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PERFORMANCE EVALUATION FRAMEWORK FOR ENGINEERING CONSULTANTS OF TAIPEI RAPID TRANSIT SYSTEMS

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ABSTRACT: The quality of performance evaluation on engineering consultants that provide design-related technical services is difficult to be measured, and only a handful of papers discussed the quality during the design stage. Although design cost is relatively far less than construction cost for a project, the decisions made in the design phase have a significant impact on the final products of the project, especially for large public construction projects. Therefore, this research focuses on reviewing and then establishing a performance evaluation framework for the consulting firms that execute detailed design and provide technical services for the Taipei Rapid Transit Systems (TRTS). By interviewing experts, this study first established a set of indicators to evaluate these firms' performance. Then, those indicators were incorporated into the four aspects of balanced scorecard (BSC) to establish the architecture of the evaluation mechanism. The weight of each indicator was calculated by analytic hierarchy process (AHP) from a survey conducted among experts. The results showed that the top-three indicators were quantity take-off, functions conformity, and budgeting. The framework of performance evaluation established by this study can be applied to measure service performance during the design stage. It not only facilitates the monitoring of consulting firms, but also helps to reduce unnecessary change orders and disputes during the construction stage.

Keywords: Engineering Consultant, Performance Evaluation, Balanced Scorecard, Analytic Hierarchy Process, Taipei Rapid Transit Systems.

1. INTRODUCTION

Taipei Rapid Transit Systems (TRTS) offers millions of daily commuters who live in the greater Taipei metropolitan area a means of safe, economic, comfortable, and convenient way to commute. The system also brings prosperous economic developments to its peripheral areas. Thus, it is crucial that construction of such system meet all its expectations through out its construction lifespan starting from the initial designing stage. It is also vital to conduct performance evaluation right from the designing stage where early amendments can be made to avoid unnecessary changes derived from the construction stage. The amendments not only increase the degree of customers satisfaction, but aslo minimize construction disputes, preventing prolongation of constrution time or possible overruns of construction costs.

2. LITERATURE REVIEW OF PERFORMANCE EVALUATION

2.1 Performance Evaluation

This research collected related performance evaluation systems of domestic public engineering organizations in Taiwan（Taipei City Government [1], Taiwan Area National Expressway Engineering Bureau under the Ministry of Transportation Communication [2], Construction and Planning Agency under the Ministry of the Interior [3]）and literature of overseas performance evaluations [4, 5, 6, 7] for comparison. Meanwhile, performance indicators of aforesaid perspectives were noted. The purpose is to investigate and evaluate different aspects, so the performance of the firms may be fully presented. The collected vast amount of performance evaluation data serve as the basis of follow-up interviews, evaluation indicator selections and evaluation mechanisms. The comparison between every evaluation mechanism and indicator aspect is shown in Table 1.

2.2 Balanced Scorecard (BSC)

While the "Balanced Scorecard (BSC)" concept and terminology was coined in 1988, the roots of performance management as an activity run deep in management literature and practice. In 1996, "The Balanced Scorecard: Translating Strategic Into Action" written by Professor Kaplan of Harvard Business School and Mr. Norton, CEO of Renaissance Solutions, Inc., dipicted the combination of science finding in conjunction with practical application. The core value of BSC highlights the concept "BSC–transform strategy into action" on the achievement of organizational vision and strategy [8].

Table 1. Comparison between Performance Evaluation Mechanisms of Domestic and Foreign Government Authorities and Research Units

Sponsoring agency or Research unit	Evaluation timing and frequency	Outcome / reward of evaluation outcome	Indi-cators	Aspect of design services performance indicator	Advantages	Disadvantages
Taipei City Government	Upon 40%, 70% and 100% of the completion of construction, a preliminary evaluation will be conducted within a 2 months period.	Based on the criteria for managing the performance of contract for technical services, evaluation outcome does not only include penalty, but also covers a 15% in the total of the follow-up evaluation.	Quali-tative	1. Services suggestion report 2. Contract regulation 3. Proprietor requirement 4. Progress management 5. Cordiality and level of professionalism.	1. Indicators possess specialty 2. Evaluation outcomes offer not only deduction in payable, but they are also influential in the follow-up buying evaluation.	1. No quantitative indicators with objectivity 2. The class interval standards are not thoroughly classified in qualitative indicators
Taiwan Area National Expressway Engineering Bureau	1. Half-year evaluation 2. Annual evaluation (average value of the half-year evaluation) 3. Evaluation upon completion	If awarded "third" in the evaluation, the evaluation mark for the following three years will be considered as reference, but this is only the internal regulation of the Agency.	Quali-tative	1. Technical quality 2. Quality control 3. Coordinated cooperation 4. Progress control 5. Personnel disposition.	Indicators possess specialty.	1. No subjective quantitative indicator 2. Sanction for the follow-up buying evaluation is yet to be evaluated.
Construction and Planning Agency	When the project is out on the market for tendering, evaluation for the layout design will be conducted.	Offered as reference for internal management, but offers no sanction for the follow-up evaluation.	Quali-tative	1. Progress control 2. Cost management 3. Technical quality 4. Coordinated cooperation 5. Personnel disposition 6. Operating layout	Not only to consider progress, quality, cost and personnel disposition, but operating layout will also be evaluated.	1. No subjective quantitative indicator 2. No sanction for the follow-up evaluation
FIDIC Guidelines for the Evaluation of Consultants' Performance	1. Once per year 2. Within 90 days of the termination of the contract, closed-case evaluation will be conducted.	Offered only for the proprietors or creditors to evaluate the services quality and obligation execution.	Quanti-tative	1. Technical code 2. Management code 3. Overall performance code	All indicators are quantitative with objectivity.	Primary purpose is for the proprietors and creditors to evaluate obligation execution, no sanction on the follow-up buying.
Britain consulting performance evaluation system	Once per year	The evaluation outcomes are offered as reference for the proprietors to select excellent firms.	Quali-tative and Quanti-tative	1. Progress 2. Cost 3. Quality 4. Proprietor satisfaction 5. Operating performance.	1. Offered the firms with identical indicator framework in uniformity. 2. Proprietors to select excellent firms through the evaluation outcomes	Since Firms participate the Construction Commission evaluation at will, Construction Commission has lower active control over management.
Operating performance evaluation of Australia consulting company	Once per year	The evaluation outcomes are offered as reference for the proprietors to select excellent firms.	Quanti-tative	1. Profits/Efficiency 2. Financial management 3. Customer satisfaction 4. Future investment	1. Offered the firms with identical indicator framework in uniformity 2. Proprietors to select excellent firms through the evaluation outcomes.	1. Since Firms participate the Construction Commission evaluation at will, Construction Commission has lower active control over management. 2. Evaluation purely conducted with company's operating indicators, the data is sensitive and will lower the willingness of the firms for participation.

Kaplan & Norton categorized performance evaluation indicators into four aspects: financial aspect, customer aspect, internal business process aspect, and learning and growth aspect, as shown in Figure 1. The four framework aspects being part of the Balanced Scorecard design process can fit corporate vision and strategic planning. Under cost saving, a strategic Balanced Scorecard can integrate with business management process and transform business thinking into the concreate scheme of business operation.

BSC has been widely used in many enterprises as a method for performance evaluation management. It strongly suggested the performance evaluation be processed by the four perspectives of performance evaluation (finance, customers, internal processes, and learning and growth) so that the deficiency of evaluating performance executed only by financial indicators can be avoided while the performance evaluation system possesses both strategic management and balance management.

2.3 Analytic Hierarchy Process (AHP)

AHP is a multi-objective decision making method developed by Professor Saaty when he conducted a problematic study on contingency plans for the United States Department of Defense. It is mainly applied in uncertainties and in the decision-making problems with several evaluation criteria, especially fit for the evaluation of qualitative information. After this method turned the complicated problems into a hierarchical chart, decision makers could make pairwise comparison according to the evaluation criteria of each level, create a comparison matrix so as to discover the relative weight among each criterion, and finally calculate the rating or weight of each selected alternatives with the relative weight to serve as a reference for decision makers [9, 10].

AHP possesses the merits of high reliability, high validity and high width of researches. After integrating the attributes of AHP in management, such as it is widely used in performance evaluation and weight establishment, this study adopts AHP to create the weight of performance evaluation indicators.

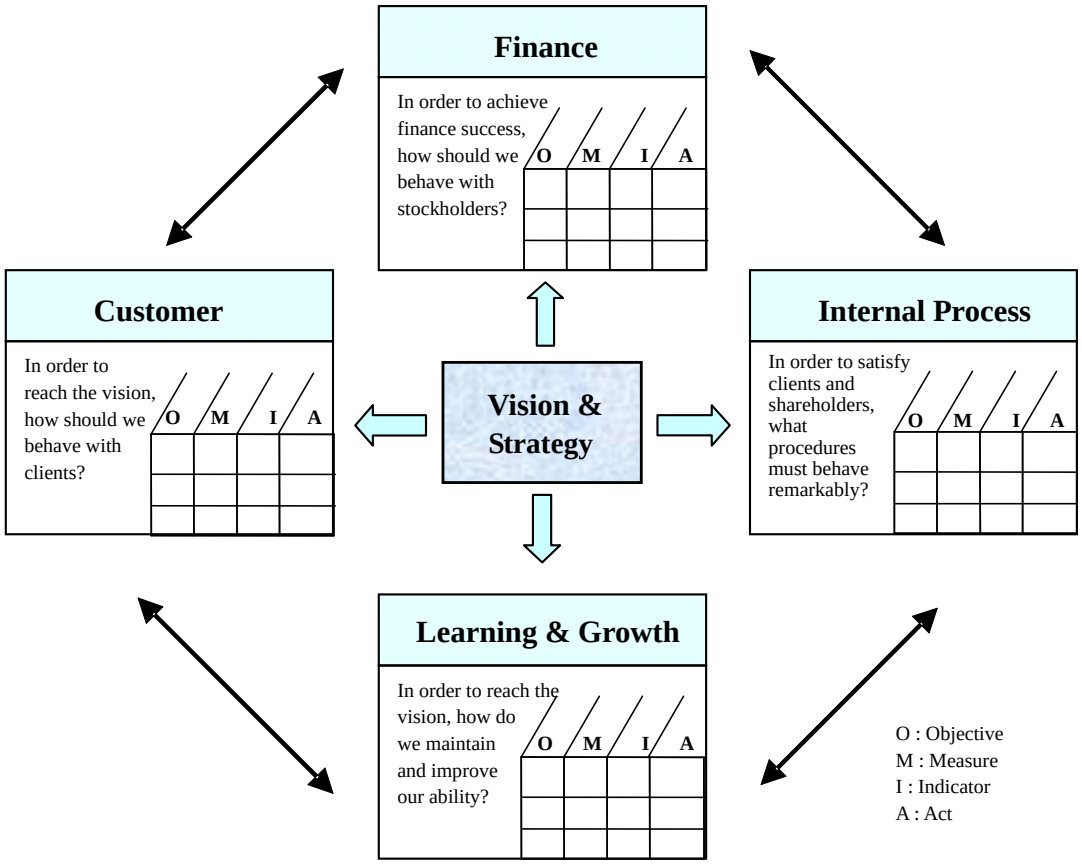

Figure 1. BSC Structure Chart（Source:[8]）

3. ESTABLISHING THE DESIGN PERFORMANCE EVALUATION FRAMEWORK

3.1 Determination of indicators and framework

After the sorting of the preliminary established performance evaluation indicators for the design firms, one supervisor and two senior engineers responsible for management of the detail design contract execution in the organization were interviewed and asked to select the indicators through their years of professional knowledge. Evaluation indicators that were deemed as of "critical importance" by most professionals were then selected as the gradual performance evaluation indicators for the construction design firm.

BSC has assisted organizations in the ability to carry out tactics efficiently with the provision of systemized framework and methods, so that the organizations might be able to progress toward its intended goals. Thus, this study attempts to apply the concept of BSC to establish the framework of performance evaluation indicators for the project team in charge of detailed design of the organization. Since purpose of a construction project is to provide the public with safety, comfort and convenience, the performance evaluation framework should regard the improvement of the quality of design services offered by the design firms as its ultimate goal. In view of that, this study places the customer perspective on the top of the list and discusses the framework of performance evaluation for design firms based on the priority of the links, customers, finance, internal processes, and learing and growth. Therefore, twenty-four indictors, catagoriazed into these four aspects of BSC, were finally selected by the experienced supervisor and senior engineeers, as shown in Table 2.

3.2 Establishing the mechanism of performance evaluation indicators

Considering the objectivity of indicator weight, this study incorporated the Analytical Hierarchy Process (AHP) to conduct expert questionnaire. Thirteen experts with more than 10 years of experience were interviewed to complete the questionnaire. Based on statistics of investigating result, the weights of four perspectives are 16.3% for client, 45.6% for finance, 22.0% for internal process, and 16.1% for learing and growth, respectively. Among them, the weight of perspective of finace, 45.6%, is the highest. It shows that owners have high expectation on achieving the goal of budget and creating effectiveness and benefit of result. Design service contractors shall take off quantity, esitamte construction cost, and fulfill owners' requirements on function accordance deliberately with minimun cost.

Moreover, the weights of the following indicators, "F1-1, Accuracy of Quantity Calculation" (16.9%), "F2-1, Conformance of Function" (13.0%), and "F1-2, Construction Cost Estimate" (11.8%) are among the highest. It shows the characteristic of high sensitivity. They shall be managed with special cares during the design stage. Besides, the weights of the following indicators,"Q2-2 , Document Management" (0.8%) "Q2-1, Document Verification Response" (1.0%) "Q1-2, Human Resource Organization" (1.0%) are lower. From the research result, it shows that the weight of internal process perspective (22%) is less than the finance persepective (45%). Since its tactic objectives to be acheived are more than those of other three perspectives; comparatively, it consists of many indicators which then causes the weight of single indicator is lower than others after AHP analysis. Although the weight of the indicator is lower, service providers still have to execute the contract with care. It would maintain the overall quality of the internal process persepective at certain level and promote service performance of projects efficiently.

3.3 Example for rating an indicator

The design performance evaluation form that established by this study is shown in Table 2. Indicator source originated from information easily retrieved in detailed design procedure could be pragmatic and applicable. Rating criteria denotes related domestic and foreign periodicals and literatures. The criteria involve the rating scale of stardard based upon contract performance of detail design firms.

From the aforesaid evaluation sheet, the heighest weighted indicator, "F1-1 Accuracy of Quantity Calculation" , is choosen as an example to explicate the content of indicators and the 5-point scale. The F1-1 indicator means consulting firms of design service must conduct the quantity calculation based upon drawings of detailed design, so that follow-up construction take-off can be proceeded. Precise quantity take-off and no missing item would affect the cost directly. The lack of requried item can result into delay of schedule for procurement of construction material. Therefore, its 5-point scale is designed as follows.

□Below 55 □60 Not following design drawings to list items or take off quantity, and missing items with errors in quantity calculation over 10% of the contract amount.

□65 □70 Following design drawings to list items and take off quantity, but missing items with few errors in quantity calculation.

□75 □80 Following design drawings to list items and take off quantity, and no missing items with very few errors in quantity calculation.

□85 □90 Following design drawings to list items and take off quantity, and no missing items with accurate quantity calculation.

□95 □100 Following design drawings to list items and take off quantity, and the detailed complete quantity calculation report is easy to cross examination and reference. Aforesaid items are checked for its compleness and accuracy.

Depending on the quantilty calucuation provided by the design service contractor, the appraiser may evaluate and check on suitable grades. After all the 24 elvaluation indicators are evaluated and checked, they are multiplied by the respective weights listed on Table 2 to attain the total of the evaluation for that consulting firm.

Table 2. Evaluation Sheet of Design Performance

Aspect	Strategy Objective	Indicator	Weight%	Score	Weighted Score
Customer (16.3%)	C_1 Promote Service Performance	C_{1-1} Design Progress	2.1		
		C_{1-2} Question Solution Proposal	3.0		
	C_2 Promote Owner Satisfaction	C_{2-1} Owner Satisfaction	8.3		
		C_{2-2} Communicate Coordination	2.9		
Finance (45.6%)	F_1 Reach Budget	F_{1-1} Accuracy of Quantity Calculation	16.9		
		F_{1-2} Construction Cost Estimate	11.8		
	F_2 Create Result Efficiency	F_{2-1} Conformance of Function	13.0		
		F_{2-2} Value Engineering	3.9		
Internal Process (22.0%)	Q_1 Practice Project Management Strategy	Q_{1-1} Project Manage Method	1.2		
		Q_{1-2} HR Organization	1.0		
	Q_2 Strengthen Document Integration	Q_{2-1} Document Review and Reply	1.0		
		Q_{2-2} Document Management	0.8		
		Q_{2-3} Accuracy of Design Document	2.9		
	Q_3 Ensure Design Quality	Q_{3-1} Quality Assurance	1.5		
		Q_{3-2} Responsibility of Change Order	2.6		
		Q_{3-3} Impact of Environment & Ecosystem	2.4		
	Q_4 Completeness of Design Document	Q_{4-1} Basic Data Collection	1.5		
		Q_{4-2} Design Analysis	1.0		
		Q_{4-3} Constructability	3.4		
		Q_{4-4} Interface Integration	2.7		
Learning & Growth (16.1%)	S_1 Promote HR Effectiveness	S_{1-1} Degree & Certificates	1.4		
		S_{1-2} Expert Experience	5.2		
	S_2 Promote Member Professional Skill	S_{2-1} Training	7.2		
		S_{2-2} Research & Development	2.3		
Total			100.0		

Notes：
59 or less: Awful Performance
60 to 69: Poor Performance
70 to 79: Fair Performance
80 to 89: Better Performance
90 to 100: Excellent Performance

4. Conclusion and suggestion

This reaserch collected performance evaluation indicators from domestic and overseas literatures. Through expert interviews, total 24 items have been selected as the indicator to service performance evaluation at the design stage of MRT detail design contract. And BSC (Balanced Scorecard) was introduced to categorize those indicators into four dimensions – customer, finance, internal process, learing and growth. Then, this research adopts AHP (Analytical Hierarchy Process) to set up each indicator's weight. The indicators were further divided using a 5-point scale that distinguishes the indicators and establishes the score-intervals between them. A complete evaluation model for consulting firms was then esblished.

As to the rating results of the design firms' design performance, the organization can require the firms to improve their poor performance in light of the indicator items in each perspective and reinforce tracking management during construction stage in order to enhance the overall quality of design services. And design firms can be offered with the performance evaluation results by which they can improve the management mechanism, design quality in their organization and further improve the firm's overall performance and increase competitiveness.

In order to enable the organization to effectively manage the design firms, it is suggested to adopt the model in this study, refer to literature such as performance evaluation, integrate the performance evaluation indicators suitable for design firms during construction stage, and re-establish the performance evaluation mechanism at construction stage according to the procedures specified in this study. Thus, design firms' quality of design service at construction stage can be constantly controlled.

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