Construction Portfolio Performance Management Using Key Performance Indicators

Mohsen Shahandashti (PhD, P.E.)
University of Texas - Arlington
Arlington, Texas, United States

Baabak Ashuri (PhD, DBIA)
Georgia Institute of Technology
Atlanta, Georgia, United States

Ali Touran (PhD, P.E.)
Reza Masoumi (PhD)
Northeastern University
Boston, Massachusetts, United States

Edward Minchin (PhD, P.E.)
University of Florida
Gainesville, Florida, United States

The purpose of this study is to determine the relative importance of key results areas (KRAs) and develop key performance indicators (KPIs) for construction portfolio performance management. The research methodology consists of the following steps: (1) Designing and conducting a fact-finding survey of owners and contractors to determine the relative importance of KRAs; (2) Designing and conducting structured interviews to develop KPIs; and (3) Assessing the usefulness of the results. Unlike the literature that has consistently highlighted the importance of risk management for construction portfolio performance management, risk management is not among top five KRAs (schedule, cost, cash flow, change management and safety) identified in the survey. This represents the significant gap in how research community and industry look at portfolio performance management. When it comes to dashboard development, contractors and owners have different KRAs within their dashboard for portfolio management. The limited knowledge about the relative importance of KRAs is one of the most important barriers towards managing project portfolios. This study is the first attempt to critically examine the literature and practice of construction portfolio performance management in order to highlight noteworthy differences between KRAs studied by the research community and implemented by the industry.

Keywords: Construction portfolio performance, Key performance indicator, Key results area.

Introduction

The practice of managing multiple projects in the construction industry is increasing in popularity. This growth allows organizations to maximize the use of their limited resources. Portfolio management (or program management) enables executives to focus on long-term strategic goals and address enterprise-level needs. Managing portfolios of small- to mid-sized projects provides unique benefits and opportunities in several management areas, such as strategic planning and risk management (Masoumi and Touran 2016; Ashuri and Tavakolan 2015; Ashuri and Tavakolan 2012; El-Adaway and Kandil 2009; Touran 2009; Veshosky 1994). However, the benefits of managing projects at the portfolio level come with challenges that should be addressed appropriately to take full advantage of the potential opportunities and achieve companies' strategic goals. The limited knowledge about the relative importance of key results areas (KRAs) is the most important barrier towards managing project portfolios. In addition, key performance indicators (KPIs) should be identified and used within proper dashboards to support the management of a portfolio of construction projects. These key performance indicators are selected from key results areas that show the importance of key

results areas. The identification of top KRAs and development of KPIs pave the way to develop effective dashboards for KRAs.

Most research studies on construction portfolio management have focused on the areas of risk management, financial management, and resource management. In the area of risk management for multiple construction projects, Kangari and Riggs (1988) investigated the difficulties in the practical application of the portfolio theory in construction. Touran (2009) developed a mathematical model to evaluate how the increase in the confidence level in probabilistic risk assessment of multiple construction projects impacts budgets. El-Adaway and Kandil (2009) developed a technique for calculating the portfolio insurance premium. Masoumi and Touran (2016) developed a framework to help organizations form their project portfolios considering the organizational strategic goals and risk tolerance level. Ashuri et al. (2018a, b) developed a risk management system for the Georgia Department of Transportation.

In the area of financial management for multiple construction projects, Kim and Liu (2007) developed a cost-based project model that is suitable for managing multiple construction projects. Kishore et al. (2011) and Kaka and Lewis (2003) developed cash flow forecasting models for a portfolio of construction projects. El-Abbasy et al. (2012), Elanouzi and Abido (2011), and Elanouzi (2009) developed finance-based scheduling for multiple projects to minimize cash flow deficit risk in financial management of construction project portfolios.

In resource management for multiple construction projects, Chen and Shahandashti (2009) created hybrid genetic and simulated annealing algorithms for scheduling multiple construction projects with multiple resource constraints. Genetic algorithm and simulated annealing have also been individually developed for scheduling multiple construction projects with multiple resource constraints (Tavakolan and Ashuri 2012a, b, c; Tavakolan et al. 2011a, b; Chen and Shahandashti 2008; Chen and Shahandashti 2007a, 2007b, 2007c). Cheng et al. (2006) focused on organizational human resource planning for multiple projects. They created a team-based human resource planning method that includes four phases: process reengineering, data preparation, human resource allocation, and simulation. Resource management for multiple construction projects is also briefly assessed in a few research studies that focus on construction program management (Shehu and Akintoye 2010; Shehu and Akintoye 2009; Shehu and Akintoye 2008). For example, Shehu and Akintoye (2008) list resource allocation and resource control as required skills and competencies for managing multiple projects. Finally, Blomquist and Müller (2006) conducted a study for the Project Management Institute (PMI) to determine the middle managers' roles and responsibilities in portfolio management. Although they identified several roles and responsibilities of middle managers in successful companies, they did not focus on portfolio performance management using KPIs in the context of the construction industry.

Despite the wide recognition of the critical role that construction performance management using KPIs plays in success of construction projects (Kumaraswamy and Thorpe 1996; KPIs Working Group 2000; Chan et al. 2004; Ramirez et al. 2004; Yu et al. 2007), only a few studies have focused on construction portfolio performance management using KPIs (e.g., Suk et al. 2012; Alvarado et al. 2004). Construction performance management refers to not only the process of monitoring past performance but also the process of improvement of individuals and teams

within a construction organization (Bernold and AbouRizk 2010). It includes measures of self-measurement and value-added processes (Bernold and AbouRizk 2010).

Suk et al. (2012) created a performance dashboard for a pharmaceutical project benchmarking program. They used a relative comparison method and weighted KPIs to generate an overall performance score at the project and portfolio levels. The overall project performance was a combined score of four performance categories: cost, schedule, quality, and dimension. Alvarado et al. (2004) proposed a method to assess schedule performance and budget performance for construction portfolios. They proposed a dashboard system for assessing the performance of portfolios. They also displayed weighted schedule performance and budget performance for a portfolio of construction projects. The earned value was the basis for weighting.

Therefore, past research efforts in the area of construction portfolio management mostly focused on financial management, risk management, and resource management with emphasis on portfolio prioritization tools and techniques, and not on the performance management. In the rare studies focused on construction performance management, the developed methodologies are either too complex for industry application or too specific to an industry sector or a performance area. Most importantly, these studies do not provide any insights into the relative importance of KRAs for construction portfolio performance management. Overall, the limited knowledge about the relative importance of KRAs inhibits our capabilities to develop effective dashboards where KRAs are necessary. The emphasis of the research is to focus on the projects that are already selected and assigned to a specific portfolio and strive for identifying KRAs and developing KPIs that are applicable to current industry practice.

The objective of this study is to determine the relative importance of KRAs for construction portfolio performance management and develop KPIs to measure construction portfolio performance in KRAs. In the context of this research, a portfolio is defined as a group of related or unrelated projects and programs managed by a single individual. This definition was arrived at after discussions within the research team including representatives from nine owners and eight contractor organizations. Survey and interview results are discussed after the research methodology is described in the next section. KPIs are developed after the survey and interview results are analyzed. The usefulness of the results is assessed before conclusions are provided. The usefulness of findings of this study was assessed through a survey that was distributed among industry experts. The reviewers were asked to rate the usefulness of the results on a scale of 1 (not useful) to 10 (very useful).

Research Methodology

The research methodology consists of the following steps: (1) Designing and conducting a fact-finding survey of capital project owners and contractors to determine the relevant importance of KRAs; (2) Designing and conducting structured interviews with selected firms to develop KPIs; and (3) Assessing the usefulness of the results.

Following a thorough literature and background review, the research team including both academic and industry members (nine owners and eight contractors) investigated and discussed the gaps in knowledge. The research team identified assessing the relative significance of KRAs as one of the main limitations of the current literature in construction portfolio performance management.

The identified gap in knowledge was used as the focus of developing survey questions. The survey questionnaire research method was used to review state-of-practice with respect to portfolio management in the U.S. construction industry. Considering the objectives of this study a survey questionnaire was designed to understand differences in portfolio performance management practices as utilized by owners and contractors of major capital projects in the U.S. Within each section, the survey respondents were required to identify, and rate statements based on their importance and expand responses if it was deemed appropriate. The main goal of the authors in the survey design was to achieve a sufficient level of rigor. Thus, every attempt was made to avoid general arguments and include well-explained statements that had grounds in the academic or professional portfolio management literature.

The industry members of the research team examined the adequacy and overall reasonableness of survey questions. In addition, the developed survey was pilot tested by five industry professionals who are knowledgeable about portfolio management. Based on the feedback from these individuals, minor modifications were made to the survey terminology or statements with the potential to deviate the respondents from the survey objectives. The final survey was distributed in an online format through e-mail to experts in the U.S. construction industry.

The online survey was conducted using SelectSurvey™. Every effort was made to increase the rate of response. In addition to Construction Industry Institute (CII) members, the Construction Management Association of America (CMAA) was contacted to reach their membership. Both CII and CMAA members were contacted to get sector-independent results that are relevant to the construction domain and not specific to only capital projects or general building. The CMAA leadership helped to reach their membership and encouraged their members to respond to this research effort. The team also contacted the members of the Construction Users Round Table (CURT). In total, 306 emails were sent to individuals in 251 organizations. The research team through follow-up emails contacted the recipients and encouraged them to respond.

The survey also served as the screening tool for selecting the potential firms for in-depth follow-up interviews. The structured interview research method was employed to develop a set of effective KPIs for construction portfolio management. The interviews engage the interviewees in active conversation and enable documentation of intriguing arguments on various aspects of implementing portfolio performance management in the U.S. construction industry, specifically main KPIs used in the portfolio dashboards.

The goal of the interview process was to engage subject matter experts on identifying common KPIs for managing the performance of the construction portfolio. The responses to the survey were analyzed to identify firms with noteworthy practice in construction portfolio performance management for conducting follow-up interviews. Willingness and cooperation of the firms, diversity in the industry sector, and geographical location were also considered in selecting firms

for an interview. The interview questions were prepared in collaboration with the industry members of the research team. The developed interview template was pilot tested with three subject matter experts with expertise in developing KPIs for construction portfolio. Based on the feedback from these individuals, minor modifications were made to the interview questions to enhance the clarity of questions and align them with the overall goal of the research.

Analysis of survey results

The research team developed and conducted an online survey with the purpose of determining the relative importance of KRAs for construction portfolio performance management. Another purpose of the survey was to help in screening and identifying the most appropriate firms for in-depth face-to-face interviews to develop KPIs for construction portfolio performance management. The response rate was about 45% of email recipients and 36% of organizations. These rates compare favorably with similar data collection efforts using online survey tools (Hamilton 2009; Nulty 2008). 139 individuals from 90 firms responded to the survey.

Descriptive information of the responding firms

Slightly over half of those responded to the survey (approximately 59%) categorized themselves as owners. The roles of those responded to the survey can be categorized as project manager (12.2%), program manager (10.1%), portfolio manager (12.2%), project director (11.5%), project controls manager (9.4%), and others (44.6%). The roles of individuals as "others" participating in the survey are typically related to the top managerial hierarchy in their firms/organizations. The roles of individuals as "others" include director of capital project management, manager of project management and controls, and engineering manager.

Figure 1 shows the percentage (number) of surveyed firms in each industry sector. More than half of those surveyed are engaged in heavy industrial construction. Several of the organizations surveyed are engaged in more than one sector of the construction industry; hence the percentages sum to well over 100. Approximately 97% of those surveyed work for an organization where people managing a group of projects.

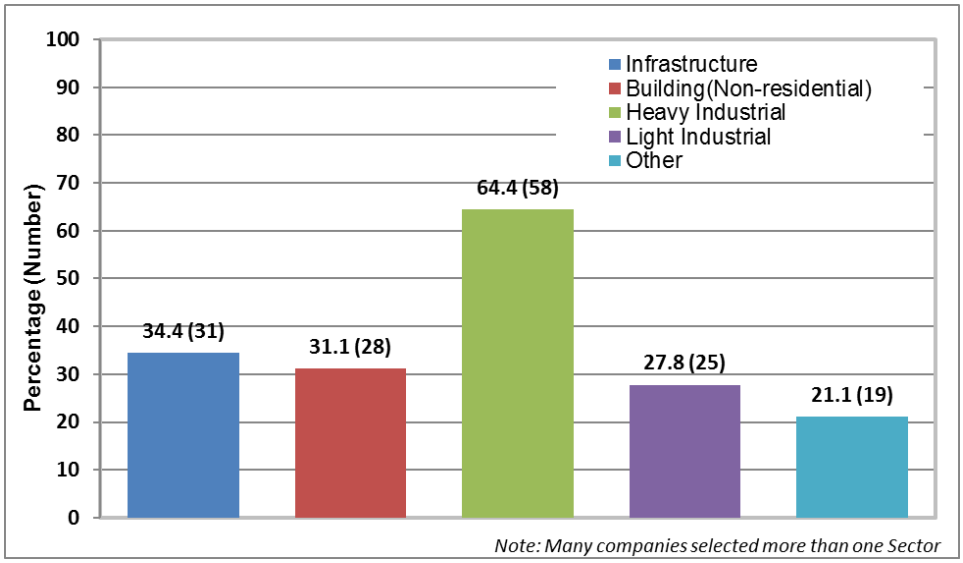

Figure 1: Percentage of Firms in Each Industry Sector.

Most organizations do not assign more than ten projects to one individual; 35.6% of organizations assign less than six projects to an individual, and 18.4% of organizations assign between 6 to 10 projects to a single manager. Almost half of those surveyed (46%) work for organizations with portfolios of over $50 million. Only 8% of those surveyed work for organizations with portfolios of less than $5 million. Over three-quarters of respondents (76.8%) work for organizations where a typical project in a portfolio has a duration of longer than one year, while about one-third (32.6%) have projects that are typically over two years in duration.

The relative importance of KRAs for construction portfolio performance management

Approximately 81% of respondents reported that their firms use metrics to measure and monitor the performance of projects at the portfolio level. The performance of projects refers to the performance in one of the following areas: schedule, cost, cash flow, procurement, resource allocation, communication, quality, scope, change management, safety, and risk management. Surprisingly, cost, schedule, cash flow, change management and safety are the top five areas in which both contractors and owners use metrics for measuring the performance of projects at the portfolio level (Figure 2). This represents the significant gap in how research community and industry look at portfolio performance management. It should be noted that inherent risk (Kim and Reinschmidt 2009) might be involved in the top five KRAs. For instance, risk analysis is typically conducted in conjunction with scheduling and cost management. KPI category in Figures 2, 3, and 4 refers to those metrics that show the performance of a company in achieving business objectives. KPIs show how effectively a company achieves its key business objectives. KPIs are different from project-level performance metrics, such as schedule and cost metrics. KPIs, such as Return on Investment (ROI) and several new customers, are not project-level metrics but company-level performance measures.

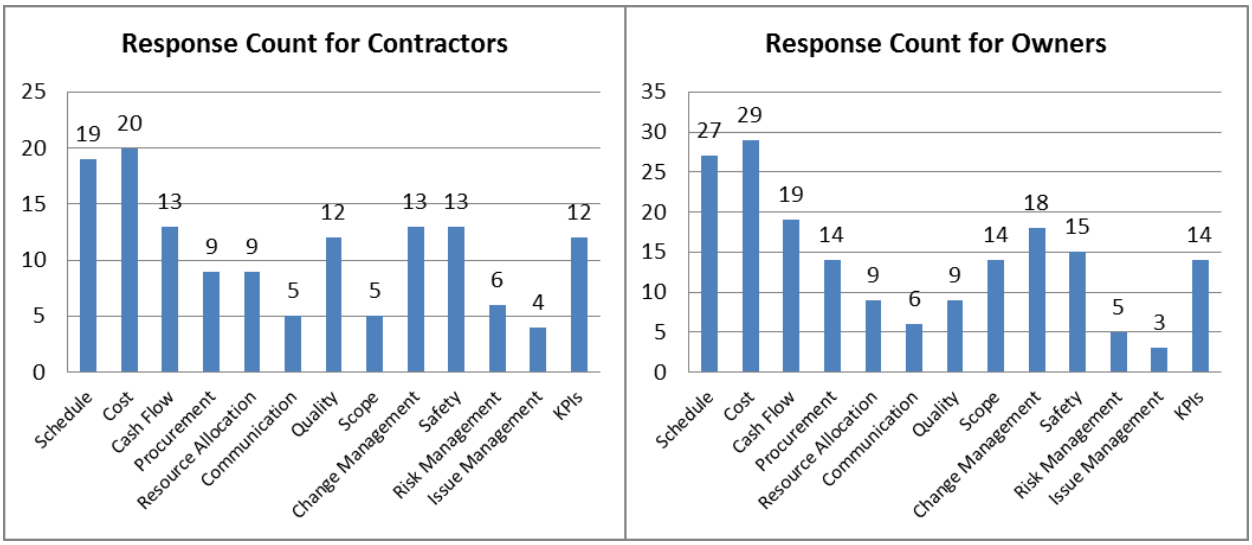

Figure 2: Statistics on Metrics in Diverse Areas for Measuring Performance of Projects in a Portfolio.

Figure 3 shows areas where firms need to improve metrics at the portfolio level. While the schedule is the top area that contractors underlined the need to improve metrics, resource management is the top area that owners highlighted the need for improvement.

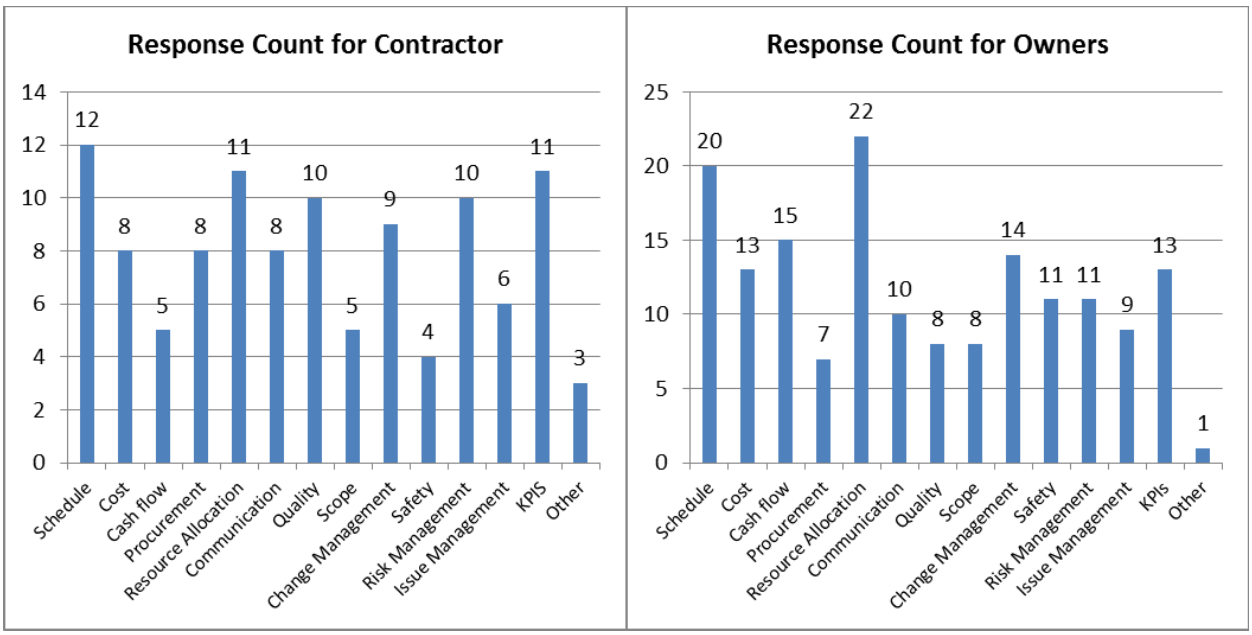

Figure 3: Statistics on Areas that firms Need to Improve Metrics at the Portfolio Level.

Approximately 60% of those questioned reported that their company uses a dashboard or scorecard to monitor the performance of portfolios. Cost and schedule are the top two areas for which contractors and owners have metrics within their dashboards (Figure 4). Besides cost and schedule, contractors chose change management as the third top area where they use metrics, while owners chose safety and cash flow as the third and fourth top areas for the use of metrics.

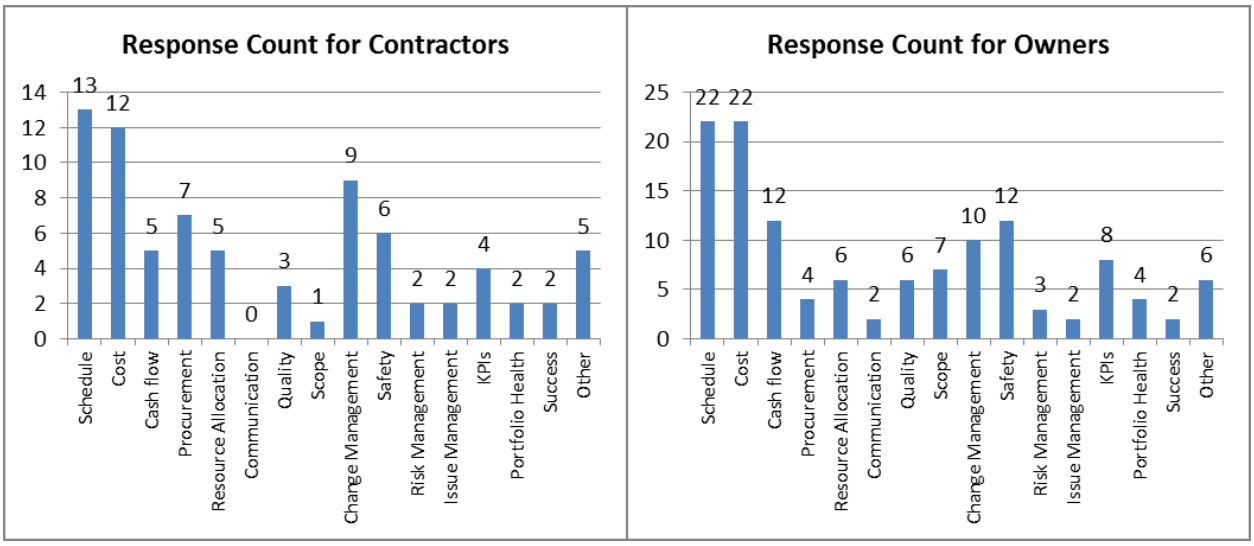

Figure 4: Statistics on Areas that Metrics Included in the Scorecard/Dashboard.

Analysis of interview results

The online survey data were analyzed for selecting a subset of surveyed firms for structured interviews. The purpose of the interviews was to develop effective KPIs for construction portfolio performance management. Therefore, 15 firms with construction portfolio performance management were selected for structured interviews. Willingness and cooperation of the firms, diversity in the industry sector, and geographical location were also considered in the selection of the 15 firms. Based on the answers to six questions in the survey, a score of 0, 5 or 10 was assigned to each response and the firms with a total score of 40 or higher (out of a possible 60) were shortlisted for the structured interview. The shortlisted roster consisted of 32 firms. Finally, 15 firms were selected considering the success in portfolio management, willingness and cooperation of the firms, diversity in the industry sector, and geographical location.

Descriptive information of the interviewees

Table 1 shows the breakdown of the interviewed firms based on industry sector. It also shows whether they can be categorized as owners or contractors.

Table 1: Breakdown of the interviewed firms.

FIRMS	Owner	Contractor	Government	Non-Government	Infrastructure	Building	Heavy	Light
1	✓			✓			✓	
2	✓			✓				✓
3		✓		✓			✓	
4		✓		✓			✓	
5	✓			✓			✓	
6		✓		✓			✓	
7	✓		✓			✓		
8	✓			✓			✓	
9	✓			✓				✓
10	✓		✓		✓	✓	✓	✓
11	✓			✓		✓	✓	✓
12	✓			✓			✓	
13	✓		✓		✓	✓		
14	✓		✓		✓			
15	✓			✓			✓	
	12	**3**	**4**	**11**	**3**	**4**	**10**	**4**

About half of the interviewees (7 out of 15) have more than 50 projects in their portfolios at top level. This implies that interviewees belonged to larger firms in comparison to the average firm that responded to the survey because the online survey (previous section) indicated that the most common case was where the number of projects in the portfolio was “less than 6”. The majority of firms (13 out of 15) have projects with typical durations above 12 months within their portfolios. Figure 5 shows the number of firms using metrics in different areas for portfolio and project management. As shown in Figure 5, there are at least three firms in each key result area that facilitated the development of KPIs.

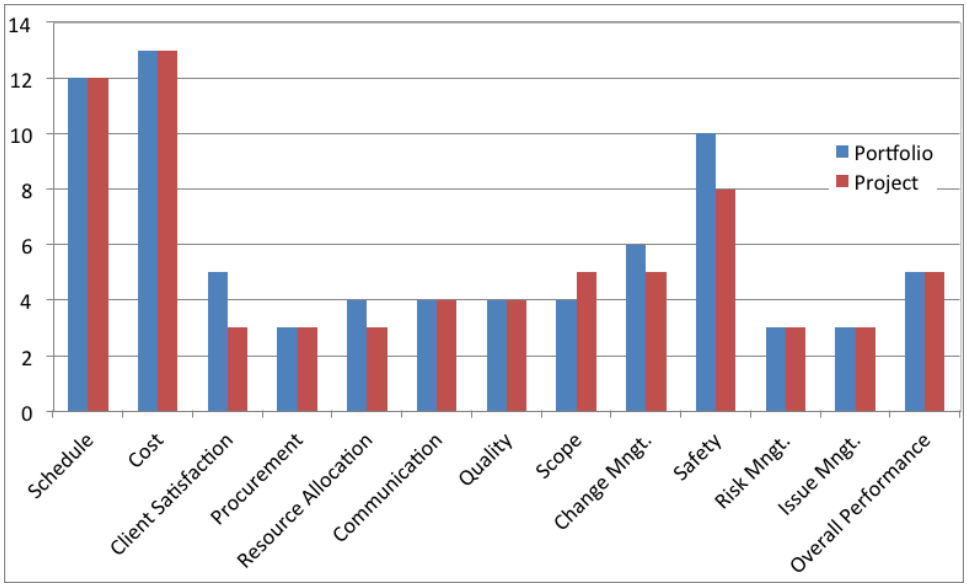

Figure 5: Number of Firms Using Metrics in Different Areas for Portfolio and Project Management.

KPIs for construction portfolio performance management

All the interviewed firms have some types of KPIs to measure portfolio management success. Some of these KPIs (e.g., number of milestones completed) can be readily calculated by rolling up project information to the portfolio level while others (e.g., bid amounts as a percentage of engineering estimates) are more complicated. Parameters that roll up from the project level to the portfolio level are safety indicators, average number of change orders, cost related metrics (e.g., cash flow target achievement rate, actual versus planned cost, annual and total portfolio budget, return on investment, percentage of projects to be finished under the budget, percentage of on-time payments to contractors, percentage of planned cost for the current year expenditure, percentage of authorization for expenditure spent on completed projects), and schedule related metrics (e.g., number of actual versus planned milestones achieved during a specific period, percentage of projects completed on time). A few firms use more complicated KPIs that are related to predictability, performance, competitiveness, productivity, and quality. It should be noted that there is a concern by most firms that too many KPIs hinder decision-making. There is a trade-off between the comprehensiveness and simplicity for managing a portfolio of construction projects. Although more KPIs may provide more comprehensive awareness about the status of construction portfolio in multiple dimensions, the complexity of having too much information may hinder decision making considering the limited cognitive capabilities of decision makers. Although information included in KPIs are important, the most important information included in a few KPIs should be highlighted through prioritization of the KPIs. Therefore, the number of KPIs should be limited to those that are absolutely required.

The fact-finding surveys and the follow-up interviews yielded a number of KPIs used by owners and contractors for portfolio performance management. Table 2 presents the KPIs that are recommended to help portfolio managers determine what to measure to improve performance in each KRA.

Table 2: Recommended KPIs for KRAs at the Portfolio Level

KRAs	Suggested KPIs
Schedule	• Number/ percept of milestones completed (or missed) vs. planned • Number/ percent of projects on (or behind) schedule • Total/ average days ahead of (or behind) schedule • Schedule durations compared to benchmarks (average for portfolio) • Number/ percent of projects with schedule durations longer (or shorter) than benchmarks
Cost/ Cash Flow	• Actual cost-to-date and revised forecast vs. planned (monthly and cumulative) • Cost variation (monthly and cumulative) – at project and portfolio level • Estimated completion cost vs. original/ current budget • Number/ Percent projects within (or over) budget • Total portfolio cost vs. budget • Project cost estimates vs. benchmarks (average for portfolio) • Number/ percept projects with costs higher (or lower) than benchmarks
Safety and Environment	• Safety and environmental incidents (first aids, recordable injuries, days-away-from-work injuries, spills, releases, etc.) • Incident frequency rates • 12-month rolling average of incident rates • Number of environmental permits outstanding • Near misses (a near miss is an event that could potentially result in damage, injury, or illness, but it did not.) • Proactive safety activities (documented audits, job safety analyses, hazard identifications, etc.)

Change Mgmt./ Scope	• Number of requests for information (RFIs) • Total number of scope changes • Total cost of scope changes/ change orders • Total changes as percent of original approved budget • Total value or percentage of estimate omissions
Resource Allocation	• Project team member turn-over • Planned vs. actual engineering/ construction hours • Planned vs. actual resources (human resources (full-time employees), equipment, etc.) • Capital efficiency (value of projects managed) per project manager • Percent utilization of resources (e.g., project team members, equipment)
Proc./Supply-Chain	• Actual vs. planned number of purchase orders/ contracts issued • Number/ percept of late deliveries • Bid amounts as percentage of engineering estimates • Locally-sourced (high value offshore, minority participation, etc.) as percentage of total procurement
Quality	• Average project definition rating index (PDRI) score at project funding (or earlier stage gates) (as a potential leading indicator of project quality) • Number of defects (welds, test failures, etc.) • Percentage of rework • Number/ percent of projects completed with (or without) significant issues • Number of deficiencies open for more than target resolution period
Risk Mgmt.	• Summary/ status of known risk issues and mitigation plans • Risks mitigation actions completed for the reporting period • Risks eliminated (or unrealized) during the reporting period • New or emerging risks identified during the reporting period
Client Satisfaction, Other	• Customer satisfaction index • Training and development status • Number (or Percentage) of projects in each project stage • Overall portfolio performance index = Number of Successful Completed Projects ∗/ Total Number of Projects Planned to be Completed *Success is defined by meeting predetermined schedule, cost, safety, and operability targets • Number or percent of projects in each project phase

The portfolio dashboard will have a limited number of simple, easy-to-understand, objective KPIs but with enough underlying detail to allow portfolio managers to drill down to specific projects. Portfolio managers need to carefully consider what KPIs actually measure as tracking a single KPI may lead to the wrong conclusions. For example, measuring overall cost performance by totaling actual cost versus planned (e.g., $200M actual cost versus $250M planned cost) for the entire portfolio can be misleading even when the numbers appear to be comparable if a number of projects are grossly overspending and others have not made progress at all. Using this KPI in conjunction with one that measures the percentage of projects that are within +/- 10% of their planned costs (e.g., 95% of projects within +/- 10% of their planned costs) would give a much better picture of overall cost performance. In this case, two KPIs are better than one. Another consideration is which KPIs to trend over time. Trending KPIs is typically used to determine whether or not performance improvement actions have been effective.

There are various methods that firms use to communicate the performance of their portfolios. On one end, there is a firm that merely reviews the performance in monthly meetings with the director. On the other end, there are firms having established databases, written reports, and dashboards for reporting and communicating the portfolio performance.

Dashboards for construction portfolio performance management

A performance dashboard can be defined as "a multilayered application built on business intelligence and data integration infrastructure that enables organizations to measure, monitor, and manage performance more effectively" (Eckerson 2006). Dashboards could be used to effectively communicate performance of portfolios of construction projects (Suk et al. 2012; Alvarado et al. 2004).

While ten firms use some sort of dashboard to report project performance, five firms do not use dashboard(s) to communicate portfolio performance in different management areas. Traffic light dashboards are extremely popular and perceived critical by upper management in most organizations. A number of companies use traffic light dashboards to report status in a variety of areas, such as scope, schedule, and cost. The recommended approach is to tie colors to pre-determined targets. The Red, Yellow and Green colors are generally used; Green = good, Yellow = caution, and Red = bad conditions of different metrics.

Identifying what KPIs are shown on the dashboard is a critical and challenging task since there are various groups and stakeholders in one organization that have an interest in the overall status of a portfolio. The interviewed firms described an ideal dashboard with the following characteristics: simplicity (too many metrics make the dashboard complicated); consistency in format (standardization); data integration and interoperability; quantitative representation; capability of drilling down to specific projects and problems; objective assessment of different areas in a consistent manner across all projects in the portfolio; transparency; accessibility; scalability (what layer of information should be provided to who, when, and how?); presentation of an optimal level of KPIs; effectiveness and usefulness of performance information; and monthly updating.

Another issue of importance was if the firms use different types of dashboards to report to different managerial levels. Three firms responded that they do not use the same dashboard for reporting to various management levels. One of these firms provides customized dashboards based on the users' needs at different managerial levels inside their firms while they also have some standard reports. Another firm provides a specific report for the board of directors, but other users have the same dashboards. One firm uses the same dashboards, but the access to the information on the dashboard for each person is different. The metrics are the same; however, the number of reports in each portfolio level varies.

Figure 6 represents schematic representation of a dashboard for construction portfolio performance management. This dashboard evaluates project status in several areas, such as cost. The Red, Yellow and Green method is used in the dashboard (Green = good, Yellow = caution, Red = bad).

Project Data				Production		Project Status							Notes
Title	Location	Capex $M	Funding	S/U BU	S/U LE	Overall	Funding	Cost	Procure	Design	Const	Startup	
Innovation Projects													
Project 1	LA	1.5	Funded	May13	May-13								...
Project 2	ATL	2.6	Funded	Oct13	10/8/13								...
Project 3	LA	3.0	Funded	Dec13	2/8/13								...
Project 4	ATL	10.5	Funded	Mar13	3/26/13								...
Project 5	LA	7.5	Funded	May13	5/13/13								...
Project 6	ATL	2.5	Funded	Aug13	8/19/13								...
Cost Projects													
Project 1	LA	6.5	Funded	May13	5/15/13								...
Project 2	ATL	4.2	Funded	Oct13	10/8/13								...
Project 3	ATL	3.6	Funded	Dec13	2/8/13								...
Project 4	LA	4.2	Funded	Mar13	3/26/13								...
Capacity Projects													
Project 1	ATL	18.5	Funded	May13	5/15/13								...
Project 2	LA	10.2	Funded	Oct13	10/8/13								...

Legend: On Track Potential Issues Major Impacts

Figure 6: Schematic Representation of a Dashboard for Construction Portfolio Performance Management

Usefulness of the Findings for the Construction Industry

The usefulness of findings of this study was assessed through a survey that was distributed among industry experts. The reviewers were asked to rate the usefulness of the results on a scale of 1 (not useful) to 10 (very useful). A unipolar rating scale was used to assess the usefulness of the findings by requesting the respondents to evaluate the presence and absence of the usefulness quality on a scale of 1 (not useful) to 10 (very useful). The reviewers were also asked to include any comments. The survey helped the research team rigorously evaluate the usefulness of the findings. Overall, 12 industry experts responded to assess the usefulness of the findings. These industry experts were affiliated with nine different organizations. It should be noted that the goal was the solicitation of industry experts' opinion on the usefulness of the findings (not the data acquisition with statistical significance).

The findings were considered useful by most of the reviewers. The average rating given to the usefulness of the findings was 7.2, and the lowest and highest ratings were 5 and 9, respectively. The findings were considered very informative and well developed. More specifically, Table 2 was considered very helpful. In addition, most of the reviewers liked the KRAs and KPIs. A reviewer indicated that in reality, "many times we do not have these basic metrics yet and much of our effort is consumed in getting these items." Hence, the metrics should be defined and redefined. The other collected comments are summarized here: "too many KPIs are hard to use in decision making and rolling up some KPIs could mask meaningful variances that need

attention", "trending some KPIs has been effective", providing a common format for data collection is a must", and "PMs must own the data".

Suggested Areas for Research and Development

The suggested areas for further research and development, collected from the survey and interviews, are summarized as the following:

- Exploring effective portfolio data management.
- The gating process, budgeting process, and benefit analysis components.
- Studying front-end planning tools and applicable front-end metrics available to portfolio managers in further details.
- Exploring Integrated Project Management Team Approach.
- Identifying different ways to select and create a portfolio from an upper management perspective.
- Studying the workload assessment tool.
- Explaining the correlation between PDRI and portfolio performance metrics.
- Exploring the need for and studying the impact of expedited approvals and expedited procurement on the smaller portfolio.
- Discussing engineering as a percentage of Total Installed Cost (TIC) issues.
- Standardizing data exchange between contractors and owners, specifically around data required to manage the portfolio by owners.

Conclusions

Unlike the literature that has consistently highlighted the importance of risk management for construction portfolio performance management, risk management is not among top five KRAs (schedule, cost, cash flow, change management and safety) identified in the survey. This represents the significant gap in how research community and industry look at portfolio performance management. The risk management research results have not yet found its way into the practice of portfolio management in the construction industry. These results also show the research need to focus further on what found important in the construction industry.

The limited knowledge about the relative importance of KRAs is one of the most important barriers towards managing project portfolios. This study contributes to the state of knowledge and practice by examining the literature and practice of construction portfolio performance management in order to highlight noteworthy differences between KRAs studied by the research community and implemented by the industry. While schedule is the top area that contractors underlined the need to improve metrics, resource management is the top area that owners highlighted in need for improvement. Cost and schedule are the top two areas for which contractors and owners have metrics within their dashboards. Besides cost and schedule, contractors chose change management and procurement as the third and fourth top areas, while owners chose safety and cash flow as the third and fourth top areas for the use of metrics. The results of the survey and the structured interviews yielded several KPIs, presented in this paper,

to help portfolio managers determine what to measure to improve performance in each KRA. This research is subject to sample size limitation. Moreover, the usefulness has not been observed; it has been evaluated based on the perception of industry experts.

Acknowledgments

This material is based upon work supported by the Construction Industry Institute (CII).

References

Alvarado, C.M., Silverman, R.P., and Wilson, D.S. (2004). Assessing the performance of construction projects: Implementing earned value management at the General Services Administration. *Journal of Facilities Management*. 3(1), 92-105.

Ashuri, B., Moradi, A., Baek, M., Kingsley, G., An, H.Y., Zhang, L., Liang, Y., and Bahrami, S. (2018a). "Enhancement of the Comprehensive Risk Assessment for Transportation Projects." Georgia DOT Research Project RP16-28, *Georgia Department of Transportation*, Atlanta, Georgia, September 2018.

Ashuri, B., Moradi, A., Baek, M., Kingsley, G., An, H.Y., Zhang, L., Liang, Y., and Bahrami, S. (2018b). "Risk Mitigation Strategies to Enhance the Delivery of Highway Projects." Georgia DOT Research Project RP16-40, *Georgia Department of Transportation*, Atlanta, Georgia, September 2018.

Ashuri, B. and Tavakolan M. (2015). "Shuffled Frog-Leaping Model for Solving Time-Cost-Resource Optimization (TCRO) Problems in Construction Project Planning." *ASCE Journal of Computing in Civil Engineering*, 29(1), 04014026.

Ashuri, B. and Tavakolan, M. (2012). "A Fuzzy Enabled Hybrid Genetic Algorithm-Particle Swarm Optimization Approach to Solve Time-Cost-Resource Optimization (TCRO) Problems in Construction Project Planning." *ASCE Journal of Construction Engineering and Management*, 138(9), 1065–1074.

Bernold, L. E., & AbouRizk, S. M. (2010). *Managing performance in construction*. John Wiley & Sons.

Blomquist, T., and Müller, R. (2006). *Middle managers in program and project portfolio management: Practices, roles and responsibilities*. Project Management Institute.

Chan, A. P. C., Scott, D., and Chan, A. P. L. (2004). Factors affecting the success of a construction project. *Journal of Construction Engineering and Management*. 130(1), 153–155.

Chen, P.H., and Shahandashti, S.M. (2009). Hybrid of genetic algorithm and simulated annealing for multiple project scheduling with multiple resource constraints. *Automation in Construction*. 18(4), 434-443.

Chen, P.H. and Shahandashti, M. (2008), Stochastic Scheduling with Multiple Resource Constraints Using A Simulated Annealing-Based Algorithm, *Proceedings of 25h International Symposium on Automation and Robotics in Construction (ISARC 2008)*, 447-451, Vilnius, Lithuania, June 27-29.

Chen, P. H. and Shahandashti, M. (2007a), Modified Simulated Annealing Algorithm and Modified Two-Stage Solution Finding Procedure for Optimizing Linear Scheduling Projects with Multiple Resource Constraints, *Proceedings of international symposium on automation and robotics in construction (ISARC 2007)*, 411-416, India.

Chen, P. H. and Shahandashti, M. (2007b), Simulated Annealing Algorithm for Optimizing Multi-Project Linear Scheduling with Multiple Resource Constraints, *Proceedings of international symposium on automation and robotics in construction (ISARC 2007)*, 429-434, India.

Chen, P. H. and Shahandashti, M. (2007c), Modified Simulated Annealing Algorithm for Optimizing Linear Scheduling Projects with Multiple Resource Constraints, *Proceeding of 5th international conference of construction project management / 2nd international conference on construction engineering and management*, p. 151, Singapore.

Cheng, M.Y., Tsai, M.H., and Xiao, Z.W (2006). Construction management process reengineering: Organizational human resource planning for multiple projects. *Automation in Construction*. 15(6), 785-799.

Eckerson W.W. (2006). *Performance Dashboards. Measuring, Monitoring and Managing your Business*. John Wiley & Sons, New Jersey.

El-Abbasy, M. S., Zayed, T., and Elazouni, A. (2012). Finance-Based Scheduling for Multiple Projects with Multimode Activities. *Construction Research Congress 2012 Construction Challenges in a Flat World*. ASCE, 386-396.

El-Adaway, I. H., and Kandil, A. A. (2009). Construction risks: single versus portfolio insurance. *Journal of Management in Engineering.* 26(1), 2-8.

Elazouni, A. (2009). Heuristic method for multi-project finance-based scheduling. *Construction Management and Economics*. 27(2), 199-211.

Elazouni, A., and Abido, M. (2011). Multiobjective evolutionary finance-based scheduling: Individual projects within a portfolio. *Automation in Construction*. 20(7), 755-766.

Hamilton, Michael Braun (2009). *Online survey response rates and times*. Ipathia Inc./SuperSurvey.

Kaka, A., and Lewis, J. (2003). Development of a company-level dynamic cash flow forecasting model (DYCAFF). *Construction Management and Economics*. 21(7), 693-705.

KPIs Working Group. (2000). *KPI report for the Minister for Construction*. Department of the Environment. Transport and the Regions, London.

Kim, C. S., and Liu, L. Y. (2007). Cost information model for managing multiple projects. *Journal of Construction Engineering and Management*. 133(12), 966-974.

Kim, B. C., & Reinschmidt, K. F. (2009). Probabilistic forecasting of project duration using Bayesian inference and the beta distribution. *Journal of Construction Engineering and Management*, 135(3), 178-186.

Kishore, V., Abraham, D. M., and Sinfield, J. V. (2011). Portfolio Cash Assessment Using Fuzzy Systems Theory. *Journal of Construction Engineering and Management*. 137(5), 333-343.

Kumaraswamy, M.M., and Thorpe, A. (1996). Systematizing construction project evaluations. *Journal of Management in Engineering*. 12(1), 34–39.

Masoumi, R., and Touran, A. (2016). A Framework to Form Balanced Project Portfolios. *Construction Research Congress*. San Juan, Puerto Rico, 1772-1781.

Nulty, D.D. (2008). The adequacy of response rates to online and paper surveys: what can be done? *Assessment and Evaluation in Higher Education*. 33(3), 301-314.

Ramirez, R. R., Alarcon, L. F. C., and Knights, P. (2004). Benchmarking system for evaluating management practices in the construction industry. *Journal of Management in Engineering*. 20(3), 110–117.

Shehu, Z., and Akintoye, A. (2010). Major challenges to the successful implementation and practice of programme management in the construction environment: A critical analysis. *International Journal of Project Management*. 28(1), 26-39.

Shehu, Z., and Akintoye, A. (2009). Construction programme management theory and practice: Contextual and pragmatic approach. *International Journal of Project Management*. 27 (7), 703–716.

Shehu, Z., and Akintoye, A. (2008). Construction programme management skills and competencies: a deeper insight. *The Built & Human Environment Review*. 1, 1-17.

Suk, S.J., Hwang, B.G., Dai, J., Caldas, C.H., and Mulva, S.P. (2012). Performance Dashboard for a Pharmaceutical Project Benchmarking Program. *Journal of Construction Engineering and Management*. ASCE, 138(7), 864-876.

Tavakolan, M. and Ashuri, B. (2012a). "Comparison of Evolutionary Algorithms in Non-Dominated Solutions of Time-Cost-Resource Optimization Problem." *The 48th ASC Annual International Conference Proceedings*, Birmingham City University, April 11-14, 2012.

Tavakolan, M. and Ashuri, B. (2012b). "Development of Fuzzy Enabled Shuffled Frog Leaping Algorithm with Activity Splitting Allowed in Construction Project Scheduling." *2012 Construction Research Congress*, ASCE, Purdue University, West Lafayette, Indiana, May 21-23, 2012.

Tavakolan, M. and Ashuri, B. (2012c). "Stochastic Optimization of Construction Projects Planning with Genetic Algorithm" *2012 Construction Research Congress*, ASCE, Purdue University, West Lafayette, Indiana, May 21-23, 2012.

Tavakolan, M., Ashuri, B., Chiara, N. (2011a). "Development of Scheduling with Hybrid Genetic Algorithm-Particle Swarm Optimization." *2011 CSCE Annual Conference, 3rd International/9th Construction Specialty Conference*, Ottawa, Canada, June 14-17, 2011.

Tavakolan, M., Ashuri, B., Chiara, N. (2011b). "Applying the Shuffled Frog-Leaping Algorithm to Improve Scheduling of Construction Projects with Activity Splitting Allowed." *Int. Conference on Mgmt. Innovation Sustainable Built Envir.*, Amsterdam, June 20-22, 2011.

Touran, A. (2009). Probabilistic Approach for Budgeting in Portfolio of Projects. *Journal of Construction Engineering and Management*. 136(3), 361-366.

Veshosky, D. (1994). Portfolio Approach to Strategic Management of A/E Firms. *Journal of Management in Engineering*. ASCE, 5(41), 41-47.

Yu, I., Kim, K., Jung, Y., and Chin, S. (2007). Comparable performance measurement system for construction companies. *Journal of Management in Engineering*. 23(3), 131–139.