Performance measurement systems in construction

PERFORMANCE MEASUREMENT SYSTEMS IN CONSTRUCTION

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In the manufacturing and construction industries, performance measurement is used as a systematic way of judging project performance by evaluating the inputs, outputs and the final project outcomes. However, very few companies systematically measure their performance in a holistic way. Moreover, the existing systems tend to focus more on product and less on process and design. This can lead to the sub-optimal quality of the performance measurement system, the misjudging of relative performance, and to complacency and the denying of appropriate rewards to the deserving. Previous studies have revealed that performance measurements can be measured in terms of financial and non-financial measures, or the combination of both. When measurements are being implemented, contractors, consultants and the management team's performances are blamed as the major reasons for the failure of a particular project. The other project stakeholders, such as client, suppliers, trade contractors and the community at large, are neglected. This paper reviews and synthesises some models for measuring construction performance that have been developed in the United Kingdom, USA, France, India, Hong Kong, Saudi Arabia and Malaysia. Based on this review and synthesis, the paper proposes the use of an 'amalgamated- model' of measurement approach that includes financial and non-financial indicators across project phases as a framework for measuring construction project performance.

Keywords: financial and non-financial measures, performance measurements systems, project stakeholders. .

INTRODUCTION

In the construction industry's present scenario, the systematic ways of performance measurement have influenced many construction firms, government sectors, public and private clients and other project stakeholders. Performance measurement is the regular collecting and reporting of information about the inputs, efficiency and effectiveness of construction projects. They use the performance measurement to judge their project performances, both in terms of the financial and non-financial aspects and to compare and contrast the performance with others, in order to improve programme efficiency and effectiveness in their organizations. Moreover, according to Steven *et al.* (1996), measurements are needed to tract, forecast, and ultimately control those variables that are important to the success of a project, and this has been agreed by many researchers and practitioners (Sinclair and Zairi, 1995; Mbugua *et al.*, 1999; Love *et al.*, 2000 and Chan, 2001). More specifically, Kelada (1999) suggests that those performance measurements not only apply to product or service quality and to business performance, but should also be extended to quality management, customer satisfaction, needs, wants and expectations, which incorporate the three stakeholders, namely; shareholder, customer and employees. The measurements can be classified along three broad dimensions. The first dimension refers to

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numerical/quantitative indicators, the second dimension focuses on qualitative/subjective matters and the final dimension refers to what and whose performances are to be measured. This is in line with Stevens (1996) views, who noted that the 'hard' and 'soft' sides of project measurement criteria are used in measuring project success, with time and cost being 'hard' and satisfaction being 'soft'. The research by Freeman and Beale (1992) and Riggs *et al.* (1992) contributes to the measurement of project success from the tangible and non-tangible aspects, where the tangible ones are in terms of cost and time, whereas the non- tangible may include customer satisfaction, the performance of the project manager, weather conditions and other attributes. The results have to be compared with the planned effort and reference value in order to identify the standard (Sinclair and Zairi, 1995; Stevens *et al.*, 1996; Atkinson, 1999; Mbugua *et al.*, 1999; Love *et al.*, 2000; Chan, 2001). This paper synthesises various systems of measuring project performance in the United Kingdom, the USA, France, India, Hong Kong, Saudi Arabia and Malaysia. The performance variables thrown up from this synthesis are then analysed to see if they reveals patterns of meaning.

SYNTHESIS OF PERFORMANCE MEASUREMENT MODELS

A literature review of the existing performance measurement models in construction, as shown in Table 1.0, would suggest that construction performance can be categorised in many ways, including the following four categories: construction project performance; construction productivity, project viability and project quality. These categories form the basis by which models have been developed to measure construction performance at various stages of development. These are discussed as follows:

Construction Project Performance Measurement models

Two models developed for measuring construction project performance are integrated performance index (Pillai *et al.*, 2002) and key performance indicator (Construction Industry Task Force, 1998)

Integrated Performance Index was developed by Pillai *et al.*, (2002) for performance measurement of R&D projects, based on their real-life experiences of working on the management system for the Integrated Guided Missile Development Programme of India. The model identified three project phases and dealt with performance elements such as performance indicators or key factors associated with each phase; the stakeholders; and the performance measurements. The three project phases identified are the project selection phase, the project execution phase and the implementation phase In order to measure the performance of a R&D project, Pillai *et al.*, (2001) listed eight prominent factors that cut across the three project phases as follows: benefit, risk, project preference, project status, decision effectiveness, production preparedness, cost effectiveness and customer commitment. By integrating these key factors using mathematical formulae, and based on their functional relationships, an integrated performance index (IPI) is computed. The usefulness of the integrated performance index is that it can be applied at all the phases of the project life cycle to rank the project for selection, to compare project performance under the execution phase and to act as an input for the management of future projects. One problem of the model is lack of clarity in the way the mathematical formulae is used to integrate the identified key factors into an integrated performance index. Given this shortcoming, this model is not well received by practitioners.

Key Performance Indicators (KPIs) is the UK construction industry's response to Egan's report (Construction Industry Task Force, 1998) to measure project performances, based on 10 identified parameters. These consist of seven project performance indicators; construction cost, construction time, cost predictability (design and construction), time predictability (design and construction), defects, client satisfaction with the product and client satisfaction with the service; and three company performance indicators namely; safety, profitability and productivity. The model begins by establishing the fundamental 'key drivers for change', which comprise committed leadership, focus on customer needs, product team integration, a quality-driven agenda and commitment to people. The quality-driven agenda in the key drivers means that the total package needs to deliver zero defects, be right the first time, deliver on time and to budget and exceed customer expectations. As part of the KPIs, definitions are provided with the industry performance graphs and a radar chart. The graphs allow analysis to be made by companies of their own results, by assessing these and comparing them with the radar chart that acts as a simple performance score-card. The strength of this model is that the overall concepts are easily understood and easily implemented by clients, designers, consultants, contractors, sub-contractors and suppliers. One problem with the model is that the KPIs are not compartmentalised along project phases.

Construction Productivity Measurement Model

One tool for construction productivity measurement of on-site performance is computerised activity sampling-*CALIBRE approach* (Winch and Carr, 2001). It focuses on the structural concrete element, given that this is potentially a major element in the budget and programme of any construction project. It measures performance, based on activity, based on an identified worker on a particular task, at a specific location, at a point in time. It measures project efficiency, in terms of ratio between inputs and outputs in the context of the total structural work programme. Inputs are 'available time' measured by observed operatives' man-hours from *CALIBRE's* activity sampling methodology and outputs as concrete delivered to the site in cubic metres. *CALIBRE's* activity sampling process has four main stages: mapping of the construction process, identifying the coding, monitoring the site (observations) and analysis, reporting and feedback. This enables data to be collected, analysed and presented to clients, contractors and other stakeholders. The result should reveal the performance of trade contractors for that particular element. This model is suitable for contractors to compare their physical productivity performance with others, and to improve on project productivity. The concept behind the model looks simple and straightforward, but still needs an expert to input the data so that the data are reliable and valid.

Project Viability Measurement Model

One model developed to measure project viability performance is the *Analytical Hierarchy Process* (AHP) by Saaty (1980). AHP has been widely used for a multi-objective decision-making approach that employs pair-wise comparison to determine the weights and priorities of various factors in relation to projects. In addition, the technique can be used to measure project success (Chua *et al.*, 1999) and the initial viability of projects for investment opportunity (Alidi, 1996). The basic assumption is that decision makers are able to structure a complex problem in the form of hierarchy, where each factor and alternative can be identified and evaluated with respect to other related factors, and finally, ranks the priorities of the projects under consideration.

Apart from this, it enables a comprehensive dialogue to be developed among all groups involved in the development of a project, in order to obtain a variety of strategic and tactical information. This technique has been widely used by the Inter-Arab Gulf Industrial Company to measure initial projects viabilities. AHP enables financial and human resources to be allocated more efficiently between projects prior to a detailed feasibility study (Alidi, 1996). The project viability AHP developed comprises four levels: the top level focuses on projected outcomes of various projects; the second level identifies the stakeholders or the groups involved; the third level identifies the groups' related objectives (budget, profit, productivity, technology transfer, etc.) with weight assigned to each objective; and the final level ranks the projects under consideration, relative to each of the objectives. The results of the synthesizing procedure rank the projects in terms of their initial viabilities.

Project Quality Measurement Models

Three models for measuring construction project quality are *project quality performance model*, based on critical variables developed by Chan (2001); *blueprint* by the Quality Performance Measurement Task Force (QPMTF) of the Construction Industry Institute (CII) for measuring quality performance on engineer-procure-construct (EPC) projects in the United States (Glagola *et al.*, 1992; Stevens, 1996); and *Quality Assessment System in Construction (QLASSIC) model* developed by the Construction Industry Development Board of Malaysia to assess the contractor's performance in terms of quality of the finished product (CIDB Malaysia, 2001b). Chan (2001) developed a *project quality performance model* based on some empirical study of project critical variables involving Hong Kong construction projects. Those variables are groups under the headings of client, project, project environment, project team leader, project management action and project procedure. These variables are regarded as independent variables where the impact and interaction of these variables will determine the dependent variable (i.e. quality performance). The client variables are identified from the nature of the organization, public or private sectors, clarity of project mission, their competency in terms of ability to brief, make decisions, and define roles. The importance of project characteristics and external environmental factors, which contribute to the project process and provide remarkable indicators in assessing quality performance, are highlighted. It is expected that the quality of a project depends to a large extent on the skills and experience of project team leaders; managerial system (in terms of decision making, choosing the correct strategy, setting-up specific objectives, selecting people, delegating responsibilities and evaluating results); and the procedures adopted during the construction process (in terms of the concept of procurement form and method of tendering). A causal relationship between the factors affecting quality performance were established, which shows that an increase in client satisfaction with quality is achievable through better project management actions, effectiveness of the team leader, viability and feasibility of procedures and stability of the project environment. One of the weaknesses of this model is that the variables are not grouped based on project phases and fail to identify the responsibilities, needs and expectations of project stakeholders in each project phase.

Blueprint outlines a process that firstly identifies project variables that are important in improving quality; secondly illustrates why and when these variables should be measured; thirdly furnishes examples of how to measure these variables; and finally suggests how the results of the measure can be used in making project decisions. Those measurements are implemented according to the project phase. Within each of the project phases, measurements are divided into the four fundamental TQM elements: customer focus, leadership, and the delivery process and employee empowerment. Apart from that, seven tools are used to facilitate the implementation of the blueprint namely; the flowchart (which defines business objectives, assigns the business team for all major phases, translates business objectives into a project objective, determine inputs, outputs and defines targets), the project-phase model, the quality-evolution chart, the cause and effect diagram, the SIPOC (suppliers, inputs, process, outputs, and customer) chart, the quality-measurement matrix and the 'critical few' worksheet. In the critical few worksheets, the team determines the measurements that align with the four TQM elements that impact on the project objectives and the SIPOC components. The strength of this model is that, it is able to assist project teams in developing a set of quantifiable and predictive quality performance indicators, which could be used across the construction industry to measure the quality of, and identify improvement areas for, the EPC process. In fact, the model embraces a complete performance measurement programme across project phases, including the seven tools to facilitate the implementation programme.

QLASSIC model is currently used by the Construction Industry Development Board of Malaysia. The five key objectives of the model are: to evaluate the quality of workmanship, to comply with a set of approved standards and specifications, to compare quality between projects, to evaluate a contractor's performance and, finally, to estimate the productivity level of the project. The model emphasises three components of construction physical works namely; structural, architectural and external. Assessments of workmanship are done, based on some standards that are set out, and points are awarded if the workmanship complies with the standards. Forty per cent of the classic points are allocated to the standard of structural works, fifty per cent for the standard of architectural works and ten per cent for the standard of external works. Assessments are conducted on the three components and points are summed up to give a total score, called the *QLASSIC score* for the building. The assessment of structural work is done during the construction process, while both the architectural and external works are conducted after the completion of the project, before handing over to the client. *QLASSIC evaluations* are done for superstructure components of a building and do not cover substructure works, mechanical works and electrical services. The strength of this model is that it is very simple to implement. However, a major weakness is that assessment of architectural and external work is not conducted until the project is completed. In summary, most of the measurement approaches above, if not all, focus on measuring project performance across project phases, by identifying key factors or indicators (financial and non-financial) at each project phase (Pillai *et al.*, 2002; Construction Industry Task Force, 1998; Chan, 2001). To achieve an optimum process success, the performances of the project client, management team, contractor group and customer/end-users associated with the project should be assessed. For example, where customers are involved at the early project phases their needs and expectations can be integrated into the project brief and implementation. However, most of the systems and techniques developed to date have only considered a specific stakeholder rather than looking at a project in a holistic way. In fact, to a certain extent, the perception of the outcome of the project will differ depending upon the particular perspective of each project stakeholder (Dainty *et al.*, 2003). For example, CALIBRE and QLASSIC models mainly assess the contractor's performance in terms of project productivity and quality respectively, and individually, whereas, the AHP model concentrates on assessing project viability. While these techniques are good on their own, they are not appropriate to an embracing view in assessing construction project performance at all project phases of a construction project. The 'blueprint' technique developed by Stevens (1996) seems to provide a complete project performance measurement programme. It may be possible to adopt as recipes, in the course of developing a holistic construction project performance framework, the models developed by Pillai *et al.*, (2002); Construction Industry Task Force (1998); Stevens (1996); and Chan, (2001). In addition, the quality, viability, productivity, stakeholders measures developed by Love *et al.*, (2000); financial measures by Kangari *et al.*, (1992); employee measures by Abdel-Razek (1997); Interaction Process Model by Bales (1950) cited in Gorse *et al.*, (2001) are relevant in such a recipe. It is proposed that an **'**amalgamated-model', which brings together the best practice from the existing techniques and models, will be more appropriate in measuring construction project performance.

RESEARCH METHOD

This research is based primarily on a literature review of measurement systems developed internationally to assess project performance. Based on various systems and techniques of project performance that have been developed, a use of an **'**amalgamated-model' of measurement is proposed to measure project performance across project phases: strategy formulation-phase, procurement-phase, and implementation-phase and project completion-phase. Twenty-eight performance indicators, dealing with financial and non-financial criteria, are proposed. These indicators are a combination of identified critical success factors, efficiency and effectiveness variables across project phases. The needs and expectations of project stakeholders (client, consultant, contractor, supplier, end-user and the community) are emphasised through 'process improvement programmes' at relevant project phases.

AN 'AMALGAMATED-MODEL' OF MEASUREMENT

Figure 1 shows a framework for an amalgamated-model (i.e. two step processes) in measuring construction project performance.

STEP 1: Project Success factor, efficiency and effectiveness performance
Fundamentally, the model starts with Step 1, which identifies the critical success factors (those inputs to the management system) across project phases. These critical success factors have a tendency to affect project performances (Cooke-Davies, 2002; Pinto and Slevin, 1987). Corporate missions, corporate objectives and top management's philosophy are proposed to be the most critical success factors at the project strategy-formulation phase, which is in line with the view of Mbugua *et al.*, (1999). In the procurement-phase, six critical success factors are proposed in terms of procurement strategy, developing a clear and concise project brief, project feasibility and viability, lead time, accuracy of preliminary cost and time estimate. In the project implementation phase, fourteen indicators are proposed as critical success factors, whereas five indicators are in the project completion stage. This step also highlights the importance of addressing the needs and expectations of project stakeholders associated with each project phase, and stresses that a project is only successful to the extent that it satisfies the needs of its intended user. In addition, the implementation of the process improvement programmes, such as value engineering, supply chain management, collaboration programmes, partnering, total quality management, health and safety, risk management, information technology and other forms of improvement programmes at each project phase, will provide opportunities for the client and project

team for the continuous development of generic construction products across project phases. Two elements of measuring project success are emphasised vis a vis efficiency and effectiveness. The efficiency element measures the ***'processes'*** (efficiency in the strategic planning, management and utilization of resources) and it relates to the project outputs. The efficiency measures would only be achieved where: standard; systems of measurements; and methodology are provided for benchmarking (George, 1968). On the other hand, the effectiveness element measures the ***'results'*** and it relates to the project outcomes such as the core business and project objectives, users' satisfaction and the use of the project. Project success is usually measured against the achievement of goals that were predetermined at its outset which is in line with the view of Dainty *et al.,* (2003)

STEP 2: Project performance indicators and scoring

Following successful implementation of Step 1, this should be followed and provide an input to Step 2, at which stage the performance indicators are considered. These indicators should be examined regularly to achieve a continuous improving project success (after CBPP, 2002). A further benefit from Step 2 of the model is that it acts as an instrument to measure project success, based on the proposed twenty-eight indicators across project phases. The radar chart or a score card system included in Step 2 should make it possible to determine a score (0-100) for each factor of a given project. The nearer the plotted line is to the outer perimeter of the chart, the higher the overall performance is for a project (after the Construction Industry Task Force, 1998). This process should be carried out at every phase of a project to ensure optimum project success at the project completion.

CONCLUSION

Many frameworks that have been developed to assess construction project performance are found to be rather more theoretically based than empirically proven. Realizing this, the paper has established, and developed, conceptual and fundamental inter-relationships between critical factors, efficiency and effectiveness performances, and process improvement programmes with project success. The research presented in the paper is part of ongoing PhD research to develop a framework to determine criteria for successful project performance. Primary data, based on a combination of a questionnaire survey, case studies and semi-structured interviews of the Malaysian Construction Industry, focussing on the Selangor and Wilayah Persekutuan areas of Malaysia, are currently being collected in order to tackle the overall aim and objectives of the research. These processes are underway and hopefully the outcomes of the empirical research will be reported at a future conference of ARCOM.

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Table 1: List of performance measurement systems developed internationally

Project Performance Measures		**Project Productivity Measures**	**Project Viability Measures**	**Project Quality Measures**		
INDIA	**UK**	**France**	**SAUDI ARABIA**	**HONG KONG**	**US**	**MALAYSIA**
Integrated Performance Index (Pillai *et al.*, 2002)	Key Performance Indicators (KPI's) Egan, 1998)	CALIBRE approach (Winch and Carr, 2001)	Analytical Hierarchy Process (AHP) (Alidi, 1996)	Critical Variables (Chan, 2001)	Blue Print (Stevens, 1996)	QLASSIC (CIDB Malaysia, 2001b)
Who is being measured: ***Client, mgmt team, customer***	Who is being measured: ***Client, contractor, mgmt team, end-user***	Who is being measured: ***Trade contractors***	*Who/what is being measured:* ***project***	Who is being measured: ***Client, mgmt team, contr., suppl., ext.factors***	Who is being measured: ***Client, mgmt team, supplier, customer***	Who is being measured: ***Main Contractor***
Major concerns Selection-phase Execution -Phase Implementation -Phase **Indicators** Benefit/merit Risk Project Preference/category bias Project Status Decision effectiveness Production preparedness Cost effectiveness Customer commitment **Stakeholders** Sponsoring organization Project management Customer	**Cost predictability** Design cost Construction Cost **Time predictability** Design time Construction time Construction cost Construction time Productivity Profitability Safety Defects Client satisfaction on product Client satisfaction on service	Measure the project efficiency - ratio between inputs and outputs in the context of total structural work programme. Inputs (man-hours observed) and Output (concrete deliveries – in cubic metres) Based on activity sampling method. **Four main Process:** Mapping the construction process(WBS) Identifying & coding Monitoring site (observation) Feedback & analysis **Results**: Benchmarking the performance of trade contractors	Used to measure the degree of initial viability of the project prior to making the final decision. **Structure a complex problem in the form of a hierarchy.** **<u>Level 1:</u>** Ranking of the various projects and focus on projected outcomes **<u>Level 2:</u>** Identifications of the groups' objectives **<u>Level 3:</u>** Establishing the weights for the objectives **<u>Level 4:</u>** Ranking the alternatives goals relative to all objectives	Client variables Project variables Project procedure variables Project environment variables Project management action variables Project team leader variables	Defines business objectives Determines project phase model Forming Business Mgmt. Team Translate business objective into project objectives Analyse key elements Determine all major inputs, outputs, customer/supplier relationship Select measurements Defines targets/ Benchmarks	Assessment used weighting system: **Str. work elements** Formwork Reinforcement Finished concrete Material quality **Architectural Work Elements** Floor Wall Ceiling Door and window Plumbing and sanitary Building components Material quality **External Work Element** Apron Drain Road surfaces & Footpath Turfing Fence &gate

(**Source**: Pillai *et al.*, 2002; Egan, 1998; Winch and Carr, 2001; Alidi, 1996; Chan, 2001; Stevens, 1996; and CIDB Malaysia, 2001b)