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PERFORMANCE MEASUREMENT FOR CONSTRUCTION PROJECTS

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Abstract
Construction industry as one of the investment-led industries has exerted significant influence on the economy in the UK. Over the past few decades, the complicated business environment and rising competitiveness have increased the difficulty in performance measurement (Neely, 2005). Before taking steps to improve project performance, it is essential to accurately and integrally measure performance. Through critically reviewing literature from 1987 to 2018, the need for an integrated measurement system is a considerable gap because contemporary frameworks just research one of the multi-facets of performance from a particular angle (Jin et al., 2013).
The aim of this research is to develop a comprehensive model (HMCPPM) to hierarchically measure performance from the contractor perspective at the project level. HMCPPM is structured for linking measurement benchmarking to the project objectives more explicitly, assessing project outcomes and guaranteeing outputs, and realizing the performance comparison among different construction projects.
The quantitative method is utilized in this research because building a performance measurement model needs to make sure the generalization and broad applicability among different construction projects. As for data collection, literature-based data and first-hand data from questionaries will be collected to accomplish the model establishment. Analytical Hierarchy Process (AHP) as a decision-aiding method could be utilized to structure the hierarchical model and calculate the weights through pairwise comparisons and judgments of experts to derive priority scales.

Keywords: Performance Measurement, Construction Projects, Quantitative Research Method, Analytical Hierarchy Process.
JEL code: M10

Introduction

Construction industry as one of the cannonading investment-led industries exerts significant influence on the economy in any country. For the prosperity of any nation, numerous stakeholders attach importance fully to construction projects. Meanwhile, over the past few decades, the gradually complicated and global business environment and rising competitiveness have emphasized the significance of performance measurement (Neely, 2005). Construction industry usually acts as a catalyst to trigger the economic growth, however, plenty of government documentation mention that construction project performance is difficult to accurately measure and meet the requirements of environmental change and progressing alteration. (Harris and McCaffer, 2013).

Beatham et al. (2004) and Costa et al. (2006) state that the current performance evaluation lacks compatibility, applicability, and rationality. Most performance measurement frameworks just assess performance from one specific perspective in accordance with the technical background of researchers. There is a lack of a concrete hierarchical model to measure performance from the contractor perspective and realize performance comparison among different projects. Incongruous measurement system causes the misunderstanding of real to-date

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performance, and it will further exert negative effects on decision-making and project objectives realization.

This research critically reviews the literature related to construction project performance measurement and find the gaps in knowledge and practice. The hierarchical model and PI equation are developed to fill the gaps. Data deriving from questionnaires will be collected and analyzed to calculate factor loading and realize model modification through confirmatory factor analysis. Analytical Hierarchy Process (AHP) will be further used for differentiating formative and reflective factors, classifying prerequisites, identifying and quantifying indicators, calculating factor loading and implementing model modification (Kline, 2015).

Research Gaps in Knowledge and Practice

After reviewing literature related to construction project performance measurement, there are six gaps in knowledge and practice. Firstly, frameworks including BSC, KPIs, and EFQM generally measure the multifaced performance from different perspectives, however, specific to the construction project, there is no comprehensive model to effectively measure the performance from contractor perspective at the project level. It remains the main gap in knowledge, which could be further researched for the better-structured model.

Secondly, construction project performance measurement is relatively subjective over the past 30 years. To some extent, financial measures have historically been accumulated across functions aiming to project level. However, the non-financial indices related to construction project performance measurement are not easy to identify, and it has not been adequately researched, aggregated and restructured into a model. Research is still limited in this area.

Thirdly, The performance measurement indicators identified by previous research are relatively overloaded. Therefore, excessive measures will decrease the execution efficiency and increase administrative cost in practice. The measurement indicators with proper quantity need to be accurately identified.

Fourthly, construction project performance is difficult to precisely compare among different projects owing to the lack of a unified performance index. Researchers and practitioners encounter obstacles to compare the performance of different projects because of the shortage of universal and feasible measurement method, model and index, which could be transferred to use in every construction project and resolve contradictions among the various performance indices.

Fifthly, most performance measurement for the construction project will be executed after project delivery. It is lack of to-date model to measure construction project performance in the middle of the construction project implementation process rather than at the end of the project.

Sixthly, most construction projects only exist the static performance measurement system, however, with the advancement of the complexity of projects and growing uncertainty surrounding internal and external environment, the dynamic and flexible model needs to be structured to counteracting the deviation stemming from the changes in actual implementation.

Research Aim and Objectives

The research aim is to develop a performance measurement model for construction projects.

To achieve this aim, the following research objectives are established.

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1. To critically analyze current performance measurement methods and frameworks;
2. To systematically review the performance measurement system;
3. To identify, quantify and normalize performance measurement indicators;
4. To calculate the priority weight of every indicator;
5. To investigate the integrated project performance index (PI) equation;
6. To develop a performance measurement model of construction projects;

Contribution

In this research, the model of construction project performance measurement is hierarchically structured through redesigning the Balanced Scorecard framework, KPIs model, switch indicators as the prerequisite, and other seven measurement indicators to comprehensively, flexibility and timely assess performance. This model fills the gaps for the lack of the construction project performance measurement model.

Perfrmance measurement indicators are all identified, quantified, and normalized in an Integrated Project Performance Index (PI) equation. Sub-factors also could be identified during the project implementation process to reflect the to-date performance status. Cooperating with the priority weights calculated by Analytical Hierarchy Process (AHP), PI could accurately measure performance and realize performance comparison within projects or even among different construction projects. It is further in favor of performance control and improvement.

In practice, the hierarchical model of construction project performance measurement (HMCPPM) and Integrated Project Performance Index (PI) exist wide applications. From the perspective of contractors, HMCPPM and PI could assist them to more accurately control the to-date performance and adopt targeted measures for improving performance. HMCPPM and PI could further be coded as a plug-in of computer software to automatically and momentarily evaluate project performance using various data of different construction projects. Furthermore, HMCPPM and PI could help the contractors show strong evidence of previous successful performance to win the bid in the tendering and bidding conference. From the aspect of clients, HMCPPM and PI are beneficial to compare performance experience among different contractors, choose more proper contractors for future cooperation, audit real-time performance, and comprehensively evaluate the level of project performance in the whole construction industry.

Main Body

Concept of Performance Measurement

To quote Neely et al. (1997), “Performance measurement can be defined as the process of quantifying the efficiency and effectiveness of actions.” Similarly, Ghobadian and Ashworth (1994) propose that performance measurement has already exerted to enhance effectiveness and efficiency in the projects. More specifically, Mbugua et al. (1999) define the performance measurements as the process for systematically gathering and assessing the information about inputs, effectiveness, and efficiency of the construction projects’ actions.

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On the basis of different priorities, some researchers more focus on the association between project objectives and performance measurement. Sinclair and Zairi (1995) define that performance measurement as a process for assessing how successful organization or individuals have been realized their objectives. To be more explicit, Kulatunga et al. (2007) define the performance measurement as a process for determining progress to attain the prearranged objectives, containing the information on the efficiency with which resources are converted to outputs including goods and services, the quality of the outputs (how successful the deliveries are and how satisfied the clients feel) and outcomes (the variation between the predetermined goals and actual consequence).

Some authors define project performance measurement from the perspective of application value. Measuring performance is to measure the ability of previous performance in evaluating the prospective performance (Lebas, 1995). Conformably, researchers hold the similar view that performance measurement could be defined as a systematic method as a tool to evaluate the inputs and outputs in the process of project execution for constant enhancement (Love and Holt, 2000, Chan et al., 2001). As for construction projects, performance measurement has been defined as the formal and typical collecting and assessing of inputs, efficiency and effectiveness of construction projects activities (Sinclair and Zairi, 1995; Stevens, 1996; Atkinson, 1999; Mbugua et al. 1999; Love and Holt, 2000; and Chan, 2001).

Therefore, the concept of performance measurement in this research is utilized covering the above-mentioned extensive perspectives as a multi-dimensional set of factors and sub-factors to integrately, effectively, and flexibly evaluate the construction project performance.

Significance of performance measurement

According to Crowther (1996), it is forthright and explicit significance to the commercial community, as the vital survival of a commerce count on the competence of assessing performance. Performance measurement as an indispensable section of project management has operated since project management existed (Bassioni et al., 2004). According to Kaplan and Norton (2001), in contemporary literature, the research of performance measurement could be retrospected the first use of the technique of planning and controlling by U.S. railroad programme in the 1870s. The constant assessment for preceding accomplishment is a critical demand for advancement and process, and suits for cross-sectional comparison with other construction projects and further longitudinal comparison with the programme level or company level.

Bourne et al. (2000), Neely et al. (2000) proposed that there are seven reasons why managers give priority to performance measurement in the management process. Reasons cover dynamic nature of all the projects including enhancing competition, explicit advancement dynamism, domestic or international quality rewards, altering institutional roles, educated customers, and information technology. Beatham et al. (2004) further explain the reasons why it is imperative to utilize performance measurement system in the construction industry for assisting analyzing questions, measuring the definite activities, and predicting the future situations. However, good performance measurement further depends on the efficiency of human resource management. Data provided by practitioners without sufficient performance management ability will restrict the utilization of useful information to make constructive decisions (Alsulamy, 2015).

As cited by Phusavat et al. (2009), quantitative and qualitative data are applied to enhancing the performance through the decision-making process as follows. Project managers

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utilize the information to thoroughly comprehend and identify the objectives in current situations and further make more appropriate decisions.

Beatham et al. (2004) mention performance measurement in the project-oriented firms is being included as a portion of strategic process control planning owing to four justifications including position checking, position communicating, priorities confirmation, and progress compulsion. Firstly, performance measurement could constantly keep track of the procedure in every phase and evaluate the ongoing situation as position checking. Secondly, position communicating as another reason could notify clients and working staff the specific working performance evaluation results with an aim to improve the transparency and promote employee involvement. Thirdly, priorities confirmation means that performance measurement is beneficial to confirm the unified priorities and sequence of every activity and during the project life-cycle. Fourthly, progress compulsion demonstrates that explicit performance measurement contributes to identify potential enhancement spaces and further promote performance advancement.

The significance and necessity for the more integrated and well-structured model to flexibly, dynamically, effectively and accurately measure construction project performance are highlighted through analyzing the importance of performance measurement.

Performance Measurement Framework

The performance measurement framework is defined as an outright series of performance measures derived in a coherent pattern in line with the forward established regulations or guidelines (Anderson and McAdam, 2004). According to Neely et al. (2001), the frameworks for measuring performance including Balanced Scorecard (BSC), Key Performance Indicators (KPIs), and European Foundation Quality Management (EFQM) are all valid and correct. However, these frameworks research the multi-facets of performance from various angles. Different theories and frameworks related to performance measurement will be reviewed and discussed with an aim to develop further a more comprehensive model, which incorporate the more suitable relevant perspectives for measuring construction project performance from contractor perspective at the project level.

Balanced Scorecard (BCS)

In 1992, Robert Kaplan, the accounting professor at Harvard University and David Norton, a consultant from Boston area propose Balanced Scorecard (BCS) to prevent researcher or practitioners for unduly focusing on the financial measures rather than operational measures. It is not suitable enough for modern business companies and commerce to assess business performance from a sole financial aspect (Kaplan et al., 2001). Owing to the profound simplicity and unmistakable effectiveness, BCS is widely accepted by different size of enterprises and hailed by Harvard Business Review as one of the most dominant ideas in the 20th century. According to Niven (2002), BCS could play a significant role as a communication tool, measurement system, and strategic management. Specific to the construction industry, Bassioni et al. (2004) note that BSC as one of the most vital performance management tool was utilized and cited during the last 75 years. BSC keeps the balance between lagging performance measures (financial indicators) and leading performance measures (non-financial indicators) and further between outcomes evaluation and drive performance assessment (Kagioglou et al., 2001).

Typically Balanced Scorecard is used at the company level. However, it could be transferred to apply at the project level because to some extent; the project could be seen as a

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temporary firm (Lundin and Söderholm, 1995, Packendorff, 1995, Grabher, 2002). Specific to the construction project, the duration of the construction project is usually relatively longer. Over a period of time, the status of the construction project is comparably stable no matter for staff composition, management structure, team collaboration, personnel allocation, resource distribution, external environment, internal process, and ultimate objectives. It is even more rational to regard construction project as the temporary company and utilize Balanced Scorecard at the project level in this research.

Although Balanced Scorecard is the most prominent model in research and practice, it still exists some disadvantages (Neely et al., 2000). BSC only generally identify the four dimensions without measurable and fixed sub-indicators. In application, the firms using BSC still spend a high proportion to go into liquidation (Bourne et al., 2000). Furthermore, actual perspectives related to construction suppliers and contractors are supposed to cover. Hence, there is a gap for exploring and developing a more comprehensive model for measuring construction project performance by referring to BSC and other theories and models.

In this research, for structuring more suitable and effective construction project performance measurement, three aspects in the Balanced Scorecard will be transferred to utilize in the second level of HMCPPM model. As for the learning and growth perspective, it is more valuable to measure organizational performance rather than project performance. Considering the various project duration and project types, the feasibility and applicability to take learning and growth as measurement consideration are not very practical. For example, it may exist low-value and high-administrative cost to evaluate the differences in learning and growth aspect for one more time doing specialized construction activities (e.g. the installation of a variety of utilities). Furthermore, according to reviewing the literature from 1987 to 2018, most vital KPIs to assess construction project performance does not pertain to this field. Therefore, for avoiding overloading the model and increasing unnecessary management cost, three perspectives (Internal business, financial and customer perspectives) of BSC will be utilized in the second level of HMCPPM model to effectively and comprehensively evaluate performance.

European Foundation Quality Management (EFQM)

EFQM is a non-profit institution build up in 1988 originally with an aim to motivate business excellence in European. Based on concise practical experiences of private or public companies across the whole Europe, the EFQM assessment format as the huge breakthrough in performance and quality management has been applied effectively (Yang et al., 2001, Van Marrewijk et al., 2004). EFQM model is used to systematically assess the business performance and proposed nine weighted criteria including five enablers and four results with details of weighted sub-criteria for every criterion (Martín-Castilla, 2002). The “Enablers” are the aspects to apply force for future “Results” delivery. To put it another way, the “Enables” is related to what a company does and the “Results” are identified with what an enterprise accomplish (Carlos Bou-Llusar et al., 2005). Five enabler criteria including people, policy and strategy, partnership and resources and processes further could be separately divided into four to five sub-criteria. Four results contain people results, customer results, society results, and key performance results.

European Foundation for Quality Mangement (EFQM) Excellence Model as one of the performance measurement framework is the commonly utilized not only in Europe but also all over the global markets (Bourne et al., 2000). For instance, more than thirty thousand institutions in twenty-five countries use the EFQM Excellence Model to evaluate the performance and improve the bottom line (Soltani and Lai, 2007).

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EFQM Excellence model effectively measures the performance for long-term organizations and to some extent, it could be transferred to use at the project level. Comparing with the utilization of EFQM Excellence Model in relatively permanent organizations to focus on efficiency, projects give more priority to project objectives (effectiveness) because it exists the obvious completion date (Westerveld, 2003).

In this research, EFQM is not in compliance with the construction project performance measurement model. Firstly, Quality-based EFQM attaches more importance to project quality, however "Quality" and "Stafy" as basic switch indicators will be only guaranteed in the acceptable qualified level, so it is unnecessary to overassess these two indicators. The more specific explanation for the hierarchical structure of construction project performance measurement model (HSCPPMM) will be discussed. Secondly, the assumption of EFQM for same weights (50%) between enablers and results shows that critical success factors (CSFs) are regarded as enablers area and project performance measurements are deemed as results area (Westerveld, 2003). However, the precise coefficient of every KPI should be accurately calculated for matching the hierarchical measurement structure in this research hence there is no evidence to support the same weights for enablers and results are both 50%. Therefore, it exists high research and practical value to develop a more proper model for construction projects to link successful performance with proper performance measurements.

Key Performance Indicators (KPIs)

The first use of KPI was in 1961 for enhancing enterprise strategy in the firm named D Ronald Daniel (Pollard and Cater-Steel, 2009). After that, KPIs was developed generically as a benchmark since 1998 through Innovation Government Movement and Construction Best Practice Programme (CBPP) (Beatham et al., 2004) and further has been widely applied by the whole construction industry (Lin and Shen, 2007) to evaluate client satisfaction, schedule and financial situation, productivity, and deficiency.

By reviewing literature related to construction project performance measurement from 1987 to 2018, diversified key performance indicators are mentioned and analyzed from different perspectives. According to Swan and Kyng (2004), Ali et al. (2013), Chan and Chan (2004), the most reasonable range for identifying KPIs to effectively measure performance is from nine to twelve. Basic statistics in the following table mentions that there are nine indicators are widely recognized by researches during the past thirty years. The mentioned times from large to small for approved KPI to measure construction project performance is the cost (recognised as measurement indicator for 26 times), time (recognised as measurement indicator for 22 times), quality (recognised as measurement indicator for 17 times), client satisfaction (recognised as measurement indicator for 17 times), safety (recognised as measurement indicator for 14 times), team satisfaction (12), profitability (10), communication (7), and Billing (7) in following table.

Therefore, nine key performance indicators will be contained and restructured in the main levels of the hierarchy model for construction project performance measurement (HMCPPM)to comprehensively and effectively measure performance.

Discussion of the different frameworks

Through reviewing the three most extensively used theories or frameworks to evaluate performance including Balanced Scorecard (BSC), European Foundation Quality Management (EFQM), and Key Performance Indicators (KPIs), these frameworks evaluate multifaced performance from diverse aspects using unique classification method. There are some

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overlapping parts among the three theories, however, the limitations of each framework cannot be ignored.

The balanced scorecard is just generally identified the four perspectives without quantitative sub-indicators to feasibly implement in a specific business. Specific to the construction project, the differences between company and project impose restrictions on BSC applicability. Although BSC is a popular model, it can not be accepted and applied to directly transfer and utilize at project level without any adjustment. Owing to the simplicity and the intuitive logic, the widespread adoption and high acceptance by users of the balanced scorecard give a concise overview of company performance. EFQM gives too much priority to quality, the subjective indicator and the weights for “Enablers” and “Results” are both 50%. However, there is no evidence of showing the reason why Enablers and Results account for the same ratio. As for key performance indicator theory, KPIs are lack of the accordance with organization or project objectives and may not achieve the strategic demands. Concrete to construction project, project objectives as most explicit project development direction needs to be identified in the concept phase of project lifecycle. Furthermore, KPIs are difficult to precisely identify.

Therefore, the three frameworks are not perfectly matched with the need for construction project performance measurement. It remains the main gap in knowledge to develop a better-structured model. Therefore, there is a lack of comprehensive performanc measurement model to more accurately and effectively assess construction project performance.

Hierarchical Model for Construction Project Performance Measurement

Through reviewing the knowledge, methods, frameworks, measurement systems and indicators, a hierarchical model for construction performance measurement is structured. After that, every indicator in HMCPPM is quantified and normalized to further develop an integrated construction project performance equation. It fills the gap in knowledge and practice for accurately, flexibly, dynamically measuring construction project performance.

After critically reviewing and discussing the project performance methods, frameworks, systems, measurement indicators adopted in the literature from 1987 to 2018, the hierarchical model for construction project performance measurement (HMCPPM) as a formal and unified construction performance evaluation system is structured for accurately and flexibly measure to-date performance by all different layers.

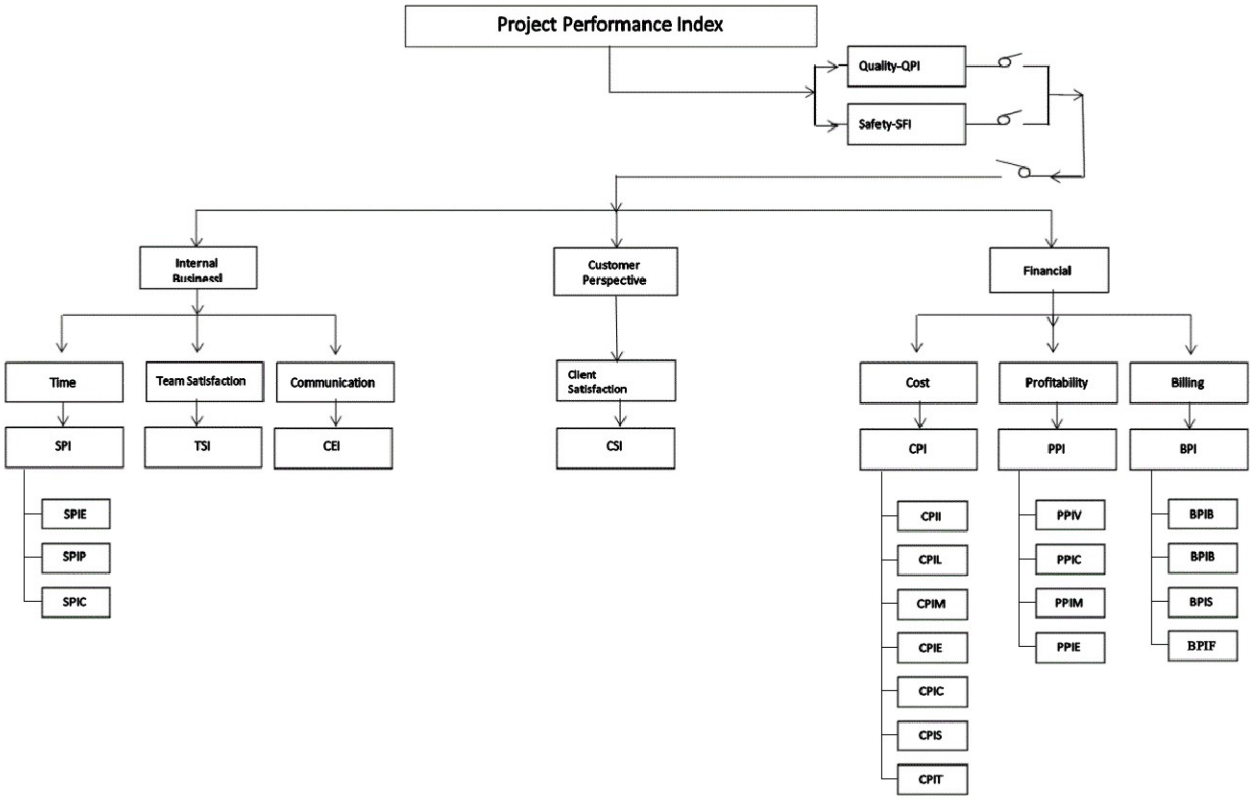

Fig. 1: **Hierarchical Model for Construction Project Performance Measurement**

As can be seen in figure 1, the first level is the integrated project performance, which should be further quantified and calculated to realize comparison among projects using project performance index (PI). Balanced Scorecard with high practical value to connect project objectives into short-term operational actions (Kaplan and Norton, 1996). Matching with the hierarchical structure and top-down method, for developing a more comprehensive and dynamic model, three aspects (Financial perspective, internal process, and customer perspective) of BSC are transferred to used at the project level as a second layer and each dimension is further divided into several KPIs following the objective-oriented performance evaluation (Bassioni et al., 2004). As for the reason why the fourth perspective of innovation and learning in BSC does not be utilized in the HMCPPM model, to some degree, it is needless for excessively taking long-term learning progress into consideration of temporarily construction project performance measurement (Kagioglou et al., 2001).

According to Parmenter (2015), the aspects of balanced scorecard could be further classified into more specific KPIs. According to a systematic review of performance measurement systems covering all the performance indicators for measuring construction

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performance from 1987 to 2018, nine KPIs was identified in this research including time, cost, quality, safety, team satisfaction, client satisfaction, profitability, billing, and communication.

Thereinto, quality, and safety as the switch indicator play a vital role in assessing whether the construction project is fundamentally qualified to keep measuring the specific performance. Quality and safety as two prerequisites screen out the qualified construction project, which meets the initial standards of successful project performance. If one of quality and safety is not qualified, there is no need to keep calculating the PI number. Another seven KPIs in the third layer separately are belonged to one of the three perspectives in the second layer. Internal business indicators include time, team satisfaction and communication. Client satisfaction belongs to customer indicator. As for financial indicators, there are three indices to measure containing cost, profitability, and billing.

Furthermore, according to different situation of each diverse construction project, indicators in the third level could be further classified into more detailed sub-indicators in the fourth level for flexibly satisfying the requirements in time.

In conclusion, the Hierarchical Model for Construction Project Performance Measurement is structured to fill the gap in knowledge and practice to optimize the accuracy and practicality of project performance evaluation. From the contractor perspective, HMCPPM could diagnose and correct the issues that might get in the way of achieving project objectives, manage expectations, improve the planning and control, advance the project process, take prompt measures for performance improvement, and further make longitudinal comparison among various construction projects. Moreover, HMCPPM and PI could help the contractors show strong evidence of previous successful performance to win the bid in the tendering and bidding conference. From the aspect of clients, HMCPPM and PI are beneficial to compare performance experience among different contractors, choose more proper contractors for future cooperation, audit real-time performance, and comprehensively evaluate the level of project performance in the whole construction industry.

Research Methodology

Quantitative research strategy will be used to test a theory. This research entails a deductive approach to the relationship between theory and research. It has incorporated the practices and norms of the model and of positivism in particular and embodies a view of social reality as an external and objective reality. As for data collection, literature-based data as second-hand data and first-hand data form questionaries will be used in this research.

The Analytical Hierarchy Process (AHP) as a decision-aiding method proposed by Saaty (1982) is a multi-criteria decision-making approach in which factors are structured in a hierarchical model. It could be calculated the weights even for intangible and subjective factors through pairwise comparisons and judgments of experts to derive priority scales.

Through AHP, Factors and sub-factors in different layers give the overall view of complicated inherent relationships in proposed conditions and assist the model users to evaluate whether the factors in different level are of the same order of magnitude. It is further beneficial for model users to easily and accurately compare the homogeneous elements.

There is no need to complete all levels of the hierarchical model and the factor in a given layer does not have to function as an attribute for all the sub-factors in below level. The feature of the AHP is suitable for the hierarchical construction project performance measurement model because it could keep the HMCPPM flexibility for adapting the potential possibilities for practitioners to further divide the index into more detailed sub-factors according to the real situation of construction projects.

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AHP could be transferred to use in construction project performance measurement (Zeng et al., 2007, Al-Harbi, 2001, Handfield et al., 2002). In this research, the hierarchy construction project performance measurement model is designed from the top (the construction project objectives) through the intermediate layers (classification on which subsequent levels depend) to the lowest level which covers more specific subfactors or indices. The structure of the model is appropriate for AHP analysis.

Data utilized in AHP usually comes from professionals judgments. Through pair-wise comparisons, priority vector calculation, consistency ratio and consistency index analysis of data from questionnaires, the priority weights (coefficient in PI equation) will be calculated. An integrated hierarchical model for construction project performance measurement will be further implemented to accurately evaluate to-date performance, provide strong evidence of performance assessment in tendering and bidding conference, proceed performance comparison among projects, assist project managers to take effective actions of performance improvement.

Integrated Construction Project Performance Equation

According to the Hierarchical Model of Construction Project Performance, the Integrated Construction Project Performance Equation should be shown as follow:

Integrated Construction Project Performance
$= f(Internal\ Business, Customer\ Perspective, Financial)$
$= f(time, team\ satisfaction, communication) + f(client\ satisfaction)$
$+ f(cost, profitibility, billing)$

In the second level of the model, integrated construction project performance could be measured by internal business, customer and financial perspectives. The equation could indicate relations.
Integrated Construction Project Performance
$= f(Internal\ Business, Customer\ Perspective, Financial)$

In the third level of the model, Internal business perspective is further divided into three indicators including time, team satisfaction, and communication. Customer perspective is shown through client satisfaction and financial perspective is classified into cost, profitability, and billing. The relation in the third level should be expressed using the following equation.
Integrated Construction Project Performance
$= f(time, team\ satisfaction, communication) + f(client\ satisfaction)$
$+ f(cost, profitibility, billing)$

Furthermore, the key performance indicators are quantified using related indices. Time (SPI), Team Satisfaction (TSI), Communication (CMI), Client Satisfaction (CSI), Cost (CPI), Profitability (PPI), Billing (BPI) are all quantified using unified standards name Earned Value Management (EVM) developed as the complement of PMBOK (Guide, 2004, Larson and Gray, 2015). Furthermore, for guaranteeing the arithmetic functions and operation among indices, all the indices in the equation should be normalized in accord with the range of CPI (Normally from 0.85 to 1.15) (Christensen and Heise, 1993, Christensen, 1994, Christensen and Payne, 1992).

Project Performance Index (PI) =

w1*SPI + w2*TSI + w3*CMI + Y*CSI + z1 *CPI +z2* PPI + z3*BPI

Where:
W is the priority weight for internal business perspective calculated in the second level of the model by AHP. w1, w2, w3 are the priority weights for SPI, TSI and CMI calculated in the third level of the model by AHP.
Y is the priority weight for customer perspective in the second level and CSI in the third level of model calculated by AHP.
Z is the priority weight for the financial perspective calculated in the second level of the model by AHP.
z1, z2, z3 are the priority weights for CPI, PPI and BPI calculated in the third level of the model by AHP.

w1+ w2+ w3= W
z1+ z2+ z3= Z
W+Y+Z= 1
w1+ w2+ w3+ Y+z1+ z2+ z3= 1

As for the calculation for the weights as the coefficient of indicators need to be considered in line with the different priorities in the construction projects performance measurement (Olson and Slater, 2002).

Conclusion

This research critically analyzes previous performance measurement literature. HMCPPM is hierarchically built to more effectively and accurately measure construction project performance. Quality and safety as two preconditions could guarantee qualified level performance with an acceptable output. Other seven factors (time, team satisfaction, communication, client satisfaction, cost, profitability, and billing) will measure performance from three aspects including internal, customer, and financial performance. In accordance with HMCPPM, integrated construction project performance equation is developed through analytical hierarchy process. The gap for lack of a comprehensive performance measurement model at construction project level from the contractor perspective is filled by HMCPPM and PI number.

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