Subcontractor Evaluation and Management Framework for Strategic Partnering

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Abstract: Recently, main contractors have shifted their attitudes about subcontract procurement to more strategic and long-term partnering philosophies. The objective of this study was to present a framework for subcontractor evaluation and management to help main contractors develop more strategic and productive relationships with their subcontract partners. As the strategic performance feedback model, the balanced scorecard concept was adopted with modification. A case study was also conducted to evaluate the framework with subcontracting strategy, performance indexes, weighting, evaluation of subcontractor performance data, and feedback methods. The research results obtained can be useful as a guideline of subcontractor management for long-term partnering and also to enhance overall productivity within the construction supply chain.

DOI: 10.1061/(ASCE)0733-9364(2008)134:11(842)

CE Database subject headings: Construction management; Subcontractors; Partnerships.

Introduction

The construction sector of many countries have recently undergone structural transformation, and projects are now subcontracted more frequently than in the past. Subcontractors are specialists in the execution of a specific job, and may supply personnel, materials, equipment, tools, and designs (Shimizu and Cardoso 2002). Subcontractors can contribute as much as 90% of the total value of a total construction project (Nobbs 1993). Therefore, as stated by Matthews et al. (1996), "it would be logical that, if main contractors want to improve their performance and productivity, they should concentrate their efforts where the majority of the work takes place." Generally, this applies to subcontractors, meaning that main contractors should increase the depth and strategic importance of their relationships with subcontractors.

Unfortunately, relationships between main contractors and subcontractors are often strained and adversarial (Dainty et al. 2001). Increasing complexity, the oversupply of specialist firms, and declining construction output have all contributed to the current antagonistic atmosphere (Kumaraswamy and Matthews 2000), and many studies have suggested adopting a partnering philosophy to overcome these difficulties.

Many studies have proposed methods to improve partnering relationships, including elements such as commitment, equity, common goals, communication, trust, cooperation, and continuous evaluation (AGC 1991; Sanders and Moore 1992; Reading Construction Forum 1995; Matthews 1996; Cheng et al. 2000; Black et al. 2001). However, these studies have mainly focused on client–contractor relationships and in particular on project-based partnering. Current management practices in this sector do not incorporate the philosophy of an up-to-date cooperative network (Shimizu and Cardoso 2002), and Dainty et al. (2001) reported that "strategic partnering between main contractor and subcontractor is not frequent in the construction industry and a need exists for attitudinal change." Although subcontractors are integral to the successful completion of most construction projects, few studies have examined issues related to subcontracting or to improving relationships between main contractors and subcontractors (Kumaraswamy and Matthews 2000; Arditi and Chotibhongs 2005). Most studies related to subcontracting have focused on issues related to improving the overall process or selecting a subcontractor. Almost no studies have developed strategies for subcontractor management or for maintaining long-term relationships, or have conducted practical research on continuous evaluation and feedback within this framework. Although it is important to investigate the subcontracting selection process, it is also necessary to improve methods for evaluating and managing subcontractors.

Therefore, this study had two objectives: first, to develop a subcontractor evaluation framework to assist with the establishment of long-term partnerships between main contractors and subcontractors, and second, to develop a subcontractor management framework to support this evaluation system to feedback. Main contractors can apply this proposed framework to enhance the overall productivity of the construction supply chain by improving the collaborative relationships between main contractors and subcontractors.

Methodology

Methods of subcontracting practice and performance evaluation used within the construction industry were examined using existing documented research. In addition, types of categories that

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Note. Discussion open until April 1, 2009. Separate discussions must be submitted for individual papers. The manuscript for this paper was submitted for review and possible publication on November 27, 2006; approved on February 26, 2008. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 134, No. 11, November 1, 2008. ©ASCE, ISSN 0733-9364/2008/11-842–851/$25.00.

must be applied during subcontractor evaluation and management were reviewed, along with current issues, application of subcontracting strategies, partnering between a main contractor and subcontractor, and feedback of evaluation results. A uniform review process revealed that the balanced scorecard (BSC) model was the best strategy feedback model to manage the various requirements of the model.

To establish a subcontractor evaluation and management framework, a case study was conducted using actual subcontractors' performance data. The framework was composed of a subcontracting strategy system, a subcontractor evaluation system, and a subcontractor management system. Its components included establishment of vision and strategy, subcontractor evaluation and management goals, four modified categories, designation of 15 evaluation criteria, and 25 subcontractor indexes with the methods of weighting, evaluation, and normalization of performance data. The results yield a total subcontractor score, which can be applied as feedback within the management process.

To acquire an unbiased and wide range of data and performance indexes for the case study, performance data from 100 subcontractors and financial data provided by a digital credit certificate company were investigated and analyzed along with other methods including a literature review, interviews, surveys, descriptive statistics analysis, and correlation analysis. Cooperative research with subcontracting managers and site managers from Korea's top 100 main contractors registered with the Construction Outsourcing Administration of Korea (CAK 2005) yielded practical and applicable research results.

Literature Review

Subcontracting Process

Prior literature on subcontracting reveals that a main contractor's subcontracting process includes strategy, registration, prequalification, solicitation, selection, contract administration, performance evaluation, management, and feedback (Hinze and Tracey 1994; Matthews et al. 1996; Shash 1998; Kim 2004; Arditi and Chotibhongs 2005; Eom and Paek 2006).

This research is based on a practicable subcontracting process used by major Korean contractors (Eom and Paek 2006) as follows: the main contractor registers subcontractors per work category through a preevaluation process. When issuing a project subcontract, the best subcontractors among the registered companies are invited to the bidding through previously evaluated results. Once the subcontractor has been selected by the bidding process, the subcontractors' performance is assessed periodically or when the contracted work is completed, and the outstanding subcontractor is selected. Through the feedback process of evaluation results, subcontractors are continually motivated to enhance performance. Therefore, achieving a long-term partnership requires continuous subcontractor performance evaluations and feedback processes in addition to simply selecting subcontractors on a per-project basis.

Performance Evaluation in the Construction Industry

During this period of globalization and increasing competition, business success depends on measuring performance. A revolution in performance measurement has transformed the process from a financial focus to evaluating performance management, including nonfinancial factors. Therefore, top management requires up-to-date and mostly nonfinancial information to make well-informed decisions. Recent reports on performance within the construction industry have identified several criteria for improvement and have emphasized the need to measure performance (Egan 1998). These requirements apply to both project-focused and organization-focused performance evaluations.

Within the construction industry, the evaluation of organizational performance has traditionally relied on efficiency, return on capital, and profitability, which have been criticized as narrow, reactive, and mostly financial (Bassioni et al. 2004). Recently, construction companies have used a more balanced approach by monitoring nonfinancial measures (Bassioni et al. 2004). Love and Holt (2000) identified the need for a longer-term and broader focus that incorporates corporate strategy, business processes, and shareholder needs.

Kaplan and Norton (1993) developed performance measurement index charts based on a BSC model using three major American construction companies: Rock Water, Brown and Root, and Halliburton. In addition, Alarcon and Serpell (1996) presented a general performance model based on cost, schedule, value, and effectiveness. Within the United Kingdom, "rethinking construction" introduced the best practice key performance indicators (Egan 1998). Beatham et al. (2002) applied the European Foundation for Quality Management (EFQM), which is an advanced version of the total quality management, to evaluate performance within the construction industry. Samuelsson and Gräns (2004) conducted a case study of the Swedish firm Skanska to assess operation performance within a local unit of a large construction company. Kagioglou et al. (2001) presented a performance management process framework based on the BSC model, but with the addition of "project" and "supplier" perspectives.

Construction is a project-oriented industry in which each project is unique and can be considered a prototype (Wegelius-Lehtonen 2001). Construction projects are typically evaluated in terms of cost, time, and quality (Ward et al. 1991; Kagioglou et al. 2001). However, Ward et al. (1991) called these three categories of project measures insufficient, and argued that other factors, such as the quality of relationships among participants and flexibility, can influence customer satisfaction and thus affect a project's success or failure (Bassioni et al. 2004).

Many models of construction project evaluation have been conducted using Construction Industry Institute (CII) metrics (Thomas et al. 2001) based on evaluation of the project's cost, schedule, safety, change, and rework factor. The Dept. of Trade and Industry (DTI) model, developed in the United Kingdom (DTI 2002), focused on project participants, and the key performance indicators (KPI) model (Cox et al. 2003) provided a common set of KPI at the project level as based on a managerial perspective.

Several recent studies have focused on existing systems for evaluating performance. Bassioni et al. (2004) reviewed contemporary performance measurement frameworks in the U.K. construction industry, including the BSC and EFQM excellence models, and suggested a relationship between project/operational-level performance measurement and strategic management. Costa et al. (2004) compared systems for measuring performance within the construction industries of four countries (the United Kingdom, Chile, the United States, and Brazil); they identified key factors in effective design, implementation of performance measurement systems, and improvement in opportunities.

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Subcontractor Evaluation and Management

As discussed earlier, although research is being actively conducted on corporation/organization and/or project performance evaluation in this industry, studies on subcontractor evaluation and management have been limited in the areas of appropriate subcontractor selection or management. Studies on subcontractor/supplier selection have employed various methods, including supplier selection based on the total cost of ownership (Ghodsypour 1996), improved multicriteria subcontractor selection employing main contractor–subcontractor partnering principles (Kumaraswamy and Matthews 2000), analysis of how rater credibility impacts the architecture, engineering, construction subcontractor rating system (Ekstrom and Bjornsson 2003), determining subcontracting procurement based on multiattribute utility theories (Lin 2003), and comparative evaluation of supplier selection processes within various corporate environments using a multiple exploratory case study approach and ISO 9000 standards (Bello 2004).

Studies on subcontractor management have focused primarily on improving the overall subcontracting process. Hinze and Tracey (1994) analyzed bidding practices, subcontracting arrangements, administrative practices, payment procedures, and project closeouts. Shash's (1998) analysis of the subcontractor bidding process focused on bid requests, submission of bid documents, pre- and postnegotiation, and relationships with the main contractor. Arditi and Chotibhongs (2005) addressed the processes of selecting, bonding, insurance, payment, safety issues on construction sites, partnering arrangements with various parties, and productivity issues.

Although these studies have clarified the importance of a partnering relationship between a main contractor and subcontractors, they have been limited by their focus on project-based partnering and have failed to discuss the process of evaluation that enables subcontractor growth in the long term.

Characteristics of Subcontractor Evaluation and Management

The standards for subcontractor management can be based on the components and indexes used within a subcontractor evaluation model, so the model must accurately reflect the characteristics of subcontracting. Based on previous research, the following characteristics were selected as necessary for a subcontractor evaluation and management system: subcontracting practice, strategy, partnering, and feedback.

Subcontracting Practice

Subcontracting procurement is done on a project by project basis, and subcontractors are generally selected through a bidding process. Financial stability is an important factor because discontinuous work execution inevitably leads to unstable cash flow (Eom and Paek 2006). As various work processes occur concurrently on site, maximizing productivity requires examining the subcontractors' ability to manage a project's complexity and uncertainty, as well as their planning, designing, and financing skills and other comprehensive management capabilities. The construction industry is labor oriented, so it is also important to consider laborer productivity and management efficiency (Eom and Paek 2006). A comprehensive evaluation of subcontracting practice must use both qualitative and quantitative indexes; it must also be systemized to allow various analyses per registered company and per work category, and to enable sharing and monitoring of results. In addition, procurement, engineering, and on-site managers should assess subcontractors, and the results should be presented in a visual format. The system throughout the entire evaluation process must be unbiased and transparent to minimize personal judgment among evaluators.

However, existing systems for evaluating subcontractors do not appear to possess standardized subcontractor evaluation criteria, methodologies, or systematic performance management (Kumaraswamy and Matthews 2000; Kim 2004). Kim (2004) conducted a survey of 100 major Korean contractors, and found the following problems related to subcontractor evaluation and management: lack of an unbiased and transparent subcontractor selection standards and evaluation system, lack of subcontractor participation and cooperative relationship, insufficient strategic management system per work category and per subcontractor, and lack of reflecting on-site opinion or nonfinancial items.

Subcontracting Strategy

Subcontracting strategy is based on the business strategy of the main contractor, and determines the managerial level and direction of the subcontractor evaluation and management system. Previous studies have found that most partnering successes have been based on the dedication to a common goal or mutual objectives (e.g., AGC 1991; CII 1991; Sanders and Moore 1992; Reading Construction Forum 1995; Matthews 1996; Watson 1999), promoting a win–win relationship as the objective among project participants. Bennett and Jayes (1998) developed a sophisticated strategy for creating (undefined) win–win relationships based on a willingness to improve joint performance and reported remarkable potential savings: 40–50% in both cost and time.

In contrast, Wood and Ellis (2005) depicted a construction industry operating with low profit margins. Under these circumstances, respective objectives conflict, and risks are pushed down the hierarchy from the client to main contractor to subcontractor; the partners in this situation do not genuinely adopt a win–win attitude. Therefore, a strategy for subcontractor evaluation and management should be systemized with the practical objective of a win–win situation based on long-term partnerships.

Partnering between Main Contractors and Subcontractors

Partnering is one way to improve performance within the construction process; it can create synergy and maximize the effectiveness of each participant's resources (Barlow et al. 1997). Not only can partnering greatly improve project performance; it can also directly benefit the entire supply chain (Wood and Ellis 2005). Therefore, subcontractor evaluation and management processes must include factors that will enhance cooperative relationships, in particular, sharing mutual objectives, improving communication, participating in collaborative work, and developing cooperative relationships.

Currently, the construction industry is facing costly progress delays due to inaccurate and untimely communication between project members (Zou and Seo 2006). Sharing up-to-date information between participants reduces errors and time delays, thereby facilitating project efficiency and ultimately improving collaboration and teamwork. Increasing collaborative work enhances mutual relationships, also contributing to enhanced levels of cooperation and productivity.

Feedback of Evaluation Results

Performance evaluation is ineffective unless it is used to guide managerial decisions (Bassioni et al. 2004). Therefore, the subcontractor evaluation and feedback process is essential to long-

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term partnerships. Grady (1991) and Medori (1998) found that feedback loops and consequent decision making were necessary to convert measurement systems into management systems. Other studies have recommended continuous evaluation to improve partnering relationships (AGC 1991; Reading Construction Forum 1995; Matthews 1996). Watson (1999) also stressed the importance of feedback to second generation partnering as one of the "seven pillars" of partnering. Welling and Kamann (2001) recommended monitoring current behavior and experiences, and pooling this information to enable construction project managers to share their experiences about how partnering relationships were managed.

Failure to assess and apply measurement data is considered a managerial fault, but has nonetheless become increasingly common among many modern organizations (Neely and Bourne 2000). It is also common for a subcontractor evaluation to be misunderstood as a temporary per-project evaluation intended to determine compensation (Eom and Paek 2006). Therefore, the management process must include continual periodical and project-based subcontractor performance evaluations and feedback of results.

Balanced Scorecard

Recent studies (Kagioglou et al. 200l; Bassioni et al. 2004; Costa et al. 2004) have identified a lack of research in the following areas of measuring performance within the construction industry: insufficient nonfinancial indexes and bias toward organizational cost and schedule, a lack of connectivity between organization and project performance, a lack of linkage with a company strategy, insufficient measuring categories to enhance future performance, a lack of framework development to assess overall performance, and a lack of analyzing actual performance data. Neely (2002) concluded that a new performance evaluation system must possess applicability in practice and connectivity with management strategy, and that it must reflect performance evaluation results and enable a visualization of total performance, in addition to balancing and combining performance indexes.

A subcontractor evaluation and management framework is a multiobjective and multiattribute evaluation that includes a subcontractor's financial stability and a project-oriented on-site evaluation. It also reflects relative importance, producing one comprehensive index score. Most existing measurements of construction industry performance focus on evaluating the organization or project, and lack the comprehensiveness required for evaluating subcontractor performance. The American CII Metrics model and the DTI model used in the United Kingdom are both frequently applied within the construction industry, but neither of these reflects subcontractor financial performance. The EFQM model is insufficient to produce an overall organizational evaluation of a subcontractor.

The BSC developed by Kaplan and Norton (1992) is a strategic planning and management tool used to align business activities to the vision and strategy of the organization and monitor organizational performance against strategic goals. It balances between short and long term objectives, lagging and leading indicators, and external and internal perspectives. It classifies diverse goals and measures into four perspectives (financial, customer, internal business processes, and learning and growth), and has a unique linkage with corporate strategy by identifying mutual cause and effect linkages between indicators. see Fig. 1.

The BSC has been called one of the most influential business ideas within the past 15 years (Marr 2001), and has led a wave of

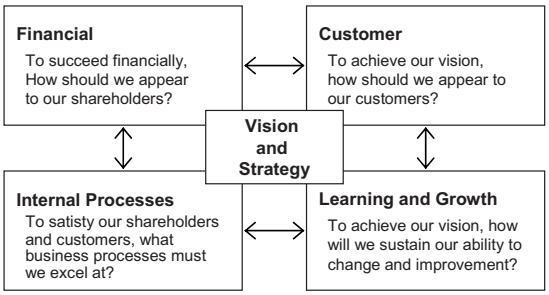

Fig. 1. Balanced scorecard framework

performance measurement frameworks that have evolved naturally and gradually from other performance measurement models (Bassioni et al. 2004). However, some studies have criticized it for being too simple (Brignall et al. 1991), claiming that four major categories are insufficient to cover all issues (Schneiderman 1999; Neely and Bourne 2000). Letza (1996) suggested that the BSC is generic and that the categories could be changed for different business environments. Accordingly, studies have developed additional general categories based on other perspectives, such as for construction projects and suppliers (Kagioglou et al. 2001).

The BSC appears to be the most suitable model for managing the characteristics and demands of a subcontractor evaluation and management framework. However, its application requires incorporating subcontractor characteristics. We therefore conducted a case study using the BSC, modifying some of its perspectives, contents and methods of evaluation.

Case Study

A case study was conducted to present a subcontractor evaluation and management framework based on the modified BSC. The proposed framework is composed of three subsystems (strategy, evaluation, and management) with six processes: establishment of vision and strategy, confirmation of evaluation criteria, selection of subcontractor index, weighting of index, performance evaluation, and feedback to management process. A detailed subsystem structure of the proposed framework is as follows.

- **Subcontracting strategy system**: To establish a vision and strategy for subcontractor evaluation and management, the system begins by setting the subcontractor management goal, evaluation criteria, and a systemized index based on the BSC's four categories. The subcontracting strategy is finally displayed as a subcontractor index and is applied as the standard for subcontractor evaluation.
- **Subcontractor evaluation system**: This subsystem calculates weighted values for each subcontractor index and evaluates the scores of subcontractor performance, and finally produces a total subcontractor score using multiplied sums of weighting and subcontractor evaluation scores. This evaluation can be categorized separately and applied when registering new subcontractors or during periodic regular evaluations or frequent evaluations of a particular project.
- **Subcontractor management system**: This subsystem uses the obtained weighting and subcontractor evaluation scores to determine the key subcontractor index (KSI) and weak subcontractor index (WSI). The managerial subcontractor index (MSI), obtained by combining both indexes, can be used to

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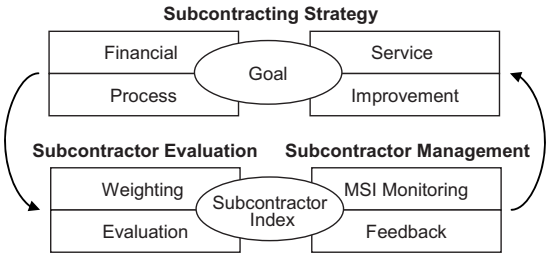

Fig. 2. Subcontractor evaluation and management framework

guide the development of a positive feedback loop to improve performance. This motivational communication enables mutual strategic objectives to be related to each participant, so it can be used as a standard to achieve long-term partnering. see Fig. 2.

Establishment of Vision and Strategy

Establishing an appropriate subcontractor evaluation and management system first requires analyzing a construction firm's vision and business strategy. This analysis can then be applied to establish objective criteria and an appropriate subcontractor index.

This study achieved this goal by analyzing the vision and strategic objectives among three major global contractors and six of the top ten Korean construction companies, as reported in previous research (Shin 2002). These contractors all shared a vision of mutually emphasizing customer satisfaction by providing the highest-quality service through global competitiveness, and their strategic goals for achieving this vision included customer satisfaction, technical edge, partnerships, and competitiveness. Partnerships referred not only to long-term partnerships with customers, but also to collaborative networks with subcontractors. Therefore, we established the strategy for the proposed system as "continuous growth of the subcontractor through establishment of collaborative relationships and value enhancement of the overall supply chain."

In the process of setting a system's vision and strategy, some consideration in strategic management could be given to other factors, especially the perspective or criteria of the models used in the Malcolm Baldrige National Quality Award. It would help to know how the companies' mission statements regarding everyday work relate to the long-term vision of each organization.

Confirmation of Evaluation Criteria

To effectively measure growth, evaluation criteria were established based on the vision and strategy. Then, the KPI was comprehensively applied to manage the execution objectives required for each criterion (Neely 2002). Based on the above-mentioned studies regarding performance measurement and the BSC (Neely 2002; Niven 2002), we drafted possible subcontractor evaluation details and a corresponding preliminary criteria list; evaluation criteria were confirmed during a one-on-one interview process. Interviews focused on supplemental opinions about appropriateness and verification after the contents of the structured questionnaire were explained. Participants included ten subcontracting managers, three business managers, and five site managers from three of Korea's top ten main contractors as of August 2005. Each participant had more than 5 years of experience. In addition, subcontractor input was collected during one-on-one interviews with two CEOs from outstanding subcontractors registered to Company L, ranked among the top 50 global contractors by ENR (2006) as of April 2005.

Table 1 presents achievement goals, selected preliminary criteria for each of the four categories, and the final 15 performance areas established through the interview process. The BSC's four categories for subcontractor evaluation and management were modified to include the financial soundness of the subcontractor, service to the main contractor, the on-site project management process, and continuous improvement.

Selection of Subcontractor Index

The subcontractor index set was obtained using a systematic index assessment process. By examining related research and the index sets from among three of the top 10 Korean major contractors from June to August 2005, and by eliminating repetitions, 126 preliminary subcontractor indexes were established. To distinguish a core index based on various evaluation standards, a three-stage screening process was conducted, including quantitative evaluation, statistical evaluation, and a semistructured survey.

First, a quantitative evaluation was conducted using seven standards selected from among the performance evaluation standards suggested in previous research (Niven 2002): validity, representation, balance, measurability, accessibility, understandability, and comparability. A pairwise comparison survey was constructed for the weighted set of seven evaluation standards and a five-point Likert scale assessment of 126 preselected indexes was completed by 20 subcontracting managers and 10

Table 1. Four Perspectives, Goals, and Evaluation Criteria

Perspectives	Goal	Preliminary criteria	Evaluation criteria
Financial	How is the financial soundness of the subcontractor?	Profitability, growth, goal achievement, activeness, stability, productivity	Profitability, growth, activeness, stability
Service	Does the subcontractor provide service satisfactory to the main contractor?	Customer satisfaction, customer loyalty, market share, service stability, strengthened customer competitiveness	Main contractor's satisfaction elements (cost, schedule, quality), main contractor's competitiveness
Process	Is the site project management process satisfactory?	Site project management, customer management, innovative process, work efficiency	Innovative project management (construction management, quality assurance & control, safety management, environmental management)
Improvement	How can the subcontractor continue to improve and create value?	Technical capability, employee capability, organization capability, information gathering capability	Technical capability, competitiveness, site organization culture

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Table 2. Selected Subcontractor Indexes

Perspectives	Criteria		Subcontractor index and measurement methods	Unit	Data[a]
Financial	Profitability	F1	Ordinary income on sales: (operation profit/revenue) × 100	%	D
	Growth	F2	Sales growth: (current F.Y. revenue/previous F.Y. revenue-1) × 100	%	D
	Activeness	F3	Turnover ratio of capita: (current F.Y. revenue/current F.Y. total capital) × 100	%	D
	Stability	F4	Total sales: 3 year average annual revenue	$mil.	C
		F5	Credit rating: credit rating score (digital credit certification company)	point	D
Service	Cost	S1	Cost saving ratio: (cost-cost variance)/cost × 100	%	E
	Schedule	S2	Schedule shortened ratio: (schedule-changed schedule)/schedule × 100	%	E
	Quality	S3	Defect occurrence ratio: occurrence per unit/participated projects × 100	%	E
		S4	Customer satisfaction rate upon completion: satisfied proj./participated proj. × 100	%	E
	Main contractor's competitiveness	S5	Number of contracts: contracts made by the parent main contractor (during 3 years)	Case	E
		S6	Information and work support: selected support or information cases/year	Case	A/B
Process	Construction management	P1	*Design review/engineering capability: level of qualification (five-point scale)*	*Point*	*B*
		P2	*Project management plan/execution: level of execution (five-point scale)*	*Point*	*B*
	Quality management	P3	Rework occurrence rate: rework occurrences/participated works × 100	%	E
		P4	*Quality management plan/execution: level of execution (five-point scale)*	*Point*	*B*
	Environmental management	P5	Env. friendly proj. capability: order of correction/participated works × 100	%	*B*
		P6	*Env. management plan/execution and training: level of execution (five-point scale)*	*Point*	*B*
	Safety management	P7	Construction accident occurrence status: number of accidents (during 3 years)	Case	E
		P8	*Safety management/execution and training: level of execution (five-point scale)*	*Point*	*B*
Improvement	Technical ability	I1	Number of technical patent: possessed technical patent and license	Case	C
		I2	Technical support capability: number of technicians	Person	C
	Subcontractor's competitiveness	I3	*Collaboration work: level of participation (five-point scale)*	*Point*	*B*
		I4	Awards and warnings: number of award (+) and warnings (−) (during 3 years)	Case	C
	Organization culture	I5	*Cooperation in work: level of cooperation and communication (five-point scale)*	Point	*B*
		I6	*Site management organization structure: appropriate organization (five-point scale)*	*Point*	*B*

Note: Items in italic font refer to those requiring qualitative evaluation. Quantitative evaluation is performed for the rest.

[a]A = subcontracting manager; B = site manager; C = subcontractor's manager; D = digital credit certificate; and E = information system (e.g., project management system, procurement system, quality management system).

site managers from 5 of Korea's top 20 main contractors as of August–September 2005; each participant had at least 5 years of experience. For these, two surveys were constructed: a one-on-one interview survey based on a structured questionnaire and an e-mail/telephone survey. The seven standards for selection were placed by order of weight: measurability (0.246), accessibility (0.202), representation (0.191), and validity (0.136); the other standards were weighted below 0.1. The 44 preindexes with the highest scores from the weighted evaluation were selected.

Next, descriptive statistics analyses and correlation analyses were conducted to systematically verify the 44 predetermined indexes, based on actual data. Data were collected from 100 subcontractors, selected randomly from the 1,067 subcontractors registered by Company L; the selected subcontractors were surveyed over a 3-month period from October to December 2005. Financial data were collected using digital credit certificate information provided by the Korea Ratings Co. (2005). Data were generally gathered from information systems and the nonmeasurable data for certain categories were collected from subcontracting and site managers. Statistic analyses and correlations analysis were performed using *SPSS* version 10.0 for Windows (SPSS Inc., Chicago). Analyses examined statistical data ranges, averages, standard deviations, skewness, and kurtosis, and screened with examination index characteristics in terms of comparability, representation, validity, and correlation-exception of one index among two highly correlated indexes. As a result of this process, 28 key indexes were selected.

Finally, informal meetings and semistructured interviews were used to assess the appropriateness of these 28 indexes, which were finally condensed to the last 25 subcontractor indexes. The informal meetings included 20 subcontracting managers and 5 managers from strategic planning and business management departments from among Korea's top 50 main contractors (each with more than 5 years of experience), two consultants from an engineering consulting firm, and two consultants from a management consulting firm. Two of these meetings were held in January and April 2006, and they resulted in verification and modification of the final subcontractor indexes.

Table 2 presents the selected index structure and measurement methods derived from this process. Quantitative data can be automated using information systems and credit rating, and main contractor and subcontractor managers can input qualitative data directly. Participation and sharing of data among subcontractor indexes stimulate voluntary growth of subcontractors or improve communication with main contractor and subcontractors. In addition, automated data input from information systems was incorporated as much as possible to minimize bias during evaluation.

Weighting Subcontractor Indexes

When applying the BSC model, it is important to manage the index by weighting the four different categories (Olson and Slater 2002). The analytic hierarchy process was used to determine the degree of importance or weight for each subcontractor index because the results of this process are less biased than personal decisions (Saaty 1980; Winkler 1990). The final degree of importance for each subcontractor index was obtained by multiplying

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Table 3. Subcontractor Evaluation Score

		Normalized subcontractor score					Weighted subcontractor score					
SI	*W*	A	B	C	D	E	A	B	C	D	E	Average
F1	*0.067*	34.2	36.0	34.4	16.2	10.2	2.29	2.41	2.30	*1.09*	*0.68*	1.76
F2	*0.064*	83.8	49.4	76.8	52.6	53.6	5.36	*3.16*	4.92	*3.37*	*3.43*	4.05
F3	0.053	74.8	39.4	64.6	95.0	88.8	3.96	*2.09*	*3.42*	5.04	4.71	3.84
F4	0.041	49.0	55.2	76.4	93.0	98.0	*2.01*	*2.26*	3.13	3.81	4.02	3.05
F5	0.046	44.4	44.4	81.8	93.0	44.4	*2.04*	*2.04*	3.76	4.28	*2.04*	2.83
S1	*0.083*	20.2	68.6	20.2	17.2	15.2	*1.68*	5.69	*1.68*	*1.43*	*1.26*	2.35
S2	*0.062*	16.2	84.8	15.2	16.2	13.2	*1.00*	5.26	*0.94*	*1.00*	*0.82*	1.81
S3	*0.067*	77.8	2.2	97.0	18.2	36.4	5.21	*0.15*	6.50	*1.22*	*2.44*	3.10
S4	0.026	92.0	96.0	76.8	83.8	54.6	2.39	2.50	*2.00*	2.18	*1.42*	2.10
S5	0.044	34.4	16.2	24.2	42.4	51.6	1.51	*0.71*	*1.06*	1.87	2.27	1.49
S6	0.017	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
P1	0.034	23.2	23.2	23.2	51.6	65.6	*0.79*	*0.79*	*0.79*	1.75	2.23	1.27
P2	0.032	66.6	66.6	66.6	49.4	66.6	2.13	2.13	2.13	*1.58*	2.13	2.02
P3	0.038	54.6	100.0	42.6	42.6	52.6	*2.07*	3.80	*1.62*	*1.62*	*2.00*	2.22
P4	0.028	67.6	67.6	67.6	47.4	67.6	1.89	1.89	1.89	*1.33*	1.89	1.78
P5	0.026	63.8	25.4	63.8	63.8	41.6	1.66	*0.66*	1.66	1.66	*1.08*	1.34
P6	0.020	70.8	36.4	36.4	23.2	30.4	1.42	*0.73*	0.73	*0.46*	*0.61*	0.79
P7	0.045	5.2	100.0	12.2	12.2	100.0	*0.23*	4.50	*0.55*	*0.55*	4.50	2.07
P8	0.019	54.6	54.6	54.6	21.2	54.6	1.04	1.04	1.04	*0.40*	1.04	0.91
I1	0.028	0.0	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00
I2	0.037	0.0	54.6	45.4	66.6	45.4	*0.00*	2.02	1.68	2.46	1.68	1.57
I3	0.033	60.6	79.8	75.8	78.8	79.8	*2.00*	2.63	2.50	2.60	2.63	2.47
I4	0.040	24.2	24.2	24.2	76.8	76.8	*0.97*	*0.97*	*0.97*	3.07	3.07	1.81
I5	0.029	51.6	51.6	51.6	51.6	51.6	1.50	1.50	1.50	1.50	1.50	1.50
I6	0.020	79.8	29.2	49.4	83.8	77.8	1.60	0.58	0.99	1.68	1.56	1.28
Total subcontractor score							44.76	49.52	47.76	45.94	49.01	47.40

Note: Italics in the weighted (*W*) category are KSIs and in the weighted subcontractor scores are WSIs.

weight by category, perspective, criteria, and subcontractor index. Each weight underwent normalization, and its sum was set at 1.

To determine comparative weights among subcontractor indexes, pairwise comparison surveys were executed separately for a main contractor in February 2006 and for a subcontractor in April 2006. To set main contractor weights, 20 subcontracting managers from among Korea's top 50 main contractors (each with more than 5 years of experience) participated in the structured questionnaire via e-mail or telephone. To set subcontractor weights, participants from 73 companies registered with Company L participated in an online survey. Of these, incomplete surveys and surveys completed by employees with less than 5 years of experience were eliminated. The completed surveys and the consistency ratio of survey results yielded effective data (30 main contractors and 36 subcontractors). Final weights were based on these data using geometric averaging of individual pairwise comparison matrices.

The survey results indicated that main contractors place more importance on a subcontractor's current financial stability and comprehensive service satisfaction rate than on their potential growth. Subcontractors place primary importance on their growth areas of technical capability, competitiveness in terms of financial performance, and site processes. These results can be used as reference data for practical application, but the weighting order can be adjusted depending on subcontractor evaluation and management strategy.

Subcontractor Performance Evaluation and Management

By applying the relative weighting described previously, it is possible to execute evaluations using subcontractor performance data. Subcontractor evaluation could then be separately categorized as a regular evaluation periodically conducted at least once a year to evaluate overall subcontractor performance, as a frequent evaluation to ensure timely evaluation, and as a registration evaluation to determine the qualifications of a potential new subcontractor. In this study, we developed a regular evaluation case to demonstrate the measurement of subcontractor performance, analysis, and feedback of the evaluation results.

Evaluation of subcontractor performance incorporates sets of both qualitative and quantitative indexes, so data normalization is required to compare these using a unified standard. To obtain more accurate measurements, this study applied the percentage ranking method to the evaluated scores. As percentage ranking represents the order in which the company scored per subcontractor index within the overall evaluation score, transformed into a percentage, it yields a relatively uniform evaluation score.

For the case study, five of Company L's subcontractors specializing in reinforced concrete were randomly selected, and performance data were collected from information systems and subcontracting managers in December 2004. Table 3 presents the normalized subcontractor score and the weighted subcontractor score. The normalized subcontractor score is one converted to a

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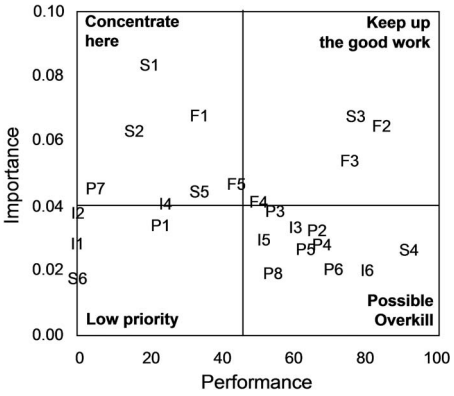

Fig. 3. Importance-performance analysis of Company A

perfect score of 100 by percentage order, and the weighted subcontractor score is the multiplied sum of the weight and the normalized subcontractor score. The total subcontractor score was determined using the sum of the normalized subcontractor scores for each subcontractor index.

Subcontractor indexes F1, F2, S1, S2, and S3 correspond to the italicized characters in the weighting (*W*) area, displaying the KSI in accordance with Pareto's Law (20:80 rule) appearing in the top 20% of 25 index weights (*W*). In addition, italicized weighted subcontractor scores indicate a WSI, meaning the value is lower than average weighted evaluation scores. The MSI was determined by combining the KSI and WSI. Company A had the lowest total subcontractor score, and its index of criticalness and vulnerability indicated F4, F5, S1, S2, P1, P3, P7, PI2, I3, and I4. By reviewing this kind of managerial subcontractor index set, which can be accessed from information systems, subcontractors can identify their strengths or weaknesses. Through collaborative efforts to improve these areas, both subcontractors and main contractors will benefit from mutual growth.

Fig. 3 presents the importance-performance analysis (IPA) for company A, conducted by applying weights and a normalized subcontractor score. The four quadrants shown in Fig. 3 are categorized by individual importance (weight) and performance (normalized subcontractor score). Although F1, F5, S1, S2, S5, and P7 fall into the "concentrate here" sector and have a high degree of importance, the performance results are below average and require more concentrated management. In contrast, F2, F3, F4, and S3 fall into the "keep up the good work" sector and have a high weight and performance, so these areas require continued maintenance for good performance. These results yield additional insight into existing processes and can aid in devising strategies for change.

Conclusions and Recommendations

Within the construction supply chain, one critical area of construction procurement management is the main contractor–subcontractor relationship. Because this relationship is so important, major construction companies have spent considerable effort to enhance productivity by cultivating excellent subcontractors and strengthening cooperative relationships. Meeting these goals requires continuous evaluation of subcontractor performance in the long term, and in particular, the management process requires a feedback process to make use of these evaluation results.

The primary objective of this study was to develop a subcontractor evaluation and management framework in conjunction with a subcontracting strategy. As evaluating subcontractor performance requires standards for subcontractor management, the characteristics of subcontracting need to be identified and clarified. The literature review revealed the following key considerations. The subcontracting strategy must be systemized within the subcontractor evaluation and feedback process with the objective of a win–win relationship through long-term partnering. In addition, as subcontractor evaluation combines multiobjective and multiattribute evaluations based at the corporate level on financial soundness and at the project level on site evaluation, these elements must be compared according to the degree of importance and combined into a single index. Moreover, the evaluation index must reflect factors that will enhance collaborative relationships, such as sharing a mutual objective, enhancing communication, and participating in collaborative work, and although the BSC model may appear to be the most appropriate model to manage these demands, its categories and methodology may need to be modified in certain ways during application to real situations.

Therefore, we developed a subcontractor evaluation and management framework using a strategic performance evaluation and feedback model based on a modified BSC. The case study yielded the following recommendations. The subcontractor evaluation and management framework should be linked with subcontracting strategy, performance evaluation, monitoring, and management processes, and it must form a positive feedback loop. The subcontractor evaluation categories should be composed of subcontractor financial soundness, outstanding service to the main contractor, an on-site innovative project management process, continuous growth, and value creation. In addition, the main contractor places primary importance on subcontractor service and financial stability, whereas the subcontractor places primary importance on technical capability, competitiveness, self-growth, financial growth, and site process. Voluntary growth can be stimulated through focused monitoring of evaluation results of the managerial subcontractor index and IPA. Further, communication with subcontractors will enable them to identify areas for concentration and improvement, and their efforts to improve will result in mutual growth, benefiting both the main contractor and subcontractor.

This study did not discuss general management concerns including subcontractor selection and client–contractor or contractor–vendor partnership enhancement issues. The case study was conducted from the perspective of Korea's major contractors, and as these companies were situated within a local construction environment, the results may have limited application within the global industry. In addition, the management information system was predetermined as the default, so small or mid-sized companies might have difficulty applying the framework. However, the proposed framework can be modified based on an individual main contractor's subcontracting strategy, so it may be applied as a guide that can be modified by changing certain indexes and weightings. This framework can enhance overall productivity within the construction supply chain by improving collaborative relationships between main contractors and subcontractors.

Acknowledgments

This study was supported by a grant from the Virtual Construction System Program funded by the Ministry of Construction and

Transportation of the Republic of Korea. The writers thank the companies, engineers, and consultants who completed the surveys and interviews, their candor is greatly appreciated. The writers also thank the anonymous reviewers and others for their helpful comments and constructive criticism.

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