Benchmarking Construction Firm Performance

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Abstract

Existing construction benchmarking models have four basic limitations if they are to be used for firm analysis on a company-wide basis. The first limitation is that the existing benchmarking models are project-specific. Second, as a consequence of being project-specific, they do not allow the measuring of the impact of certain technological and managerial attributes on overall firm performance. Third, current benchmarking models do not take note of trade-offs between the different metrics of performance. Fourth, the relationship between how much was expended on the metrics and the performance of those metrics (a return on investment of sorts) is absent.

This paper critiques existing construction benchmarking models and proposes a new construction benchmarking model that provides a performance metric for measuring firm performance on a company-wide basis and supports trade-off analysis among several performance metrics. Additionally, the proposed model relates the effort expended on the metrics of performance to the level of performance of those metrics and aids in the identification of management practices that lead to superior performance.

Key Words: IT utilization, construction, industry, contractor, performance, research, managerial attributes

1. Introduction

In recent years, the construction industry has recognized benchmarking as a possible catalyst for aiding the performance of the industry and improving its competitive edge in the global market. Benchmarking aims at comparing the performance of firms relative to each other, allowing these firms to recognize their weaknesses and strengths compared to the industry. It aids in the identification of industry leaders who exhibit superior performance as a result of using best industry practices. Since the time when the construction industry recognized benchmarking in this way, there have been several benchmarking models proposed. El-Mashaleh [1] critiques these benchmarking models and argues that, if the goal is to measure company-wide performance, they all fall short in four respects.

First, the existing benchmarking models are project-specific. This limited view communicates a single metric performance on a single project and by no means translates to the overall performance of the firm. Second, as a consequence of being project-specific, the existing benchmarking models do not allow the measurement of the impact of certain technological and managerial attributes on overall firm performance. Third, the current benchmarking models do not support an understanding of the trade-offs among the different metrics of performance. Fourth, the relationship between how much was expended on the metrics and the performance of those metrics (basically a return on investment) is absent.

In a highly competitive environment, the long-term success of construction firms depends on improving performance by continually acquiring and applying new knowledge. Existing models have limitations in their ability to guide the industry into both benchmarking and identifying practices of superior performance.

This paper proposes a new construction benchmarking model that provides an overall performance measure for the firm and supports trade-off analysis among the several performance metrics. Additionally, the proposed model relates the effort expended on the metrics of performance to the level of performance of those metrics and aids in the identification of management practices that lead to superior performance. The proposed benchmarking model is deployed using data that was collected from 74 construction firms.

2. Previous Benchmarking Models

Camp [2] defines benchmarking as “the continuous process of measuring products, services, and practices against the toughest competitors or those companies recognized as industry leaders.” CII adopts the following definition of benchmarking: “a systematic process of measuring one’s performance against results from recognized leaders for the purpose of determining best practices that lead to superior performance when adapted and implemented.” [3] The following discussion presents three construction benchmarking models:

- Fisher et al. [4]
- Hudson [3] and CII [5]
- CBPP [6]

2.1 Fisher et al. Benchmarking Model

The Fisher et al. [4] benchmarking model was probably the first notable benchmarking effort in the history of the construction industry. Houston Business Roundtable (HBR) assembled a group of owners and contractors to solicit ideas and compile initial benchmark data for use by the construction industry. Data were collected from 17 companies for 567 projects regarding actual versus authorized cost, actual versus target schedule, actual versus estimated construction labor, and change orders versus original authorized cost (scope changes). Fisher et al. [4] summarized the results in the literature and these results should be studied by all who wish to learn about how well companies and owners do at predicting cost and schedule of projects and related topics.

2.2 Hudson and CII Benchmarking Model

Hudson [3] performed his benchmarking study under the guidance of the Benchmarking and Metrics Committee (BM&M) of CII. The database of this report consists of 901 projects from 37 owner and 30 contractor companies. The report supplies these norms depending on type of construction, project size, project nature, and project location.

2.3 Construction Best Practice Program Benchmarking Model

The Construction Best Practice Program (CBPP) benchmarking model is also known as the Key Performance Indicators (KPIs) model. The CBPP [6] indicates that the purpose of the KPIs, developed and implemented in the UK construction industry, is to benchmark a project or a company against the range of performance currently being achieved across the industry. It provides a framework to check how a construction business compares with the rest of the industry and helps firms to focus on their main priority areas of improvement.

The CBPP [6] argues that clients of the construction industry want their projects delivered on time, under budget, safely, efficiently, free from defects, and by profitable companies. The ten KPIs reflect the aforementioned criteria, as seven of the indicators relate to project performance, while the rest relate to company performance.

3. Critique of Existing Models

The reasons that existing models fall short of measuring company-wide performance were analyzed. The reasons can be categorized into the four areas discussed in the Introduction.

3.1 Measuring Project-level Industry Norms of Some Performance Metrics

The results of measuring project-level industry norms on a few, even well-chosen, metrics by no means translates to the overall performance of the firm. There are no answers to the question: where does a certain firm stand compared to other firms when considering overall performance (i.e., all metrics simultaneously)? An overall performance report card for the firm is sought. Overall performance takes on a particular importance to guard against improvement in one metric while losing on other metrics. Towill [7] stresses that "it is important to emphasize that improvement in one business performance metric (say cost) must not be sought at the expense of another (say quality or safety)"

3.2 No Measurement of the Impact of Technological and Managerial Attributes on Firm Performance

As a consequence of being project-specific, the existing benchmarking models do not allow measuring the impact of certain technological and managerial attributes on overall firm performance. The current models account for such measurement but on a single metric performance (i.e., impact of team building on schedule performance on a certain project). This limitation makes it difficult to identify practices that lead to superior company-wide performance. For example, advances in technology have been widely regarded as major sources of improvement in the competitive position of firms and industries, but, using existing models, overall firm performance cannot be tied to the level of technology adoption or utilization.

3.3 Tradeoffs Among Different Metrics of Performance

The current benchmarking models do not support an understanding of the trade-offs among the different metrics of performance. For example, if the firm's cost performance has improved, but schedule performance has declined, how can one determine whether this trade-off is favorable or not favorable? That is, whether the overall performance of the firm is better or worse? McKim et al. [8] mention this trade-off among the different metrics of performance when they state that "as various techniques are available to control the cost, schedule, and quality individually, these three indicators of performance are highly interrelated and effect one another…these indicators are highly interrelated and require some balance and trade-off among them to achieve efficient overall control over project performance."

3.4 Cost / Performance Relationships

The relationship between how much was expended on the metrics and the performance of those metrics is absent in existing models. Two firms that arrive at the same performance are considered to be similarly efficient. This is clearly not the case if one firm is expending more resources (i.e., money, personnel, etc.) than the other firm. It makes more sense to consider the firm that commits fewer resources to arrive at a certain performance as a better performer than the firm that is spending more resources to arrive at the same performance.

4. Benchmarking Model Development

4.1 Development of Metrics of Performance

Camp [2] and Spendolini [9] argue that identifying what is to be benchmarked, or the benchmarking metrics, is often one of the most difficult steps in the benchmarking process. Hudson [3] indicates that the BM&M committee adopts the following definition for a metric: "a quantifiable, simple, and understandable measure which can be used to optimize performance." Hudson [3] also indicates that the BM&M committee adheres to the following principles for metrics used in the CII benchmarking system:

- A metric must provide a value to its stakeholders.
- A metric must focus on continuous improvement and establish an objective target.
- A metric can be influenced by adoption of better practices.

Additionally, Hudson [3] recommends utilizing "The Metrics Handbook" for devising metrics. "The Metrics Handbook" is published by the United States Air Force [10]; it characterizes a good metric as one that conforms to the following attributes:

- It is meaningful in terms of customer requirements.
- It tells how well organizational goals and objectives are being met through processes and tasks.
- It is simple, understandable, logical, and repeatable.
- It shows a trend, i.e. measures over time.
- It is unambiguously defined.
- Its data are economical to collect.
- It is timely.

Camp [2] states that benchmarking metrics are determined from the basic mission of the organization or business unit. How important are these benchmarking outputs or metrics in satisfying end users or customer needs? Ultimately a process exists for this purpose only and whether it should be benchmarked depends on the answer to this question. Benchmarking is the mechanism to ensure that customer needs are satisfied by industry practices. Spendolini [9] supports Camp's statement by linking what is to be benchmarked to the Critical Success Factors (CSF) of a business, which are the factors that have the greatest impact on the performance of the organization. Watson [11] defines CSF as "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where 'things must go right' for the business to flourish. If results are not adequate, the organization's efforts for the period will be less than desired. CSF are measured in basic business terms and are selected as measures of business effectiveness (quality), efficiency (cycle time), or economy (cost)."

To guide the selection of the benchmarking metrics, Camp [2] and Spendolini [9] recommend posing Xerox's ten questions:

- What is the most critical factor to business success (e.g., customer satisfaction, expense to revenue ratio, return on asset performance)?
- What factors are causing the most trouble (e.g., not performing to expectations)?
- What products or services are provided to customers?
- What factors account for customer satisfaction?
- What specific problems (operational) have been identified in the organization?
- Where are the competitive pressures being felt in the organization?
- What are the major costs (or cost "drivers") in the organization?
- Which functions represent the highest percentage of cost?
- Which functions have the greatest room for improvement?
- Which functions have the greatest effect (or potential) for differentiating the organization from competitors in the market place?

For the most part, the literature bases performance upon schedule adherence, cost performance, customer satisfaction, safety performance, and profit. Therefore, this research considers company-wide performance based on these five metrics. These metrics along with the associated method of measurement and calculation are shown in Table 1, which also shows that schedule performance is measured in terms of how often projects are delivered on/ahead of schedule. Similarly, cost performance is measured in terms of how often projects are delivered on/under budget. For both metrics, schedule and cost, the measurement is limited to projects closed in the last two fiscal years.

Customer satisfaction is measured in terms of the percentage of repeat business customers. Net profit after tax as a percentage of total sales for the last fiscal year is used to measure profitability of the firm. Safety performance is based on two indicators: Experience Modification Rating (EMR) and OSHA recordable incidence rate.

Table 1: Metrics of Performance Along With Their Measurement Method

Metric	Measurement/Calculation
Schedule performance	Percentage of the time projects are delivered on/ahead of schedule in the last 2 fiscal years (i.e., how often are projects delivered on/ahead of schedule?) Calculation (for projects closed in the last 2 fiscal years): Percentage = [(Number of projects delivered on/ahead of schedule) / (Total number of projects)] * 100%
Cost performance	Percentage of the time projects are delivered on/under budget in the last 2 fiscal years (i.e., how often are projects delivered on/under budget?) Calculation (for projects closed in the last 2 fiscal years): Percentage = [(Number of projects delivered on/under budget) / (Total number of projects)] * 100%
Safety performance	OSHA recordable incidence rate Calculation: Obtain last reported OSHA recordable incidence rate
	Experience Modification Rating (EMR) Calculation: Obtain last reported EMR
Customer satisfaction	Percentage of repeat business customers Calculation: In general, percentage of customers that come back for a repeat business with the firm
Profit	Net profit after tax as a percentage of total sales for the last fiscal year Calculation (for the last fiscal year): [Net profit after tax / Total sales] * 100%

4.1.1 Data Envelopment Analysis

DEA is concerned with evaluation of performance and it is especially concerned with evaluating the activities of organizations such as business firms, hospitals, government agencies, etc. In DEA, the organization under study is called a DMU (Decision Making Unit). A DMU is regarded as the entity responsible for converting inputs (i.e., resources, personnel, money, etc.) into outputs (i.e., sales, profits, customer satisfaction, metrics of performance, etc.). It is their performance that is to be evaluated. DEA utilizes mathematical linear programming to determine which of the DMUs under study form an envelopment surface. This envelopment surface is referred to as the efficient frontier. DEA provides a comprehensive analysis of relative efficiency for multiple input-multiple output situations by evaluating each DMU and measuring its performance relative to this envelopment surface. Units that lie on (determine) the surface are deemed efficient in DEA terminology. Units that do not lie on the surface are termed inefficient and the analysis provides a measure of their relative efficiency.

The following example illustrates the basic idea behind DEA. Figure 1 plots the firms Input x1/Output y and Input x2/Output y as axes. From the efficiency point of view, it is natural to judge firms that use fewer inputs to get one unit of output as more efficient. Therefore, the line connecting C, D, and E is the "efficient frontier." This frontier should touch at least one point and all points are therefore on or above (in this case) this line. All the data points can be "enveloped" within the region enclosed by the frontier line, the horizontal line passing through C, and the vertical line through E, suggesting the name Data Envelopment Analysis.

The relative efficiency of firms not on the frontier can be measured by referring to the frontier point in the example. Say Firm "A" is inefficient. To measure its inefficiency, let OA, the line from zero to A, cross the frontier line at P. Then, the efficiency of A is to be evaluated by: OP/OA = 0.8571.

The analysis can be extended to identify improvements by referring inefficient behaviors to the efficient frontier. The projected values for inefficient firms to become efficient can be calculated. From Figure 1, Firm A for example, can be effectively improved by movement to P with Input x1 = 3.4 and Input x2 = 2.6. The coordinates of P (3.4 , 2.6) are the projected values for A to become efficient. In the same sense, Firm B can be improved by movement to Q with Input x1 = 4.4 and Input x2 = 1.9.

The metrics of performance shown in Table 1 are the outputs to be used in conjunction with the proposed benchmarking model. Two inputs are accounted for in this part of the model: expenses on safety as a percentage of total sales and expenses on project management as a percentage of total sales. By considering these two inputs, the benchmarking model is relating the effort expended on the metrics of performance to the performance in the areas of those metrics. Firms that spend more on project management are expected to have better schedule performance, cost performance, customer satisfaction, and profit. Similarly, firms that spend more on safety are expected to have better safety performance.

Expenditures on safety are annual cost of safety programs and salaries of safety personnel. Expenses on project management are project management personnel salaries, annual costs of project management training, and annual costs of project management software acquisitions and updates. The reciprocal of EMR and OSHA incidence rate are used as the benchmarking model variables in order to convert these unfavorable measures to favorable ones, since the lower the values of EMR and OSHA incidence rate, the better the safety performance.

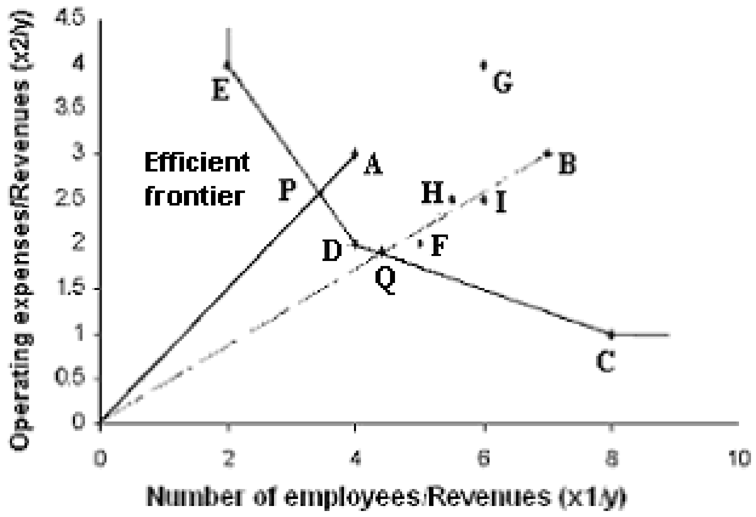

Figure1. Firm Efficiency as shown by DEA

5. Data Collection

The data for this research were collected through a survey questionnaire that collects general information about the person completing the survey, general information about the firm, and the performance of the firm on a company-wide basis. Firms are asked to supply their Schedule Performance, Cost Performance, Safety Performance (OHSA incidence rate and EMR), Customer Satisfaction, Profit, expenses on safety, and expenses on project management. The survey questionnaire was posted on the University of Florida web site and 545 practitioners were contacted by e-mail to fill out the survey. The research team received 88 responses, which accounts for a 16.15% response rate. The 88 respondents represent 74 firms.

6. Results and Analysis

This section benchmarks firms based on their performance against five metrics of performance: schedule adherence, cost performance, customer satisfaction, 1/EMR, and profit. The benchmarking analysis identifies efficient and inefficient firms and supplies inefficient firms with projected values for the metrics of performance. These projected values serve as a road map for inefficient firms to improve their performance and become efficient.

6.1 General Information

Fifty-two percent of respondents were upper management, 28 percent were middle management, and 13 percent were lower management. Forty-three percent of the firms that the respondents worked for were general contractors (GC), 29% were companies that could function as a GC or construction managers (CM), 10% were CM firms, and the rest were some combination of design-build, GC, CM, subcontractors, or specialty contractors. Thirty-one percent of the firms work solely in the commercial construction area, 23% do commercial or industrial construction, 12% do commercial, residential, or industrial construction, and the rest were made up of heavy/highway contractors or some combination of some or all previously-mentioned areas of construction. Figure 2 shows the sizes of the firms, by revenue. Table 2 provides descriptive statistics for the metrics of performance along with the number of firms. OHSA recordable incidence rate is not reported because only a few firms supplied it.

6.2 Benchmarking Firms' Performance

Several DEA models were developed to benchmark firms' performance. Table 3 shows two of these. Model 1 is named FULL since it includes all metrics of performance and has both inputs. Model 2 is named SCCPE because it includes the following metrics: Schedule Performance, Cost Performance, Customer Satisfaction, Profit, and EMR. Model 2 uses unity (1) as input, just as several examples found in DEA literature [12] , Ozcan and McCue [13]. The reason behind using "1" as input lies in the fact that few firms supplied sufficient details in answering this part (expenses on safety and expenses on project management) of the survey questionnaire.

6.2.1 Model 1: FULL

For the FULL model, scores average 0.88 with a standard deviation of 0.23. The highest score is 1.0 and the lowest score is 0.22. Among the 21 DMUs, 16 are efficient (score = 1.0) and 5 are inefficient (score < 1.0).

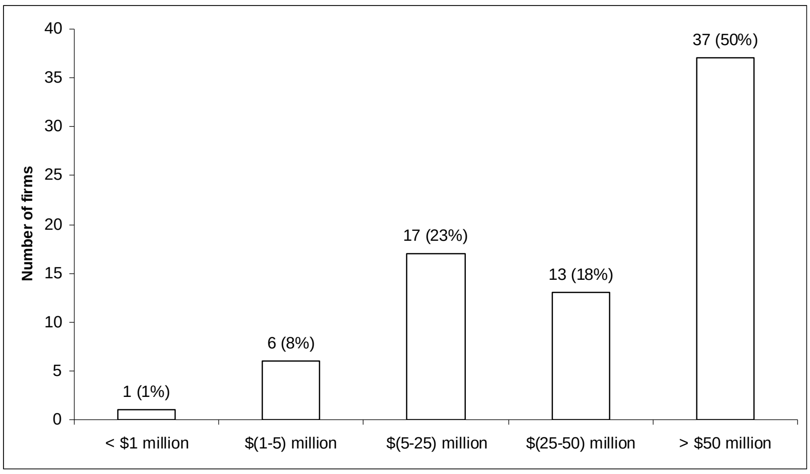

Figure 2. Firms' Revenue

Table 5 supplies the projected values for seven important metrics. The projected values are of particular importance to inefficient DMUs. By arriving at the projected values, inefficient DMUs have the opportunity to become 100% efficient. For example, in order to be considered efficient, Firm AN has to reduce safety expenses and project management expenses by 54% and

Table 2: Metrics of Performance Descriptive Statistics

Metric	**Number of firms**	**Mean**	**Sd**	**Min.**	**Max.**	**25th Quartile**	**75th Quartile**
Schedule performance (%)	69	80.3	23.12	10	100	75	95
Cost performance (%)	69	81.75	15.22	10	100	75	90
Customer satisfaction (%)	67	60.34	25.25	10	100	40	80
EMR	35	0.702	0.1356	0.45	0.95	0.61	0.8
Profit (%)	23	3.066	2.645	0.14	12	1.5	3.875
Safety expenses (%)	43	0.98	1.344	0.1	5	0.25	1
Project management expenses (%)	40	4.311	3.26	1	12	2	6

48.7% respectively. At the same time, AN has to improve its schedule performance, cost performance, 1/EMR, customer satisfaction, and profit by 5.26%, 7.69%, 4.11%, 26.92%, and 120.73% respectively. By meeting the above criteria (reducing inputs and improving outputs), AN can raise its score to 1.0 and can then be considered 100% efficient.

Table 3: DEA Models to Benchmark Performance

Model #	**Model name**	**Number of firms**	**Inputs**	**Outputs**
1	FULL	21	– Project management expenses – Safety expenses	– Schedule performance – Cost performance – Customer satisfaction – Profit – 1/EMR
2	SCCPE	28	1	– Schedule performance – Cost performance – Customer satisfaction – Profit – 1/EMR

6.2.2 Model 2: SCCPE

This model includes 28 firms. The outputs are: schedule performance, cost performance, 1/EMR, customer satisfaction, and profit. Table 7 provides descriptive statistics for the results of the SCCPE model. The scores average 0.943 with a standard deviation of 0.0888. Again, the highest score is 1.0 and the lowest score is 0.602. Ten DMUs are efficient, while 18 are inefficient. The information from the SCCPE model can be used in exactly the same way as the information from the FULL model.

Table 5: FULL Model Results

No.	**DMU Input/Output**	**Score Data**	**Projection**	**Difference**	**%**
5	AN	0.51			
	Safety expenses (%)	0.25	0.115	-0.135	-54.00%
	PM expenses (%)	1.95	1	-0.95	-48.72%
	Schedule performance (%)	47.5	50	2.5	5.26%
	Cost performance (%)	65	70	5	7.69%
	1/EMR	1.31	1.37	0.05	4.11%
	Customer satisfaction (%)	65	82.5	17.5	26.92%
	Profit (%)	2.05	4.525	2.475	120.73%

7 CONCLUSIONS

This is the first construction benchmarking model introduced to the industry that accurately rates the efficiency of a construction firm on a company-wide basis and identifies the areas that the firm must improve upon in order to be the on par with the most efficient firms in the industry. It accomplishes this by measuring a firm against the five metrics identified by a consensus of the literature as the five most important measures of company efficiency.

The model also produces and reports the magnitude of the deficit that a company must overcome in each of the five areas measured in order to become as efficient as the most-efficient firm(s) in the industry.

The data from a diverse set of 74 firms, randomly chosen were analyzed and then two different versions of the model were validated. Each model performed satisfactorily, identifying the efficient firms and instructing the inefficient firms about where to concentrate their efforts and telling them how much improvement is needed in each area measured.

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