# "HOPE IS NOT AN EFFECTIVE RISK MITIGATION TECHNIQUE"

A Research Perspective Issued by the

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## Purpose of Research Report

In December 2011 Navigant Consulting co-sponsored and participated in developing the SmartMarket Report prepared by McGraw Hill Construction entitled Mitigation of Risk in Construction: Strategies for Reducing Risk and Maximizing Profitability. This groundbreaking report was based on interviews with owners, architects/engineers, construction managers and contractors concerning their risk mitigation strategies. The report is available at www.navigant.com/NCF. The quote on the cover is from a panel discussion on this report at the 2011 Construction Superconference and is attributed to David A. Hecker, Kiewit Group General Counsel and summarizes the purpose of this research report.

While the report did query the participants on the level of risk mitigation employed, the 2011 report did not delve into the techniques most frequently used. The Navigant Construction Forum™ decided to expand upon the research begun in the earlier study to determine what techniques are most commonly used. The research conducted by the Navigant Construction Forum™ included surveying the senior consultants of Navigant's Global Construction Practice who are frequently engaged on behalf of clients to perform risk identification, analysis and mitigation on major projects globally. This research report presents the findings from this survey.

Risk management is a cornerstone of successful project management and comprises many steps. Over the past several decades, the techniques available to identify, analyze and mitigate risks have evolved dramatically. The question remains, how well known are these methods and which methods are the most effective for managing risk on complex projects? This research report analyzes a comprehensive sample of 34 experts to determine the extent to which various tools and techniques are relied upon by risk analysis practitioners and risk managers in (1) identifying, (2) analyzing and (3) mitigating the major risks experienced in global capital improvement projects. Further, the study investigates the correlation between past risk experienced and risk management techniques utilized.

# Risk Identification, Analysis and Mitigation Techniques

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## INTRODUCTION

Risk is an uncertain event or condition that, if it occurs, has either a positive or negative effect on the project objectives.[3] Parties to construction agreements, for the most part, do not spend significant resources attempting to allocate favorable uncertainties; those risks that, should they occur, will favorably impact project execution or delivery (e.g., weather much better than average or a decrease in some basic commodity prices). Nor do they pay large insurance premiums to cover the spectrum of possibilities that could, if they occur, result in lower project costs. Construction managers tend to focus on negative risk.[4] Prior analyses have demonstrated that the interaction between different types of risk can cause a nonlinear impact on project outcomes.[5] In other words, the cumulative or synergistic effect on project cost and schedule due to risks on a project may be greater than the sum of the discrete impacts caused by each individual risk factor. In order to effectively control the project risks and their associated cost, project owners and managers utilize processes to identify, analyze, monitor, and mitigate risk. Collectively these processes are referred to as risk management.[6]

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[3] Project Management Institute, Project Management Body of Knowledge (PMBOK Guide), Fourth Edition, Newton Square, Pennsylvania: Project Management Institute. 446. 2008.

[4] Bruner, Philip Lane and Patrick J. O'Connor, Bruner and O'Connor on Construction Law, St. Paul, MN: West Group, Section 7.5, 2002.

[5] Ackermann, F., C Eden, T Williams, and S Howick, "Systemic Risk Management: A Case Study", Journal of the Operational Research Society, 58: 40. 2007.

[6] Project Management Body of Knowledge (PMBOK Guide), Fourth Edition, 273 - 312.

Risk management is a fundamental requirement of every business, including those engaged in the construction industry. The necessity of risk management is evident in virtually every aspect of the process. For example, construction firms often bid on multiple projects with full knowledge that they will not win each one. However, this approach can result in the pursuit of projects that cannot be completed profitably without active risk management.[7]

In general, all construction projects are somewhat unique creating unique potential risk exposures for each project. Further, the myriad risks that impact a construction project are often interconnected and positively correlated, increasing the severity of risk impacts when they occur.[8] Construction projects also require coordination of multiple parties, including architects and engineers, general contractors, specialty subcontractors, suppliers, materialmen, owners, and government agencies (such as permitting agencies and fire departments) to name but a few. The need for high-level coordination adds complexity to the risk management effort.[9]

In addition, complex projects often have multiple objectives. Construction projects must complete the project on time, on budget, safely and within specified quality parameters.[10] Further, the relative ranking of priorities within the parameters may differ among various parties. For example, an owner may value a quality project built to specifications over the timeliness of project completion. However, the general contractor for the same project may value timely completion more highly than ensuring all elements are performed precisely to specification if there is a punitive liquidated damages clause related to the schedule. Therefore, the structure of the relationships between the parties and their ability to communicate with and effectively incentivize their counterparts is essential to the successful management of project risk.

Collectively, the number and combination of risk factors that are endemic to construction projects make construction projects unusually susceptible to negative project outcomes. Compounding these issues, as Patrick Zou states, is that "the weakest attribute in construction organizations and the industry as a whole is risk analysis". Further, the maturity of a firm's risk management process may be linked to the size and history of a construction organization.[12] Typically, only the largest firms with significant historical databases of information have established processes and the capability to perform effective risk management. Even so, Dr. Francis Adams reviewed empirical work on the application of rigorous, quantitative risk management methods to contract risks such as payment delays and differing site conditions.[13] The results of these studies suggested that such risks are often analyzed in a somewhat arbitrary manner.

Therefore, active risk management is a key differentiator for parties in construction projects and can be a major source of competitive advantage or conversely, a cause of business failure in the construction industry. It is, however, insufficient to simply examine the risks borne by one of the parties during a risk investigation. The entire project must be viewed holistically to ensure that potential interactions between risks are accounted for. Accordingly, the purpose of this study is to investigate best practices for

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7 Whitecotton, Danny J. and Brett M. McPherson, "Reducing Construction Risks through Project Controls", 1992 AACE Transactions. 2: L.1.1.

8 See e.g.; David Hulett et al. Integrated Cost and Schedule Risk Analysis Using Monte Carlo Simulation of a CPM Model. AACE Recommended Practice 57R-09. Ackermann, F., C Eden, T Williams, and S Howick, "Systemic Risk Management: A Case Study", Journal of the Operational Research Society, 58: 39 – 51, 2007.

9 Bruner and O'Connor on Construction Law, Section 7.6.

10 Chilcott, Alan, "Risk Management – A Developing Field of Study and Application", Cost Engineering, 52: 9, 9, 2010.

11 Zou, Patrick, Ying Chen and Tsz-Ying Chan, "Understanding and Improving Your Risk Management Capability: Assessment Model for Construction Organizations", Journal of Construction Engineering and Management, 136: 861, 2010.

12 Ibid. at 862.

13 Adams, Francis K., "Construction Cost Risk Management: A Study of Practices in the United Kingdom", Cost Engineering, 50: 1, 22- 33, 2008.

risk management in a construction setting. Specifically, the objective of this research is to identify the major risks on construction projects in order to provide a baseline upon which parties can build their own risk management databases, both directly experienced by the focal organization as well as risks experienced by other parties involved in the project. Once this baseline of project risk has been established, this study endeavors to discover the tools and techniques used by construction management experts to identify, analyze and manage risk. To begin, we examine the discrete components of the risk management process.

## The Risk Management Process

A construction project can be considered as a bundle of risks.[14] A four-step process is typically followed in order to understand the nature of the risks and effectively manage these risks collectively:

1. Risk Identification: Identify all project risks
2. Risk Analysis: Analyze potential impact of each risk
3. Risk Mitigation: Determine mitigation strategies for each risk
4. Controlling and Monitoring Risks: Active oversight throughout the project life cycle

Each of the above steps is essential to an effective risk management process. The process is sequential in that, once all risks have been identified, they must be analyzed and assessed in order to determine the probability and materiality of the risk. After the risks have been analyzed and the probability and materiality determined, a plan to mitigate the risk must be established. Finally risks must be actively monitored throughout the course of project execution.[15] Each of the elements of risk management is examined in greater detail below.

**Risk Identification**

Risks can be classified in several ways. For instance, the Association for the Advancement of Cost Engineering International ("AACE International") utilizes an external and internal distinction between risks.[16] External risks are defined as those situations in which the organization cannot control the likelihood of occurrence but can mitigate the impact, should it occur. Examples of external risks include natural disasters, government regulations and market conditions. Internal risks, on the other hand, are those in which the organization has some degree of control over both the likelihood of occurrence and the severity of impact. Schedule delays and contractual disputes are examples of internal risks. Another general way of broadly breaking down risks is to categorize them as objective and subjective.[17]

Other associations segregate risks by source or type, and utilize a system of checklists in order to ensure that all major risk categories have been identified. The Belgian Building Research Institute maintains such a database.[18] In its ninth annual survey of Owners, the Construction Management Association of America ("CMAA") utilized a list of 28 representative risks in order to gauge owner perceptions. Further, the US Department of Energy ("DOE") maintains a comprehensive list of risks that can impact construction projects with 11 subcategories and hundreds of more specific considerations. This checklist is the basis of the risk categories utilized in our survey regarding the relative frequency and severity of project risks.

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[14] Gorham, Anne, "Navigating Construction Contracts: Comparison of Risk Allocation of Standard Forms", Thomson Reuters / Aspatore, Negotiating and Structuring Construction Contracts, 2009.

[15] Krishna, R.V., "Risk Management: What Contract Administrators Should Know", Contract Management, 45: 4, 51, 2005.

[16] AACE International, Skills and Knowledge of Cost Engineering, Fifth Edition, Morgantown, WV, AACE International, 31.3, 2004.

[17] Bruner and O'Connor on Construction Law, Section 7.7.

[18] Shatteman, Damien, Willy Herroelen, Stijn Van de Vonder, and Anton Boone, "Methodology for Integrating Risk Management and Proactive Scheduling of Construction Projects", Journal of Construction Engineering and Management, 134: 886, 2008.

The importance of the risk identification process cannot be understated. Many experts believe that risk identification is"… arguably the most important part of a risk assessment program".[19] Unfortunately, risk identification is still not performed in a rigorous manner in many organizations. The process is often anecdotal and therefore the outcome is highly dependent on the judgment and expertise of the people assigned to examine the risk level of the project.[20] It bears reminding that"the failure to contemplate or allocate risks does not make them go away but can, in fact, increase the risks associated with the project."[21] In other words, failing to address the potential for risk in a timely manner may increase either the likelihood of its occurrence and/or the severity of its impact.

Risk management staff must rely upon a variety of structured methods to ensure that they have captured as many potential risks as possible. This research report investigates 12 different risk identification techniques that have been previously discussed in industry literature. A list of these techniques can be found in Table 1 below.

### Table 1 - Risk Identification Techniques

| TECHNIQUE | DEFINITION | EXAMPLE | METHOD TYPE |
|---|---|---|---|
| Individual expert assessment | The use of a single expert to identify all of the potential risks on the project through analysis and past experience | A senior project staff member brainstorms all possible risks during the estimating process and provides information to the estimators | Tacit Knowledge |
| Multidisciplinary group assessment | The use of a panel of experts to jointly identify all potential risks on a project by relying on their individual expertise | Senior staff from the finance, legal, operations departments as well as outside consultants are brought together to discuss and determine potential risks for the project | Tacit Knowledge |
| Structured / expert interviews | Formal interviews of subject matter experts, combined with collected data, are used to identify risks | An estimator interviews internal or external experts and collects their input in order to have a list of risks that may potentially impact the project | Tacit Knowledge |
| Delphi Technique | A highly structured, iterative expert interviewing method in which multiple experts provide answers, receive feedback based on the collective response of all the experts, and then are given a chance to revise their answers based on the feedback. The process iterates until a preset stopping point. | | Tacit Knowledge |
| Checklists | Use of a pre-established list of items, from which risk pertinent to the current project would be selected | The operations department maintains a 10 page list of potential risks that can occur on any infrastructure project, from which a subset of potential risks for the current project are selected | Explicit Knowledge |
| Risk records | Past project records are reviewed to determine what risks occurred on similar projects in the past | Change order logs for prior projects are reviewed for unanticipated conditions | Explicit Knowledge |

[19] Bruner and O'Connor on Construction Law, Section 7.2.

[20] Ibid, at Section 7.6.

[21] Ibid, at Section 7.9.

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| Prompt lists | Instead of providing a checklist of risks, a list of questions is used to focus attention on potential areas of risk | Senior management maintains a list of questions to be asked at the commencement of each major phase of the project | Explicit Knowledge |
| Free and structured brainstorming | A semi-structured thinking session in which all potential risk sources are considered and subsequently assessed to determine if such a risk has the potential to occur on the project | | Analysis |
| Assumption analysis | The identification and documentation of assumptions made during the planning process, and the identification of potential risks that would result from the failure of any of these assumptions | | Analysis |
| Pondering "what could go wrong" analysis | An unstructured thinking session with one or more parties, where all involved attempt to think of possible risks | An informal meeting of project managers is called in which the preliminary budget is drawn up and parties perform a line by line review to determine potential cost risks | Analysis |
| Diagramming techniques | The use of graphical techniques, such as fishbone (cause and effect) diagrams to structure thinking about potential risks on a project, which is typically performed during the project planning phase | | Analysis |
| Synectics | A technique similar to brainstorming, but more involved. The focus of the method is to use comparisons, classifications, metaphors and analogies to correlate seemingly unrelated ideas in order to bring ideas to the forefront that would otherwise not be incorporated | | Analysis |

These methods can be grouped into three broad categories.

1. The first group of techniques utilizes internal and external expert knowledge and past experience to compile a list of potential risks, which is stored tacitly in the minds of risk management and other project staff. Some examples include individual expert assessment, structured interviews, and panel group analysis. These techniques are titled "tacit knowledge methods", meaning that the information is not formally recorded, and only available in the minds of the organization's members.
2. A second group of techniques relies upon a systematic evaluation of the project and potential risks associated with project tasks and outcomes. These techniques do not rely heavily upon past experience, but rather seek to identify risks using logic, deduction, or free association. Examples of these techniques include brainstorming, pondering (or "what could go wrong" analyses), and diagramming techniques. These techniques are referred to as "analysis methods".
3. The final set of methods utilizes past experience that has been explicitly recorded for future use and reference. Examples of these methods include risk records, checklists and prompt lists. These methods are known as "explicit knowledge methods".

Each of these methods has strengths and weaknesses. For example, the methods that rely on experts' guidance often allow for targeted and accurate responses based upon knowledge of the project and past experience.[22] However, expert systems are vulnerable to deviations from past experiences.[23] Experts are also subject to various biases that affect all individuals, such as the availability heuristic (where information that is most salient or recent in memory has a disproportionate impact on recall and analysis).[24] In comparison, analytical techniques may uncover new risks that expert systems may not capture, but these methods are slow to implement and the results may be incomplete due to a lack of sufficient knowledge or experience on the part of the analytical team. Finally, explicit knowledge systems provide a wealth of past information that can be easily applied, but such systems take a long time to construct and require constant updating in order to capture new information as projects are completed. In addition, several risks, such as detrimental contractual provisions, are difficult to codify explicitly and are often not subject to rigorous measurement and analysis.[25] In general, a combination of methods and techniques from each type of identification scheme will likely yield the best results.

**Risk Analysis**

Once all the project risks have been identified, the potential impact of each risk must be evaluated. Fundamentally, all risk analysis techniques serve the same function, which is to determine the expected loss (or gain) for a particular risk. Losses are not necessarily defined in monetary terms (e.g., they can be defined in terms of time (delay) or an unattained level of certification, such as LEED Silver versus LEED Gold). However, in many cases, in order to maximize the ability to compare relative risk, a monetary value is assigned to each risk element (for example, liquidated damages or lost operating profits for every day of delay can be used to quantify the cost of lost time). Simply put, risk analysis entails gathering as much information as possible regarding frequency and severity of risk and using this information to estimate its expected impact. A comprehensive summary of all of the risk analysis techniques examined in this research report can be found in Table 2 below. While each method approaches this question in a different manner, virtually all of them look at two key elements of a risk: frequency and severity.

### Table 2 - Risk Analysis Techniques

| TECHNIQUE | DEFINITION | EXAMPLE |
|---|---|---|
| Parametric Estimating | Algorithms or cost-estimating relationships that are based on empirical estimates, typically using a regression-based approach | Permitting costs as a percentage of total costs are estimated by regressing permitting costs on total project costs for all projects during the past five years |
| Range Estimating | Range estimating is a risk analysis technology that combines Monte Carlo sampling, a focus on the few critical items, and heuristics (rules of thumb) to rank critical risks and opportunities | See AACE Recommended Practice RP 41R-08 - Risk Analysis Using Range Estimating for additional information |
| Expert Judgment and Assessment | Expert opinion is solicited to determine the potential impact of a risk, utilizing past judgment and experience | An estimator determines that the potential cost impact due to differing site conditions is 10% based on his experience on the past 50 projects of a similar nature |

[22]McKeithan, K. B., J. S. Reitman, H. H. Rueter, and S.C. Hirtle, "Knowledge Organization and Skill Differences in Computer Programmers", Cognitive Psychology, 13: 307-325, 1981.

[23]Simon, Herbert A., "Making Management Decisions: The Role of Intuition and Emotion", Academy of Management Executive Journal, 1: 57 – 64, 1987.

[24]Tversky, Amos and Daniel Kahneman. 1973. Availability: A heuristic for judging frequency and probability. Cognitive Psychology. 4: 207 – 232.

[25]Adams, Francis K. 2008. Construction Cost Risk Management: A Study of Practices in the United Kingdom. Cost Engineering. 50: 1, 22.

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|---|---|---|
| Risk Registers | A structured document outlining all major risks, their relative frequency and severity, an estimate of the overall impact of the risk, the strategy for mitigation, the current status of the risk, among other key variables | See Krishna 2005 (cited elsewhere herein) for an example of a risk register |
| Risk Matrices | A table (often color coded) in which risks are placed in different groupings along two axes, where one axis is typically frequency and the other is typically severity | See Mulambya 2007 (cited elsewhere herein) for an example of a risk matrix |
| Monte Carlo Simulation | Use of simulation tools, such as @Risk, to model the outcome of a project under uncertainty by measuring the result of a number of simulations | See AACE Recommended Practice RP 57R-09 - Integrating Schedule & Cost Risk for an example of using Monte Carlo simulation to measure cost and schedule risk |
| QQIR Method | A quantitative method using “fuzzy logic” to convert qualitative statements (such as rarely or often) into quantitative metrics that are refined over time and additional input | See Sachs 2009 (cited elsewhere herein) for an exposition of the QQIR method |
| Bayesian Knowledge Updating Techniques | A quantitative method using Bayesian statistics to convert qualitative statements regarding “degrees of belief” into quantitative metrics that are refined as additional data is provided | See Choi 2009 (cited elsewhere herein) for an exposition of the Bayesian methods applied to construction |
| Fuzzy Knowledge Updating Techniques | Another quantitative method using “fuzzy logic” to convert qualitative statements (such as rarely or often) into quantitative metrics that are refined over time and additional input. | See Choi 2009 (cited elsewhere herein) for an exposition of the fuzzy updating methods applied to construction |
| System Dynamics Analyses | A holistic analysis of all project elements in which “feedback loops” amongst the various WBS components are modeled to determine dependencies between work scopes and potential areas for multiplicative impacts | See Nasirzadeh 2008 (Can. J. Civ. Eng. 35: 820 – 831) for an exposition of systems dynamics analyses applied to construction settings |
| Decision Tree Analyses | Use of decision analysis tools, such as PrecisionTree, to model the outcome of a project under uncertainty by creating a comprehensive model of the various risk probabilities that comprise the project | See Dey 2002 (cited elsewhere herein) for an exposition of the decision tree analysis applied to construction |
| Risk Filters | A technique to determine the most critical risks that can impact a project through the use of ranking algorithms to ensure management focuses on the risks with the greatest impact | See http://www.pqri.org/pdfs/MTC/Risk_Rank_Filter_Training_Guide.pdf for more information. |
| Risk Games | A technique used with all parties to a construction agreement to help identify the potential number of risks and their related impact on all parties, which can help identify which party is most capable of bearing the risk | See Wassenaer 2009 (The ‘Big Risk Game’, Construction Law International) for an exposition of the risk games method |

**Frequency**

With respect to frequency, any risk that has been identified may or may not materialize on the project. The frequency of a risk can be defined as the probability that the risk will occur during the course of the project. The relative frequency of a risk occurring is usually estimated in two ways. In the first case, a qualitative estimate of the risk (e.g., none, low, medium, high) is performed in order to broadly define the relative difference between the frequency of one risk as compared to another. In some situations the data available on certain risks, such as differing site conditions and payment delays, is insufficient to make a rigorous quantitative estimate and, therefore, the analysis is based largely on the subjective prediction of the risk analysts.[26] However, where hard data is available, frequencies are often estimated based upon past experience. This past experience is often stored in a database that houses a collection of quantitative metrics collected for each project logged with the dataset. Using data collected from prior projects, the estimated probability of the occurrence of an event can be computed in multiple ways. One simple method is to determine what percentage of all of the projects stored in the database actually experienced that risk. To add sophistication to such an analysis, the parameters regarding the specific project can be used to determine a probability of occurrence conditional on those parameters.

For example, an owner is undertaking a road-building project. The owner routinely undertakes both vertical (e.g., homebuilding) and horizontal (e.g., roadwork) projects in the course of overall project development, and wants to estimate the probability that a copper price increase will impact the project. By utilizing the information that the current project is a roadwork project, the owner may decide to exclude homebuilding projects from the analysis because many of the projects that encountered copper price increases were homebuilding projects (due to the more extensive use of copper wiring and piping). Including these homebuilding projects would likely overestimate the likelihood that such an impact would occur on a road-building project. Therefore, the probability of occurrence would be conditioned on the fact that the project is for the construction of a road, not a block of homes. Decision tree analyses can also help perform these analyses and are utilized to model the interdependencies between certain risks occurring, conditional on the relative frequencies of other risks.[27] For example, an increase in the probability of a differing site condition will likely increase the probability of a financial overrun.

Even where quantitative data is not available, a number of techniques, such as the QQIR method,[28] Bayesian knowledge updating and fuzzy knowledge updating techniques[29] have recently been developed in order to provide a quantitative probability estimate when only qualitative data (i.e., classifying a risk as low, medium, or high) is available. While the inner mechanisms of these techniques are beyond the scope of this paper, in each case, the technique relies upon mathematical algorithms to convert a qualitative statement into a range of probabilities. As more qualitative estimates are provided over time (either over the course of multiple projects or through the use of multiple expert estimates during the planning phases of a particular project) the algorithm is able to narrow the range of probabilities to a tighter and tighter interval, increasing the confidence in which the average of that range can be applied to a specific project for planning purposes.

[26] Adams, Francis K., "Construction Cost Risk Management: A Study of Practices in the United Kingdom", Cost Engineering, 50: 1, 22, 2008.

[27] Dey, Prasanta, "Project Risk Management: A Combined Analytic Hierarchy Process and Decision Tree Approach", Cost Engineering, 44: 3, 13 – 26, 2002.

[28] Sachs, Tillman, and Robert Tiong, "Quantifying Qualitative Information on Risks: Development of the QQIR Method", Journal of Construction Engineering and Management, 135: 56 – 71, 2009.

[29] Choi, Hyun – Ho and Sankaran Mahadevan, "Construction Project Risk Assessment Using Existing Database and Project-Specific Information", Journal of Construction Engineering and Management, 134: 894 – 903, 2008.

### Severity

While the frequency of a risk is essential to determining relative impact, severity of that risk is equally critical. Like frequency, the severity of a risk can be variable. In other words, the material impact of the risk may not be predetermined and may take a range of values. For example, when a contractor makes bulk purchases of steel, the amount of inflation that occurs may vary between signing the contract with the owner and the purchase of the steel. The magnitude of these variations is independent of the probability that any steel price increase will occur. The severity of a risk is therefore the expected potential cost impact, conditioned on that fact that it has already occurred. Multiple methods can be applied in order to estimate the cost impact for the severity of a risk.

AACE International has published numerous recommended practices[30] for estimating the expected severity of a risk, including range estimating, parametric estimating and expected values.[31] Each methodology has strengths and weaknesses, and is often most appropriate at certain points in the risk management process. For instance, the use of parametric techniques is most appropriate at the front end of project planning, when more specific information is not yet available and risk severity must be estimated with past information that has not been tailored to the specific circumstances of the project. As the project scope is subsequently and iteratively fleshed out and finalized, more targeted methods such as range estimating become more appropriate. Severity estimates are often used in conjunction with risk frequency data to plan the size of a contingency account. If this method is used, care should be taken to ensure that the overall estimate generated is absent any "risk factors" as these amounts will be included in the contingency and, therefore, their inclusion will result in the overestimation of project costs.[32] Such overstatement may result in the rejection of an otherwise viable project due to rejection by Net Present Value ("NPV") or other economic return methodology.[33]

### Risk Mitigation

Once all project risks have been identified and analyzed, the next step is to determine a mitigation strategy for each risk. This research report discusses a number of popular risk mitigation strategies, which are presented along with representative examples of their use in Table 3 below. Each of these mitigation strategies is appropriate in certain instances, but may not be as effective in other settings. In order to determine the suitability of a risk mitigation technique in a particular situation, certain questions are explicitly or implicitly asked by risk management professionals to determine the most effective mitigation strategy. Some of these questions include:

1. Can it be feasibly implemented?
2. What is the expected effectiveness?
3. Is it affordable?
4. Is the time available to develop the strategy?
5. What effect will there be on technical performance?

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[30] Available for downloading free at www.aacei.org/professionalresources/recommendedpractices.

[31] See, e.g., John Hollmann et al., Risk Analysis and Contingency Determination Using Expected Value, AACE Recommended Practice 44R-08; Kenneth Humphreys et al., Risk Analysis and Contingency Determination Using Range Estimating, AACE Recommended Practice 41R-08.

[32] Risk Analysis and Contingency Determination Using Range Estimating, AACE Recommended Practice 41R-08.

[33] Braeley, Richard A., Stewart C. Myers, and Franklin Allen, Principles of Corporate Finance, New York, NY, McGraw-Hill/Irwin, 143 – 169, 2008.

These questions help pinpoint the most effective mitigation strategy for a given situation.[34] In addition to these questions, there are certain key dimensions of risk mitigation that determine the relative effectiveness of various techniques. An excellent model of the key dimensions of risk mitigation strategies is the Risk Mitigation Decision Matrix included in the FMI/CMAA 9th Annual Survey of Owners. The two dimensions of interest for risk mitigation are the degree of responsibility that the firm possesses for a risk (ranging from low to high), and the approach that management takes to addressing that risk (ranging from passive to active).[35]

### Table 3 - Risk Mitigation Techniques

| TECHNIQUE | DEFINITION |
|---|---|
| Reduce Risk Severity | The use of active mitigation techniques, such as hiring inspectors or additional quality control personnel, to detect and limit the range of impact of a risk, should it occur. These mitigation steps cost time and resources, which must be balanced against the potential loss the risk may cause. |
| Contractually Transfer the Risk | Use of contractual mechanisms, such as liquidated damages clauses, no damages for delay clauses, indemnification, and/or limitation or waiver of liability clauses to place the responsibility for uncertain events on other parties for which the contract serves to indicate mutual agreement for this risk transfer. |
| Avoid the Risk | Active avoidance of a particular task or scope of work, such as demolition of a building that may have asbestos in it, in order to ensure that the risk is not encountered. |
| Require Bonding | A method that can be used to mitigate counterparty risk, such as risk of performance. In such an example, if the counterparty is unable to perform its obligations, the bonding company will provide some or all of the funds required to complete the work using another party. |
| Accept the Risk | The conscious acceptance that a risk may occur without the pursuit of mitigation strategies. This technique may be appropriate if the potential impact of the risk is deemed to be very low. |
| Purchase Insurance | The use of insurance policies to protect against potential risks. This insurance can be “off the shelf” and readily quotable or a customized product depending upon the type of risk involved. |
| Hedging | The use of financial instruments, such as options or futures contracts, to mitigate potential financial risks such as currency fluctuations as well as other types of risks, which may require more customized products. |
| Payment Retention | The retention of a portion of counterparty’s payment until the completion of all obligations as an incentive to complete performance. In AIA standard form contracts, this amount is typically 10% of the contract value. |

[34] Chilcott, Alan, “Risk Management – A Developing Field of Study and Application”, Cost Engineering, 52: 9, 14, 2010.

[35] CMAA and FMI Corporation, “Beyond the Bell Curve”, FMI/CMAA Ninth Annual Survey of Owners, Raleigh, NC, FMI Corporation, 5, 2008.

Figure 1 illustrates where the eight mitigation strategies examined within this article fall within the CMAA typology.

**Figure 1 - Mitigation Strategies as Compared to CMAA Typology**


It should be noted that mitigation options are not mutually exclusive and that firms will often utilize one or more technique when managing a risk.[36] For example, a specialty contractor may be hired to perform hazardous waste removal (contractually transferring the risk) but the general contractor would also be wise to require bonding for that subcontractor in order to guarantee performance. If this precaution is not taken and the subcontractor is unable to perform its duties, the risk would pass back to the general contractor, who thought that it had addressed the risk. Further, even when mitigation strategies are in place, active management and subsequent action, such as contract administration and monitoring, are required to ensure that the risk is effectively controlled.[37]

Not every situation requires an "active" risk management approach. In certain situations it may be best to simply recognize but ignore a risk. One such instance is when both the severity and the frequency of a risk are low and therefore the additional cost to perform active risk mitigation techniques is not worth the added benefit of potentially alleviating the impact of the risk, should it occur.[38]

[36] Bruner and O'Connor on Construction Law, Section 7.4.

[37] Frankel, James and Kenneth Lazaruk, "Preventing Legal Problems during Construction", Risk Management, 38: 11, 35 – 36, 1991.

[38] Even passive risk management techniques, such as contractual transfer, are not without cost as the other party bears the potential cost of the risk and therefore will pass on at least a portion of the cost through the contractual mechanism. Furthermore, if the organization attempting to mitigate the risk is better equipped to handle the risk, the cost of simply ignoring the risk may be less than the cost incurred via the contractual mechanism due to the comparative advantage of the firm in bearing the potential cost of the risk.

**Monitoring and Controlling Risk**

After mitigation strategies have been identified the organization needs to set up a plan for monitoring and controlling the various risks to which it will be exposed. While there are a number of tools that organizations may use to perform these tasks, this research report discusses one example only – the risk register. The risk register is a consolidated document or set of documents that contains the results of the risk identification, analysis and mitigation steps. The risk register is a formal process that identifies, quantifies and categorizes the risks facing an organization, develops cost-effective methods to control them and positions the organization to achieve its stated goals. The process generates information for decision making at all levels of the organization and allows all members of the organization to speak cogently about the risks the organization faces.[39] The risk register provides a detailed description of all identified risks including description, category, cause, probability of occurrence and current status, among other elements.[40]

As a result of their integrative nature, risk registers must be kept current and updated. In order to do so, there should be regularly scheduled meetings with management and the risk management group or a similar division within the organization to review the status of the risk register. By enforcing these procedures the risk register becomes the working document that functions as the bedrock of the firm's risk mitigation plan for any particular project.[41] While risk registers serve to communicate information regarding risks to management and the project team, there are often problems with this approach. As Ackermann indicates, there are two primary issues with the use of risk registers. He states, "Firstly, the risk registers become a bureaucratic procedure instead of being treated as a valuable exercise. Secondly, and possibly as a result of this behavior and the focus on engineering/technical risks, those risks identified in the register tend to address only a small proportion of all types of risk."[42] However, if these pitfalls can be avoided, the risk register serves as a best practice for risk management, and in concert with other tools, such as Monte Carlo simulations, can help to enhance the coherence of the entire risk management process.[43]

[39]Leonard, Barry J., "Assessing Risk Systematically", Risk Management, 42: 1, 12 – 17, 1995.

[40]Chilcott, Alan, "Risk Management – A Developing Field of Study and Application", Cost Engineering, 52: 9, 9 – 17, 2010.

[41]Krishna, R.V., "Risk Management: What Contract Administrators Should Know", Contract Management, 45: 4, 51, 2005.

[42]Ackermann, F., C Eden, T Williams, and S Howick, "Systemic Risk Management: A Case Study", Journal of the Operational Research Society, 58: 39, 2007.

[43]Mulambya, Emmanuel. 2007. "The Value Added by Linking the Project Risk Register to Quantitative Risk Analysis", 2007 AACE International Transactions, Risk.08, 1 – 6.

## METHODS AND MEASURES

The Navigant Construction Forum™ conducted a comprehensive survey of 34 experts in Navigant's Global Construction Practice in late 2011 and early 2012. The topics addressed in this survey included background information on the expert's past clients and past working experience; demographic information; the expert's estimation of the frequency and severity of the risks that they had experienced; their perceived level of their own risk management experience on behalf of owners or contractors; as well as questions regarding the techniques with which they were familiar and that they thought were most effective for performing risk identification, analysis and mitigation efforts. A subset of the questions asked on the survey has been analyzed for the purposes of this research report.

The survey was administered through a survey module on the company's intranet system. Respondents were instructed to spend only limited amounts of time on each question in order to elicit "top of mind" responses, which help to mitigate cognitive bias, such as the availability heuristic, when the experts assessed the frequency and severity of the various risk categories.[44]

Of the 80 experts contacted for this assessment, 34 responded over a four-week period, a 42.5% response rate. Demographic variables were collected for all experts surveyed. These controls included the gender, age, office location, and number of years with the firm. In addition, past experience of the experts was measured using two metrics. These metrics included the number of project types on which they worked and the number of sub-practices of which the expert is a part (measured by using the categories maintained by the firm). In addition, we collected data regarding prior firm types worked for and prior client firm types.

The demographic variables indicate that a representative cross section of the Navigant Global Construction Practice's experts was collected with 24% of the respondents working in international offices, while the actual proportion of experts working in international locations at the firm is 26%. The average years of experience working for the firm ranged from 1 to 29 years, with 9.6 years being the average. Multiple types of project experience within construction were also included, with some of the representative project types including, but not limited to:

1. Residential and Mixed Use Buildings
2. Roads and Highways
3. Power Plants
4. Water and Wastewater Projects
5. Schools and Universities
6. Military Bases

While the sample size may appear to be small, the average number of years of experience for these individuals is 9.6 years, as mentioned above. Collectively, this group of 34 individuals possesses over 325 years of project and risk management experience at their current firm alone. Moreover, many of these individuals have worked in other capacities within the construction industry, with over two thirds of the respondents having prior work experience with general contractors, and at least a third of the respondents having prior work experience with private owners, architect/engineering firms and other consulting firms. In addition, as discussed above, when experts are operating within the bounds of their expertise, research indicates that they demonstrate superior decision making and information processing capabilities.[45]

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[44] Tversky, Amos and Daniel Kahneman, "Availability: A Heuristic for Judging Frequency and Probability', Cognitive Psychology, 4: 207 – 232, 1973.

[45] Glaser, Robert, "Expertise and Learning: How Do We Think About Instructural Processes Now That We Have Discovered Knowledge Structures?" In Complex information processing: The impact of Herbert Simon. Hillsdale, NJ, Erlbaum, 269-282, 1988.

## Relative Frequency and Severity

Each of the experts was queried on the relative frequency and severity of a number of construction risks. In order to determine the expert's familiarity with the risks under investigation, past experiences with various construction related risks were captured with fourteen binary variables based on an adoption of the risks captured in the U.S. Department of Energy Risk Management Guide.[46] The risks categories investigated include:

1. Front-end Planning Risks
2. Market-Related Risks
3. Technical Risks
4. Budget Risks
5. Contract/Specification Risks
6. Site Risks
7. Staffing Risks
8. Organizational Risks
9. Design Risks
10. Procurement Risks
11. Project Execution Risks
12. Regulatory/Compliance Risks
13. Contract Administration Risks
14. Disputes and Claims Risks

For each of these risks, representative examples were provided to ground the answers of the respondents. For example, for Contract/Specification risks, the following examples were provided:

"Unclear scope definition or technical requirements, conflicting, excessive, or deficient requirements, poor incentive structures."

Similar illustrative examples were provided for all fourteen risk categories.

After this information was collected, the experts were asked to estimate the relative frequency and severity of each of the risks above. The experts utilized a pre-established scale to rank the relative frequency and severity of each risk.[47] The gradations of these scales can be found in Table 4.[48] In addition to this data, information was collected on the number of past project types and sub-practices on which the expert had worked in order to provide additional insight into how past experiences may influence the ranking of the various risk types by the experts.

### Table 4 - Relative Frequency and Severity Scales

| RELATIVE FREQUENCY SCALE | RELATIVE SEVERITY SCALE |
|---|---|
| 1 - Highly Unlikely (<.005% of projects) | 1 - No Impact to Project Cost |
| 2 - Very Unlikely (.005 - 1% of projects) | 2 - No Significant Impact to Project Cost (<1% Increase) |
| 3 - Low (1-10% of projects) | 3 - Slight Impact to Project Cost (1 - 10% Increase) |
| 4 - Possible (10-68% of projects) | 4 - Moderate Impact to Project Cost (10 -25% Increase) |
| 5 - Likely (68 - 90% of projects) | 5 - Significant Impact to Project Cost (25 - 50% Increase) |
| 6 - Almost Certain (90 - 100% of Projects) | 6 - Catastrophic Impact to Project Cost (>50% Increase) |

[46] U.S. Department of Energy, Risk Management Guide, 2011. https://www.directives.doe.gov/.

[47] A no response option was also provided in addition to the scale to allow respondents unfamiliar with a certain risk type to respond accordingly.

[48] The frequency scale is adopted from Mulambya (2007) and the severity scale is adopted from Chilcott (2010) (previously cited herein).

**Risk Management Techniques**

In order to assess the prevalence and relative importance of the various techniques employed for identifying, analyzing and mitigating risk, three different sets of measures have been constructed from a review of prior literature. For risk identification, a combination of techniques presented in Adams[49] and Chilcott[50] were included. In all, twelve techniques were examined. Table 1 (previously shown) provides the name of each technique, a brief definition of the technique and a representative example of how the technique would be applied in an actual construction management setting, where applicable.

Binary variables were created for each with a positive response corresponding to familiarity with, or past use of, the technique. In addition, two additional variables were coded corresponding to the techniques with which the expert was "most familiar" and the technique the expert believed was "most effective". Only one technique could be selected for each of these responses but the technique selected could be the same for both responses (e.g., an expert could have stated that they were most familiar with risk records and believe that this particular technique was most effective). A "none of the above" option was provided as well to allow for those experts with no experience with any of these techniques to provide an accurate response to these survey items.

A similar approach was undertaken with risk analysis tools. In this case, techniques described throughout the literature were selected and included in a comprehensive list of risk analysis techniques. Table 2 (previously shown) provides all of the techniques for which binary variables were coded and the source of those techniques within the literature. As was performed with the risk identification methods, two additional measures were developed that captured the risk analysis technique with which experts were "most familiar" and the technique that they believed was "most effective". Again, a "none of the above" option was provided as well to allow for those with no experience with any of these techniques to provide an accurate response to these survey items.

Risk mitigation techniques were also captured in a similar manner. A comprehensive list of techniques discussed in Chilcott[51] was adopted in order to determine the relative familiarity of the experts with the techniques discussed in that work. The mitigation techniques for which data was collected and representative definitions of those techniques can be found in Table 3 (previously shown). Unlike the other two techniques, data for these variables was not coded on a binary basis. For these variables, the relative frequency of usage for each of the techniques was coded on a six-point scale, defined as follows:

0. Never

1. Rarely (<5% of engagements)

2. Sometimes (5 - 15%)

3. Often (15 - 35%)

4. More than most others (35 - 75%)

5. Almost exclusively (>75%)

This additional detail is captured so the relative frequency of mitigation technique usage can be estimated. In addition, this data has been interpreted on a binary (i.e., familiar/not familiar) basis. Finally, data regarding the expert's self-assessment of the maturity of their risk management processes was collected on a five-point scale based on the measure defined in Zou.[52] This scale ranges from 1 (No Risk Management Process) to 5 (Very Mature).

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[49] Adams, Francis K., "Construction Cost Risk Management: A Study of Practices in the United Kingdom", Cost Engineering, 50: 1, 22 – 33, 2008.

[50] Chilcott, Alan, "Risk Management – A Developing Field of Study and Application", Cost Engineering, 52: 9, 9 – 17, 2010.

[51] Chilcott, Alan. "Risk Management – A Developing Field of Study and Application", Cost Engineering, 52: 9, 9 – 17, 2010.

[52] Zou, Patrick, Ying Chen and Tsz-Ying Chan, "Understanding and Improving Your Risk Management Capability: Assessment Model for Construction Organizations", Journal of Construction Engineering and Management, 136: 854 – 863, 2010.

## FINDINGS

As an exploratory study, several procedures were performed to uncover both descriptive statistics regarding the relative prevalence of risk management strategies within the expert population but also to test potential correlations both within and between the various components of the risk management process. Table 5 below provides the descriptive statistics for some of the variables examined in this study. As can be seen from the table, a wide range of experts is represented in the study. Some individuals have experience with every risk category examined in this research report while other individuals have been exposed only to one risk type, with the average individual experiencing 10 of the 14 risks at some point in their career. Table 6 illustrates the relative frequency with which each of the major risk categories have been experienced by the experts that comprise this sample.

### Table 5 - Descriptive Statistics

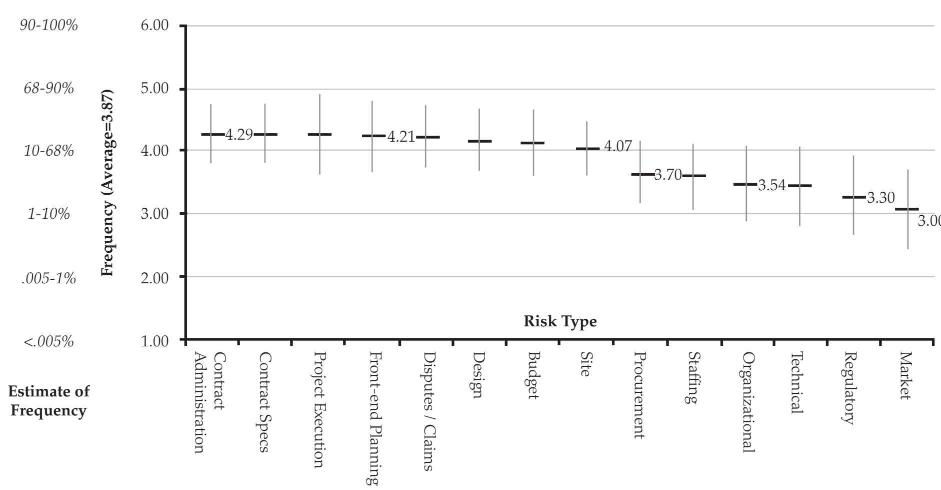
| | N | MINIMUM | MAXIMUM | MEAN | STD. DEVIATION |
|---|---|---|---|---|---|
| Office (International = 1) | 34 | 0 | 1 | 0.24 | 0.431 |
| Gender (Male = 1) | 34 | 0 | 1 | 0.94 | 0.239 |
| Age | 34 | 31 | 71 | 46.68 | 8.923 |
| Years at Firm | 33 | 1.0 | 29.0 | 9.561 | 6.938 |
| Number of Sub-practices | 34 | 1 | 7 | 3.15 | 1.893 |
| Past Project Types | 34 | 1 | 23 | 13.21 | 5.825 |
| Risks Experienced | 34 | 1 | 14 | 10.00 | 3.534 |
| Identification Methods | 34 | 0 | 9 | 4.35 | 2.398 |
| Analysis Methods | 34 | 0 | 9 | 3.71 | 2.394 |
| Mitigation Methods | 34 | 0 | 8 | 6.15 | 2.002 |
| Valid N (listwise) | 33 | | | | |

### Table 6 - Relative Prevalence of Risks Experienced

| RISK TYPE | % OF RESPONDENTS FAMILIAR WITH RISK |
|---|---|
| Budget Risks | 73.5% |
| Contract/Specification/Statement of Work Risks | 97.1% |
| Contract Administration Risks | 70.6% |
| Design Risks | 88.2% |
| Disputes and Claims Risks | 91.2% |
| Front-end Planning Risks | 73.5% |
| Market-Related Risks | 50.0% |
| Organizational Risks | 61.8% |
| Procurement Risks | 70.6% |
| Project Execution Risks | 82.4% |
| Regulatory / Compliance Risks | 58.8% |
| Site Risks | 82.4% |
| Staffing Risks | 70.6% |
| Technical Risks | 47.1% |

With respect to the analysis of risk frequency, the results indicate that there are well defined groups of risk with similar relative frequencies as illustrated in Figure 2 below. There appear to be three broad groupings of risk. At the high end, seven of the fourteen risks are thought to occur with a similar frequency with responses ranging from 4.07 to 4.29. These risks deal primarily with contractual and front-end risks such as contract specification, front-end planning and design. However, it should be noted that the two risks cited as the most frequent are project execution and contract administration which are the "blocking and tackling" of construction projects and whose period of potential risk exposure is often the longest of any of the risks examined.[53] The second grouping of risks, comprised of five additional risks, ranging from 3.30 to 3.70, comprise more internal risks such as staffing, procurement and organizational risks, as well as technical risk (which can be considered an internal risk because this risk deals with whether the firm has the technical capabilities to perform the work). Finally, market risk stands alone with a value of 3.00, indicating that the experts believe that market risk, outside of standard procurement issues (such as late delivery, or cost escalation due to backorders), does not occur very often (using the scale provided, market risks are expected to 1-10% of the time, as compared to the most frequent risk of 4.29, which corresponds to the risk occurring somewhere between 30 - 80% of the time).[54]

## Figure 2 - Frequency Rankings




**Notes:**

[1] The solid marks in the middle of the lines denote the average of the responses. The vertical lines represent a 95% confidence interval for the estimate.

[2] On average, for all risk types, the expected frequency of a cost impact is between 10-68%

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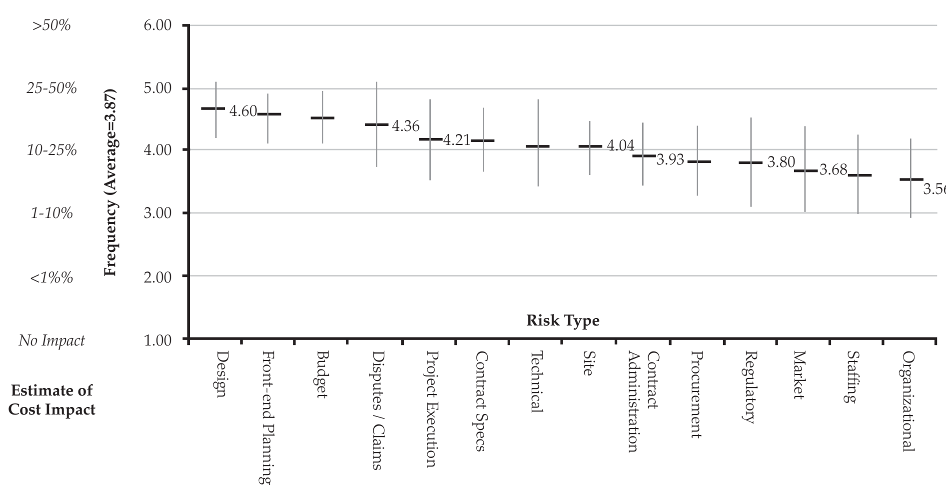
53 In other words, the number of opportunities for a risk to occur is the highest for these risk categories due to the extensive length of time that the project is exposed to these risks. As a simple probabilistic example, even if each day the risk of a project execution error is 1% (with a resulting probability of nothing wrong occurring of 99%) as the number of days increases, the probability of nothing going wrong continues to decline by the formula (1 – P (Nothing Going Wrong) = 1 – (.99) ^N, where N equals the number of days of project execution. In comparison, procurement risk will occur only during specific windows of time on the project (e.g., order time, delivery time, transit time). Once the product is on site, the procurement risk no longer applies.

54 This amount has been computed by taking the average of the "4"" range (10 – 68%) ≅ 30% and the average of the "5" range (68 – 90%) ≅ 80%.

A similar approach can be taken when analyzing the risk severity responses, which are shown in Figure 3. While the groupings are not as clear with severity (i.e., the gaps between the relative rankings are smaller), there appear to be several distinct groups as well. At the top end, with values around 4.60, front-end planning and design risks are considered to be the most severe, followed closely behind by budget. This is to be expected since these risks occur at the outset of the project and any issues encountered and overlooked or not properly mitigated during the front end of the project have a disproportionate impact on project cost, as illustrated in Figure 4.[55]

This disproportionate impact on cost is due to the compounding effects of any early problem. For example, if a design error regarding pipe runs is not discovered until late in the project, a substantial amount of rework may need to be done on the structural and civil components of the building in order to mitigate the error or a complete redesign of the entire space may need to occur in order to meet specifications or applicable codes. After these front-end problems comes disputes and claims (value = 4.36) whose impact is severe largely because of the uncertainty in the ultimate outcome of the claims process. Claims can be overstated in order to maximize the chances of recovery of some amount and therefore the magnitude as well as the variability of the potential loss is high. This variability of loss is illustrated by the relatively wide confidence interval for this estimate. The next group of risks, from project execution to site risks (values ranging from 4.21 to 4.04) relate to a variety of execution risks, primarily whether the project can be performed productively and to specifications. The remaining risks are a mixture of internal and external risks that all have ratings of less than 4.00, and in general represent relatively specialized risks that impact discrete areas of performance and as a result may not be considered to have a substantial or global impact on project execution and related costs.

## Figure 3 - Severity Rankings

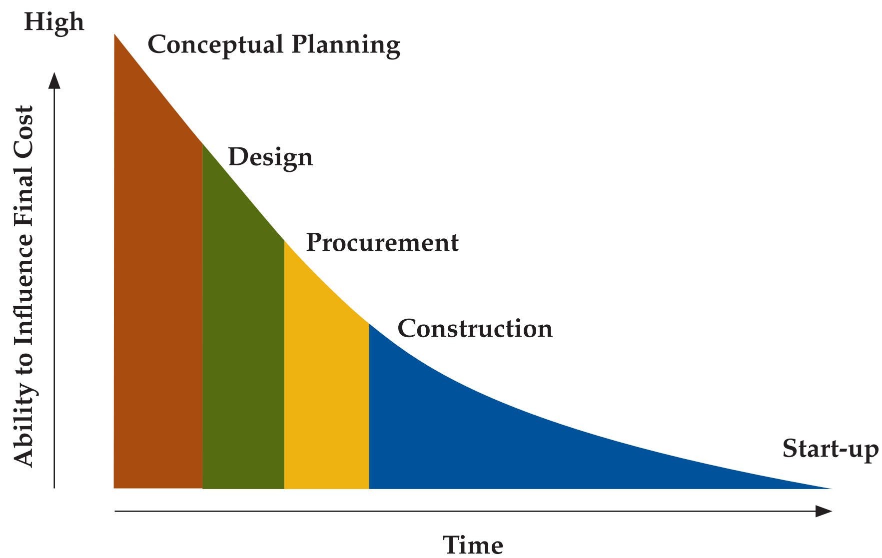



**Notes:**
[1] On average, for all risk types, the expected severity of a cost impact is between 10-25%, conditional on the risk occurring.

[2] The solid marks in the middle of the lines denote the average of the responses. The vertical lines represent a 95% confidence interval for the estimate.

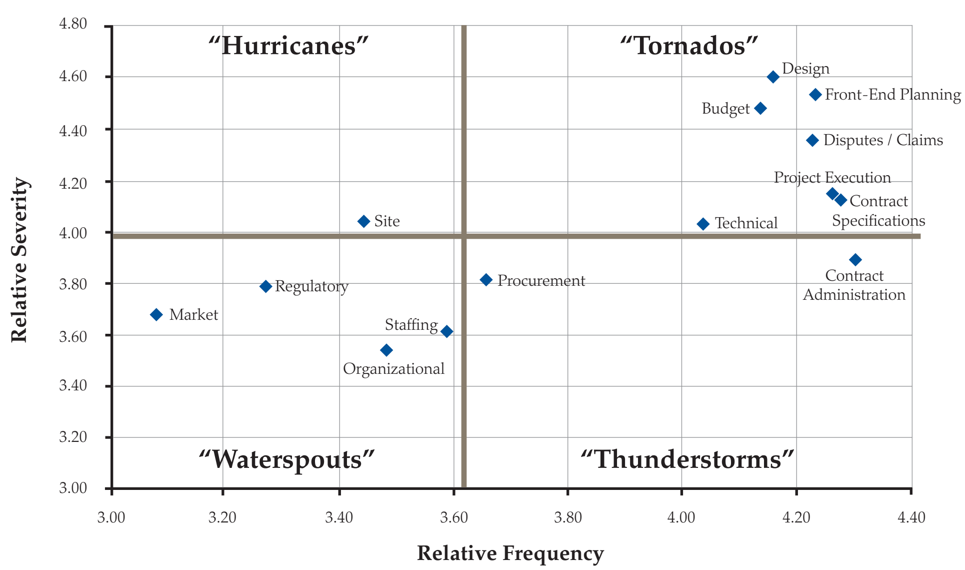
[55] A similar probabilistic analysis can be performed here. Analyze the project from the perspective of the budget. In the beginning, there are very few line items, each of which has large dollar amounts associated with them. As the project becomes more defined, the number of line items increases and the cost per line item decreases. If risk is modeled as a random error affecting these line items, the higher the cost per line item, the higher the overall impact to the budget will be if there is an event that results in a cost increase for that line item.

**Figure 4 - Changes in Risk Severity Over the Course of Project Execution**




Looking at frequency and severity in concert, this research report adopted the FMI/CMAA scheme for classifying the relative frequency and severity of risks. Their 2 x 2 matrix classifies risks as waterspouts (low frequency and severity), thunderstorms (high frequency, low severity), hurricanes (low frequency, high severity) and tornadoes (high frequency, high severity). Using this classification scheme and dividing the range of responses in half (e.g., the relative frequency of risks is divided so that low frequency is defined as the bottom 50% of the range and high frequency is defined as the top 50% of the range), the risks classified by our expert sample have been split into the four categories, as illustrated in Figure 5.

**Figure 5 - Relative Impact of Risks Examined**



Unlike the CMAA study there do not seem to be as many risks that have been categorized in the upper left or bottom right quadrants (corresponding to a high level in one variable and a low level in the other variable). The correlation between the two variables of interest, frequency and severity, is over .70 indicating a significant positive relationship between the perceptions of risk frequency and severity (i.e., a high score for one of the variables indicates that the other variable will also be scored high and vice versa).

In order to manage the various risks discussed above, the survey respondents (on average) are familiar with approximately 4.4 risk identification techniques, 3.7 risk analysis techniques (both of which comprise ≅33% of all techniques under study for each category) and 6.15 risk mitigation techniques (≅75% of all mitigation techniques examined). It is not surprising that the average survey respondents, as experts in managing construction risk, have been exposed to such a large percentage of the mitigation techniques relative to their average exposure to risk identification and analysis techniques.

Most experts surveyed have worked with a variety of clients. The percentage of respondents with past hands-on experience with major construction organization types ranged from 40% to 100% (for public owners). Virtually all respondents have worked with general contractors, private owners and public owners as clients in the past. However, in spite of this large body of experience, the average expert believes that their risk management methods are only somewhat mature (the mean is 2.91, as defined by the 5 point scale described previously). Table 7 provides a summary of the information related to past clients and experience, as well as the expert's self-evaluated risk maturity level.

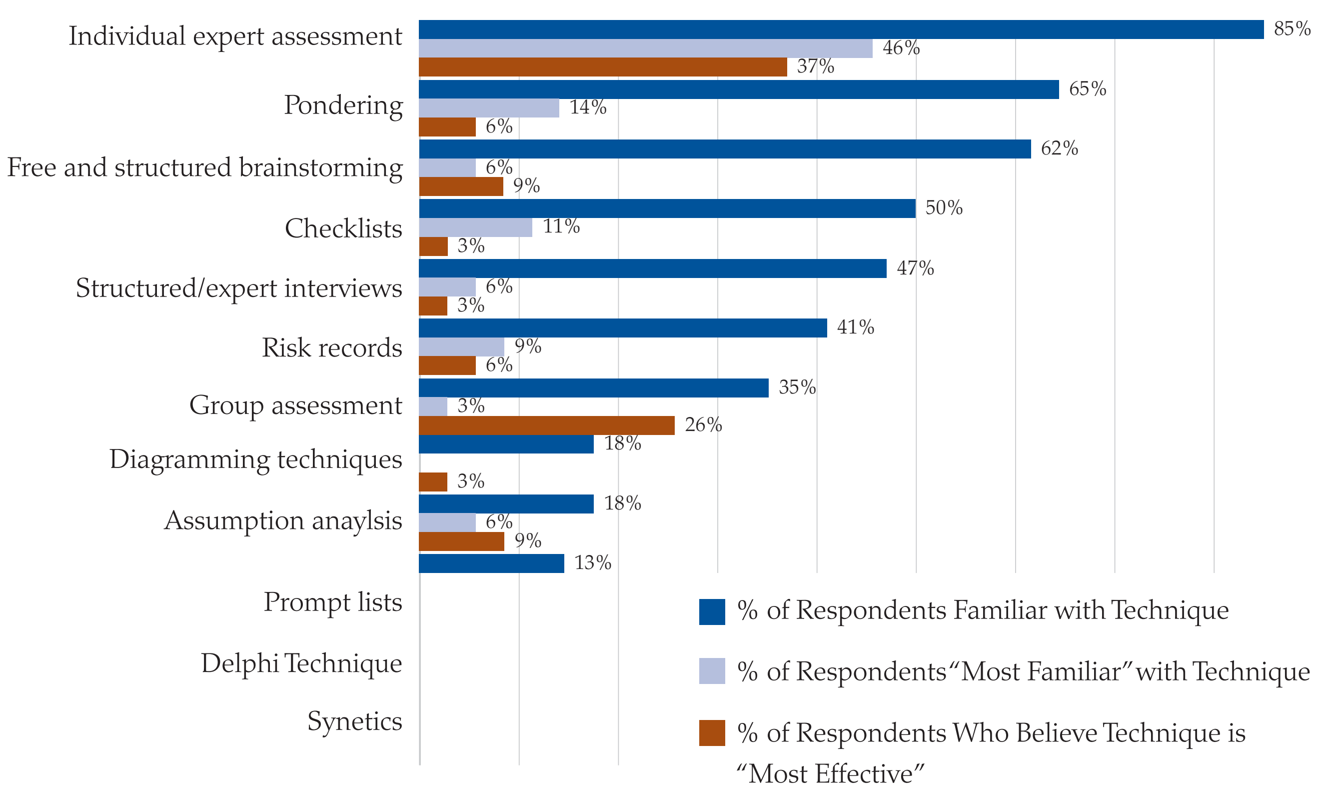
### Table 7 - Past Experience and Assessment of Risk Management Maturity

| | N | MINIMUM | MAXIMUM | MEAN | STD. DEVIATION |
|---|---|---|---|---|---|
| **Past Clients** | | | | | |
| Other Parties | 34 | 0 | 1 | .41 | .500 |
| Insurance Agencies | 34 | 0 | 1 | .79 | .410 |
| Subcontractors | 34 | 0 | 1 | .85 | .359 |
| Architects / Engineers | 34 | 0 | 1 | .79 | .410 |
| General Contractors | 34 | 0 | 1 | .91 | .288 |
| Public Owners | 34 | 1 | 1 | 1.00 | .000 |
| Private Owners | 34 | 0 | 1 | .97 | .171 |
| **Past Work Experience** | | | | | |
| Other Parties | 34 | 0 | 1 | .18 | .387 |
| Other Consulting Firms | 34 | 0 | 1 | .53 | .507 |
| Law Firms | 34 | 0 | 1 | .21 | .410 |
| Insurance Agencies | 34 | 0 | 1 | .18 | .387 |
| Subcontractors | 34 | 0 | 1 | .26 | .448 |
| Architects / Engineers | 34 | 0 | 1 | .47 | .507 |
| General Contractors | 34 | 0 | 1 | .71 | .462 |
| Public Owners | 34 | 0 | 1 | .38 | .493 |
| Private Owners | 34 | 0 | 1 | .41 | .500 |
| Risk Management Maturity | 34 | 1 | 5 | 2.91 | .900 |
| Valid N (listwise) | 34 | | | | |

As a whole, the respondents utilized a variety of risk identification methods. Figure 6 provides, for each technique, the percentage of experts that are familiar with the technique. In addition, the graphic illustrates the percentage of experts who believe they are most familiar with a particular technique, as well as which technique they believe is most effective. While it is to be expected that construction experts would be highly familiar with the use of individual expert assessment, only three techniques have been used by a majority of the respondents. At the other end of the spectrum, two of the techniques have not been used by any of the experts.

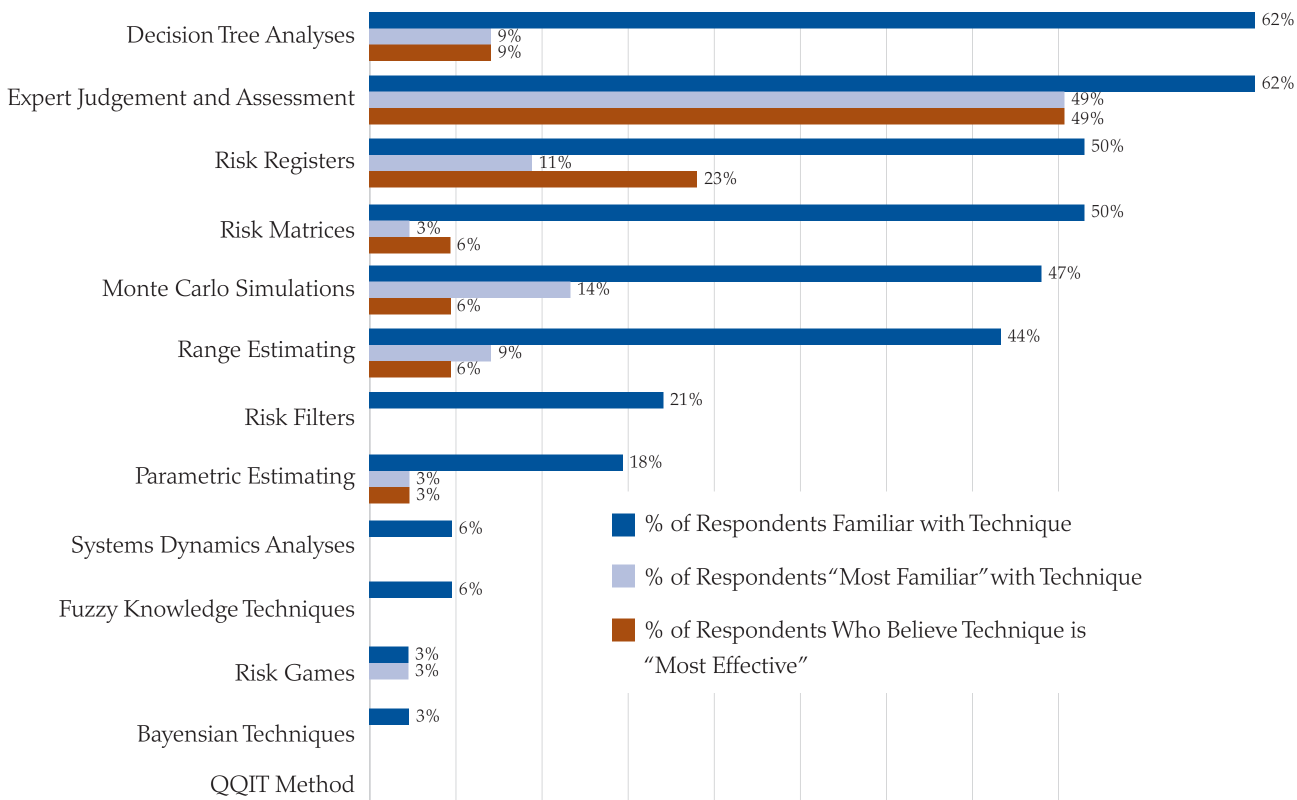
There is little consensus amongst the experts as to what is the most effective technique for identifying risk. However, the two most commonly chosen elements are individual expert assessment and group assessment. More importantly, while only 35% of respondents were familiar with the group analysis, 75% of those respondents (26% of the total sample) stated that this technique was the most effective. This is an interesting finding, because group level assessment performed by a variety of experts in multiple fields should be more effective at identifying a greater proportion of all the potential risks on a project, due to the experts' ability to provide potential sources of risk within their various areas of expertise.

**Table 6 - Risk Identification Techniques**



While there is a relatively smooth gradient between the various techniques for identifying risk, there is a more abrupt distinction between the frequently used analysis techniques compared to the lesser used methods as illustrated in Figure 7. In addition, there appears to be widespread consensus (49% of responses) that the best method for analyzing risk is the use of expert judgment and assessment.[56] Interestingly, while decision tree analysis is tied as the most recognized method among all the risk management techniques, only 9% of the respondents believe that it is the most effective technique. This may be due in part to the fact that, while decision tree analyses are readily understood from a theoretical perspective, they can be difficult to implement in practice. Specifically, the estimation of probabilities at several levels of the decision tree is often subjective and may not be viewed as an effective and objective method of analysis for this reason. Another technique that has been gaining popularity over the past decade is risk registers.[57] Based on the responses to the survey, just over half of the respondents were aware of risk register techniques and approximately half of those individuals believe that the use of risk registers is the most effective method for analyzing risk. However, there has not been a significant amount of interest in the more marginal methods such as risk games and systems dynamics analyses. This may be due in part to the relative newness of these techniques, the potential limitation of technique applicability or a perception that these techniques are not as effective as other methods.

**Table 6 - Risk Identification Techniques**




[56] This may be due in part to bias caused by the pool of respondents drawn from.

[57] Leonard, Barry J., "Assessing Risk Systematically", Risk Management, 42: 1, 12 – 17, 1995.

Consistent with the data collected in Adams[58], there appears to be an awareness of quantitative risk management techniques within the respondent population. Specifically, decision tree analyses, Monte Carlo simulations and range estimating are quantitative methods that have experienced increased interest in the literature over the past several years and have found application in many settings.[59] However, based on the relatively low percentage of respondents who stated that they are either most familiar with these techniques or believe that they are most effective, it appears that these techniques have still not displaced more qualitative methods such as the risk register and the use of individual expert assessment.[60] There does seem to be an increased interest in quantitative techniques as several quantitative techniques are now used by over 40% of the sample population. In time, it may be the case that the more marginal methods examined in this study will continue to gain popularity as the relative familiarity with these newer techniques, such as Bayesian modeling, becomes more widespread. Conversely, it may be the case that these methods are not used because their relative complexity outweighs any additional knowledge gained rendering their utility in construction risk management settings insufficient for them to be in widespread use.

With respect to mitigation techniques, almost all of the methods are widely practiced. Every technique has been practiced by at least half of the respondents. There is a high correlation between the mitigation techniques with which people are most familiar and the technique that they believe to be most effective. However, 19% of the sample did not select any of the stated techniques as the most effective. While Figure 8 suggests that there is a large discrepancy between the relative use of mitigation techniques based on the expert's perceptions of their effectiveness, in the end almost all techniques are used to a similar extent, with the top three techniques (Payment Retention, Contractual Transfer, and Risk Reduction) being used as the primary mitigation technique in approximately 50% of cases, with each technique being utilized on a roughly equal basis, as shown in Figure 9.

[58] Adams, Francis K., "Construction Cost Risk Management: A Study of Practices in the United Kingdom", Cost Engineering, 50: 1, 22 – 33, 2008.

[59] David Hulett et al. Integrated Cost and Schedule Risk Analysis Using Monte Carlo Simulation of a CPM Model, AACE Recommended Practices. 57R-09.

[60] The Adams study illustrated a similar relative lack of awareness and use while sampling a wider pool of job types, including engineers, quantity surveyors, and project managers, among others.

**Figure 8 - Risk Mitigation Techniques**

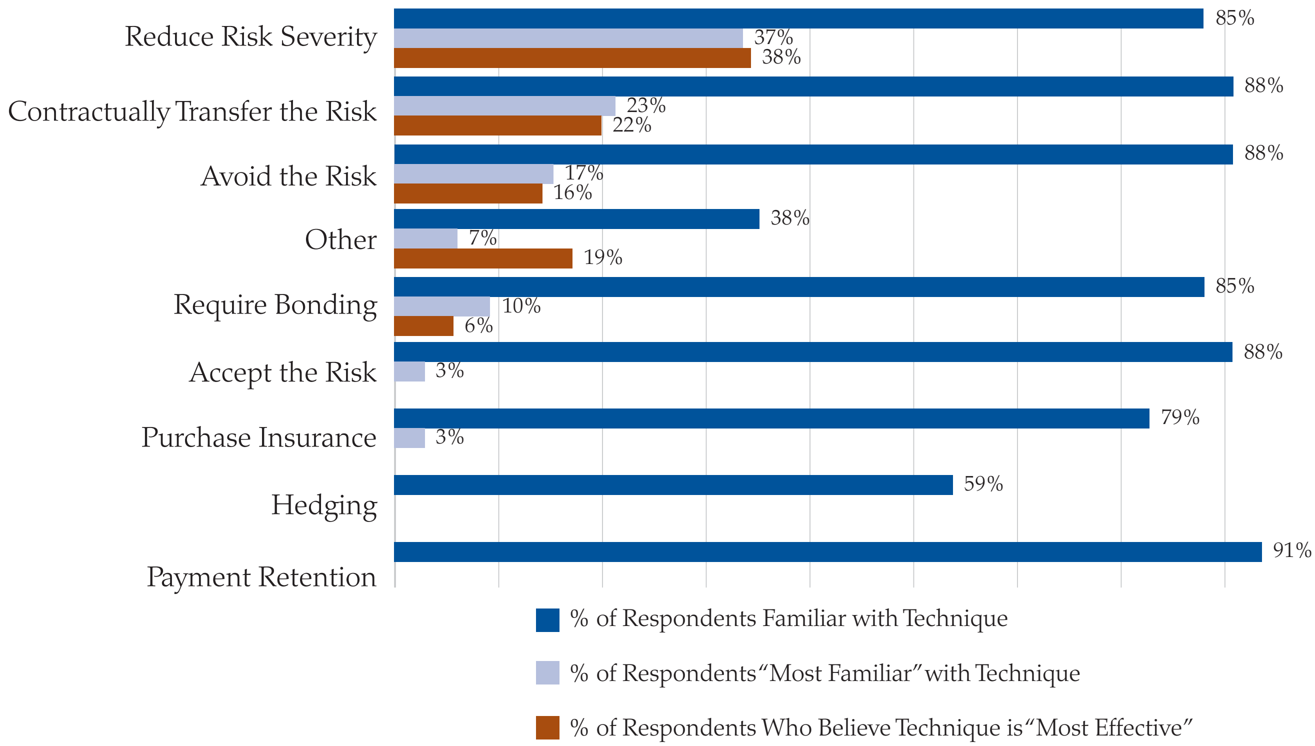
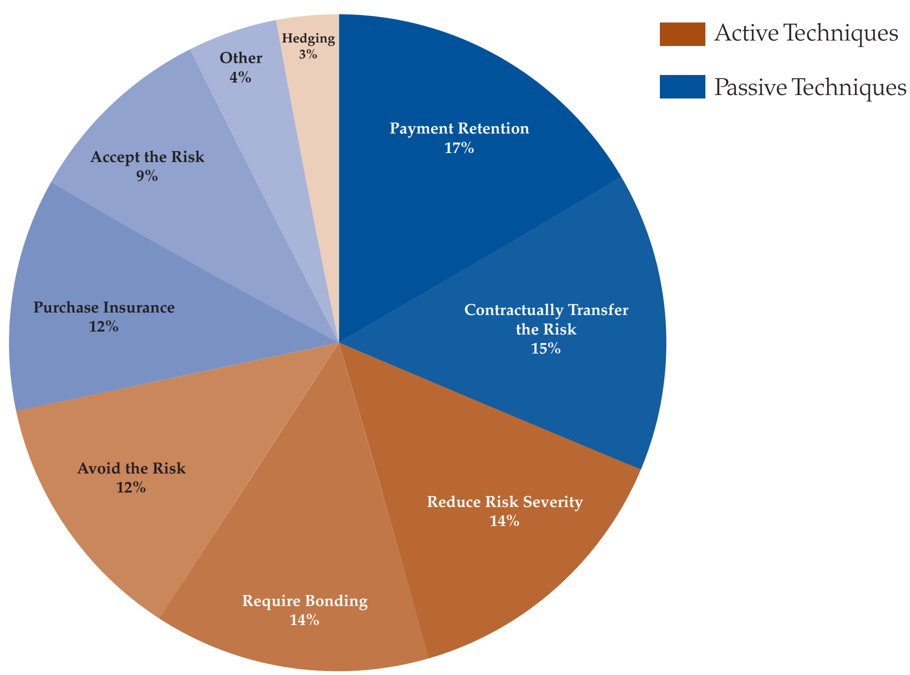



**Figure 9 - Relative Frequency of Risk Mitigation Technique Usage**



The relative use of mitigation graphic indicates that hedging as a technique is used very rarely. This may be due in large part to a lack of hedging opportunities in many instances. While it is possible for international projects to mitigate currency risk through hedging and commodity price risk domestically, this method of risk mitigation may not have the versatility of some of the other methods such as a contractual transfer or insurance. Alternatively, it may be the case that the use of hedging is not yet well established in the industry and, as financial innovations continue to permeate the sector, the use of this technique will increase. As discussed earlier in this study, risk mitigation strategies can be classified along two dimensions: the level of ownership of the risk by the firm and relative activity of the firm in mitigating the risk. This study indicates that a majority of respondents believed active risk management (in the form of reducing risk severity and avoiding risk) is the most effective tool for mitigating risk. Passive risk management techniques are not as highly valued with a passive recognition and acceptance of the risk not considered as most effective by any of the experts. This is not to say that such a technique is not used when appropriate as the data on relative usage indicates that this method is used on a regular basis. However, acceptance of a high level of ownership for a risk in this technique and its associated impacts coupled with a lack of active management results in the experts rejecting the technique as the most effective method for handling risk in a general sense.

## CONCLUSIONS

As was stated in the 2011 McGraw Hill Mitigation of Risk in Construction SmartMarket Report, "…good risk management is a business imperative in construction."[61] To that end, this study has attempted to systematically examine almost every aspect of the risk management process and ascertain expert opinions on each of these elements. To begin, this research report looked at the risk management process to understand the key elements of a successful risk management system. In so doing, it became clear that, in order to have an effective risk management process, relevant estimates of the frequency and severity of major risks are required.

Based on a survey of construction experts, the research report established estimates of the frequency and severity for fourteen major risk categories and, using that information, determined the risks that are most likely to have a severe impact on the job. Furthermore, the report utilized the same pool of experts not only to establish what tools and techniques are commonly used but also to glean insights into what the construction experts believed to be the most effective techniques for identifying, analyzing and mitigating risk. Moreover, the research report was able to estimate the relative usage of each of the mitigation techniques by those same experts.

[61] McGraw-Hill Construction SmartMarket Reports. Mitigation of Risk in Construction: Strategies for Reducing Risk and Maximizing Profitability, the McGraw Hill Companies, 4, 2011.

The stakes are high in construction risk management. Recent studies have shown that, on average, 24% of projects are late in completion, 19% go over budget and 11% involve the dispute and claims process.[62] Therefore, it is essential to ensure construction professionals are sufficiently armed with accurate assessments of the relative risk of various project elements and that they are able to distinguish between the most effective tools and techniques for managing risk compared to the rest of the options. To that end the key takeaways from this report are:

1. The most harmful risk types are associated with front-end planning, design, budget and disputes and claims. Each of these risks occurs with relatively high frequency and also results in a significant loss when they occur. Note that three of the four risks mentioned are associated with the beginning of project execution. The fourth risk is a pervasive risk that requires careful and diligent monitoring of other risks throughout the course of the project.
2. Of the twelve techniques examined, the most effective risk identification techniques are individual and group level assessment. However, these techniques should be complemented by past datasets and other analytical tools, such as brainstorming.
3. Based on a review of thirteen methods, the most effective risk analysis techniques vary depending on the risks examined, but expert assessment and risk registers are considered to be the most effective with other more specialized quantitative tools such as decision tree analyses and range estimating being used as well.
4. Active risk mitigation approaches are considered most effective. This is the case both in terms of when the level of risk ownership is high (through risk reduction strategies) as well as when risk ownership is low (avoidance of the risk).

It is important to bear in mind that, while historical order and precedent are important, random events can and do happen.[63] Those firms that consistently and diligently execute their risk management programs are best able to take advantage not only of a fortunate turn of events, but also to mitigate potential issues on their next project.

[62] Mitigation of Risk in Construction: Strategies for Reducing Risk and Maximizing Profitability, 4.

[63] Beyond the Bell Curve, FMI / CMAA Ninth Annual Survey of Owners, 3,

## Future Efforts of the Navigant Construction Forum™

In the second quarter of 2012, the Navigant Construction Forum™ will continue its analysis of construction industry issues. The Navigant Construction Forum™ is in the process of performing a survey of industry experts to determine current trends related to construction claims. It is expected that the results of this survey will enable construction industry participants to become more attuned to such new trends.

Further research will continue to be performed and published by the Navigant Construction Forum™ as we move forward. If any readers of this report have ideas on further construction dispute-related research they believe would be helpful to the industry, they are invited to e-mail suggestions to jim.zack@navigant.com.

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