Linking Contractor Planning and Risk Prediction to Project Performance

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Project risk management includes the practices of identifying and minimizing cost and schedule impacts, both before and during construction projects. The Capital Facilities Group at a client organization adopted a unique approach to risk via a value-based project delivery method on their projects. During selection, contractors submitted a preliminary risk assessment that was evaluated by the client selection committee. Before contract award, the selected contractor developed a risk management plan to minimize project risks. Finally, during project construction, the contractor recorded all encountered risks and their actual cost and schedule impacts. The objective of this study is to determine if there is a link between contractor risk prediction and project performance by comparing the correlations between identified risks and the cost and schedule impacts of the actual risks. The risks were classified as being: client, contractor, designer, or unforeseen. The significant findings of this research were: the greater the percentage of identified design risks, the lower the design delay rate was on projects and the greater the percentage of identified client risks, the higher the client change order rate. The findings provide a quantifiable result from the impact of proactive risk management and planning practices prior to construction start.

Key Words: Risk Management, Public Policy, Project Delivery, Performance Measurement

Introduction

Risk is commonly defined as an uncertain event that, if it occurs, affects the achievement of the project's objectives positively or negatively (Hillson 2009; Williams 1995). The construction environment is replete with risk and is often the reason that the industry appears to be unprogressive (Flyvbjerg et al. 2002). Construction projects are more likely to be negatively impacted by uncertain events than any other industry sector (Flanagan & Norman, 1993). For this reason, a large amount of research within the built environment studies risk management in order to reduce the impact of uncertainty. Risk management within the industry typically includes fives phases of risk management, as: risk planning, risk identification, risk assessment, risk planning, and risk monitoring (Hubbard 2009). The focus of this research is on contractor risk identification and its impacts on project performance.

Early Risk Identification

Risk identification is considered to be a critical phase in which project stakeholders examine the project details for any uncertainty (PMI 2010; Batson 2009). Although risk identification is considered critical to project success, a 2010 study found that there is still much to be desired regarding construction organizations' abilities and perceptions of identifying risks (Zou et al. 2009). Various tools and techniques such as checklists and brainstorming activities can be found within the risk management literature. Typically, identification tools are used once project team members have been selected and are working under a legal contract. This paper examines projects in which identification tools have been used during the selection process. Within this paper 'early risk identification' is defined as risk identification performed by the contractor during the selection phase and before a binding contract. Construction project risk is any event that may impact the project's cost or schedule. Unlike a 'low-bid' selection process, a 'best-value' selection process scores several selection criteria to select a vendor, in some cases the contractor's ability to identify project risk is included within the selection criteria (Perrenoud et al. 2014). The process of scoring contractors' abilities to identify project risks is also often included during the prequalification phase of alternative delivery methods (Potter & Sanvido 1994). This paper reviews the practices of a Capital Facilities Group at a client organization and their approach to identification of potential project risks during the selection process. The paper links these risks and their potential impact on project performance.

Project Performance

The definition of project success varies from person to person and from project to project, but the "Iron Triangle" (time, cost and quality) has been the conventional method for measuring project performance (Atkinson 1999). However, Bryde and Brown (2005) reasoned that stakeholder satisfaction is as important as the three measurements within the iron triangle. Toor and Ogunlana (2010) encouraged that research should expand on this macro level of measurement due to the evolving responsibilities and characteristics of the construction industry and break down success factors into a micro level measurement. Researchers have also advocated the need to include project management success measurements, such as team relationship, complexity of project, and risk management (Low and Chuan, 2006; Cookie-Davies, 2002; Shenhar et al. 1997). A micro level measurement of risk management would include contractors' abilities to identify risk, Belout & Gauvreau (2004) specified the important role that risk identification has on project performance. A great amount of studies have compared project data against these critical success factors, but a gap in the research was found by the authors related to measuring contractor risk identification capabilities against project success.

The research questions driving this study are: 1) Does contractor identification of project risks prior to contract award improve project performance (on time, on budget)? 2) If contractor identification of project risks prior to contract award does improve project performance, which sources of risks (i.e. client/designer/contractor/unforeseen) experience the greatest positive impact on project performance? To answer these research questions, two research hypotheses were developed as:

- $H1_0$: Identification of certain types of project risks, as part of the contractor selection process, has no impact on project performance (in terms of cost or schedule).
- $H1_A$: Identification of certain types of project risks, as part of the contractor selection process, improves project performance (through reduced cost or schedule impacts).

Methodology

The goal of this research was to measure the impact of contractor risk identification on project performance. The data for this research was collected from capital improvement projects carried out at a public university's Capital Facilities Group (CFG) from 2005 to 2012. During this time, the CFG had a total of 187 construction projects (total value of \$70M, mean value of \$367,720, standard deviation of \$610,965). The CFG was studied due to their usage of a unique risk-focused contractor selection process (Figure 1). The selection process required contractors to identify the top risks that could potentially impact the project within a two-page limit. Once the project was awarded, the CFG used a risk management tool that required contractors to track the risks that actually occurred during the construction of the project and the cost and schedule impacts associated with each risk. Risk templates and tools were provided by the CFG. The contractor-identified risks (IRs) were compared to the impacts of the project actual risks (ARs) to measure the impact of risk identification on project performance.

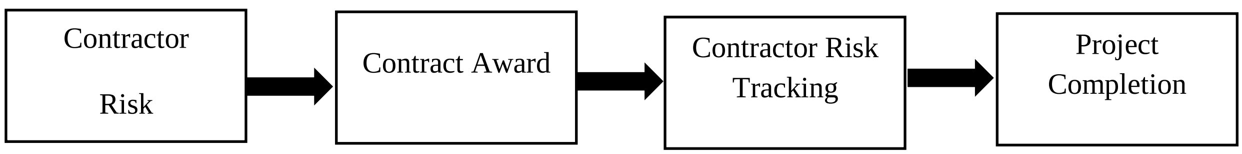

Figure 1. CFG Risk Management Approach

Identified Risks (IRs)

The identified risks (IR) were compiled from the awarded contractors' proposals for all 187 projects. The CFG classified risk according to their risk classification structure (Table 1). To aid in proper risk classifications, examples of each CFG's risk source were compiled, also shown in Table 1. The IRs were classified by the researchers according to the CFG's four-category risk classification (Client, Contractor, Designer, and Unforeseen). To calculate agreement with nominal data, across multiple observers, Fleiss' kappa statistic (1971) was used. A random sample of 100 IRs were selected and independently classified by all three researchers using Table 1 as a guide, resulting in a kappa statistic of 0.47. According to Landis & Koch (1977), kappa statistics in the range of 0.41 – 0.60 represent a moderate strength of agreement and 0.61-0.80 represent a substantial strength of agreement. Another random sample of 10 IRs were selected and independently classified by all three researchers using both Tables 1 and 2 as guides, resulting in a kappa statistic of 0.63. The agreement among evaluators was therefore considered substantial (Landis & Koch 1977).

Table 1

CFG's Risk Source Classifications

No	Source Classification	Definition: Issues resulting from…	Examples
1	Client Impact	• Issues resulting from a client change, including client decisions to add or delete scope. • Anything caused by end users or building occupants, students, etc. • Existing conditions of the site/building (i.e. asbestos).	Client added additional work; Disruption of end users, building occupants, students, etc.; Unknown existing conditions related to the site/building; Budget and/or schedule unattainable; Access to areas.
2	Contractor Impact	• Contractor action or lack thereof. • Subcontractor action or lack thereof.	Contractor unable to perform scope; Contractor means and methods; Contractor does not have experience in particular area; Subcontractor delays or poor quality; Safety of contractor personnel; Staging; Dust; Safety.
3	Designer Impact	• Errors and omissions in design. • Chosen products or design elements.	Error or incorrect value in drawings; Items not addressed in drawings; Chosen products/design (specifications) will not work within existing conditions; Lead time on products; Design does not meet code requirements.
4	Unforeseen Impact	• Environmental causes.	Weather conditions; Governmental issues; State inspections.

A total of 1,516 IRs were identified by contractors and classified, with the most frequent source classification being "client" type, closely followed by "designer" type (Figure 2). Some risks could not be classified due to contractors' low level of detail and lack of description of why a particular item would be a risk (labeled, "undefined/not a risk").

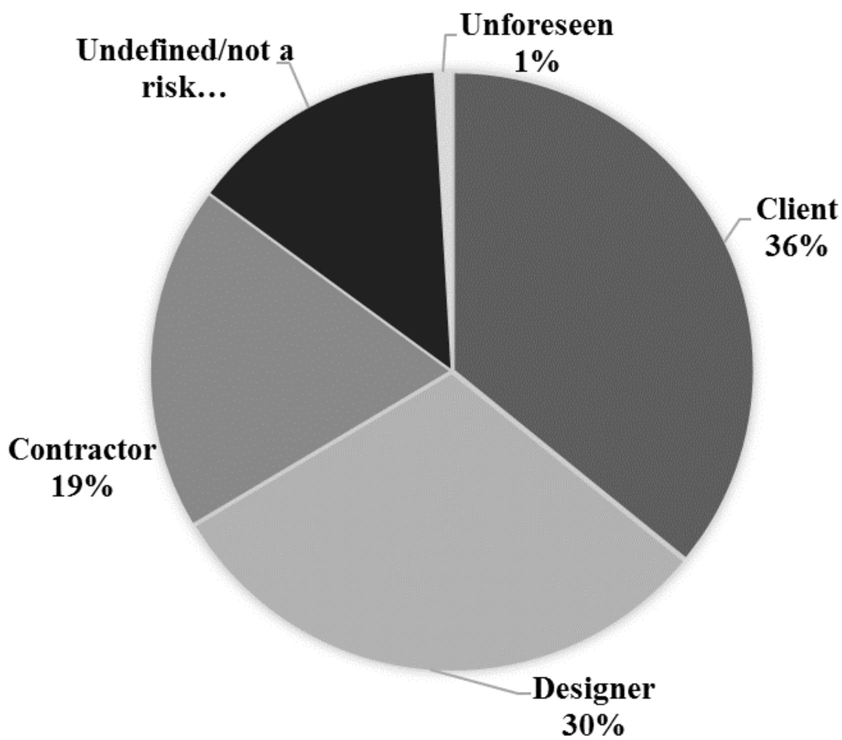

Figure 2. IRs by Source Classification

Actual Risks

Once the contract award was made, the CFG used a tool that required the contractor to input any actual risks (AR) that caused a change to the awarded cost or schedule (i.e. change order) during the construction. The contractors tracked these ARs by inserting: a description of the change, classification of the change by CFG's risk source, and calculation of cost and/or schedule impact change from the awarded cost or schedule on a weekly basis. These ARs were also validated by the CFG through regular review of the items, and discussion with the contractors.

A total of 1,150 ARs were recorded, with the average cost change per project due to ARs as $32,211 (Table 2). The most frequent source classification of ARs was "client" type (Table 3). In addition, the highest cost and delays occurred in the "client" type source classification, with the designer type delays being the second highest. Ironically, the contractor type of change order rate was 0%. The correlations between IRs and project performance were measured by source classifications.

Table 2

Overview of Impact of ARs

No	Criteria	Total	Avg. per Project	SD	Max.	Min.
1	Number of ARs	1150	6	7	42	1
2	Cost Changes due to Ars	$6,143,306	$32,211	$60,246	$452,077	$(10,095)
3	Days of Delay due to ARs	7105	1776	1845	4970	651

Table 3

ARs by Source Classification

No	Criteria	CL	CO	DS	UN
1	Number of ARs	712	116	173	149
2	% of Quantity	62%	10%	15%	13%
3	$ Cost Changes due to ARs	$4,587,499	$(4,677)	$649,161	$911,322
4	CO. Rate	7%	0%	1%	1%
5	Days of Delay due to ARs	4,970	651	805	679
6	Delay Rate	29%	4%	5%	4%

CL = client, CO = contractor, DS = designer, and UN = unforeseen

Data Analysis

The goal of this research was to measure the impact of contractor early risk identification on project performance. The correlation between contractor IRs prior to construction and the impact of the ARs during construction was investigated. Since the IRs, ARs, cost changes, and delays all used the same source classifications, correlations were simplified. The correlations between IRs and project performance were measured by source classifications. For example, the percent of client type IRs was compared to the change order rate of client type ARs for each project. Then, the percent of client type IRs was compared to the delay rate for client type ARs for each project. Note that the risks identified in Table 2 were only actual project risks (and were not necessarily identified at the bid stage).

Prior to conducting the Pearson's product-moment correlation analyses, the authors applied a natural logarithm transformation of the project schedule and cost impact (project performance) data to normalize the distribution of the data. After transforming the data, analyses revealed three statistically significant relationships (Table 4): Client IR and Client Cost impacts [$r(133) = .180$, $p < .05$], Client IR and Designer Cost impacts [$r(34) = .297$, $p < .05$], and Designer IR and Designer Schedule impacts [$r(34) = -.483$, $p < 0.01$].

Table 4

Pearson Correlations between Percent Identified Risks (IR) and Source Project Impacts

	Cost Impacts				Schedule Impacts			
	CL (N = 133)	CO (N = 3)	DS (N = 34)	UN (N = 55)	CL (N = 118)	CO (N = 32)	DS (N = 34)	UN (N = 40)
Client IR	.180*	-.939	.297*	-.176	.110	.038	.172	-.092
Contractor IR	-.095	.633	-.206	-.037	-.050	-.104	.122	.090
Designer IR	-.016	.524	-.052	.212	-.029	.037	-.483**	-.036
Unforeseen IR	-.122	N/A	-.037	.044	-.099	.079	.283	-.090

CL = client, CO = contractor, DS = designer, and UN = unforeseen
$^{*}p < .05$. $^{**}p < .01$.

While there are two statistically significant relationships of Client IRs (between Client Cost impacts and Designer Cost impacts), the strength of association is weak. However, there is a highly statistically significant and substantial association between Designer IRs and Design Schedule project impacts. Specifically, the data appears to indicate that contractor identification of designer-related risks prior to award meaningfully reduces project delays (caused by design issues). While this result may appear intuitive (i.e., identifying risk before starting a project should help minimize issues during the project), these preliminary findings provide clear evidence of the positive impact of contractor early risk identification and project pre-planning. As previously mentioned, the CFG's unique risk management approach provided an environment that allowed early risk identification, which may not be possible in all environments.

Interpretation of these results highlights the significance of the findings and areas needing attention in risk identification. Contractor risk identification has the potential to increase awareness of project issues and improve project performance. Where the risk source can be controlled by the contractor (i.e. contractor type), risk is less likely to occur due to a low percentage of IRs and a zero percent of contractor type change order rate. However, where the risk source cannot be controlled by the contractor (i.e. client and unforeseen), risk may not be less likely to occur and may still result due to external causes. In cases where design source risk is present, identification of design source risks may lead to a lower designer source delay rate.

The primary limitation of this study was that the research data was generated from the contractors themselves. That is, the type of and quality of risk data reported came from the contractors. To mitigate this limitation, the owner's project managers were directed to review each risk report and direct the contractor to make adjustments as necessary.

Conclusion

The goal of this research was to measure the impact of contractor risk identification on project performance. Revisiting the research questions and hypotheses: 1) Contractor identification of project risks prior to a legal contract can improve project performance; 2) The designer type of identified risk has the greatest positive impact on project schedule performance. The research provided clear evidence of the positive impact of contractor early risk identification and project pre-planning based on construction projects carried out at a capital facilities group over a seven-year period. The results of this research are important for industry members as well as researchers because they contribute to the body of knowledge on risk management, specifically the value of pre-contract risk identification. By providing a link between contractor risk prediction and project performance, the practices of risk identification by contractors should be encouraged, especially in design as the area that the greatest benefits in project performance were seen. Further, the observed increase in client change order rate with greater risk identification should be segmented according to the details of the risk and any major outliers or significant scope changes should be outside of the analysis of this study. Another area of future research could be in profiling the contractors by some form of risk prediction index or proficiency.

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