting procedure on proceeding to the final round, the favourable outcome is that the experts will have reached unanimity on the issues under investigation[85].

This method has been commonly applied in the field of construction management research. For instance, Zhang et al[86] conducted a three-round Delphi survey exercise towards 20 experts in real estate about the key competitiveness indicators for new real estate developers in Mainland China. The same research method was applied in a study by Urge-Vorsatz et al[87] to assess 20 policy instruments for carbon dioxide (CO_2) reduction from buildings. According to Chan et al[88], the Delphi method can offer a merit in situation where it is important to define areas of uncertainties, or disagreement among experts. The Delphi survey method is therefore considered to be a desirable tool for obtaining a set of the most important KPIs and their suitable associated weightings to be applied in evaluating the success of TCC construction projects, because of the rather subjective nature of the opinions.

Format of Delphi rounds

Four rounds of Delphi survey exercise were launched from March to August of 2011. According to Mullen[89], two, or three rounds of Delphi survey are preferred and found in a multitude of previous research studies. However, after considering the scope of this study (i.e.

[84] Hallowell, M.R. and Gambatese, J.A. (2010) Qualitative research: application of the Deiphi method to CEM research, *Journal of Construction Engineering and Management,* ASCE, 136(1), 99-107.

[85] Manoliadis, O., Tsolas, I. and Nakou, A. (2006) Sustainable construction and drivers of change in Greece: a Delphi study, *Construction Management and Economics*, 24(1), 113-130.

[86] Zhang, X., Shen, L.Y., Skitmore, M. and Xia, B. (2010) Key competitiveness indicators for new real estate developers, *Journal of Financial Management of Property and Construction*, 15(2), 143-157

[87] Urge-Vorsatz, D., Sonja, K. and Sebastian, M. (2007) Appraisal of policy instruments for reducing buildings' CO_2 emissions, *Building Research and Information*, 35(4), 458-477.

[88] Chan, A.P.C., Yung, E.H.K., Lam, P.T.I., Tam, C.M. and Cheung, S.O. (2001), Application of Delphi method in selection of procurement systems for construction projects, *Construction Management and Economics*, 19(7), 699-718.

[89] Mullen, P.M. (2003) Delphi: myths and reality, *Journal of Health Organisation and Management*, 17(1), 37-52.

identifying the KPIs and their relative importance for TCC/GMP projects), four rounds of Delphi survey were decided to be undertaken.

Design of the questionnaire for Round 1 was based on a comprehensive review of desktop literature about the performance measurement of construction projects in general and of TCC/GMP projects in particular. In Round 1, the respondents were requested to select a minimum of five but a maximum of ten KPIs from a consolidated list of 15 various key performance measures which were considered to be the most vital KPIs to evaluate the success of TCC/GMP projects in Hong Kong. They were also welcome to suggest additional indicators which had not yet been included on the survey form, if deemed appropriate. Round 2 of the questionnaire survey dealt with all the KPIs provided on the questionnaire from Round 1, in addition to those KPIs suggested by the panel of experts in Round 1. After Round 1, the results were consolidated and then presented to the expert panel in Round 2. They were requested to freely adjust their original perceptions, or options in Round 2.

In Round 3, the Delphi experts were requested to rate the level of importance against each of the selected KPIs identified from Round 2 based on a criterion that all of them were selected by at least 50% of experts) according to a five-point Likert scale (1 = least important and 5 = most important). While analysing the data, the focus ought to be on the opinions of the group rather than those of individuals. Therefore, a concordance analysis measuring the consistency of the experts' responses over successive rounds of the Delphi survey was required. In Round 4, a summary of consolidated results obtained from Round 3 was presented to the experts. They were invited again to review their individual choices provided in Round 3 in the light of the mean value scored by all the experts, and make further adjustments to their option selections if necessary. The consistency of the results of Round 3 and Round 4 were analysed and compared by the Kendall's concordance test statistically.

Selection of expert panel

The success of a Delphi survey highly depends on the careful selection of experts[90]. A group of experts was selected to provide their opinions on the KPIs for TCC/GMP construction projects in Hong Kong. A purposive sampling method was adopted to select the group of experts[91, 92, 93], since the experts should have gained in-depth knowledge and basic

[90] Same as 73
[91] Same as 22
[92] Yeung, J.F.Y., Chan, A.P.C. and Chan, D.W.M. (2009) Developing a performance index for relationship-based construction projects in Australia: Delphi study, *Journal of Construction Engineering and Management,* ASCE, 25(2), 59-68.
[93] Chan, D.W.M., Chan, A.P.C., Lam, P.T.I., Yeung, J.F.Y. and Chan, J.H.L. (2011b) Risk ranking and analysis in target cost contracts: empirical evidence from the construction industry, *International Journal of Project Management*, 29(6), 751-763.

understanding about the TCC/GMP underlying principles and extensive hands-on experience in the construction industry. So the following criteria were devised to identify the eligible expert panel for this Delphi survey. Only those practitioners who fulfilled all of these three criteria were invited to participate in this Delphi survey, with the purpose of soliciting the most representative and reliable opinions from them.

1. Participants should have acquired extensive working experience of at least ten years in the construction industry of Hong Kong.
2. Participants should have been engaged, or participated in the management of at least one TCC/GMP construction project in Hong Kong.
3. Participants should hold a position of at least a professional grade in the TCC/GMP projects concerned with a sound understanding of TCC/GMP schemes or principles (e.g. project manager, project architect, project design engineer, project quantity surveyor, etc).

Results of Delphi survey

Round 1: Identifying the most important KPIs

The questionnaire of Round 1 was developed on the basis of an extensive review of desktop literature on various generic performance measures for construction projects in general (e.g. time performance, or cost performance), followed by a series of pilot interviews with some senior industrial practitioners involved in TCC/GMP construction projects in particular (e.g. trust and respect, or claim occurrence) for verifying the validity of those KPIs sought. The questionnaire together with an invitation letter, which explained the purpose of the research, were dispatched to the 72 “eligible” potential respondents via postal mail, as identified from previous research studies on TCC/GMP in Hong Kong[94, 95], in March 2011. The experts were informed of a total of four rounds of questionnaire survey to be conducted within the next few months. A total of sixteen practitioners ultimately confirmed to participate in this study. The sixteen members of the expert panel represented a wide spectrum of construction professionals: three from client organisations, ten from contractor companies and three from consultant firms. The composition of the expert panel provided a holistic, balanced view for this Delphi study. Table 2 serves as a summary of their personal profiles.

[94] Same as 16
[95] Same as 78

Table 2: Personal profiles of the Delphi panel members

Expert	Position	Role	Year of working experience in construction industry	Hands-on participation in at least one TCC/GMP project
1	Assistant Project Director	Client	More than 20 years	Yes
2	Partner	Consultant	16-20 years	Yes
3	Construction Manager	Contractor	16-20 years	Yes
4	Contract Advisor	Contractor	11-15 years	Yes
5	Project Manager – Contract and Cost	Contractor	More than 20 years	Yes
6	Engineer	Consultant	More than 20 years	Yes
7	Engineer	Contractor	More than 20 years	Yes
8	Commercial Manager	Contractor	More than 20 years	Yes
9	Construction Manager – Estimating and Subletting	Contractor	More than 20 years	Yes
10	Estimation Manager	Contractor	16-20 years	Yes
11	Contracts Manager	Contractor	More than 20 years	Yes
12	Commercial Manager	Contractor	More than 20 years	Yes
13	Technical Director	Consultant	16-20 years	Yes
14	General Manager (Contracts)	Contractor	More than 20 years	Yes
15	Quantity Surveyor	Client	More than 20 years	Yes
16	Contract Advisor	Client	More than 20 years	Yes

The experts were requested to choose a minimum of five but a maximum of ten KPIs that they believed to be the most important KPIs to evaluate the success of TCC/GMP construction projects from a summary list of 15 various key performance measures identified from the reported literature and pilot interviews. They were also welcome to provide additional KPIs for TCC/GMP schemes in Hong Kong wherever deemed appropriate.

Finally, 16 responses were gleaned and six extra KPIs suggested by the expert panel were carefully analysed. Table 3 shows the indication of relative importance of all the KPIs (i.e. 15 listed on the survey form and an additional six suggested by the expert panel) by the 16 experts in Round 1 of this Delphi survey. Their frequencies of hit are also shown in the same table.

Table 3: Results of Round 1 Delphi survey

Key Performance Indicators (KPIs) for TCC/GMP construction projects	Total frequency	Percentage
1. Mutual trust between project partners	15	93.75
2. Time performance	14	87.50
3. Magnitude of disputes and conflicts	11	68.75
4. Final out-turn cost exceeding the final contract target cost or guaranteed maximum price value or not	11	68.75
5. Client's satisfaction on quality of completed work	11	68.75
6. Contractor's feedback on client's decision making process	9	56.25
7. Time required for the settlement of final project account	10	62.50
8. Contractor's involvement in project design	8	50.00
9. Design quality	8	50.00
10. Time needed from the commencement of project design up to contract award	6	37.50
11. Percentage of contractor's alternative design proposals approved by consultants in first go	6	37.50
12. Safety performance	5	31.25
13. Contractor's satisfaction on TCC/GMP contractual arrangement	6	37.50
14. Environmental friendliness	2	12.50
15. Cost per m^2 of construction floor area (CFA) including foundations	1	6.25
16. Form of contract to be used	1	6.25
17. Contractor's ability to perform cost management	1	6.25
18. Appropriateness of risk allocation	1	6.25
19. Time allowed for pre-construction preparation works	1	6.25
20. Contractor's claim consciousness attitude	1	6.25
21. Amount of works that the tenderer has in hand at the final stage of tendering	1	6.25

Note: Additional KPIs suggested by the expert panel are shown in *italics*.

Round 2: Refining the selected KPIs

The questionnaires for Round 2 were mailed to the members of the expert panel in May 2011. In this round, the results of Round 1 were consolidated and presented to the experts and they were requested to reconsider whether they would like to change any of their original choices, or not after second thought, in light of the consolidated results from Round 1. Only seven experts returned their completed questionnaires within a stipulated deadline of two weeks. An individual email was subsequently issued to remind all the experts who had not yet returned their completed questionnaires, followed by a phone call if necessary. Finally, 14 responses

were received towards the end of May 2011 and two experts withdrew from the study due to the heavy commitment of their current workload.

Table 4: Results of Round 2 Delphi survey

Key Performance Indicators (KPIs) for TCC/GMP construction projects	Total frequency	Percentage
1. Mutual trust between project partners	**14**	**100.00**
2. Time performance	**12**	**85.71**
3. Final out-turn cost exceeding the final contract target cost or guaranteed maximum price value or not	**11**	**78.57**
4. Magnitude of disputes and conflicts	**10**	**71.43**
5. Client's satisfaction on quality of completed work	**10**	**71.43**
6. Time required for the settlement of final project account	**10**	**71.43**
7. Contractor's involvement in project design	**10**	**71.43**
8. Contractor's feedback on client's decision making process	6	42.86
9. Design quality	6	42.86
10. Time needed from the commencement of project design up to contract award	6	42.86
11. Percentage of contractor's alternative design proposals approved by consultants in first go	4	28.57
12. Safety performance	4	28.57
13. Contractor's satisfaction on TCC/GMP contractual arrangement	3	21.43
14. Contractor's ability to perform cost management	2	14.29
15. Appropriateness of risk allocation	2	14.29
16. Contractor's claim consciousness attitude	2	14.29
17. Form of contract to be used	1	7.14
18. Time allowed for pre-construction preparation works	0	0.00
19. Amount of works that the tenderer has in hand at the final stage of tendering	0	0.00
20. Environmental friendliness	0	0.00
21. Cost per m^2 of construction floor area (CFA) including foundations	0	0.00

Notes: (1) Additional KPIs suggested by the expert panel are in *italics*, and (2) KPIs with percentage of 50%, or higher are shown in **bold**.

As observed from Table 4, there are seven KPIs with a frequency percentage of 50%, or higher selected by the Delphi panel of experts. Hence a total of seven most important KPIs was identified specifically for measuring the performance of TCC/GMP construction projects in Hong Kong, in descending order: (1) Mutual trust between project partners; (2) Time performance; (3) Final out-turn cost exceeding the final contract target cost, or guaranteed maximum price value, or not; (4) Magnitude of disputes and conflicts; (5) Client's satisfaction on quality of completed work; (6) Time required for the settlement of final project account; and (7) Contractor's involvement in project design. Apart from the traditional KPIs about time, cost

and quality, the remaining four KPIs primarily focus on the measures of working relationship between the employer and the contractor.

Round 3: Establishing individual weightings for the seven most important KPIs

In the third round of the Delphi questionnaire, experts were requested to indicate the level of importance (rating) on the top seven selected KPIs based on a 5-point Likert scale (i.e. 1 = least important; 2 = slightly important; 3 = important; 4 = very important; and 5 = most important) to evaluate the performance of TCC/GMP projects. Finally, all the 14 panel members submitted their completed questionnaires in July 2011 pursuant to some email reminders.

Table 5: Results of Round 3 Delphi survey

Key Performance Indicators (KPIs) for TCC/GMP construction projects	**Rank**	**Mean rating**	**Corresponding weighting**
Mutual trust between project partners	1	4.71	0.180
Final out-turn cost exceeding the final contract target cost or guaranteed maximum price value or not	2	4.14	0.158
Time performance	3	4.07	0.155
Magnitude of disputes and conflicts	4	3.50	0.134
Client's satisfaction on the quality of completed work	4	3.50	0.134
Contractor's involvement in project design	6	3.21	0.123
Time required for the settlement of final project account	7	3.07	0.117
Number of respondents	14		
Kendall's coefficient of concordance (W)	0.552		
Critical value of W from statistical table	0.137		
Degree of freedom	6		
Level of significance	<0.001		
H_0 = Respondents' sets of rankings are unrelated (independent) to each other within each group. Reject H_0 if the actual value of W is larger than the critical value of W from statistical table			

Note: Mean rating: 1 = least important and 5 = most important

A statistical analysis was undertaken on the 14 survey forms received in which the mean ratings of the seven most important KPIs were calculated. Hence, a preliminary basket of the most important KPIs together with their respective weightings, were generated based on the mean ratings advocated by the expert panel. Each of the seven KPIs was gauged with a measurement scale of score between 1 and 5, where 1 denotes "least important" and 5 denotes "most important" for the KPIs to evaluate the success of a TCC/GMP project. The weighting of each KPI was calculated as their individual mean ratings divided by the total mean ratings of all the KPIs under consideration, as derived using the equation below. This derivation has been in fact adopted by several researchers before[96,97,98,99,100].

[96] Chow, L.K. (2005). Incorporating fuzzy membership functions and gap analysis concept into performance evaluation of engineering consultants – Hong Kong study, *Unpublished PhD thesis*, Department of Civil Engineering, The University of Hong Kong, Hong Kong.

$$W_{KPIa} = \frac{M_{KPIa}}{\sum_{g} M_{KPIg}} \qquad \text{for a = 1}$$

where W_{KPIa} represents the weighting of a particular top seven KPI in Round 3;

M_{KPIa} represents the mean rating of a particular top seven KPI in Round 3; and

$\sum_{g} M_{KPIg}$ represents the summation of the mean ratings of all the top seven KPIs in Round 3.

Table 5 gives a summary of the seven most important KPIs, together with their corresponding weightings. They include: (1) Mutual trust between project partners, with a weighting of 0.180; (2) Final out-turn cost exceeding the final contract target cost, or guaranteed maximum price value, or not, with a weighting of 0.158; (3) Time performance, with a weighting of 0.155; (4) Magnitude of disputes and conflicts, with a weighting of 0.134; (5) Client's satisfaction on the quality of completed work, also with a weighting of 0.134; (6) Contractor's involvement in project design, with a weighting of 0.123; and (7) Time required for the settlement of final project account, with a weighting of 0.117. A composite performance measurement index (PMI) for TCC/GMP construction projects in Hong Kong is thus generated by the following equation:

Performance Measurement Index (PMI)

= 0.180 x Mutual trust between project partners
+ 0.158 x Final out-turn cost exceeding the final contract target cost, or guaranteed maximum price value, or not
+ 0.155 x Time performance
+ 0.134 x Magnitude of disputes and conflicts
+ 0.134 x Client's satisfaction on the quality of completed work
+ 0.123 x Contractor's involvement in project design
+ 0.117 x Time required for the settlement of final project account

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[97] Yeung, J.F.Y, Chan, A.P.C., Chan, D.W.M. and Li, L.K. (2007) Development of a Partnering Performance Index (PPI) for construction projects in Hong Kong: a Delphi study, *Construction Management and Economics*, 25(12), 1219-1237.

[98] Yeung, J.F.Y., Chan, A.P.C. and Chan, D.W.M. (2009) Developing a performance index for relationship-based construction projects in Australia: Delphi study, *Journal of Construction Engineering and Management,* ASCE, 25(2), 59-68.

[99] Eom, C.S.J. and Paek, J.H. (2009) Risk index model for minimizing environmental disputes in construction, *Journal of Construction Engineering and Management*, ASCE, 135(1), 34-41.

[100] Same as 23

The PMI is composed of seven weighted KPIs as identified in Round 2 of the Delphi survey and their weightings were computed by the individual mean scores divided by the total mean scores. The PMI was derived based on the assumption that it is a linear and additive model. The unit of measurement of the seven KPIs is different, so it is unlikely to have a multiplier effect between them[101,102,103]. Practically speaking, it is simpler and easier to use this linear model equation in practice to measure the performance standards of TCC/GMP construction projects in Hong Kong.

Since the Likert scale of measurement was used in both Round 3 and Round 4 of the Delphi survey and the data are ordinal in nature, non-parametric statistical tests are considered as more appropriate to be applied in this study. The Kendall's concordance analysis, which is a non-parametric test, was adopted to measure the level of agreement of different respondents on their rankings of factors based on mean scores within a particular group. This statistical test aims to ascertain whether the respondents within a particular group respond in a consistent manner, or not[104,105]. The value of the Kendall's coefficient of concordance (W) ranges from 0 to 1, where 0 reveals perfect disagreement and 1 indicates perfect agreement. A significant value of W (i.e. the actual p-value less than the allowable value of 0.05) can reject the null hypothesis that there is a complete lack of consensus among the respondents within one group[106,107]. The result of Kendall's concordance analysis is revealed in Table 3. The actual value of Kendall's coefficient of concordance is larger than the critical value of 0.137 from the statistical table[108] and the significance level is less than 0.001, it can be concluded that there is a considerable level of agreement on the responses among the respondents within the group of panel experts in Round 3.

Round 4: Re-evaluating the weighted KPIs in Round 3

In Round 4 of the Delphi survey, each participating expert was given the consolidated results obtained from Round 3. The mean ratings of the 14 experts for each KPI, together with individual expert's own ratings suggested in Round 3 were provided. Each expert was then invited to re-consider their own ratings to see whether they would like to adjust their original

[101] Same as 81
[102] Same as 82
[103] Same as 83
[104] Kvam, P.H. and Vidakovic, B. (2007) *Nonparametric Statistics with Applications to Science and Engineering.* John Wiley & Sons.
[105] Same as 78
[106] Chan, A.P.C. (1998) Perception on variations – a tale of three cities, The *Australian Institute of Quantity Surveyors Refereed Journal*, 2(1), 42-54.
[107] Same as 19
[108] Siegel, S. and Castellan, N.J. (1988) *Nonparametric Statistics for the Behavioural Sciences.* McGraw-Hill Inc.

options with reference to the mean scored by all the 14 experts. The final round questionnaire was dispatched to the same group of panel experts via postal mail in mid-August 2011. All the completed questionnaires were ultimately received for further statistical analysis.

Table 6: Results of Round 4 Delphi survey

Key Performance Indicators (KPIs) for TCC/GMP construction projects	**Rank**	**Mean rating**	**Corresponding weighting**
Mutual trust between project partners	1	4.71	0.176
Final out-turn cost exceeding the final contract target cost or guaranteed maximum price value or not	2	4.36	0.163
Time performance	3	4.21	0.158
Magnitude of disputes and conflicts	4	3.64	0.136
Client's satisfaction on the quality of completed work	5	3.50	0.131
Time required for the settlement of final project account	6	3.21	0.120
Contractor's involvement in project design	7	3.07	0.115
Number of respondents	14		
Kendall's coefficient of concordance (W)	0.649		
Critical value of W from statistical table	0.137		
Degree of freedom	6		
Level of significance	<0.001		
H_0 = Respondents' sets of rankings are unrelated (independent) to each other within each group. Reject H_0 if the actual value of W is larger than the critical value of W from statistical table			

Note: Mean rating: 1 = least important and 5 = most important

Most of the experts had reconsidered their ratings provided in the previous round and had made adjustments to their ratings. The consistency of the experts' weightings was again computed by the Kendall's coefficient of concordance (W). Table 6 shows no change for the order of their mean ratings, except that the respective ranks of "Time required for the settlement of final project account" and "Contractor's involvement in project design" are inter-changed between Round 3 and Round 4. In addition, their corresponding weightings are similar to those of Round 3. A significant improvement to the Kendall's coefficient of concordance from 0.552 in Round 3 to 0.649 in Round 4 is discerned, indicating that the rating exercises in Round 3 and Round 4 have successfully contributed to improved agreement among the panel of experts and higher reliability of this study. So after Round 4, the PMI can be re-computed according to the revised model equation below:

Performance Measurement Index (PMI)

= 0.176 x Mutual trust between project partners
+ 0.163 x Final out-turn cost exceeding the final contract target cost, or guaranteed maximum price value, or not
+ 0.158 x Time performance
+ 0.136 x Magnitude of disputes and conflicts
+ 0.131 x Client's satisfaction on the quality of completed work
+ 0.120 x Time required for the settlement of final project account
+ 0.115 x Contractor's involvement in project design

Discussion of Delphi survey findings

After four rounds of Delphi survey, it was found that the top seven weighted KPIs for TCC/GMP projects in Hong Kong emphasise project success, relationships and people in broad terms. Traditionally, project success is measured by project performance with reference to time, cost and quality[109, 110]. The findings are consistent in this regard because time performance, cost performance and quality performance take the third, second and fifth positions respectively in this study. On the other hand, the findings stress on relationships and people. There is no doubt that the other four out of the top seven weighted KPIs, that is: (1) Mutual trust between project partners; (2) Magnitude of disputes and conflicts; (3) Time required for the settlement of final project account, and (4) Contractor's involvement in project design, are important goals pursued by many of the project stakeholders who administer TCC/GMP contracts. The results are also in line with the previously published literature on KPIs for TCC/GMP projects[111,112,113]. The top seven KPIs are briefly discussed below.

Mutual trust between project partners

Wong and Cheung[114] considered that the establishment of mutual trust is essential for the success of partnering application. Black et al[115] carried out partnering studies and concluded that the development of mutual trust among partners is critical to the success of partnering implementation. Partnering is always adopted in parallel to TCC/GMP contractual

[109] Chan, D.W.M. and Kumaraswamy, M.M. (2002) Compressing construction durations: lessons learned from Hong Kong building projects, *International Journal of Project Management*, 20(1), 23-35.
[110] Same as 42
[111] Same as 22
[112] Same as 32
[113] Same as 51
[114] Wong, P.S.P and Cheung, S.O. (2005) Structural equation model of trust and partnering success, *Journal of Construction Engineering and Management,* ASCE, 21(2), 70-80.
[115] Black, C., Akintoye, A. and Fitzgerald, E (2000) An analysis of success factors and benefits of partnering in construction, *International Journal of Project Management*, 18(6), 423-434.

arrangements in Hong Kong as reported by Chan et al[116, 117] and Anvuur and Kumaraswamy[118]. Another similar study by Yeung et al[119] on evaluating the success of partnering projects in Hong Kong via a Delphi survey study also supported that "mutual trust and respect" is one of the essential KPIs for partnering projects.

Time performance

Time performance is one of the common KPIs worldwide[120,121]. Lam et al[122] regarded time as one of the KPIs for design-and-build construction projects in Hong Kong. Time performance was also perceived as one of the KPIs used to measure the success of a TCC underground railway extension project[123] and of a private office building project[124] in Hong Kong. Frampton[125] opined that TCC/GMP procurement strategies allow early commencement of activities before design is fully completed. It would be interesting to see if TCC/GMP schemes outperformed in terms of time certainty.

Final out-turn cost exceeding the final contract target cost, or guaranteed maximum price value, or not

The main feature of TCC/GMP is to incentivise the contractor to achieve cost savings by aligning the individual interests of the employer and those of the contractor together[126]. According to the fundamental principle under TCC/GMP schemes, both contractual agreements provide cost incentive to service providers to save cost during project delivery by linking the benefits of employers and service providers together. It is logical that the cost performance (i.e. whether final out-turn cost exceeding the final contract target cost, or guaranteed maximum price value, or not) of TCC/GMP schemes constitutes a significant KPI for this kind of projects like Chan et al[127.128].

[116] Same as 22
[117] Same as 32
[118] Anvuur, A.M. and Kumaraswamy, M.M. (2010) Promises, pitfalls and shortfalls of the guaranteed maximum price approach: a comparative case study. In: Egbu, C. (Ed) *Proceedings of the 26th Annual ARCOM Conference*, 6-8 September 2010, Leeds, United Kingdom, Association of Researchers in Construction Management, 1079-1088.
[119] Same as 82
[120] Same as 35
[121] Same as 41
[122] Same as 42
[123] Same as 22
[124] Same as 32
[125] Frampton, J. (2003) Can't be too sure on paper, *The Sydney Morning Herald*, November, 2003
[126] Rose, T. and Manley K. (2010) Client recommendations for financial incentives on construction projects, *Engineering, Construction and Architectural Management*, 17(3), 252-267.
[127] Same as 22
[128] Same as 32

Magnitude of disputes and conflicts

This finding is consistent with Lam et al[129] and Toor and Ogunlana[130]. TCC/GMP projects are usually implemented in parallel with the partnering approach[131,132]. It is suggested that partnering can be perceived to be a useful means to transform the contractual relationship into a cohesive, integrated project team with common goals and clear procedures for resolving disputes in a timely and effective manner[133]. It would be vital to evaluate whether TCC/GMP procurement strategies could effectively reduce disputes, or confrontations between contracting parties. Magnitude of disputes and conflicts can relate to how well the relationship between the client and contractor will be based on the gain-share/pain-share mechanism under TCC/GMP forms of contract.

Client's satisfaction on quality of completed work

Quality is referred to as conformity to contract specifications and client's satisfaction on constructed facilities. It is always ranked among the top priorities of construction projects[134]. Not surprisingly, quality of completed work was chosen as a KPI for TCC/GMP projects. The same has been widely reported in other literature on performance measurement in construction[135,136].

Time required for the settlement of final project account

A research study by Yiu et al[137] evaluated the performance of consultants in the construction industry of Hong Kong at four different stages, namely: (1) design/planning stage; (2) tender process stage; (3) construction stage, and (4) final account stage. The last stage (final account stage) recognised the settlement of the final account contributing to the success of a construction project. Early settlement of the final project account was regarded as one of the benefits of employing TCC/GMP schemes[138]. This KPI "time required for the settlement of

[129] Same as 42
[130] Same as 49
[131] Same as 16
[132] Same as 19
[133] Bench, R, Webster, M. and Campbell, K.M. (2005) An evaluation of partnership development in the construction industry, *International Journal of Project Management,* 23(8), 611-621.
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final project account" would be useful for gauging TCC/GMP projects for whether they can materialise this merit.

Contractor's involvement in project design

The significance of integrating the construction expertise into the design process has been recognised by the construction industry[139]. Mosey[140] shared similar perception that design contributions should not be made by design consultants only, but also by contractors and specialist suppliers to achieve a complete and functional design. This aspect is particularly important in TCC/GMP construction projects, since in many cases the contractor is involved at an early stage of project delivery, for example, at design stage[141]. The contractor's involvement in project design would probably affect the project outcomes in terms of time, cost and quality.

Conclusions

A vast amount of research studies about the performance measurement of construction projects has emerged over the past few decades. However, a comprehensive desktop literature review manifests that not much has been undertaken on the performance measurement of projects procured with the TCC and GMP forms of contractual arrangements. This study has identified the seven most important KPIs and has developed a holistic framework for assessing the overall performance of TCC/GMP projects within the construction industry of Hong Kong through a four-round Delphi survey. The top seven weighted KPIs sought in descending order include: (1) Mutual trust between project partners, with a weighting of 0.176; (2) Time performance, with a weighting of 0.163; (3) Final out-turn cost exceeding the final contract target cost, or guaranteed maximum price value, or not, with a weighting of 0.158; (4) Magnitude of disputes and conflicts, with a weighting of 0.136; (5) Client's satisfaction on quality of completed work, with a weighting of 0.131; (6) Time required for the settlement of final project account, with a weighting of 0.120; and (7) Contractor's involvement in project design, with a weighting of 0.115.

The main contribution of this study is that it has generated a solid framework for the performance measurement for projects procured with TCC/GMP contracts. The developed performance measurement tool helps compute a composite performance measurement

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index (PMI), which is composed of the most important KPIs for TCC/GMP projects in Hong Kong, to provide a single measure of project performance. It sets a benchmark for measuring the overall performance levels of TCC/GMP projects in Hong Kong, provided that there is an ample amount of completed projects in the local construction market for analysis. Project team members can just input their necessary values of individual project performance measures, and then compare the performance levels of different TCC/GMP projects within an organisation, between organisations or within the construction industry as a whole, to see where their TCC/GMP projects stand in relative terms. By doing so, the different performance levels of TCC/GMP projects can be evaluated and compared objectively on the same basis for benchmarking purposes at project completion, and can be monitored throughout the entire construction period as well.

Construction senior executives and project managers can use the PMI to measure, monitor, evaluate and upgrade the performance levels throughout the construction stage of project delivery of various TCC/GMP projects to strive for construction excellence with optimal outcomes. The established performance measurement tool has also enriched the existing knowledge base of both practitioners and academics in the construction industry about the KPIs for TCC/GMP schemes. Although the PMI model is primarily generated for Hong Kong, further research can be undertaken to applying the same research methodology to different geographical locations where TCC/GMP are more common such as the United Kingdom and Australia, to produce similar indices for international comparison between the East and the West.

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